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# Historical overview on the evolution and organization of the activities concerning S&T indicators on European level.

## I. INTRODUCTION

The activity on the Science and Technology Indicators at the European Commission did not appear until 1993, a bit at the same period when Japan and France published their own first Reports on S&T indicators (in 1991 and 1993 respectively). We do not count the one from the OECD, published since 1988, which contains mainly tables with data. The United States have published their own Report since the end of the second world war (the first NSF report dates from 1951).

## II. HISTORICAL OVERVIEW OF THE SCIENTIFIC POLICY

One can wonder about the reasons of this advance of some forty years[1] of the great power of the post-war period (USA) on his old allies or adversaries. There is no doubt that it is necessary to see the initial effort of raising urgent concern of the latter. After massive destruction, this leaves little place to the hegemonic claims. This is contrary to the policy preached by Vannevar Bush since 1945 who has assigned the American public funds to basic research and higher education in order to preserve in the future the new military and economic predominance of the United States. Also its only rival, the Soviet Union, had suffered a lot. Bandaging their wounds, forced to get along to hold an acceptable rank, the European countries delegated the concern to benchmark themselves among one another at the scientific and technical level to the International Organizations such as UNESCO. Concretized initially by the Treaty of Paris (1951) on Coal and Steel, then the Treaty of Rome (1954), this European agreement develops only gradually its own competencies and its organization. At the research level, the Community makes use of article 235 in 1974 to extend its field beyond the nuclear power and the coal/steel. In line with this, it sets up an evaluation activity in 1977, which will be first method of

[1] This same shift is observed on the level of the evaluation of the public policies in general and the scientific policy in particular, the United States starting the analysis of the social behavior as of the 1920 and being introduced in Europe only much later. In our view, the American advance results from the need for an increasing intervention of the federal state between oligopolies and the giant trade unions, a necessarily massive intervention and the effects or potential imbalances of which, could have also massive consequences and that thus had to be measured imperatively.

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control of its research projects. The Commission receives a specific research mandate only in 1987, when the Single Act formalizes the Framework Programme, its operations and its control. Thus from the second Framework Programme on (1987-1994), the Commission departments dispose not only of an evaluation unit, a strategy unit and a unit of prospective studies to direct its RTD activities, they also have a specific programme to improve each of these instruments of evaluation and control, namely the Monitor Programme.

Things were now more or less organised within the Communities to prepare the appearance of an " indicators " preoccupation. This was confirmed in the Monitor programme, which was designed at the time when France prepared its first Report[2-3] on the Indicators of S&T. This programme included an "Indicators" network to develop the measurement of certain Community activities: international co-operation, impact of the Framework Programme,...

There was just a momentum needed to transform this latent concern into an urgent necessity. We will come back on what we could call the needs for a decision maker, "needs" which are seldom properly or logically defined in the spirit of this person in charge, but for this are not less throbbing.

Before we make an attempt to define these needs and the way they envolve with time or legislation, it is worth to narrate a personal experience which occurred half way through the Monitor Programme, during one of the session of the above mentionned « indicators » network, and which illustrates the mood in which the indicators were initiated.

> « As we were organizing this fifth or sixth meeting, we felt the concrete urgency of consulting the potential users on the series of rather sophisticated ex-post indicators developed by the academics of the network : there was a good reason for that, since none of these nice specific indicators had ever appeared in any evaluation report yet. We had thus invited, amoung several national decision makers, our own Director in charge of S&T policy. He was expected to open the workshop. His main message was one of mere complaints : none of the existing reports were helpful… Eurostat Statistics on S&T appropriations by socio-economic fields were mere tables of boring data ; DGXII booklets on national S&T policies were too Members States centered, allowing no comparison ; evaluation reports were too programme oriented… As for the NSF report, it was too limitating in information on the European Union. What was needed were several pages giving clear, outspeaking data on the place of Europe compared to its main competitors. But which information should be given in priority, the policy maker could not provide… »

Basically, as a national representative of a Ministry of Science put it, the very same day, the decision markers is bombarded so often with so much information from so many sources that it is a real challenge for him to make-up his mind when faced with a political decision on S&T matters : statistics of all kinds (national, OECD…) on one side, written information from Universities, from the ministries on the other hand and lastly policy questions stemming from national departments, from the government…

In that stage, it is necessary to return to the political decision maker and examine more systematically the never ending – but useful - flow of data which he has to exploit to conduct any kind of policy. He has to take into account a number of factors; not only of the past (previous actions and their results which he has to evaluate), but also of the

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[2] Science and Technology Indicators 1993, report of OST, Economica.

[3] We only know that Denmark had been the pioneer of this kind of report in Europe, with the report of the ministry for Research " Udviklingen I forskning og teknologi I 1980 ' erne ", Copenhagen, 1991.

present (his country's condition compared to others', based on statistics and the indicators derived from these statistics, the state of techniques and in particular emerging techniques, by organising a proper technological survey, in the case of research) and finally of the future ( of the possible strategic actions envisaged by other players and his owns, while anticipating their risks and consequences, and imagining a number of alternative strategic scenario's). The strongest pressure by far is that of the present (shocks of any nature, political, economical, social, scientific breakthroughs, and last but no least, the opinion of the press and the public).

Let us try to organise and situate all that data for what we commonly call Science and Technology Indicators in order to discern the reasons for their popularity, which they still enjoy currently

## III. THE PLACE OF THE " INDICATORS ": WHAT DO WE PUT IN EC CONCEPT?

Rather than considering the production of indicators in a sequential way as is desired to set-up a programme (ex-post evaluation, recent statistics, technological / strategic / prospective survey), we simplify the ideas by concentrating on the way the data and the required information are obtained. Doing so, we can distinguish three types of data; the statistics, the evaluation and the Indicators. This leads to two immediate advantages. First of all, the range of variables taken into account is reduced from five to three and second, this distinction reflects significantly the type of organisation itself, largely depending on the mode of collection considered.

Under the label **statistics**, we group all the data that are methodically collected for the benefit of the central government in each of the Member States. In spite of their aridity of exploitation, the statistics have been used since the beginning of times. Sumer counted his population and his reserves on clay shelves as of 5000 before Jesus-Christ; the Kings of France introduced the term itself around 1328 a/c., by establishing "the condition of the fires, goods and the statistics of the Kingdom. If one seeks to characterise the statistics, they allow, because of their regularity in time and space, to perceive the evolutions quantitatively and to make cross-country comparisons, at the expense of a considerable organisation and duration, if one wants to be able to trust the collected data.

In addition, one will group under the label **evaluation** all the information deriving from the " ad hoc " efforts made in order to follow the execution of a policy. Whether this information relates to the resources ex-ante (inputs), or to the results (outputs) or to the impact, all information is generally speaking much more qualitative than the data provided by the previous statistics group. One could compare the evaluation to a photography, often subjective and qualitative, of a particular action at a particular moment in time, with an important social and human component, bias to pay for the actuality of the obtained information. For our purposes, we have to include not only the ex-ante photographs, such as choice of propositions, prospective and Delphi studies, technological surveys and risk assessments, but also ex-post photographs such as repartition tables, monitoring, evaluation reports, impact studies.

We will qualify finally as "**indicators**" all the combinations drawn from the data obtained by the two preceding ways and/or drawn from all other kinds of data, which aim at seeking and building any significant relation between the variables considered, allowing to comprehend the impact of public actions. The academic studies and analyses, the indicator's Reports, the summaries for politicians are as much products of

presentation as they are attempts to rationalise the knowledge with a more or less open spectrum. The indicators constitute the latest step of presentation, in the exploitation and organisation of data for the decision maker.

In this sense, Indicators bridge a gap between statistics, which are the raw material, and the qualitative recommendations to policy makers. They allow those who formulate these recommendations to build upon comparable data.

## IV. THE CO-EVOLUTION OF ASSISTANCE TO DECISION MAKING AND OF S&T POLICY IN THE COMMUNITY

### a) The emergence of assistance to S&T decision-making

Departing from the rough way of grouping the information necessary for decision making, one could try and derive interesting correlations. One can follow on the one hand the appearance of, or disaffection in one way or another of understanding the events and preparing the actions, on the other hand, the hierarchical importance attached to the organisational unit in charge of following the corresponding activities.

Thus, in the case of services of the Commission, one will find in table 1, compared to the various milestones of the community S&T policy, the appearance of such or such " product " in each of the above groups. Figures 1 to 5 on the other hand give the courses of the S&T statistical, evaluation, strategy, prospective and indicators units in the organisation chart of the Commission and more particularly of DG XII, Eurostat or the JRC[4] during the implementation of the successive Framework-Programmes.

Thus, although the statistical office of the Community (Eurostat), respectively 12 and 7 years after the birth of ECCS[5] and Euratom comprises in 1962 already six Directions, the unit of the statistics on " Research, Science and Education " appears only in 1975. This is only slightly in advance on all the other forms of evaluating the community research (fig. 1). However, this unit was very quickly involved in the work of harmonisation and contributed largely to the quality of the data of the OECD and the drafting of the handbooks of the series of Frascati. It has published each year, starting in 1974, the NABS data of the EU (Nomenclature for Analysis of Comparison of the Budgets and Scientific programmes). The products published, although very relevant, did not lend themselves easily to the reading for decision maker, often under time pressure. Moreover, the absence of engineer-economists to analyse the statistics was a further draw back for the public decision maker.

On top of that, the unit disappeared in 1989, only to reappear in 1990 (fig. 3) under the heading "Research and Development, Statistical methods".

Charged with the set up of methods for the new S&T statistics (regional data, innovation data, data on human resources, it has had to work in close collaboration with the unit

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[4] JRC= Joint Research Centre. The mission of the CCR is to tackle the trans-border problems (environment, risks) or to carry out important trans-national research (measurement of reference, standards, ...). The CCR materialises the gathering of the scientists of the various member states, stimulating the feeling of membership in Europe. It was installed by the European Commission of the Atomic Energy in 1958 and is currently made up of 11 Institutes of different expertises divided over 5 European sites.

[5] ECCS = European Community for Coal and Steel (1951)

"Coordination of S&T policy of the member states" under the impulse of CREST[6], to launch the COPOL series (comparison of R&D policies of the member states), member state by member state. Eurostat practically did not innovate in the presentation of its S&T products during the last 10 years.

When then does the second form of decision maker support, namely that of evaluation, appear?

Until 1974, the Commission departments, in the two fields of research where they were implicated, nuclear power and coal-steel, carried out the research in two different ways, directly in the sites of the Joint Research Centre and with their own personnel (Euratom) or subcontracting to the European coal and steel research centers (ECCS). Assessing tenders for research contracts was posed only for ECCS (ex-ante), other research was the subject of a competition between the national programs and Euratom itself, but at the Institution budgetary level (Euratom having its own reactor type, ORGEL).
The conferences or the committees of experts, the annual reports of the Institutes dealt as ex-post evaluation, as they were subjected to the purely scientific judgement of the experts in the field, and without the term " evaluation " being specifically used. One must quote then that starting from 1972, the first " indirect " research projects, nuclear and non-nuclear of DG III "Industrial, Technological and Scientific Affairs", gave place to examinations of the proposals by experts (ex-post evaluation) and to programmes closing conferences dealing as ex-post evaluation (purely scientific).

It is necessary to take a look at the circumstances of that time to understand the progressive ripening of the idea of a global community S&T policy and to define its organization and its requirements: the fusion of executives arised in 1967 because the success of the EEC to lower the barriers for foreign trade and to realise a custom union made the disparity of regional policy, agriculture and technology between the different Member States very clear. It prevented also all coordination between these policies, the more because Euratom was in crisis very as much as the whole nuclear sector. Therefore Europe had failed to make the efforts of the Member States coherent. The latter had worked in dispersed order and remained confined in their national markets.

If we add to this the sudden awareness of technological differences between Europe and the USA (the "American Challenge" of J.J. Servan-Schreiber dates from 1969), the events of May 1968 due to industrial reorganizations and the threat from the Spring of Prague, one understands better the multiple initiatives (Aigrain Report, creation of COST, the memorandum of Colonna, the Top of Paris) which finally led to the action plan and to the Council Resolution of 1974 to use the article 235 to make place for new research, the Community henceforth having its own S&T policy.

This new era of institutional research even obtains a legal framework more codified than the Resolution foresees, consisting for the first time of permanent forums for technology forecasting and evaluations, and of an action plan focussing on forecasting, evaluation and methodology.

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[6] CREST = Committee on the European Research on S&T. This Committee, constituted of representatives of the Member States and the Commission, was founded in 1974 to help the Council and the Commission to co-ordinate the national policies and to define projects of Community interest in S&T.

These provisions are translated in the foundation, in 1975, of DG XII "Research, Science and Education", including a Directorate, called "R&D Policy", flanked by an eclectic unit " Planning, analysis and evaluation of systems and programs ". This unit covered at the same time the ex-ante and the ex-post evaluations. Three years later, it splitted into two units, one incharge of the "Long-term Forecasting, Preparation of R&D decisions and inter-direction coordination" in the Directorate R&D Policy", and the other in charge of ‘‘Studies: Methodology of Research, Evaluation and Technology Assesment’’, "In the Directorate Programmes and Scientific co-operation"

It will take the Commission four additional years to concretize the ex-ante aspects of the evaluation. This was done through the establishment of the first FAST programme (Forecasting and Assessment of S&T) in 1978. The memorandum of Colonna recommended already technology forecast indicators in 1970 as a prepartory tool to define the research programs. This period from 1978 to 1988 constituted the golden age of the European Forward studies[7], which also surfed on the wave of the universalization started by the Club of Rome (" Limits of the growth " go back to 1972). The"Prospective" unit, attached to the DG "Science - Research and Development" is an integral part of the decision-making process of Community S&T policy and contributes inter alia to the definition and the inclusion of the ESPRIT programme in the1st and 2nd framework programmes. This is what makes all the originality and constitutes a substantial European passing manoeuvre vis-à-vis the American "Office of Technological Assessment" -OTA-, created two years before in 1972, which functions in parallel with the decision makers.

The ex-post part of the evaluation is harder to formalize into concrete structures: symposia for its development are organised (Milan 1976, Communication to the Council 1979, Copenhagen 1978) and some exercise-tests of evaluation are set up (first evaluation report "Economics of Energy " in 1980), before an action plan is approved by the Commission in 1983. The unit "Research Evaluation " receives this function only in 1982. From then on its action also forms an integral part of the implementation process of the Community S&T policy [8](fig. 2).

It is at this time that the methods of the ex-post evaluation are defined: a mid term evaluation and a final evaluation of each program and a theoretical research on the evaluation methodology (in-depth exploration of the methods, use of independent experts, continuation of studies and diffusion networks of the obtained knowledge).

Between 1984 and 1986, all these effort and attempts are suddenly concretized by the installation of a true S&T policy by DG XII and the organisation of the 1st Framework Programme (1984-1987) which now groups all the programs that existed before (of energy, of raw materials,...). Legally, the Framework Programme was established by the signature of the Single Act (1986) which officialises politically the research mandate of the Commission, (setting priorities, distribution of budget, planning). This legalisation coincides with the entry of Spain and Portugal (1986) into the Community. At the

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[7] In addition to DG XII, a Directorate for «Future programmes» was also initiated at the Commission, establishing "Forward studies " at the JRC ISPRA, and two units " Forecasts " (in the DG XVI-Regional Policy and XVII-Energy) then followed by DG XIX (Budgets) in 1997, DG III (Domestic market) and DG VIII (Development) in 1982.

[8] The example of the DG XII is also reflected in the General Directorates " Development ", (1975) and "Regional Policy " (1979) as at the JRC (1975) where as many units of evaluation or impact are created.

[9] As an indication, the units responsible for these three actions counted a manpower of respectively 20 agents of all statutes (FAST), 10 (SAST) and 25 (SPEAR) in 1992.

conceptual level, evaluation and strategy are incorporated in the same Directorate and work together in order to define and justify the programmes (fig. 3). The MONITOR programme (1989-1993), which emerged at the end of the 2nd Framework Programme, gets for this functional organization the methodological support which enables to refine the effectiveness of the three actions (FAST, Forecasting and Assessment of Science and Technology; SAST, Strategic Analysis of Science and Technology; SPEAR, Specific Programs dealing with Evaluation Activities in Research)[9]. At that time, there was no question of indicators at the Commission apart from the restricted academic circle gathered in one of the networks of the SPEAR program (approximately 20 experts).

b) The modes of assistance to decision-making multiply and specialize: phase of divergence

However, certain initiatives of the Member States or of the Commission itself suggest that this beautiful unit of MONITOR did not solve all the aspects of a public Science and Technology policy: The new President of the Commision, not only founded a Forward Studies Unit (not limited to research, it is true) on his arrival in 1990, but during the reform of the JRC (1987-1991) had confirmed at Ispra the Institute of Future Technology Studies (fig. 3).

Whereas the organization of the scientific policy had sustained without problems throughout the 3rd Framework Programme (1990-1994), the settling in of the 4th Programme suffered from a number of rearrangements. Several units faced displacements in the four following years (fig. 4). The unquestionable success of the FAST program, the more discrete SPEAR programme whose tasks, well delimited, gave them a good visibility, compensated for the weak results of SAST, a bit pressed between the two others progammes.

However, none of these programmes had sufficiently been able to capitalize, nor had accumulated results over a sufficient time to survive without damage the abrupt separation from the operational function of the methodological support from MONITOR. The latter, in our view, prematurely and inadequately replaced by the " Targetted Socio-Economic Programme", found no more support, nor justification (competed by the Forward Studies Unit and the JRC Institute) and, very quickly, (1996) the units ex-FAST and ex-SAST disappeared. The unit " Evaluation " owed its survival, in addition to its "money of the taxpayer" character, only to the compaign it launched to optimize the heavy load that the burden of two evaluations per programmes (mid-term and final) put on specific programmes of the 4th Framework Programme. As a result the collection of statistics on projects the on-line monitoring and its annual monitoring report were handed over to the programme managers. The progammes evaluation for its sake, was to be performed by independent experts, named by the Committees of Programmes and asked to deliver every five years a report of dealing as final evaluation of the previous programme and mid-term evaluation of the on going programme (and of specific programmes that are part of it).

The successive splitting of the "Strategy" Direction in three Directions, one of " Strategy and Coordination ", the other in charge of the " Framework Programme " and the last of

"Socio-Economic Research", the latter on topics very distant from those of the R&D policy carried out hitherto, further complicated the tasks of the services. Figure 4 is, under this view point, symptomatic of the frenzy of reorganization caused by this multiplication of functions generated by the Monitor programme and the better knowledge this latter had provided on the determinants of S&T policy.

At the beginning of the 4th framework programme (1994), the direction "S&T Policy" picks-up the strategic qualification of the former SAST unit (" Actions of RTD: Strategy and Accompanying measures"), divided itself between two subfunctions: upstream, information on the events conditionning the strategic definition of the Framework Programme ("Framework Programme and Technological"), on the one hand, and down stream, implementation outlined with the unit "Generic Technological Initiatives ". The term "watch" was thus appearing for the first time at the Commission, whereas the industry, at least the pharmaceutical industry, practised it on a large scale and in a systematic way for ten years. It disappeared logically less than two years later, when the JRC was recognized as much more suited (from its past experiences and its dimensions) for this activity, ultimately less critical for a great public institution and its litigious decision-making processes than for a company seeking its niche. It was, on this subject, even decided to delocalize the Institute of Prospectives Studies from Ispra to Sevilla, (1994), with its own specific unit in charge of " Technological Watch" (Fig.4).

Less than one year later, the appointment of the new Commission and a new Commissioner for research results in the inclusion in a newly created Directorate «Targetted Socio-Economic Research", of a unit " European Technology Assessment Network " ETAN overtaking the tasks of units " FAST " and " Generic Technologies’’. It leads too, to the appearance of the unit " Indicators and Accompanying Measures" in the direction "Strategy", a unit which we will comment on later.

The last reorganisation of the General Directorate in 1997, brings the unit ETAN logically back in Directorate "Actions of RTD: Strategy and Co-ordination" and assigns the unit "Evaluation of the Programme" to the Directorate "Actions of RTD: Framework Programme". In addition, the reorganisation results in gathering the two Directorates "Human capital and Mobility" and "Targetted Socio-Economic Research" – this latter, a practically stillborn child - in only one Directorate. As for the Institute of Technological Prospective in Sevilla, it reduces the technological watch to very targeted fields (anti-pollution technologies), and embarks in the technical-economic analysis of key development areas of S&T. These key areas are those susceptible to lead to a reconfiguration of society (fig. 5) and reflrcting the direct interests of the decision makers, in the medium term.

c) Emergence of a new report on S&T Indicators

The third form of presentation of information of help to policy decision-makers is the one that we have called "indicators of S&T". Timidly suggested in 1963 within the framework of Euratom as a means of favouring co-operation between member states, the usefulness of comparable data sets allowing comparisons settles in progressively thanks to a combination of circumstances under the influence of some outstanding personalities.

We already evoked how much the diffusion network of the SPEAR progamme has lost contact with the needs of the users in 1992. The approach initiated by the new Commissioner for Science and Development at his arrival, adopted and implemented in complete symbiosis by the Director General and Directorate "Actions of RTD: "Framework–Programme", is a posteriori, a good example of the validity of the theory of organisational success.

Indeed, an inter-device ad hoc group (trans-unity working group, GTT) punctured on the various units and under the responsibility of the most qualified agent of the Directorate, receives the specific task to carry out as soon as possible an European Report on Scientific and Technical Indicators. As a result, the members of the group enjoyed an environment free from hierarchical gravity and had a random access to the Director. More important, however, was the protection against the effect of advertisement and the possible mediocrity of the performance of this group.

The targetting of the product was also extremely judicious, bringing an undeniable added value with respect to its competitors, which had been carefully studied in advance (coverage widened to 50 countries, against 23 with OECD, indicators on the actual programmes of the Commission untraceable elsewhere, focus on international co-operation).

A circumstance too often neglected relates to the customers' requests and the support. In the case of the new Commissioner, of its successor and especially of their Cabinets, many and pressing requests were never missing, in particular during the development of the 5th Framework Programme, soon after the publication of the first edition. This makes it possible to permanently rectify the adequacy of the product to the privileged customers requirements. Lastly, the cooperative development process of the report and the organisation of the contributions, (shared between contractual external authors and Institution insiders, but ultimately taken over again by the responsible group), has been extremely positive for the quality of the report.This process led,by its learning effect, to the members of the group becoming specialised in one or two topics each , even if, during the final drafting, the extra work appeared unbearable to all.

Much attention has also been given to the publicity made for the report and its diffusion in the press, libraries worldwide, Community documentation…..

The first European Report on S&T indicators (1994) was well received, as it filled an obvious gap in the panoply of the European decision-makers. It was useful as a reference work because of its data on European programmes and on co-operation between countries and as a comparison tool of the policies, resources and scientific and technical results of about 50 countries. The second (1997) edition improved by adding to it a state of the literature and analyses of a majority of topics of scientific and technical policy, in the most impartial possible way. These analyses do not comprise any political recommendation.

The first two reports highlighted a certain number of insufficiencies or obstacles, in particular at the level of data: their coherence, their accessibility and their facility of processing.

At the beginning of the 5th Framework programme (1999-2002), the unit (called in the meanwhile "Competitiveness Economic analyses, indicators") was attached directly to the General Director (fig. 5). In addition to producing the triennial European Report on S&T Indicators, it replies to possible requests of the Commissioner, the General Director or other Commission Departments, and proceds with its own studies while pre-empting the future political requests (series of working documents). Within the context of the 5th Framework Programme, it is charged moreover with a sub-line of the specific research programme "Human Potential and Mobility" entitled "Common Base of Indicators of Science, Technology and Innovation". The concept is the following: in order to be able to conceive, co-ordinate and evaluate the strategies and policies of RTD carried out in Europe, it is necessary to have indicators relevant and comparable at various levels (national, regional, European, world), including indicators measuring progress towards a sustainable development. This type of activities, undertaken with the Statistical Office

and the Services concerned of the Commission and in co-operation with the institutes specialised in Europe, will make it possible to gradually constitute a European common-base of indicators on science, technology and innovation. It will be crucial to co-ordinate and finance, possibly on the bases of precise terms of reference deriving from the obstacles experienced in the development of the two preceding European reports on S&T indicators, the necessary work required for elaborating appropriate statistics and new indicators covering the Union and the main industrialized countries.

Thus it will be possible to put at the disposal of european and national parlamentary evaluation offices, of other services of the Commision or concerned member states and all who are interested a set of coherent data available electronically, together with the necessary services to process, analyse and to correct use of the data.

Is this unit appropriate for the new needs of decision - makers?

This is what the section hereafter will try to examine.

## V- THE FUTURE OF S&T INDICATORS : How to match with new forms of technology policy ?

a) The preparation of the 5th Framework Programme : first signs of the need for new indicators

It is apparent from the previous historical overview that Science and Technology Indicators emerged in a period where the linear view on innovation implemented through the financial support of R&D in large companies was dominant. The technological competitiveness of a country or region was measured by its technological output position (e.g. patents, publications, …) or by its input position (R&D expenditures, budgets,…). Input and output based indicators were necessary to compare the relative position of one's country, region or economic block and analyse the evolution over time of that position. The Science and Technology Indicators Reports really fulfilled a gap in the market of policy advice.

The relative success of the initial S&T Reports also legitimized the creation of a community of researchers that attribute a substantial part of their time to the improvement of S&T indicators as a scientific domain. Many of these scholars belonged to other communities such as econometrics, macro-economics, bibliometrics, statistics, looking for new opportunities to apply their research methods. In Europe, the financial support and prestige of the European Report on S&T Indicators was a motivation for a number of Member States (eg. Finland[1988], Sweden[1992], the Netherlands[1994], Belgium[1998], Ireland[1999], to name just a few) to produce an S & T Report. The snowball effect of these local initiatives attracted new scholars into the domain, a new scientific paradigm emerged (Dosi, 1982).

As with any new paradigm, a number of trajectories have evolved:

(1) a group of scholars devotes an enormous amount of time in the improvement of classic Indicators such as the patent based ones under impulse of OECD's blue sky indicators programme (Van Pottelsberghe and Guellec, 1998) or within the sein of private organisations (Narin, 1997).

(2) A second community of researchers has focused on the analysis of existing indicators and the integration of these indicators in different theoretical models. A

recent overview can be found in the special issues of Research Policy (1999), Research Evaluation (April-August, 1999) and Scientometrics, following the 5th Conference on S&T Indicators (jointly sponsored by the European Commission).

(3) a third group of scholars implemented the methodology of creating S&T indicators in their own country blocks inside or outside Europe (eg. Latin America, Asia, Northern Europe,… ; Argenti et al., 1990 ; Debackere, 1998).

(4) Finally, a fourth group of scholars has started to elaborate new indicators reflecting current themes of interest : eg. Technology and innovation indicators in the service industries (Sirilli, 1998); Indicators of high tech exports (Clarysse, Sloan and Muldur, 1998),….

It is exactly in this latter trajectory of scholars that the first signs of unsatisfaction and criticism can be found reflecting a basic shift in policy since the first elaboration of S&T indicator reports.

Although the S&T Indicator Reports fulfilled a gap at a certain period in time, the linear view of innovation lost some of its importance. Straightforward state aid towards R&D has become under criticism. A number of countries have experienced that this kind of aid is often not sufficient. The systemic view on innovation stressed the importance of improving the relations between the different actor's in a country's or block's Science and Technology System as a necessary complement to the mere state aid advocated in the linear view. Also at the European level, this systemic view emerged. The eventual shortcomings of the traditional S&T Indicators became very clear in the preparation of the Fifth Framework Programme.

Also at the European level the emphasis on the commercial value of R&D projects financed by the Commission, became quite important. In order to justify investments in certain technologies, the Commission needed to show that the technology was not only interesting and challenging from a scientific point of view but that in Europe there existed also an industrial base to commercialise this technology. In addition, policy makers attached more attention to the 'soft technology' programmes in the Framework Programme, including Innovation and Targeted Socio-Economic Research programmes. In a response to that, the Commission needed indicators that both closely reflect the technology output (eg biotech, IT, …) and that can be related to upstream (science indicators) and downstream (industrial indicator) activities. Furtheron, it needed a whole set of new indicators to justify and orient its decisions regarding the innovation-related actions.

The shortcomings mentioned above made it clear that the indicator community had been too much focused on the elaboration of indicators within their specific discipline, i.e. indicators of publication activity (publications, citations,….), indicators of technological acitivity (R&D expenses, patents,…) or indicators of economic activity (value added, sales,…) without paying much attention to the relations between these different disciplines. In fact, whereas innovation policy analysts already advocated the systemic view on innovation and policy makers started to implement it, the indicators community still worked within a very linear paradigm. Only a small number of pioneers, among which Narin et al. (1998) is probably the most well-known, worked on these interfaces (his work focuses on the links between technology and science).

We could conclude that the preparation of the Fifth Framework Programme revealed that the existing programme evaluation reports (monitoring, five-year evaluation) and indicator Reports both were insufficient as a basis for policy formulation. The evaluation and monitoring reports tend still to be too programme specific and especially do hardly contain any real data. The Indicators Report on the other hand produces numbers which are too aggregated to be really useful. Further on, the Report should focus on the interfaces between the fundamental knowledge base (science), the technology base and the industrial activity in a country.

As a result of this experience, a number of changes have been made in the way the indicators are constructed within the sein of the Commission Services :

(1) the preparation of the Fifth Framework Programme indicated that a systematic data base is needed which allows to link the three domains: industrial activity, scientific output and technology input/output. It is not sufficient to say that a particular domain is interesting because a number of research groups work on it. What is the use of a domain for which little or no commercialisation power exists in Europe? Or, for which it is difficult to build the complementary assets necessary to bring the technology to the market. To be able to link the different scientific domains, technological areas and industrial sector, specific focus is needed on the definition of technological domains : the current division which is based on the IPC-codes[10] that can be found in the patent databases is far from sufficient. These codes are made by administrators, who themselves are very much remoted from the technology. For instance, a domain such as biotechnology is not easy to reconstruct based on the patent indicators. First attempts have been done by Barré (1997 ;1998), among others, to link the results of the French Technology Foresight (the key technologies) to the patent classification. Therefore, the Commission Services chose to go beyond the mere production of a tri-annual Report on S&T Indicators. Instead, it launched a programme which provides a substantial budget for research targeted towards the questions of systematic data contruction, interrelations between the different indicators and technology specific indicators.

(2) The Fifth Framework preparation exercise also made clear that staff involved in policy preparation should not be too remoted from the actual policy making. After a couple of publications, the production of an Indicator's Report becomes a stand-alone business with very few relation to the actual user. However, indicators as such tell very little if they are not translated into policy language. In fact, the Indicator's world has become a scientific community on its own, which has become, like most scientific communities, very closed for outsiders. In other words, if you are not accustomed to the terminology, it becomes quite difficult to interpret these indicators. Therefore, changes were made in the way the Indicator's unit is organised within the Commission Services (see also the previous section). The Indicators unit has become attached directly to the Director General of DG XII. In this function it is expected to focus more on the general strategic analysis of technology policy in Europe, using indicators as a supporting instrument for this analysis. Therefore, the production of indicators is not a stand-alone activity anymore. Much economic engineering is needed to translate these statistical data into policy relevant

[10] IPC stands for International Patent Classification

suggestions. The indicators group becomes more a strategic study department which has the production of indicators as just one key activity, among others.

b) Back to the Member States : How does the future of policy support look like ?

As aforementioned, technology policy has changed dramatically in the past few years. In the eighties, it consisted mainly of the financial support towards R&D projects within large companies (direct state aid). The rationale for such policy support was derived from the neo-classic growth theories that stipulate that technology is, next to export and size of the internal demand, the main driver of economic growth. However, the private sector tends to under-invest in R&D because it cannot fully capture the economic returns due to knowledge spillovers. In line with these arguments, governments started to financially support R&D in the form of interest-free loans or straight state aid. In this view, indicators such as R&D expenses per head of the population (supported by government) are nice instruments to evaluate whether the efforts made by your country are in line with other countries' efforts. Indicators which position a country, region or country block in the R&D landscape are long term predictors of economic growth. In the early nineties, which is the period when at the European level little or no indicators were available, the Science and Technology Indicators were very welcome. They provided the first confirmation of the need for a Framework Programme : EU was lagging behind the US and even Japan in terms of R&D investment and output.

Being very useful to give a long term indication of potential for economic growth, the classic Science and Technology Indicators add much less value from a longitudinal perspective. Policy makers want every now and then (each couple of years or so) a reliable snapshot of their country's current position. However, the yearly changes in the Science and Technology Indicators are rather minor. In addition, new forms of technology policy have emerged in the early nineties, which complement the mere financing of R&D projects. Many countries observed that financing R&D was not sufficient to increase the economic potential, at least not in the short term. In what has become known as the European Paradox, it was pointed out that Europe was quite strong in research, but lacked the power to commercialise its research efforts. Thus, a mere financing policy is far from sufficient. The systemic view on innovation backed this hypothesis from a theoretical point of view and provided support to create different forms of technology policy that are more oriented towards increasing the efficiency with which R&D results are commercialised.

These new policy actions can be summarised in at least three different categories:

(1) a number of countries such as the Netherlands and UK have developed a clear innovation policy to support the competitive strength of their SME population.

(2) an increasing number of initiatives have been taken to develop a policy towards high growth, high tech start-ups. Regulations to promote spin-off activities, public seed, mezzanine and early growth venture capital, Business Angel Networks supported by government, etc…are all examples of these kind of activities.

(3) Finally, a number of countries such as Ireland and UK have spent increasing attention towards the sensibilisation of large companies both to increase their R&D activities and to make the management of their R&D portfolio more efficient. R&D audits, benchmarking exercises, R&D management training support are just a few of these examples.

Also at the Commission level, elements of these three new directions in technology policy can be retrieved. The regional funds (DG XVI) in collaboration with DG XXIII (SME) have been quite active in the promotion of innovation to increase the competitive position of SMEs and regions. DG XIII, responsible for the INNOVATION programme, took a number of new initiatives in the Fifth Framework Programme to support Business Angel Networks and the use of seed capital (Aernoudt, 1999). Finally, DG III already started its Benchmarking exercise under the Fourth Framework Programme and continues it even more intensively under the Fifth Programme.

What does this mean for the support of policy decisions and in particular for the creation of Science and Technology Indicators? Innovation policy towards SMEs implies a huge amount of non-financial, non-technical support in the form of consultancy and sensibilisation. The traditional S&T Indicators are not very useful to provide support for this kind of policy. The policy advisors which are involved in this kind of preparatory activity clearly need indicators that are situated at a much more micro level, telling them something about the different target groups that they can reach, the needs of these target groups and the way how their consulting activities can fulfill these needs. Further on, innovation policy in this sense involves both technical activities, regional development and support of SMEs. These policies have traditionally been dispersed in different Directorates or Ministries. Policy support instruments should tackle the different perspectives that can be found in these businesses. The indicators that address the needs of this new policy dimension should capture the multi-dimensional character of an innovation policy, which goes beyond the mere positioning of a country's R&D position.

The emergence of a clear investment policy (new forms of financing that include risk capital and equity participation) towards the particular group of high growth, potentially high tech SMEs asks for new indicators which map the role of venture capital, the amount available for different categories (ranging from early seed to late growth) and the mechanisms that are available in each country to match demand with supply. Further more, clear insights are needed in the use of this venture capital.

Finally, the awareness raising efforts of new technology policy perspectives need indicators and evaluation data at the micro level of the enterprise. Various member states (eg. The UK R&D scoreboard) have created these kinds of data. However, most databases are not internationally comparable and can thus not be used to assess the R&D activity at company level. Further on, much more information is needed on how efficient companies organise their R&D. One can see a real challenge for the indicators business here as well.

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## Table 1
## THE PLACE OF INDICATORS IN S+T POLICY

## HISTORICAL COMPARED DEVELOPMENTS

| | EUROPEAN UNION<br><br>MILESTONES | STATISTICS | EVALUATION | INDICATORS |
|---|---|---|---|---|
| 1996 | | | 1st EC monitoring reports | |
| 1994 | | | | **1st European Report on S+T Indicators** |
| 1992 | Maastricht Treaty | | 1st EC global F.P. evaluation<br><br>1st EC horizontal report | |
| 1990 | | | | 1st NISTEP report on S+T indicators |
| 1988 | | 1st COPOL booklets | | OECD report on MSTI (present form) |
| 1987 | European Single Act | | | |
| 1981 | | | **1st EC Evaluation reports** | |
| 1975 | | **1st Annual R+D Statistics Report EUROSTAT** | | |
| 1974 | **RTD Community policy** | | | |
| 1965 | Fusion ECSC-EEC-EURATOM | | | |
| 1957 | **Rome Treaty (EEC/EURATOM)** | | | |
| 1951 | Paris Treaty (ECSC) | | | 1st NSF report on S+T indicators |