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Targeted research and technological innovation, and their relationships in a new socio-political context: Approaches to their evaluation

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Introduction

Science and technology policy-making and the study of its effects on innovation are requiring a "more sophisticated understanding of the ways on which science and technology interact" (to quote, as an example, N. Rosenberg, *Science and Public Policy*, vol 18, number 6, pages 335-346, 1991).

The exploration of these relations has been and continues to be at the core of the models that, along the period initiated after the Second World War, have been used to promote and analyse the science and technology activities and their outcomes. The "science model" left pace to the "science push-market pull – R&D model", inspired on linearity, a model that represented the technological change leading to innovation as closely dependent and based essentially on scientific results. More recently, after acknowledgement of the insufficiencies of the linear model, models have evolved considering that science and technology and innovation are part of a system, a "social" system, whose essential activity is learning and which is also "dynamic".

This orientation has corresponded with the idea that biology, and not physics, ought to inspire the economics of technology and innovation (application of the theory of Darwinian evolution, see for a review, J. Mokyr, *Bulletin of Economic Research*, vol 43, number 2, pages 127-149, 1991). The microeconomics view has been at the onset of recognising the limitations of the dominant neoliberal theory based on the concept of a stable and unique equilibrium. An important lesson that has been learned from the use of evolutionary, biology based, models is that history – and culture – matters. As Mokyr has stated (see reference cited above) "... It is simply impossible to understand long-term economic growth without some kind of Schumpeterian theory of technological creativity and innovation. The neoclassical equilibrium paradigm seems singularly unsuited to that task".

Evaluation and its limits

In spite of this discourse, the indicators and methods applied to evaluate science and technology outputs and their effects on innovation, are still, and mainly, based on the concept of linearity. The bibliometric methods used to measure scientific production

and its technological counterpart, i.e. scientific articles and patents, are looking to productivity, whereas the economical and human resources devoted to science and technology are being seen as the inputs to the system. This output/input model of evaluation is leaving aside any assessment of the interactions between science, technology and innovation and their actors, and may present limitations to the use of econometric models, since they can not take into account the role of human actions and influences in the process as well as the influence of cultural values and of the environment. However, citation and referencing data have been used in some emerging fields (biotechnology and bioscience) to detect the links between science and technology (Narin and Noma, *Scientometrics*, vol 7, N^{os} 3-6, pages 361-381). The situation seems to need an alternative. We have attempted such an alternative by using a sociological – historical (analytical-descriptive) approach. The methodology has found grounds in a biological (biochemical) metaphor that addresses the dissection of a programme (identification of its structure) and how this correlates to the function (activities funded, links and influences with the environment). The methodology is based on the use of quantitative techniques through surveys addressed to the main actors of the research and technology activities (the main researchers and/or the managers of the projects). The most relevant point of this approach rests, not on the use of survey, but on the type of survey: its structure and configuration.

1. The general frame of reference. A European view

The application of methods and practices to evaluate the public policies and their programmes addressed to the attainment of goals is experiencing a phase of great expansion and experimentation. The European Union and the Commission are contributing in a decisive manner to this type of exercises in such a way that this is forming a position towards the support by the Member States to the evaluation exercises as a means for gaining rationality in the process of making decisions or to frame the launching of the respective actions.

There are nevertheless relevant differences between the European countries with respect to tradition and intensity in the evaluation practices corresponding to the realm of public

policies and programmes. The North European countries possess greater experience in the use of evaluation practices as an instrument for the process of making decisions. In this context, it is worth to mention the relevant role played by the main actors involved in the management of the programmes themselves. Other countries like Belgium, the north of Italy and several regions of France are beginning to consider the evaluation as a "help system" for the planning and management of the public intervention. This development is matching with the put into practice of a series of European programmes of socio-economical nature and significance like the Structural Funds Programme and several programmes of Control and Regulation. In the great majority of the Southern European countries, the evaluation practices are still being considered as a single regulatory imposition that constrains the process of decision making, what implies a limited influence on the political arena. In many cases, the relevance of the evaluation practices in these "less-developed" countries, in terms of evaluation capacity and skill, is even more limited by the absence of quantitative (or able to be measured) objectives as well as by the deficits in an information of quality, which are necessary factors for the attainment of good results in the evaluation exercises. The work performed through the drive and support of the European Union/Commission has allowed the identification of a series of factors and components deemed necessary to carry out evaluation activities with enough quality and appropriateness to monitor and assess programmes which are running or just have ended. They are the following:

1) analysis of the capacity to absorb the economic resources of the programme while it is going on;
2) identification of the tangible products obtained as compared with the foreseen ones;
3) analysis of the efficiency of the programme (i.e. assessment of the costs of unit of product);
4) evaluation of the impact;
5) evaluation of the impact in socio-economical terms; and
6) identification of the hurdles that are against the success of the initiative.

From them, the evaluators may provide adequate data and proposals to evolve further evaluation processes and to give recommendations with regard to issues related to organisation and to the reallocation of resources, according to an eventual reprogramming.

The lack of adequate information may hamper the quality, in-depth and relevance of the processes of analysis and evaluation. Therefore, the Public Administrations share the responsability for establishing effective systems of follow-up and providing the information with sufficients levels of quality and extent.

1.1 Procedures for the evaluation of programmes

The prevailing trend in the evaluation of programmes, mainly of socio-economical characteristics, follows alternative approaches. In the first place, the "bottom-up" approach is applied with the aim of collecting and valuing information at the projects level in order to process and integrate it into the analysis of the programme. As the number of projects is usually high, this approach enforces upon the selection of a sample. An advantage of this approach is that it allows the gathering of information by means of surveys and interviews on the results and impacts of every project.

The analysis of the impact requires statistical data and information. The existence of data bases may allow the performance of longitudinal studies based on the history of each case in view of correlating the results of the programme with the basic objectives. When the data base is lacking, several other methods, as for example the focal groups, can be used, but taking into account that the building of good control groups is a pre-requisite to value the programme and its effectively. The second approach looks to the "top-down" analysis which does not imply to reckon to samples and permits to process the information with a high level of aggregation. This approach is based on the data that are afforded by the respective agencies, though additional instruments such as case studies or in-depth studies are needed to gather detailed information with respect to the projects.

It is also possible to employ a mix or dual approach combining the "bottom-up" and "top-down" lines. This blended system of analysis seems best suited to carry out more complete evaluation exercises and thus, it is adequate for the application to the "ex-post" assessment of programmes or for their follow - up according to a thematic perspective. In any one of these approaches, the existing shortcomings in information, as it can be obtained from the official reports and sources, can be overcome by

additional sources of information from the clients, actors or managers of the programmes. To this end, the evaluation exercises rest on in-depth analyses, surveys, interviews, protocols and questionnaires aimed to get the opinions and reactions of these actors, any one of these instruments having been used in view of the characteristics of each programme or of the availability of well checked information.

1.2 The research and development (R&D) programmes. Their special traits

All the outlined methodology has been applied to the evaluation of programmes of socio-economical natures. The challenge is to adapt these procedures and instruments to the R&D programmes which are holding specific properties and characteristics when compared to socio-economical programmes. Some of them are:

- The influence of R&D activities on economy and society is long ranging; those activities act in an interactive and indirect way with socio-economy.
- The input economical indicators used are essentially macro-economical ones such as the percentage of Gross Domestic Product devoted to R&D activities as well as the number of human resources employed in those activities. They are distributed in three (macro) subsectors: Government, Higher Education and Business. Any correlation of these "top-down" informations and data with "bottom-up" actions is extremely difficult.

  The indicators of production and results ("output") relate mainly to the dynamics of the scientific community - research publications and documents concerned with /the dissemination of knowledge and, eventually, with its protection rights (patents). There are no indicators of economic outputs with the exception of data on the technological balance ("degree of sufficiency").
- The functioning of R&D programmes is shaped by the sociological and behavioral patterns of the scientific community.
- The R&D programmes and the agencies involved in the management of the programmes are run and controlled by scientists and technologists who are acting in their double capacity as clients and managers and then are involved in a series of processes of interaction and feed-back.

- In the R&D programmes, there is a frequent mix of the levels of planning and management, unlike what occurs with the socio-economical programmes. There is scanty information on the relevance of the role of those agencies with respect to these two levels of intervention.

2. A specific model to evaluate R&D programmes

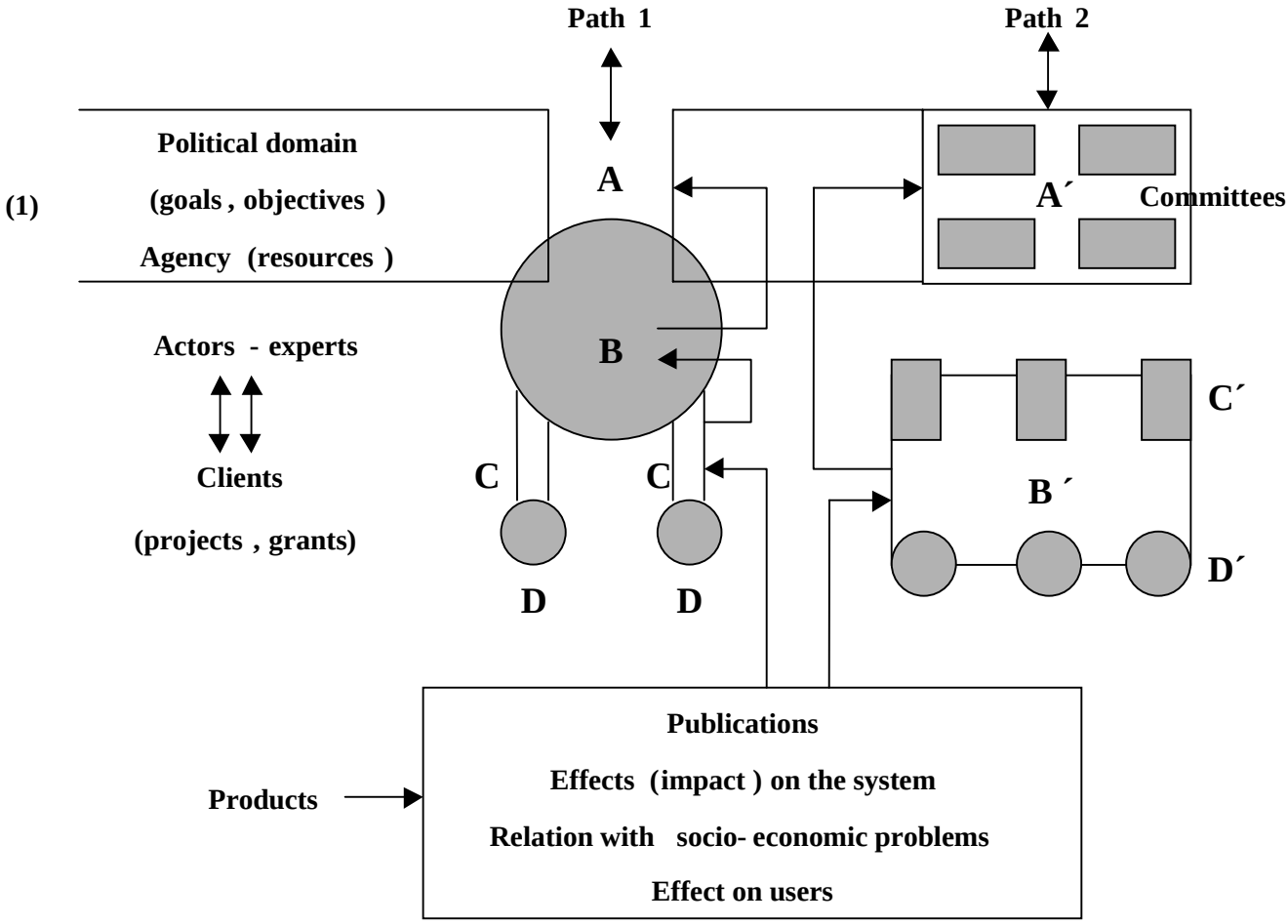
The philosophy of biology provides with grounds to analyse and assess the activities linked with the development of science and technology from the perspectives of the social sciences. I have resorted to this strategy to explore, from the point of view of the evolutive biology, the relationships between the life technologies and their socio-economical implications (Muñoz 1997).

Following the theoretical lines of the evolutive biologist Ernest Mayr (1982), I have coined the term *biología operativa* ("Operational biology") to integrate the notions of structural and functional biology (Muñoz, 1994) as to confront the evolutive biology notion. The "operational biology" offers, in my opinion, the possibility to propose a model for the evaluation of R&D programmes which is rooted in the process of cellular transduction. The model ("transducing model") as depicted in fig. 1 offers the following advantages and analytical possibilities.

1. It allows to distinguish (and assess) the different steps or levels of action in R&D programmes.

a) Planning level which corresponds to the political domain on which the objectives are defined and established.

b) Management and funding level which operate in the allocation of economical resources through the intervention of the agencies. Two paths are possible: path 1, where the objectives are passively diffused to the agency (A) that is acting as transmitter and controller. In path 2, the agency (A') is not receiving targeted objectives and, therefore, becomes a transducer which allocates resources through experts committees.



(2) Analogy : Cell function

Relationships and regulations

Coupling	Structures	Actors
	Function	Clients

(3) Methodology :

Separation of the parts (different elements) and analysis of the results .

Possible integration

Figure 1.- The "transducing " model of R&D programmes

c) Level of programme execution, on which the expert-actors and the clients-beneficiaries are interacting. In path 1, there are two types of actors: the experts ("peers") and burocrats (B) who are allocating resources in relation to the pre-established goals to the clients (receptors) as groups (C) or individuals (D). In path 2, the experts are acting within the function of agency A' , whereas the clients - beneficiaries are represented in rectangle B' and they will receive grants - in aid, fellowships as collectives (C´) or individuals (D') to perform research activities in a complex institutional and operational environment.

d) Level of production with the products poured in the scientific-technical "milieu" recorded in the statistics of the respective agencies or poured into the external "milieu" (society in broad terms). The assessment of the products deriving from path 1 needs to be carried out in fragmented way (from the experts and clients) while in the case of path 2, the analysis of the products requires a more complex and integrated way (from the agency and the different types of actors).

e) "Feed-back" level that applies to any of both paths and that influences the future decisions at every level of the programme.

2. The model attempts to make an analogy of the research programmes with the functioning of the cell where there is a coupling between structure and function. This analogy eases the process of evaluation by measuring the global or partial results of the programme and by identifying the variables: the independent such as the coupling between the parts or processes of the programme and the dependent ones such as the composition of the experts committees ("structure") or the interactions between the experts and the clients ("regulation").
3. The model allows the separation of the parts or elements of the programme driving to a reductionist methodology for the analysis or leading to an integrative view from the analysis of the parts, in an analogous manner to the methods applied in the biochemical analysis.

The conceptual frame of this methodological approach stems in the significance of the microlevel of analysis to understand the relations between the top-down and the bottom-up approaches to the proposals and actions of the main agents of the science and technology system. It runs parallelisms with the philosophy that led, in a different order of things, to the application of technology assessment (TA), the instrument that during

the decades of seventies and eighties helped to the process of decision–making in the emergence of a goal–oriented model of technology programme. Various models of technology assessment can be distinguished depending on the mediation between science, politics and the general public: the “instrumental model”, the “elitist model”, the “participative model”. Our methodology is not purely related to that of TA, but it borrows some characteristics to the first two models: the instrumental and the elitist ones, whereas it shows its independent nature because our methodology is used to the “ex-post” evaluation of science and technology programmes (and processes), whereas the T.A. aims to assess “ex – ante” the appreciation of the eventual consequences of the scientific and technological developments and programmes. (Bechmann, *Science and Public Policy*, vol. 20, number 3, pages 11-16).

3. Examples of Evaluation Exercises. Case Studies

We have attempted to introduce and develop the culture of evaluation of research and development programmes by carrying out a series of evaluations on various R&D programmes and/or innovative technologies or sectors. Through these exercises the rationale was to combine an interesting research agenda with a possible use of the results by the policymakers and managers of the R&D activities. The subjects of study were selected by applying a series of criteria:

- They must hold academic, scientific and technological relevance;
- They should reflect, whenever this were possible, the demands from bodies of the Administration;
- They should represent an important share of the resources allocated by the agencies involved;
- They should be attacked after a good scientific, cognitive and managerial background from the team (at least from one of its members) involved in the evaluation;
- They should constitute a relevant contribution to the innovation patterns of Spain (emerging technologies, important socio-economical topics) and to the conomic wealth of the country or of any of its regions.

3.1 National Programmes from the National R&D Plan

The National R&D Plan was the instrument established by the *Law for Promotion and General Coordination of the Scientific and Technical Research* (referred popularly as the "Law for Science", Law 13/1986). The idea underlining the establishment of the Plan was to coordinate research from a "top-down" approach making recourse to the option of planning through objectives and goals fixed by the political authority where the different actors should play the game.

For obvious reasons, some programmes of the National R&D Plan were good canditates as subjects of evaluation. Applying the criteria outlined before, the following programmes, all belonging to the first National R&D Plan extending from the period 1988-1992 (93), were selected: *New Materials, R&D on Pharmaceuticals and Health.*

3.1.1. The New Materials National Programme

The evaluation was based on a mixed approach using official information from the agencies (see below) and a survey addressed to the principal investigators of the research projects funded by the programme. A complex text on the results of the exercise has been published as a Documento de Trabajo (Working Paper) by Espinosa de los Monteros *et al.*(1994).

The purpose of the current analysis is to provide an overview of those results as filtered by the "transducing" model lens.

The driving force for the evaluation exercise was the research interests of the CSIC team who presented a project to the National Plan for its funding. The project was approved and funded. Thus suggesting some interest from the Administration.

The instruments for the evaluation were analysis of the information gathered from official sources and a postal survey addressed to 431 principal investigators (54 per cent

from universities, 35 per cent from CSIC and the remaining 11 per cent from semi-public organism associations from firms and government interface organisations).

a) Structural Characteristics

- The programme was targeted with predetermined priority lines, expressed in broad terms but well suited from the technical point of view.
- The main Agency responsible for the management of the programme was the Secretariat of the National R&D Plan with specific action on the research projects and on infrastructure and accompanying measures.

  The Centre for Technological and Industrial Development (CDTI) was the agency involved in the management of the industrially oriented projects ("proyectos concertados" which are collaborative projects between public sector research centres and industries and "proyectos de desarrollo tecnológico" implemented by the industries alone).

  The involvement of the two agencies can be assimilated to *path* 1 according to the model of fig. 1.

b) Results (the operational functioning)

b-1) The regional distribution of the resources was gathered from the data provided by the main Agency. The results summarised as follows indicate an uneven and quite peculiar profile.

- Main share corresponding to percentages higher than 10 per cent: Madrid (42.2%) and Cataluña (15.7%).
- Medium share corresponding to percentages between 5 and 10 per cent: Aragón (9.4%), País Vasco (8.9%), Comunidad Valenciana (7.4 per cent) and Andalucia (5.5%).

b-2) The conclusions about the products of the programme are:

- Relevant contribution to the building and development of a scientific community able to compete both internationally (publications increased in number and

importance in internationally refereed journals) and nationally (the researches were granted of staff-tenured positions in universities and CSIC).

- Mismatch between the scientific objectives and the industrial ones. Researchers from the public sector pursued publications and training of personnel with low applicability of their research even in those projects identified as "applied research". On the other hand, projects from the 11 per cent of the other organisms revealed a low degree of scientific productivity but a high rate of applicability in their results.
- Contribution to the establishment of good infracture and well equipped laboratories.
- Formation of a well trained, highly skilled personnel. This result has led to a paradoxical situation: this personnel is excessive for the socio-economical demand but its offer is insufficient for the scientific and technical needs.
- All the users of the programme seem to be satisfied but definition of success and estimation of satisfaction was different for the most important groups of actors; researchers and industrialists. The effects of the programme on the users apperared to be divergent depending on the users´ affiliation.

3.1.2 The National Programme on R&D on Pharmaceuticals

The rationale underlying the evaluation followed the same pattern as that indicated for the Materials Programme. The same driving force and the same instruments supported the evaluation of the programme on pharmaceutical research and development.

The evaluation was based in the analysis of the information provided by the agencies involved in the management of the programme and in a survey addressed to a universe of 124 principal investigators of the research projects (80.6 per cent from universities, 18.5 per cent from CSIC and 1 from a hospital located in Barcelona). This distribution shows already a marked difference with respect to he New Materials Programme as the R&D on Pharmaceuticals programme appears strongly linked to university reserach.

A complete text on the evaluation of the programme has been published as Working Paper in Espinosa de los Monteros *et al.* (1995 a).

a) *Structural Characteristics*

- The programme was targeted with a general goal and several specific aims of general nature as well as with ten technological objectives.

  The general aim of the programme was to foster and coordinate the R&D activities of the publics sector and the firms operating in the pharmaceutical area, one of the leading sectors in business R&D expenditure but unable to compete satisfactorily in a global world. The specific aims were still quite general such as: the promotion of pharmaceutical research to increase its size and excellence; the establimment and maintenance of an adequate infrastructure; the training of personnel both in Spain and abroad; the education of skilled support personnel; the integration of renowned scientists from abroad into Spanish research laboratories; coordination of the activities between the public research sector and the private research centres and firms.

  These broad objectives implied the intervention of three agencies. The main Agency was the Secretariat of the National R&D Plan involved directly in the funding of research projects and infrastructure as well as in the support of accompanying measures. The training and educational activities were managed by the General Directorate of Scientific and Technical Research (Ministry of Education and Science). The line related to innovation and technological development was run by CDTI.

  It is worth noting that the line of industrial links geared by CDTI held the lion´s share of the financial resources (52.4 per cent of the total funds of the programme).

  The three agencies involved in the R&D on pharmaceuticals programme acted according to *path 1* of the model (fig.1).

b) Results

b-1) The regional distribution following the same separation marks as in the Materials programme (see above) was:

- Medium share: Comunidad Valenciana (9%), Andalucía (7.7%), Canarias (7%), Castilla-León (5%).

  This distribution presents a marked differential profile with respect to that shown by the *New Materials* programme-incorporation of Galicia, Canarias and Castilla-León among the winners - and disparition of Aragón. The important share in number of projects and in funding by three universities (Santiago de Compostela (Galicia), La Laguna (Canarias) and Valencia (Comunidad Valenciana) who were the leaders, provide clues to this specific profile.

b-2) Some conclusions about the products of the programme are:

- Relevant contribution to production of knowledge but rather poor impact on the domains related to development and technological innovation.
- The training of young researchers has been one of the relevant assets of the programme whereas the policies and criteria applied to the allocation of fellowships raised a great level of criticisms. A significant part of the trained scientists were incorporated in the public research sector (42%) and other part (15%) were integrated in industries.
- The priorities of the programme were both too broad in scope and far away from the interests of the Spanish pharmaceutical industries. The research was driven by curiosity-instead of being moved by the will to solve problems of practical relevance.
- The Spanish pharmaceutical industries are not very prone to collaborate with the public research sector. They present divergent aims, interests and professional tracks.
- The absence of skilled technical personnel flaws the research potential of the area in particular in connection with the applied aspects - clinical trials - of this

sector. The programme confirmed the need for it but was unable to correct for the deficits.

- From the technological objectives prioritised by the programme, only three of them; "experimental and clinical pharmacology" (35 per cent), "drug systems designed through specific mechanisms and strategies" (27 per cent) and "search for new leader compounds of therapeutic interests" (19 per cent) have shown a reasonable level of accomplishment.
- The administrative bodies involved in the pharmaceutical policies (drug approval, prices settlement , regulations and norms) were not interested or unaware of the research outcomes of the programme. This reveals a strong rupture in the coordination mechanisms and in the flow of knowledge production from the science base towards practical goals.
- The success of the projects of industrial nature is only on average: there were a short number of projects and a small collaboration with the public sector.
  Among it , the hospitals, that were absent from the research realm, emerge as a new actors, though their funding was comparatively very low with that obtained by universities or CSIC from the collaborative projects with the industry.
- The users of the programme show a different degree of satisfaction: research > industry > hospitals.

3.1.3 The National Health Programme.

The evaluation of this programme showed the same patterns and responded to the same forces driving the evaluation of the two former programmes.

The instruments applied for the evaluation were the same as those applied to the other two programmes, albeit a differential feature resulted from the population of principal investigators and their affiliations. Among the 235 ones detected, 124 of them (52.8 per cent) belonged to universities, 45(19 per cent) to CSIC, 44 (18.7 per cent) to hospital and 22 (9.4 per cent) to other organisms (charities, foundations and centres adscribed to the National Health System).

There is a detailed publication on the evaluation of the Health Programme as Working Paper (Espinosa de los Monteros *et al.*, 1995 b) as well as a synthesis paper (Espinosa de los Monteros *et al.* 1996).

a) *Structural Characteristics*

- The programme was targeted, like in the case of the R&D on Pharmaceuticals, with a broad objective and five aims of basic nature complemented with nine more precise technological objectives.
- As in the former programmes, three agencies were involved in the implementation with the main role played by the Secretariat of the R&D National Plan, the other two being involved in the same type of activities and lines of action as stated for the R&D on Pharmaceuticals programme. Their way of action can then be assimilated to that of *path 1* (model of fig.1).

  An interesting distinctive feature of the Health National Programme concerns the distribution of sources; in this case, the lion´s share of the programme funds corresponded to research projects and infrastructure 76.6 per cent of the total) while the industrial related projects spent only the 13.5 per cent of it.

b) *Results*

b-1) The regional distribution profile shows marked differences with the other programmes analysed.

- Main share: Madrid (41.8%), Cataluña (23.5 per cent), Andalucía (11.4%).
- Medium share: Comunidad Valenciana (6.9%).

This uneven share reflects the strength of the medical academia concentrated on universities and a certain number of hospitals (Hospital Clínico y Provincial de Barcelona, Hospital de la Santa Cruz y San Pablo (Barcelona), Hospital del Valle de Hebrón (Barcelona) as well as the importance of the regions (demography, quality of medical care, level of technologies applied to health) in the Spanish Health System.

b-2) The analysis of the results (outcomes) of the programme has allowed to draw a series of conclusions similar to those outlined for the R&D on Pharmaceuticals Programme, but with some noteworthy specifities.

- The contribution to the production of scientific knowledge has been relatively high (medium - high) but perhaps insufficient for the predominance of the research side in the frame of this programme on Health.
- The good training of young research personnel (as an asset of the programme) contrasts with the poor use of these human resources in further research and technological careers.
- The priorities of the programme were once more too broad and lacked focus. Only four one of the nine technological objectives " Health problems related to environment and health and life styles" with 31 per cent of the projects, Cancer" (24%), Immunology (11%), and Toxicology (10%) have attained good records in accomplishment. The other five, some of them so relevant in scientific and social terms such as "Aids" " Health problems related to aging", "Human genome" and "Development of health technologies" received a testimonial attention from the demand side.
- The objectives were far from the interests of industries. This together with the low level of resources devoted to industrially - oriented projects has led to a low participation of the Spanish firms in the programme. Only 12 businesses were involved in the programme through the period 1989-1993. Moreover, the collaboration of these firms with the main public organisations involved in the execution of the programme universities and CSIC was very low (seven universities and one institute from CSIC were involved in 11 collaborative projects out of 18, while the remaining 7 were performed in collaboration with hospitals).
- Though some hospitals were players of the Health Programme, their representation was rather symbolic as compared with the research potential of these institutions (see below on the evaluation of the Health Research Fund, FIS from its acronym of the Spanish name *Fondo de Investigación Sanitaria).*
- The lack of links between the research interests of the public sector and the industry was more than evident. This is particularly true for the CSIC centres - in spite of the relevance of the biomedical research area for this institution.

These points out to a basic structural problem in the shaping of research on health carried out by the CSIC research laboratories.

- The size and stability of the research groups involved in the execution of the Health Programme was smaller than in other National Programmes and this was denounced by 54 to 66 per cent of the researchers responding to the survey who considered that size and stability as insufficient for a goal research performance.
- The administrative bodies responsible for the health policy in Spain (i. e, the Ministry of Health of and Consume and the Regional Authorities) did show moving away from the evolution and outcomes of the National R&D Programme on Health.

3.2 The National Research Fund **("Fondo de Investigación Sanitaria", FIS)**

This fund was created in 1980 relying on the tradition of a previous fund established in 1968 which aimed to direct the 15 per cent of the allowance of the pharmaceutical industry to the Spanish Social Security System to promote research activities and to fund travel fellowships and scientific meetings.

As José Ramón Ricoy, who was the first fully dedicated Director of the FIS, has pointed out (Ricoy, 1996), three periods can be distinguished in the history of FIS. The first period corresponded to the use for research in medicine of the funds from the industry (the so called "*etapa del Descuento Complentario*" "stage of the Complementary Discount") extending from 1968-1980.

- The second period was through 1980-1987 on which the FIS was managed with a partially employed Director where the Funds began to build its identity.
- The last period that began in April 1987 when the position of a fully dedicated Director was established.

3.2.1 The evaluation project

The evaluation exercise that was undertaken by our team focused on this third period (1988-1995) and responded to the driven forces of the responsible of the agency who, at the end of 1995, decided it was time to develop a full exercise of evaluation of a

research programme for the first time of the short life of science and technology policy in Spain.

The evaluation had to be funded through the figure of a research project since the statute of FIS made the agency unable to establish any contract. The project was articulated under the direction of E. Muñoz with a multidisciplinary team composed by medical doctors, biomedical researchers, social scientists. Some of them had been formerly involved in the political and scientific management of FIS, others had experience in bibliometrics and some other were experts in the analysis of public policies. An external panel (advisory committee) composed of relevant science practioners and policy makers was also established as a sort of monitoring control of the evolution of the project.

The project was framed under the underlying idea of the "transducing model". In view of the complexity of the task the project aimed to define the structure of the programme and to analyse the functioning of the agency (the "transducing machinery") and the outcomes of this functioning (publications, impacts on the health system and/or on the institution or centre where the research was performed, influence of research training and knowledge transfer on the careers of the professionals of the Spanish Health System).

The basic search lines in the study were:

- the information derived from the Annual Reports of FIS and its records and data bases,
- the analysis of the call for proposals through the different years of the FIS activities and the breakdown of resources between the different lines of activity
- the focus of the analysis on the research projects and the training scheme ("Becas de Ampliación de Estudios", fellowships for enlargement of professional skills)
- the follow-up of the allocation of resources through the different thematic areas as a way to explore the implicit or explicit political decisions underlying that allocation.
- The correlation between the production of knowledge and the share of resources as a function of projects, organisation, regions as a means to analyse the

eventual influences - scientific, circunstantial, political - in he process of making decisions.

- Search for the possible relationships between the objectives attained with the research projects and the health system; exploration of the impact.

The desk analysis of documents, surveys and interviews were the instruments used for the analytical development of the project.

Results on the structure and function of FIS activities

The work has permitted to obtain a wide set of results whose detailed presentation can not be the subject of the present report. Some of the results of the study are available as grey or public literature (Muñoz *et al.*, 1999, Espinosa de los Monteros *et al.* 1999 a and b; Sanz-Menéndez and Diaz Benito, 2000). An outline of the main conclusions is as follows.

- The R&D activities funded by the Spanish National Research Fund (FIS) did not correspond to a targeted, well-defined programme. The funding agency (FIS) behaved according to a pattern corresponding to path 2 of the model depicted in figure 1.
- The share of resources was markedly influenced by the criteria of "excellence", relevance and power of the scientific community. So, regional, institutional and organisational distribution of the sources were mapping the most influential research communities ("Matthew effect").
- There is for the first time in the analyses of research programmes performed in Spain, the possibility to correlate the sources allocated by a funding agency with the research outcomes (bibliometric analysis). This allows to analyse the productivity (efficiency and efficacy) of a research programme by type of project, type of research, thematic area, institution or region.
- The exercise carried out allowed for a contrast between the motivations and interest of the researchers performing that activity in hospitals with those of the hospital managers and administrative heads.

- The group in charge of the analysis of the training subprogramme led by Sanz-Menéndez expressed criticisms about the methodology used because it made difficult to evaluate the causality of the public action. However, after using the survey method praised by us, they conclude that it was possible to detect processes situations and changes in the level of education and training of the users of the FIS subprogramme with (unavoidable) evidence.

4 *Some presumptive conclusions*

- We have discussed in theoretical terms and presented examples on the application of a methodology to evaluate R&D programmes that permit to obtain conclusions extending beyond the linear types of analysis based on the input/output approaches or on the arguments of causality followed by the proponents of the classical methods of evaluation of public policies.
- The method proposed by us found its grounds in biology as a source of analogies while the former methods and models based on linearity found its base in the analogies with physics.
- It is obvious that the methodology proposed by us can raise and it is going to raise criticisms. But science progresses and the scientific method proceeds by performing empirical analysis (experiment) and by raising criticism, and/or support to them. To stay attached with not totally convincing methodologies and approaches is to fight against the unavoidable path of progress.
- The methods used by us, should they be referred simply as studies of the type of "public opinion polls", allow to draw attention to the evolution of R&D programmes, on how complex they are for an appropriate management, on how they can be (and are) influenced by several type of actors (producers and clients). In summary, they permit to approach the analysis of complexity thriving in an extremely complex social "milieu".

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