POLICY-MAKING PROCESSES AND EVALUATION TOOLS: S&T INDICATORS

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Summary

In the first part, we define S&T indicators are inputs of quantitative knowledge into the decision-making processes. They bring pieces of information into the process and help the actors to interact meaningfully with each other. S&T indicators can measure activities at different scales (micro, meso, macro), dealing with the different aspects (allocation of resources and definition of objectives) and the different contexts of decision (scientific, operational, strategic).

In a second part, it is stated that S&T indicators must have reliability and relevance to be useful in the decision-making processes. Then, we distinguish four categories of indicators: the human and financial resources aspects (inputs), the S&T production aspects (outputs), the interactions (co-operations, linkages, knowledge flows…) and the performance aspects.

In a third part, we state that S&T indicators production is an activity which deals with public policy debate and decision making; it is also, of course, a technical activity. The former has to do mostly with the relationship to the users of the indicators, the latter with the question of the source data which will be used to produce the indicators. The various source data for the indicators are presented, with their characteristics of level of aggregation, statistical, legal and technical status.

In a fourth part, we make a criticism of the indicators and show they cannot be used alone for decision-making, proposing a 'mixed' approach using both qualitative and quantitative elements.

Finally, in a fifth part, we suggest indicators are a useful device for public policy decision-making, provided they are considered not as results, but as entry points for debate. We conclude saying that indicators ultimately help build linkages and debates among an extended group of social actors, the result being that science and technology can enter in democracy

1. Introduction

1.1 The National Research and Innovation System

The national research and innovation system is the set of institutions, such as innovating firms, universities, public research organizations, knowledge based services, governmental institutions, which are involved in the production, diffusion and use of knowledge. The goals of such a system may be:

- the production of scientific knowledge,
- the contribution to higher education,
- the participation to industrial innovation and, more generally, to the scientific and technology base of industrial competitiveness,
- the production of the scientific expertise needed for the conception and implementation of public policies concerning health, environment, food safety, transportation, energy, etc.,
- the contribution to the strategic objectives of the state, expressed in terms of defense capabilities or technological self reliance in key areas.

In a 'knowledge society', the national research and innovation system plays a major role in the competitiveness of nations. It is a determinant of the quality of life enjoyed by the citizens of a nation. The efficiency of the national research and innovation system of a nation depends both on the quality of its institutions, and on the quality of their interactions.

In what follows, we will concentrate on that part of the system that consists in public institutions, so that we will deal mostly with public research and with public policy making activities.

1.2 Scale and Object of the Decisions on Research Activities

The efficiency of the national research and innovation system is rooted into the relevance of the decisions each one of its actors is making day after day. Such decisions affect each institution but also, in the longer term, the dynamics of the whole system and determine its capability of evolution and adaptation.

These decisions can take three different scales, corresponding to different kinds of institutions:

- micro scale: individual scientist, teams of researchers, research project;
- meso scale: research institutes, universities, research programs, scientific disciplines;
- macro scale: national policies.

At each one of these scales, the decisions may have two different objects:

- decision on the allocation of resources (as, for example, the funding of a research project);
- decisions on the definition of objectives and general organization (as, for example, the launching of a new program, or the reform of an organization).

Decisions concerning allocation of resources often suppose some sort of explicit or implicit ranking of the entities among which the choices are to be made, while decisions on the definition of objectives and general organization usually take the form of a process involving the management of the organization concerned.

We obtain a typology of six kinds of decisions concerning S&T activities by combining the scale and the object of decisions (Table 1). These decisions encompass what is called policy-making and evaluation, the former referring largely to the definition of objectives and general organization, the latter to the allocation of resources.

Scale	Object of decision	Example of decision
Micro (individual researcher, research team, laboratory, project)	Allocation of resources	Choice of project to fund
	Definition of objectives and general organization	Setting of the scientific objectives of a laboratory
Meso (research institution, university, program, scientific discipline)	Allocation of resources	Budgetary priorities within an institution
	Definition of objectives and general organization	Orientation of a program or of an institution
Macro (national level, S&T policy)	Allocation of resources	National budgetary priorities
	Definition of objectives and general organization	Orientation of national policy

Table 1. Scales and objects of decision concerning S&T activities

1.3 The Nature of the Decisions and the Actors Involved

Another way of looking at the decisions concerning S&T activities is to distinguish decisions dealing with issues internal to the scientific community, those dealing with the operationalization of research activities and those dealing with the relationship between scientific institutions and society.

Decisions of scientific nature will put forward the criteria of the scientific quality of a piece of research. Only scientists will be involved in the decision, according to the process of 'peer review': only scientists recognized as peers are legitimate to decide on the scientific issues.

Decision of operational nature will be concerned by criteria of efficient and proper use of resources. The actors involved are those in charge of the management of the resources, having operational objectives.

Decision of strategic nature will rely on criteria of socioeconomic relevance of a scientific activity. They will be concerned with determining the relevance and objectives of research and technological development. Here, a variety of actors representing social actors will also be involved, in particular those of the political decision-making system.

Nature of decision	Criteria of the decision and actors involved	Example of decision

Scientific nature	• Scientific quality • Scientists ('peers')	Choice among research projects for funding
Operational nature	• Proper use of resources procedural and regulatory validity of management • Managers, accountants,	Procedures of preparing, executing and monitoring the budget; contract, industrial property and personnel management
Strategic nature	• Relevance of objectives and overall organisation • Decision-makers, politicians	Budgetary priorities Institutional strategy

Table 2. Nature of the decisions concerning S&T activities

Decision-making regarding S&T activities will involve groups of persons, organized in committees or panels: decisions in S&T activities are characterized by their collective nature, rooted in the fact that either the peers or the political system are the source of legitimacy: in both cases the decision making process will be based on collective work.

Being so collective and complex, decision-making processes regarding S&T activities need knowledge inputs. S&T indicators are inputs of quantitative knowledge useful for the decision-making processes. Their role is both to bring pieces of information into the process and to help the actors of the process interact meaningfully with each other. All decisions regarding S&T activities, whatever their scale, object and nature, are concerned by this process. In the field of research activities, decisions, whatever their scale, object or nature, are often called 'evaluations'. In what follows, we will stick to the concept of decision-making, since evaluation concerns a particular aspect of the decision-making processes.

2. S&T Indicators: Definition, Terms of Reference and Categories

2.1 Definition

S&T indicators are quantitative measurement of parameters describing research activities and actors. Like all measurements, indicators explicitly relate to a conceptual model or a representation of how things work. The most frequent model is the input-output model: resources flow to research activities, which in turn produce outputs (scientific and technological results), which ultimately will produce impacts on society and the economy.

Indicators differ from statistical measurements in the sense that indicators are explicitly related to a policy question or a decision to be made. S&T indicators will therefore refer to the various possible decisions in the field of research, which can be synthesized as in Table 3 (below). S&T indicators can measure activities at different scales (micro, meso, macro), dealing with the different objects of a decision (allocation of resources and definition of objectives) and the different contexts of a decision (scientific, operational, strategic contexts).

In all cases, the *raison d'être* of indicators is to test an hypothesis: if a decision is to be done, the preparation of that decision consist in understanding the way the sub-system related to this decision will function and in imagining alternative actions and checking their relevance. All this points to an attitude of formulation and testing of hypothesis. It is very important to notice that such an attitude requires both a knowledge of the demands of stakeholders, and the construction of a conceptual framework, which will help identify the relevant parameters and useful hypothesis.

We can determine the form of S&T indicators and the circulation they will have by distinguishing them by their purpose:

- General interest S&T indicators: usually at national or regional scales, can be published widely in the form of an 'S&T indicators report', both for purposes of communication and support for general policy making;
- S&T indicators prepared for a particular question or decision to be made: they usually take the form of a dossier or a report of small diffusion, mostly for the use of those directly involved;
- S&T indicators related to an institution: they often take the form of a report both for internal use and for interaction with stakeholders.

Many countries publish every year, or every two years, a national S&T indicators report. Some have it published it entirely on a web-site. Research institutions publish partly their indicators on their web-site. This stresses the communication role of S&T indicators which must be recognized as tools that accompany the decision making process.

	Object of decision	**Nature - criterion of decision**		
		Scientific evaluation Scientific quality	**Operational evaluation Operational efficiency**	**Strategic evaluation Societal relevance**
Micro (individual researcher, research team, laboratory, project)	Allocation of resources	Scientific quality of a researcher, research team, laboratory or project	Operational efficiency of researcher, research team, laboratory or project	Societal relevance of a researcher, research team, laboratory or project
	Definition of objectives and general organization	Scientific interest of the orientation of a researcher, team or laboratory	Operational efficiency of the organization of the project, team or laboratory	Societal relevance of the orientation of a researcher, team or laboratory
Meso (research institution, university, program,	Allocation of resources	Scientific quality of research institution, university, program	Operational efficiency of research institution, university, program	Societal relevance of research institution, university, program

scientific discipline)	Definition of objectives and general organization	Scientific interest of the orientation of a research institution, university, program	Operational efficiency of the organization of the research institution, university, program	Scientific interest of the orientation of a research institution, university, program
Macro (national level, S&T policy)	Allocation of resources Definition of objectives and general organization	Scientific interest of the orientation of the research and innovation system	Operational efficiency of the research and innovation system	Societal relevance of the S&T policy orientations

Table 3. S&T decisions and indicators.

2.2 Characteristics of S&T Indicators Useful for Decision-making

S&T indicators, if they are to be of any use in the decision-making processes should tend toward two basic characteristics: their reliability and relevance.

2.2.1 The Reliability Criterion

The reliability of an indicator is the confidence one can have that it measures exactly what it pretends to measure. There are two components to reliability:

- the accuracy of the computation of the indicator,
- the coherence between what is measured in reality and it is measuring.

The accuracy of computation is obtained through the transparency of the data collection and treatment processes. Source data must be referenced, treatments must be made explicit and reproductible. The production of the indicators has to be challengeable and disputable. Criteria of scientificity apply to the production of indicators.

In practice, limitations to accuracy come from difficulties to have full transparency on the production of source data and the complexity of the treatments which make it almost impossible to explicit and share the various steps. Some sort of validation of computation occurs through comparison of results obtained by different indicators producing units, hence the importance of the diversity of indicators production capabilities.

The coherence between what is measured in reality and what is said to be measured depend on the conceptual aspects of indicators production. Two questions can be mentioned:

- How precise are the definition of the measured parameters. For example, there are many ways to define what is a researcher (one can include, or not, the post-doctoral students), so that risks of non comparability are high between two measurements, unless it is very precisely indicated what is the definition used.

- How is made the correspondance between the parameter actually measured and it is measuring. This is the whole problem of the 'proxies': for example, a classical 'proxy' for measuring the technological orientation of a public research institution or a university, is to build an indicator of its patenting activity. But in the case the patenting is contrained by the resources devoted to the patenting bureau of the institution or university, the proxy will measure the evolution of the budget of the bureau, and not the technological capability of the institution!

2.2.2 The Relevance Criterion

In the definition of an indicator, its relevance for decision-making processes is of particular importance. S&T indicators have to address the questions which are at stake in all the possible contexts as shown in Table 3. They need to measure parameters of entities of various scales, from laboratory to national level (micro, meso, macro scales) and parameters describing the human and financial resources aspects (inputs), the S&T production aspects (outputs) or the institutional, financial or cognitive interactions (co-operations, linkages, knowledge flows…).

They have to address allocation of resources issues or definition of objectives and general organization. In the first case, the indicators will have to help ranking entities or at least make comparative statements; in the second case, they will rather help positioning an entity in its context, comparing the positions and evolutions with other entities.

In general, measurement of the evolutions along a sufficient time period, comparisons among entities (regions, countries, laboratories...) and geographical or institutional dimensions of the indicators permit to help their relevance.

In brief, the relevance of an indicator will depend on:

- the proper understanding of what is at stake and of what is the demand of the stakeholders and decision makers,
- the quality of the underlying conceptual model, which helps define both the parameters to be measured and the hypothesis to be tested and discussed.

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Biographical Sketch

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