



HAL
open science

Policy-making in science policy : the 'OECD model' unveiled

Luisa Henriques, Philippe Larédo

► **To cite this version:**

Luisa Henriques, Philippe Larédo. Policy-making in science policy: the 'OECD model' unveiled. Research Policy, 2013, 42 (3), pp.801-816. 10.1016/j.respol.2012.09.004 . hal-00793819

HAL Id: hal-00793819

<https://enpc.hal.science/hal-00793819>

Submitted on 29 Feb 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Policy-making in science and technology policies: the 'OECD model' unveiled

Luisa Henriques^{a)1} Philippe Larédo^{b)}

a) European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Edificio Expo, Avda. Inca Garcilaso s/n. 41092 Seville. Spain

b) Université Paris-Est (ENPC, LATTs) Cité Descartes, 6 av. Pascal, 77455 Marne-la-Vallée Cedex 2, France and Manchester Business School, Manchester Institute of Innovation Research, University of Manchester, Booth Street West, Manchester M15 6PB, United Kingdom

Preliminary version of the article published by Research Policy (42, 801-816)

Abstract

The paper unveils the 'OECD model' for policy-making in research and development diffused by the Organisation for Economic and Co-operation and Development (OECD) in the 1960s. Detailed analysis of the national reviews conducted by the OECD permitted the identification and characterisation of five central functions that organise the policy process and its implementation. The main functions identified are horizontal coordination and advice, planning and budgeting, priority-setting, resources allocation and administration. The paper further explores the reasons for the fast diffusion of the model in OECD countries and beyond, as well as the features that explain its longevity.

Keywords: Policy-making; S&T policy; OECD; National systems of innovation.

1. Introduction

Science and technology (S&T) policies², defined as the mobilisation of national research and technology capabilities and resources to promote economic growth of a country, were institutionalised in most European countries in the aftermath of the Second World War. It is widely accepted that the OECD played a crucial role in its conceptualization and diffusion (Edquist, 1997; Elzinga and Jamison, 1995; Godin, 2007; Lundvall and Borrás, 2005; Rip and Meulen, 1996; Sharif, 2006). However there is no literature about the framework for S&T policies diffused to policy-makers, or the structures that composed it, the functions performed, and the characteristics of actors involved.

Therefore the 'model for policy-making for national science and technology policies' diffused by the OECD in the late 1960s similarly has not yet been object of in-depth studies. This model, which we term as the 'OECD model', entails a description of the functions and

¹ Disclaimer: The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

² From hereafter, we will use the terms S&T policies, science policies or research policies interchangeably.

'implementation structures'³ of the policy-making cycle for S&T policies as it was developed and recommended by OECD in the institutionalisation phase of these policies. The purpose of this paper is to uncover the components of the 'OECD model', explain the reasons for the successful and fast adoption of the model by the OECD countries, and the factors that explain its durability despite of the new theoretical insights, new vision of the innovation process and attempts to change it at policy level. The idea came from previous research on the construction of the Portuguese innovation system. In fact, neither national systems of innovation literature nor previous articles associated with science policies provided a framework which accounted for the policy-making structures developed and the steps and attempts taken by actors; as numerous documents mentioned the influential role played by OECD, we reconstructed the 'OECD model' or framework to allow their study (Henriques, 2006).

The research is based on a novel source of information not used in previous studies: the reviews of the national science policies done by OECD over two decades, between the 1960s and the 1980s. Functions and components of the policy-making process associated to research and innovation policies are made explicit from the analysis of the OECD reviews.

The paper is structured as follows. We start with the description of the methodology applied in the analysis of the reviews of S&T policies reports and the processes applied by the OECD. The reasons for the need of a government intervention on the S&T system are then considered. Section 4 contains the description of the 'OECD model' with the definition of each function and respective implementation structure. Sections 5 and 6 examine the structuration and institutionalisation of the policies through the 'OECD model' and suggest one central explanation for its durability. Section 7 concludes that the substitution of the 'OECD model' can only occur when all the factors that sustain it and constitute its force simultaneously change in parallel.

2. Methodology

Methodologically this paper differs from work previously done on the OCDE role in S&T policies, as our approach is focused on the analysis of the reviews of national research systems and policies produced by the OECD and not on interviews or analysis of articles and reports presenting the OECD framework. We have chosen to explore the concepts and models from the analyses and recommendations contained in national science policy

³ We use here the term 'implementation structures' for policy implementation, as defined by Rip and Nederhof (1986).

evaluations. Functions or components of S&T policies have not yet been explored with an historical approach⁴.

The OECD has done most of the national science policy reviews immediately after the national reports were issued⁵ from the last half of the 1960s until the beginning of the 1990s⁶. The countries reviewed cover a wide range of research systems in terms of their level of development and size. Reviews of countries with large developed systems were intertwined with small-developed ones, and with less developed systems in large and smaller countries.

The OECD official discourse stated that there was not one model for research policy-making applied or recommended due to the institutional, historical and cultural specificities of countries (OECD, 1966b, 1967b). There was however a constant identification of good practices in policies and structures to be diffused to countries through recommendations, which constituted the 'international yardstick' (Freeman, 1995) applied by the OECD to measure the development and quality of national research systems. Uncovering this 'yardstick' is our object of study.

The review process was well standardised and applied consistently to all countries. It was composed of four phases. The first phase consisted in the preparation of the background report by the OECD Secretariat with the support of the country. The second phase was an information mission. The team of evaluators visited the country to discuss with the most relevant actors of the system, and visit the main research facilities. It included as well the checking of the information gathered before, and the formalisation of reviewer's assessment as the Examiners Report. In the third phase, the examiners presented the report to the OECD Committee for Scientific and Technological Policy (CSTP). Then, in the so-called 'Confrontation Meeting', the recommendations were discussed with national authorities of the analysed country. The fourth and final phase was the publication of all the documents of the review by the OECD.

In addition, the evaluators mobilised formed a small interlinked community (according to Harvey Brooks interview in Cohen, 1994). Evaluators were mainly from countries with high-developed research systems, namely France the United Kingdom (UK), and the United States of America (USA). They held high-ranking positions in the administration of public

⁴ Godin (2009) has published an historical account on the evolution of the concept of research and innovation systems. For more information on his work on the OECD see http://www.csiic.ca/innovation_f.html

⁵ National country reports are the preliminary reports done by the OECD Member States to collect data and information on the research system. The purpose of the exercise was to help the corresponding national statistical offices to be acquainted with the methodologies in development by the Frascati Manual team.

⁶ The reviews were discontinued for a period because of the problems in operationalising methodologies to address the national innovation systems framework (OECD, 1998).

bodies, universities, research institutes and companies; some have been in ministerial positions, or were well-known scientists and policy analysts, widely acknowledged for their role in the institutionalisation of modern research policies. We shall come back in section 5.1 on this point while the Annex presents an exhaustive list of the OECD evaluation teams.

The science review reports published by the OECD kept track of the process. In most cases, the reports are composed of three main parts. One part, in many reports the first chapter, is the background report with the analysis of the structure of the research system of the country under review, authored by the OECD secretariat, or rarely by invited experts. The Background Report describes the analysis of the structural characteristics of the national research system, based on desk research and statistical analysis using the OECD normalised input and output indicators; and compares the key components of the system to the implicit model. The second part of the report, the core component, is the Examiners Report. It contains the assessment by the evaluators of the research system and their suggestions and recommendations to national authorities. The third part contains the minutes of the 'Confrontation Meeting'.

The richness of the information contained, the normalised structure of reports, and the continuity associated with the stable and connected group of evaluators make of these reports valuable sources of information for uncovering the 'OECD model' diffused. We used an inductive research analysis to identify the keywords defining the categories that lead to the definition of the functions and elements of the model for the policy-making. Then these categories were searched in all reviews and annotated. A comparative analysis was then conducted that showed the existence of strong communalities in the elements and functions. Whenever variations were encountered, they were de facto mentioned in reports and justified by the specific context of the system.

After, it was verified whether the model categories were present in the OECD documents that codified and diffused the knowledge acquired to promote the institutionalisation of national S&T policies. These included the reviews of national research systems, the first analytical framework for a national S&T policy structure proposed by a team led by Pierre Piganiol (Piganiol et al., 1963), other OECD reports, and the proceedings from the seminars held by the OECD on the topic.

3. The need for a national S&T policy

National S&T policies were a creation of the 1960s. For long, support to scientific activities was mainly provided by princes or kings, and later in the nineteenth century by philanthropy and industries (David, 2001). In the first half of the twentieth century, responsibility to allocate resources to scientific production was spread over several actors, namely national research

councils, private foundations, industries and governments, without a central national actor. Research councils were the mediators between scientists and governments, acting on behalf of governments. They addressed the training of researchers, research activities of their research institutes, and research activities of university academics (Freeman, 2002; Henriques, 2006). The dominant rationale for the public funding to the academic research was the 'Republic of Science' paradigm (Braun, 1998; Jacq, 1996; Polanyi, 1962): researchers, through peer review, were responsible for the distribution of public funds allocated to the research councils, without any intervention by national governments. Governments were intervening on research through mission-oriented topics or problem-solving issues like security, health or metrology (Bozeman, 1997; OECD, 1967a; Smith, 1990). Until then, and because of the reasons mentioned above, S&T policy for civil research was not consolidated as a political object (Jacq, 1996), like other policies in traditional areas of government intervention, such as education, agriculture, or industry. Public incentives to science existed but as part of education or cultural policies. Only Japan was an exception to this panorama with a formulated and approved national S&T policy targeting economic and social development (OECD, 1967a).

The 1960s witnessed a shift toward the institutionalisation of national S&T policies in most leading OECD countries. Reasons for this shift have been proposed by several authors; the major reason for the new path proposed is centred on the success of experiences in programming and mobilising resources to achieve national objectives during the Second World War, the Manhattan project being the most visible case. Another reason lied in the impact of the report by Vannevar Bush, 'Science the Endless Frontier' and the subsequent creation of the National Science Foundation (NSF) and of the President's Science Advisory Committee (PSAC) (Salomon, 1977; Smith, 1990). As 'the race to the moon' illustrates, prestige and competition between leading countries were also strong motivations for governments to be interested in S&T development (Freeman, 1987; Freeman, 1995; Salomon, 1977).

The main argument of OECD for an autonomous research policy was centred on the need to align and coordinate the increasing high volume of national resources dispersed in sectoral ministries and research councils to contribute to the economic growth and development and to achieve national objectives (OECD, 1968; Piganiol et al., 1963). High levels of resources, in their opinion, should not be left to discretionary distribution by researchers. Researchers on the other side were viewing government intervention as a limitation to their freedom in performing research (Polanyi, 1962; Smith, 1990). Summing up, OECD proposal consisted in transferring coordination and allocation of resources from the intermediary level of the research councils to the top layer of the Government.

4. Functions and 'implementation structures' in the 'OECD model'

OECD never produced an explicit model or framework about the functions and structures for a national S&T policy. However, in the reviews of national S&T policies and other OECD reports there are abundant traces and imprints of such a model both in terms of functions defined and ways to put them operational. Through comparative analysis of the reviews done by OECD, we were able to unveil the 'OECD model' for policy-making in science and technology and the structures needed for their implementation. The model is simple and anchored in the overall government policy cycle. Five main functions were identified: 1) horizontal coordination and advising, 2) planning and budgeting, 3) priority-setting, 4) resources allocation, and 5) administration. Associated to each of these functions, the model defines an implementation structure, with particular characteristics to serve the specificities of the research sector but sufficiently flexible to fit in the overall framework of a policy-making cycle and to correspond to the rationale targeted.

Two reports were seminal in influencing the construction of the OECD model. The first one is the seminal report by Vannevar Bush (Bush, 1945) that recommends to the American government how policy coordination for the research sector and allocation of funding should be implemented. The second report, the Piganiol report, expands further the embryonic model proposed by Bush to include other components that is coordination, administration and evaluation aspects (Piganiol et al., 1963).

Both reports have the same approach to S&T policies, which represents a discontinuity with the status quo of the time in funding and coordination of national research resources. Both take a linear approach to the innovation process to justify the importance of the non-military research outcomes to the welfare of economies. Both proposed that a national policy for S&T should be included as a sectoral policy part of the national public policies, with an autonomous budget in the national budget. Because of the nature of the sector, the policy should be formulated and coordinated at the highest level possible in the hierarchy of Government. It should be implemented by an independent agency, created *ex nihilo*. As the agency should not perform research or have any operational management responsibilities, the enlargement of responsibilities of existing research councils in the management of policies was not recommended. The Piganiol report contains a rough proposal for the five main functions we have identified, but our analysis has improved their level of disaggregation and definition, including a clearer assignment of responsibilities. We describe and characterise the functions in the OECD model in turn.

4.1. Horizontal co-ordination and advice

The central pillar of this model is the creation at Government level of a central authority in charge of policy and non-military resources devoted to S&T. This was a major shift from the then prevailing way of public intervention mainly done vertically at the level of the different ministries through their national laboratories, or by research councils. Sporadically there were members of governments with a science portfolio but without effective policy instruments, and these experiments were rapidly abandoned. France is a good illustration with the creation of a secretary of state in the government of Pierre Mendès-France in 1954. OECD clearly urged Governments to adopt horizontal coordination: *'the state finds itself constrained to assume a directing and coordinating role in the social evolution thus imposed by science and technology. The authorities must add science to their traditional activities'* (OECD, 1966 b p.14).

The justification for such a change in coordination and decision-making was based on three major factors. The first one was the need to have science as a national priority in the move towards a scientific-based civilisation to increase policy credibility, as expressed by the German Chancellor Erhard (OECD, 1966 b, 1967 b; Piganiol et al., 1963). The second was the requirement to focus on areas or structures addressing societal needs (OECD, 1966a, b, 1966a, b, 1967a; Piganiol et al., 1963). The third was the imperative of coordinating public funds for S&T at Government level (OECD, 1966 a, 1969, 1973).

Coordination to be effective had to be done by a member of Government with responsibilities on the coordination of funds and policy options to ensure a high level political coordination and to enforce decisions⁷. Coordination by the Prime minister was the preferred solution or, if not possible, by a Minister solely responsible for the S&T portfolio with the responsibility of planning and formulating the national research budget. A shared role of coordination with Parliament, adopted in some countries, was also acceptable (OECD, 1967b).

The most important feature was the transformation of previous vertical coordination into horizontal coordination at Government level, namely the policy coordination of sectoral ministries with scientific infrastructures (OECD, 1968; Piganiol et al., 1963). This horizontal coordination should be comprehensive and include not just civilian resources, but also the bulk of funds devoted to research on nuclear and defence research.

⁷ To illustrate this point, we quote the Italian science minister at the time of the review, Mr. Arnaudi, who defines his role regarding the other ministers as an intruder in others portfolios. In the French version of the review he says 'Plus de dix ministres entreprennent des recherches scientifiques, moi je n'en administre aucune ; je suis comme une personne pourvue d'un grand nez qui met toujours son nez dans les affaires des autres' (OECD, 1969, p.35)

The coordination model proposed was in part derived from the military research successes. Several review reports mobilised as an argument the success of the Manhattan project and proposed to follow its main management lines for S&T policies, highlighting the well-defined mission and objectives, and the ability to coordinate various actors. However, in contrast to the hierarchical military model, OECD recommended coordination to be based on decentralised formulation and decision-making processes.

In the OECD model, for the coordination function to be effective it had to be associated with an advisory one. This association is mentioned and checked in most review reports (OECD, 1966a, b, 1969, 1971a, 1973; Piganiol et al., 1963). Two structures were accepted for providing advice, a scientific advisor to the President or Prime minister or an advisory council. A high level technical secretariat should also exist to provide assistance to the advisory structure and to the political body responsible for the coordination.

Researchers, industrialists, and representatives from public administration and possibly from the society should be the members of these advisory bodies. Their presence would insure a successful implementation of policy, because it was expected that the advice would reflect the key actors' strategic thinking and plans and likely to be included in the policy formulation (OECD, 1969, 1971b). Therefore, individuals with high prestige in the scientific community and capacity to influence processes (the key actors) were preferred to the traditional appointment of members as ex-officio.

The role of these bodies was to evaluate the national research system, applying quantitative approaches (input and output research indicators), and building consensus in society regarding the importance of science. The main output were reports to feed into the policy-making process, namely for the preparation of national medium-term plans and research budgets.

4.2. Planning and budgeting

Planning was a central function in the 'OECD model' because it was crucial for institutionalising a national S&T policy. This reflected the fact that in most western countries, until the 1970s, the policy options and resources were part of national medium term plans for economic and social development. To be effective, the S&T plan should be part of the national planning process to guaranty the involvement of Government and Parliament in the S&T policy.

The time span of S&T plans could vary from three to five years for a medium-term perspective of the public investment. Active participation of members of Government in the formulation of the plans was also a requisite to achieve coherence in objectives that cross

several policy domains and to integrate research priorities (OECD, 1969). OECD recommended that existing national bodies in charge of the formulation of national plans should take the responsibility of national S&T plans.

OECD was supportive of flexible approaches to planning in science to avoid deterministic approaches from Government that would not be aligned with the strategies of research communities and main actors. Therefore, national plans were encouraged to include bottom-up initiatives (OECD, 1968).

During the diffusion period of the OECD model, national plans have lost importance and attractiveness or disappeared. In fact, it coincided with the period when leading countries, such as France and the United Kingdom, implemented 'prospective' or foresight exercises for research policy instead of the traditional national plans (OECD, 1981). OECD adapted the function according to the changing historical circumstances, proposing as well foresight exercises in order to keep the medium to long-term framework in the public investment. Recommendations were focused then on the creation of specialised centres in technology forecasting for technical and social change. Such a centre was proposed, as early as 1971, in the review of the Spanish research policy (OECD, 1971b).

OECD gave great importance to the need of having a national research budget associated with the S&T plan and priority setting exercises. A research budget according to OECD has to include all research appropriations of funding agencies and public research performers, including expenditures in nuclear research and defence. There was a strong refusal of budgets calculated ex post from the addition of public organisations budgets, without being linked with priority-setting and monitoring exercises, as well of the ones not covering defence expenditures (OECD, 1966a, b, 1974, 1991).

Research budgets were fundamental mechanisms to the OECD, because they would promote change in administrative procedures in national budgets and give visibility to science in the national political agenda (OECD, 1966a). A research budget would foster public discussion on science strategies, and would facilitate coordination among political bodies, namely Government and Parliament (OECD, 1974, 1991). Finally, research budgets would also act as a shield to protect national research public investment, whenever a country would face budgetary restrictions (OECD, 1986).

The scope and organisation of research budgets and the depth of discussions in national parliaments differed in OECD member states. In some countries, the approach was for the block vote, which means that the overall budget was approved without a description of programmes and organisations benefitting from the resources. Other countries preferred an intermediary aggregation format, the science vote. In this case, the basic research budget

was in an aggregated form, while the more applied research budget was specified. The other format was the detailed discussion in the Parliament of every programme included in the budget.

The importance given to the existence of an operational research budget was such that OECD was rather critical of member countries that were not following the mechanism as described above. For example, Japan was criticised because of the division of research lines between university-based and other sectors, preventing the development of an interlinked and coherent policy (OECD, 1967a). France was criticised because its research budget did not include the military and nuclear research expenditures, reducing the national budget to a small fraction of the total research public expenditure (OECD, 1966b).

4.3. Priority-setting

The introduction of priority setting in the decision-making process is a cornerstone of the OECD model to support planning and allocation of resources. It opposes to the traditional mode of spreading resources based on individual strategies, or of dividing resources equally among domains, structures or peers without any previous concerted effort. Priorities for national research funding became an issue only in the 1960s, when the design and processes for national S&T policies were developed. Before, the allocation of block-grant funds was at the core of public funding, either directly from the national budget to public institutes and research laboratories or indirectly via research councils' budgets. Governments chiefly relied upon the needs expressed by each organisation and/or individual researchers. According to the model, priorities have to be defined at Government level in order to impact on direct funding, and to be translated into national programmes to support research through competitive project-based research funding. The aim was to drive organisations and researchers to address in their research activity the nationally defined priorities.

OECD defined prioritising as a dialectic and interactive process. It combines the logic of knowledge production with the country needs for economic growth through mediation of three spaces: scientific communities, industrialists and the government (OECD, 1991). In fact, consensus among the interested parties and participation of industry were considered vital to address the needs of actors in the policy-making process (OECD, 1984). Two types of priorities were defined, thematic and structural (OECD, 1991). A thematic priority is a set of scientific fields or themes targeted for preferential funding, whereas a structural priority focus preferential funding to solve shortcomings or promote changes in the overall functioning of the system.

Although considered by OECD as a key function in the model, there was no recommendation or suggestion in the reviews analysed on how to implement priority-setting processes.

Contrary to UNESCO (1977), methods for determining scientific priorities were not developed. OECD assumption was that each country would determine the best mode to design collective discussion and consensus building, taking into account not only national idiosyncrasies, but also the traditional agenda setting processes of public administration (OECD, 1981).

4.4 Allocation of resources

Allocation of resources is the privileged instrument for accomplishing political objectives and priorities established through the planning, priority-setting and budgeting phases. OECD defines allocation of resources as the process of deployment and use of country's scientific potential (people, money, and institutions) for specific aims (OECD, 1966a). This function is institutionalised in the form of national funding programmes to address specific objectives and targets. The programmes have a dedicated budget for that purpose, which is distributed through competitive processes in order to select the best research project proposals. They are a complement of the other central funding channel, the block grant funding directly distributed to organisations based on disciplinary boundaries (OECD, 1968; OECD, 1969; OECD, 1981; OECD, 1984).

The funding of research projects promoted by national programmes represented a discontinuity in the way Governments and research councils were distributing resources to research. Previously research councils were allocating the funds directly to their institutes to support their research activities, and to fund fellowships, mainly for training new researchers. With the national programmes, in addition to the previous schemes, a new funding scheme was introduced: the project-based funding to support the research activity of a team to achieve a given research objective in a fixed period. The policy argument was that this approach would allow governments to cross the organisations' boundaries and pick the best teams.

The institutionalisation of the 'peer review' by funding agencies is associated with competitive project funding promoted by national programmes. Peer review is the mechanism applied in general in the evaluation and selection of project proposals, ensuring that the qualified scientists evaluate and compare their novelty and scientific quality. The best known criteria applied by funding agencies for the evaluation of projects are the intrinsic and extrinsic merit of projects proposed by the director of Oak Ridge Laboratory, Alvin Weinberg, in a seminal article (Weinberg, 1963). OECD specified it further by considering that projects should be evaluated according to their merits and to their potential impact or relevance to the country needs (OECD, 1968). National funding programmes complement the traditional block funding and represent since then the direct intervention of public authorities in research systems.

Competitive funding promoted discontinuity in the management of research funding with the creation of new professional organisations directly responsible for their administration and of the S&T policy-making.

4.5 Administration

The OECD model proposes a new public body devoted to the administration and implementation of research policies and national programmes. Both the Bush and Piganiol reports advocate the creation of a national science office. To support this institutional innovation both the reports and reviews argue that research councils and ministerial departments are not the adequate bodies to tackle the new administration responsibilities because of two reasons. The first reason was the inability of traditional vertical organisations to cope with the management of a horizontal coordination function (OECD, 1969). The second reason had a more pragmatic nature and was associated with the workload of research councils with the operational management of their research laboratories (OECD, 1966 a, b, 1969).

A specialised agency without laboratories was preferred for the administration of the policy-making cycle. The agency should be placed under the remit of the Prime Minister to ensure an effective inter-ministerial coordination. The agency should have professional staff, preferable a combination of professionals who were either senior civil servants or researchers, trained to carry out plans and to prepare decision-making processes at political level. The agency functions would include the technical support to the advisory structures, the development of studies on the research system, and the management of national programmes.

Two agencies served as model for the new body, the French Direction Générale de la Recherche Scientifique et Technique (DGRST), whose mission was to formulate and design science policy and its implementation (OECD, 1966b), and the Japanese Science and Technology Agency (STA) (OECD, 1967a). Both were independent bodies with good reputation among actors endowed with a large budget to launch and manage national programmes (OECD, 1969). The NSF, mentioned in nearly all comparative studies, was not suggested as model as it has never had a direct role in policy-making.

5 . Structuration and institutionalisation of S&T policies through the diffusion of the OECD model

The 'OECD model' unveiled above is de facto a normative model proposed implicitly by an international organisation and its network of experts. Even when it required important institutional changes, the principles underlying the model were adopted by OECD member

countries in a short period. The question is then: why was the model so easily adopted in OECD member states and in the world, and which are the characteristics that make it so attractive? We have identified three main factors that have contributed to the selection of the model by national governments: the homogeneity of the model associated with a good degree of flexibility in its implementation; the sound theoretical foundations namely in rationales and concepts in association with a solid statistical system; and finally the diffusion process applied. We review them in turn after having examined the extent of the diffusion of the OECD model.

5.1 The wide adoption of the OECD model

In order to capture better the extent of the diffusion of the model, we look at the process of adoption of the different functions one after the other. In the model, the existence of a central authority with coordination power at governmental level is crucial. In less than one decade, the majority of the OECD countries had a minister responsible for science, whereas when the OECD action began in the early 1960s there were only ministers responsible for science portfolios in the Netherlands, UK, Japan and France (Finnemore, 1993; Jang, 2000). In the earlier stages of implementation of research policy, Prime Ministers or Presidents have often played a central role in coordinating the research efforts, e.g. Japan (OECD, 1967a) or Belgium (OECD, 1966a). With time, they became progressively less involved, and the responsibility of science issues was transferred to ministers in charge of research. There is however one exception to this movement: the USA never created a central authority for research. In this case, state agencies were able to keep their autonomous and distributed power. Rare are the countries without formal advisory bodies at policy and intermediary levels with important roles in priority-setting and in providing advice in national programmes (Braun, 1998; Rip and Nederhof, 1986). There is quite some variety in their composition, some being composed only by scientists, and others with other societal actors. The advisory function has followed the same path as for the political responsibility, moving from the level of Presidents or Prime Ministers to the ministers responsible for the science portfolio level. This was also the case for the American PSAC that has seen its role and proximity to the President decreasing over time (Smith, 1990).

Following the OECD model, plans for S&T should define the choices and strategies of national Governments for the medium to the longer term. As such, this function was linked with the cold war period when planning was a key tool for government activity. It was one of the earliest functions to be implemented. Planning bodies on S&T issues existed since the 1950s, pioneered by France, Norway, Switzerland and Italy and diffused in the 1960s to other OECD countries (Benum, 2007; OECD, 1966b, 1969, 1970, 1971b). S&T planning has

decreased in importance along with national planning. In general, foresight exercises coupled with medium-term programmes for science replaced them. Budgeting and priority-setting were often associated with planning exercises, yet they could be developed autonomously depending upon the approach of the country. OECD highlighted the importance of having a research budget because of the measurement of public investment devoted to R&D. In 1958 France became the first country to have a research budget, and to implement a research block vote (OECD, 1966b). Two decades later research budgets were already a reality in most of the OECD member states (OECD, 1981).

The third function priority-setting remains important in most countries. Although an exception in the OECD model, as no prescriptive format or way of implementation was proposed. Only late in 1991, did the OECD produce a report on the issue acknowledging the variety of approaches taken by countries and concluding that priority-setting was the 'corner-stone of the S&T policy' (OECD, 1991). Priority-setting has remained untouched in the past 40 years and keeps its relevance (Feller and Cozzens, 2007). In fact the role of advisory councils in the process, with a combination of core senior researchers and industrialists heavily involved in priority setting processes also remains (Braun, 1998; Rip and Nederhof, 1986).

The last two functions - allocation of resources and professional administration – have become the most influential functions in S&T policy-making. The need for a professional body was explicitly recommended in the reviews. Bodies of this kind were created during and after the 1960s in most OECD countries, either as new organisations or from the reorganisation of existing ones. All countries have national programmes, either of a structural nature or based on thematic priorities. Most have now institutionalised project-based competitive funding modes based on peer-review. Project funding was taken into the model by copying the North-American experience launched by the NSF (see Smith, 1990 for an historical account). Martin and Irvine (1992) already noted a progressive decline of block funding in most OECD countries. Lepori et al. (2007) demonstrate on a number of EU countries, including countries that were known to rely mostly on block-funding such as France, that there has been a regular increase of competitive funding in the overall funding over the last 30 years.

The OECD model advocates the creation of a professional body to administrate research policy and manage funds targeting national priorities, independent from the research councils. Although not all countries adopted the same organisational frame, the professionalisation of the administration in charge of research policy-making is a reality in all countries. Three types of organisations co-exist for project-based funding: ministries with departments responsible for the management of national programmes and corresponding funding allocation; research councils which have evolved towards the profile prescribed by

OECD with research institutes integrated in the university system, and agencies created in general ex novo.

5.2. The homogeneity of the model

We have shown already the importance that the evaluation of countries research systems and policies and of its systematic reporting had in the development of the OECD model. The review process, the limited number of evaluators and the reporting format used were effective in constructing a homogeneous model for policymaking. The analysis of the research system and policy structures and functions of each country was to a certain extent systematically done through the application of the same grid of analysis and same S&T indicators. Each report, as described in the Methodology section, was following a preconceived format. Although there has been some adjustment in the format, as knowledge was acquired through experience, the main components of the report remained remarkably stable.

When looking at contents, the reports address, in a consistent way, the same topics and issues. In broad terms, they provide an analysis about the existence in the evaluated research system of the functions and implementation structures defined in the model. When those elements are present, reports also assess their consistency with the idealised model. For example, in the Portuguese review (OECD, 1986) the lack of horizontal coordination and of a research budget were highly criticised and suggestions made about how to implement them. Similarly, France (OECD, 1966b), which was one of the first countries to adopt a research budget and had implemented a well-developed process, was criticized because was including only the civil non-nuclear research, leaving outside from the process the large stake of research expenditures devoted to the military and nuclear research.

The homogeneity was also achieved because a reduced number of well-connected evaluators were doing the reviews and writing the reports, which were supported as well by a small stable technical secretariat at the Science and Technology division of OECD. The list of evaluators presented in the annex shows that evaluators were key actors in the established national research systems with leading positions in governmental bodies, advisory committees, research councils, and at influential universities and industrial research laboratories. As leaders of the evaluation teams there were key experts for the OECD, like Pierre Piganiol, author of the seminal OECD report (1963), and Harvey Brooks (Brooks, 1971), author of another important OECD report on the role of science and technology in society, or Christopher Freeman, leading author of the OECD Frascati Manual. Other leaders of the reviews were former ministers or directors of research laboratories, such as Lord Bowden, former British minister of state and principal of Manchester College of S&T,

the Earl of Halsbury the first Chancellor of Brunel University, and A. Pannenberg director of the Philips Laboratories.

The combination of normalised procedures with a common format in reporting, and the limited number of highly involved individuals promoted the diffusion of a homogenous model for policymaking in S&T. However, it does not explain the reason why national governments have adopted the model so easily and fast, taking into account that its adoption implied important institutional changes.

5.3. The selection of the model

Two models were in competition when OECD was promoting the need for governmental intervention in science and technology. The new model, the 'OECD model' described above, supported the approach for a national-level policy for S&T, confronting the then established approach based upon the autonomous management by research councils and academies of science (the Republic of Science model).

The two models represented opposing views for government intervention. The prevailing model until the 1960s was widely supported by research communities. There was no central authority in control of the distribution of resources, nor any form of global accountability or relevance of the Government funds allocated to science. The patronage of science was favouring what Michael Polanyi denoted as the 'Republic of Science', meaning that, in order to preserve the researchers' autonomy in choosing and exploring their research themes, a kind of 'invisible hand', similar to the one attributed to market mechanisms, should be applied in the allocation of resources to research (Polanyi, 1962). In essence, the argument was that the new scientific knowledge produced would benefit in the end the countries' welfare. Selection of excellence would also come from the 'mutual adjustments of individual initiatives' without any need for a central authority to steer the process.

Two central factors have contributed to the prevalence of the OECD model: the theorisation of science as a public good, and the development of a linear approach to innovation for statistical purposes.

The construction of an economic rationale for policy intervention was fundamental for the selection of the OECD model by policy-makers. In fact, theoretical developments in economics occurred during the period of inception of the model. Nelson (1959) and Arrow (1962) showed that research has the attributes of a public good, because of that the support from public policies is crucial for having a socially optimal investment in research. The main argument is that research is a risky enterprise with uncertain outcomes, and has increasing returns with use, and is only appropriable to a limited extent. Therefore, knowledge needs to

be protected from imitation (intellectual property rights system) and externalities produced, and needs to have alternatives to traditional financing mechanisms. Both argued for public policies to intervene in research in order to maximise its social value, promoting its wider free use, and reduce the sub-optimal allocation of resources by private investment. Summing up, the rationale for government intervention is defined as the failure of market mechanisms to optimally allocate resources to research, and the need to substitute it by public incentives. It is fascinating to observe the translation of this new rationale into practice, almost without delay. It was almost immediately tested in the field by the authors who were also engaged in the construction and implementation of the model, and actively engaged in policy discussions. Nothing illustrates it better than the introduction by Nelson in his 1959 article: the article opens with a reference to the impact of the launch of Sputnik in America regarding the level of funding needed by basic research.

The second major factor deals with the conceptualisation of the innovation process as a linear model of innovation. The linear model for innovation has a fuzzy origin (Godin, 2006). It assumes that eventually results from basic research will be at the origin of new products or processes. Some argued that the linear model was already implicitly conceptualised in Vannevar Bush's report (Rip and Meulen, 1996; Salomon, 1977). Nevertheless, it has mainly been applied later for expressing the relationship between S&T and economic development. According to Freeman (1977) the linear model was formalised for statistical purposes: it systematised the innovation process, enabling the identification of autonomous components and the measurement of research inputs and outputs. In turn, this linear approach to innovation was transposed to the country level in order to identify the structures that compose a national research system and the functions that they are responsible of. Therefore, actors performing R&D were organised in sectors by institution type (government, higher education, business and not-for-profit) and type of research performed to achieve nationally defined objectives. This supported a division of labour in the research system: universities should perform basic research⁸, public laboratories applied research, and business technical development.

Finally, the adoption of the model was influenced by an indirect but important factor. Freeman (1987) argues that the model enabled to address the growing claims by the ministers of finance for accountability and credibility in spending of public research funds. This was linked to the development of professional management and implementation of the processes proposed. On the one hand, the model proposed a more flexible and less risky

⁸ Our choice is to use the term basic research instead of fundamental research. Both terms have equal meaning, dealing with the search for new knowledge regardless of its application. Both were used interchangeably (Godin, B., 2000).

funding instrument - the research projects, with a limited duration and associated to an objective – as compared with the traditional recurrent funding of research centres. On the other hand, it reduced the autonomy of traditional research councils and allowed more direct governmental control over public investments.

5.4. The diffusion and implementation of the model

A third important dimension must be taken into account to explain the fast adoption of the model, that is the role played by OECD and the diffusion process promoted by OECD. To analyse this third aspect, we mobilize the approach developed by DiMaggio and Powell, (1983) for the identification of the mechanisms that drive institutional change through the adoption of leading models. They identified three main mechanisms for isomorphism in institutional change. The first one is coercive isomorphism promoted through regulatory frameworks like environmental regulations that enforce similar behaviours and structures. The second mechanism relates to mimetic processes, consisting in the implementation of leading models through either copying or adoption in order to legitimate or to cope with uncertainty. Finally, the third mechanism results from normative pressures associated with the professionalization of a field, as the professionals tend to share the same culture because of common educational backgrounds, or being part of the same professional associations and organised networks. Of the three mechanisms proposed, only mimetic processes explain the diffusion of the model. The strength of the OECD has never been linked with regulatory pressure, as regulations have never been part of its mission. On a similar way, it remains difficult to speak of the professionalisation of the field. The central explanation lies then in the effectiveness of the 'diffusion process' adopted by the OECD. These drove countries, one after the other, to copy and adopt the idealised model proposed similar to what happens when large corporations adopt organisational models developed by leading consultants to face the unknown.

One first element lies in the ways OECD selected the evaluators. These reviewers had experience gained from their leading positions in the novel structures for S&T policy-making that the most advanced countries were implementing (see above). Beyond this, the diffusion of the model comprised a set of initiatives targeting governments and officials for mutual learning and trust. The initiatives focused primarily on creating awareness by national governments for such policy, and on the sharing of experiences on implementation of a new and specific policy area (Elzinga and Jamison, 1995). The two inter-ministerial conferences held in 1963 and 1966 (Godin, 2007) aimed at this policy learning, and to achieve the necessary consensual agreement on the launch of such mechanisms and structures in their countries. Secondly, the approach developed targeted scholars and national statistics offices

to collaborate in the setting up of a system for collecting data on S&T activities in order to have, in the words of Piganiol (1963), a sound 'factual base' to support policy-making. Thirdly, the OECD organised workshops and seminars, involving government officials, researchers and experts, to create a shared culture in policy-making and evaluation (e.g. Seminar at Jouy-en-Josas, February 1967). Finally, the cross-fertilisation of ideas between policy-makers and the emergent academic community on science and technology studies favoured the creation of strong ties between them, helping the institutionalisation of specialised research centres and the progressive construction of a body of knowledge on science policy studies (e.g. SPRU, Science and Technology Policy Research at the University of Sussex, in the UK).

This approach to diffusion has proven to be very powerful and explains the central role played by OECD not only in generating the 'OECD model' but also in ensuring its wide implementation. It is however important to note that it is not specific to S&T policies. In fact, similar procedures of peer-review and knowledge sharing have been applied by OECD in other areas with similar degrees of success (Marcussen, 2001; Porter and Webb, 2007); It is based on a powerful technical secretariat combined with the involvement of influential national key-players and leading experts, in association with peer-review processes for policy learning and peer pressure.

6. Durability of the OECD model

The end of the 'Endless Frontier' period in S&T policies is controversial. Although some claimed that this period of S&T policies was a parenthesis during the Cold War period (Callon, 1994, 2003; Etzkowitz and Leydesdorff, 2000), others mention that the model implemented in the 1960s for S&T policies remain today almost unchanged (Feller and Cozzens, 2007). We incline towards the second view, especially when looking at the accounts of the European national policies produced regularly by the ERAWATCH process (<http://cordis.europa.eu/erawatch/index.cfm>). The question for us was thus to understand why present institutional arrangements and policy processes still fit the model, despite the criticisms on its adequacy and the new theoretical developments that claim to have undermined its foundations.

Of the new concepts and approaches developed, the national system of innovation framework (Edquist, 1997; Freeman, 1987; Lundvall, 1992; Nelson, 1993), has been by far the most influential and the most pervasive. A striking feature is that it was born within OECD, Lundvall, one of its proponents and part of the OECD for a period, cites a first elaboration by Freeman as early as 1981. The national innovation system approach was rapidly adopted as rhetoric by scholars and policy makers (OECD was one of the first spaces

to follow Finland in its adoption as a framework to approach countries). However, following Godin (2009) it did not generate major evolutions in the implementation structures developed within research systems. One central feature of the framework is to consider the interactive nature of the innovation process: Kline and Rosenberg (1986) were then speaking of the chain-linked model, von Hippel (1988) was underlining the role of 'lead users' in the framing of innovations and, following Polanyi (1966) the tacit part of knowledge required actors to directly cooperate in order to absorb it (Cohen and Levinthal, 1990). All this led to emphasize, following Lundvall, learning processes and the need for an institutional framework favourable to actors' cooperation (also promoting behavioural changes of actors, see the recent elaboration by OECD of the notion of behavioural additionality).

This framework contains also a deeper criticism of the prevailing rationale for public intervention, market failure. The new evolutionary rationale suggests enlarging the scope of policies. In the older one (which helped the diffusion of the OECD model), policies were primarily focused on the development of firm innovation capabilities through grants, subsidies and taxes (additionality effect). The new rationale puts on the fore structural change and the promotion of coordination and connectivity among structures (Metcalf, 1997). The focus of the systems failure rationale lies on the ability of the system to enhance innovation capabilities, through the establishment of linkages among firms and knowledge producers and users, through the creation of infrastructures to cater for missing links, and through the improvement of framework conditions (bridging and populating effects) (Edquist, 2002). Metcalfe and Georghiou (1997) recognised quite early that both rationales are not exclusive but complementary. Many authors argue that this has not driven to any change in policies and that market failure remains the dominant rationale for public policies related to research and innovation (Box, 2009; Dasgupta and David, 1995; Smith, 2000). We see two main reasons for this, which we examine in turn.

First, most of these new pressures were accommodated through progressive adaptation of existing processes and instruments. Project-based funding remained central, as many national (and European) programmes became 'collaborative' (Metcalf and Georghiou, 1997) or 'technological' (Callon et al., 1997), highlighting university-industry but also industry-industry linkages⁹. Selection mechanisms have been adapted towards 'extended peer review' (whether by enlarging the notion of peers, or by adopting a two-step process), with on-going discussions about the ability of such mechanisms to address interdisciplinarity (Lamont et al., 2006) or to cope with the relevance of science (Scott, 2007). These two cases are exemplary of the answers developed: they did not deal with the model as such, nor even

⁹ They also provide a channel to cope with new approaches about the diversity of knowledge sources and the greater variety of knowledge producers (see for instance Gibbons, et al., 1994).

with the reshaping of one of its dimensions, but with ways to implement specific aspects through progressive and incremental evolutions in instruments and operational schemes.

Second, a major achievement of the 1960s was the standardisation of research statistics. The Frascati Manual (1963) aimed at standardising methodologies to collect data and build new input-output indicators for establishing an international statistical system for S&T. Its purpose was to provide governments with comparative data on research systems on a regular basis. The clear-cut homogenous definition of the components of R&D, as well as the identification of sectors of performance allowed the stabilisation of S&T statistics at the international level. The manual was first implemented for the country reports statistics and its results mobilised in the national reviews. Its application in all OECD member States as well as the production by OECD of annual comparative datasets provides a central feature of most national policies. Initially only focused on inputs, this referential has been enlarged by adding elements of outputs using publications, patents and the innovation survey, developed along similar approaches as for the inputs, with the Oslo Manual. However Godin (2007) argues that these additions have not changed the central feature of the measurement system, and Lepori et al. (2008) advocate for a new approach, positioning indicators, that take into account the wide variety within types of actors¹⁰ and keep track, like in the multiple rankings that have flourished, the identity of actors and of their strategies. This has driven Freeman and Soete (2009) to consider that the indicators defined at that time probably are not relevant for explaining today's research systems.

These two features explain why the model has been resilient in the face of new understandings developed. Furthermore, the new institutional transformations seem to have reinforced it. At one end, the development of European programmes has been based upon the use of project-based funding and has been even an experimental ground for both collaborative programmes and extended peer reviewing (Bobe and Violla, 1997). The creation of the European Research Council is a further path in the same direction. At the other end associated with growing regionalisation, specialists of regional research and innovation policies have qualified them as 'national policies writ small' (Laranja et al., 2008).

7. Conclusions

National science and technologies policies were institutionalised in the 1960s through the impetus and work done by the OECD. OECD argument for the need of a national S&T policy

¹⁰ In particular the growing globalisation of industrial R&D, e.g. some 200 groups represent half the world industrial R&D.

had its foundations in a wide shift on the role of research and development that should be focused on national needs and the promotion of economic growth.

The 'OECD model' for research policy-making has never been revealed. This paper proposes a first presentation of this model, with the identification of the functions and the institutional arrangements that compose it. The model represents a break from the tradition of having public resources fragmented between departments and distributed at the intermediary level without governmental steering. It has its seeds in two influential reports by Vannevar Bush and Pierre Piganiol and was unfolded through an innovative mechanism proposed by OECD: national country reviews.

The analysis of the national reviews conducted has identified five functions and their corresponding implementing structures. At the political level, three functions were critical to the policy-making process. *Horizontal coordination*, organised at Government and performed by the Prime Minister or a Minister responsible for the portfolio, is considered central to guarantee a centralised decision-making process, and to achieve an S&T policy that insures the coordination of plans and actions of the different government bodies with research responsibilities. *Advice* on the definition of policies and in the monitoring of their implementation should be produced by a standing committee for S&T composed of scientists, industrialists and civil society: this was considered by the OECD as a privileged channel to insure that the national strategy is 'co-constructed' and thus widely shared and accepted. Medium to long term *planning* associated with the setting-up of research priorities should be reflected in a *national research budget*. It was seen as critical to insure the involvement of the Parliament in scientific affairs, the definition of longer term involvement helping face pressures for cuts in difficult budgetary times. A lasting institutional innovation was the creation of a *specialised administrative body* in charge of supporting the policy-making process and administrating national programmes through competitive funding allocation.

One surprise in retrospect is the speed and depth of the diffusion of the model and its de facto generalisation to all OECD members (with the exception of the US, where only some aspects were already in place). Our explanation lies in the combination of three dimensions. A first dimension deals with the simultaneous development of the policy model itself, the linear model of innovation and a new economic rationale which included in its deployment, the main policy instruments required. The two other dimensions are associated to OECD practice itself. We have demonstrated how homogeneous was the application in the country reports of the de facto model. We also have outlined the numerous mechanisms put in place to gather policy responsiveness and generate mimetic processes.

We are also struck by the stability of the model. We see two main reasons that explain this stability. First and foremost, three functions are not specific and tend to prevail in all fields as long as the field is considered 'autonomous' in term of public action. What made it different (and still makes it) lies in two dimensions: First its pervasive nature, requiring horizontal coordination between classically vertical departments, and its way to deliver effects - long term and indirect - rendering difficult any immediate apprehension and driving to specific processes and structures for planning, priority-setting and accounting. These have not been touched by the new understanding developed in the ways innovations materialise and in the ways to characterise national systems. We thus have only witnessed progressive and incremental evolutions in the ways these functions are performed, i.e. the growing role of foresight in planning; the growing place of technological/collaborative programmes in the implementation of national programmes, and the increasing importance of evaluation in administration. Furthermore, the second dimension that makes the model lasting is associated with the measurement system. The simplicity of the linear model of innovation and of the rationale of market failure associated with it, enabled to develop a powerful and lasting statistical description and monitoring of research systems. The incapacity of developing indicators associated to the new understandings of innovation systems may well explain why promoters of the systems failure rationale have all fallen back on existing policies, arguing at best for adaptative policies. This situation represents a major challenge for science and innovation policy studies, especially at a time when Europe is developing a new measurement system to monitor the progress towards the European Research Area.

Acknowledgements

The Fundação para a Ciência e a Tecnologia and The PRIME network of excellence are acknowledged for the support and environment provided for this research endeavour.

References

- Arrow, K., 1962. Economic welfare and the allocation of resources for invention, *The Rate and Direction of Inventive Activity: Economic and Social Factors*, National Bureau of Economic Research Inc., pp. 609-626.
- Benum, E., 2007. *Making research count: Norway and the OECD connection (1965-1980)*. Minerva Springer 2007.
- Bobe, B., Violla, H., 1997. Panels of experts of the European Commission, in: Callon, M., Laredo, P., Mustar, P. (Eds.), *The Strategic Management of Research and Technology*. Economica International, Paris, pp. 31-40.
- Box, S., 2009. OECD work on innovation - A stocktaking of existing work. STI working paper 2009/2.
- Bozeman, B., 1997. Beyond state of siege: institutional design and the federal laboratory system, understanding the dynamics and role of public sector research, Conference de Notre Dame, Paris.

- Braun, D., 1998. The role of funding agencies in the cognitive development of science. *Research Policy* 27, 807-821.
- Brooks, H., 1971. *Science, croissance et société - une perspective nouvelle*. OECD, Paris.
- Bush, V., 1945. *Science, the endless frontier. A report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development*. National Science Foundation, Washington D.C..
- Callon, M., 1994. Is Science a Public Good? *Science Technology and Human Value* 19, 395-424.
- Callon, M., 2003. The increasing involvement of concerned groups in the R&D policies: what lessons for public powers, in: Geuna, A., Salter, A., Steinmueller, W.E. (Eds.), *Science and innovation. Rethinking the rationales for funding and governance*. Edward Elgar Publishing, Inc., Cheltenham Glos.
- Callon, M., Laredo, P., Mustar, P., 1997. *The Strategic management of research and technology*, Economica International, Paris.
- Cohen, I.B., 1994. *Interactions - some contacts between the natural sciences and the social sciences*. The MIT Press.
- Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* Vol. 35, No. 1, 128-152
- Dasgupta, P., David, P.A., 1995. Towards a new economics of science. *Research Policy* 23, 487-522.
- David, P.A., 2001. From keeping "nature's secrets" to the institutionalisation of "open science", University of Siena Lectures.
- DiMaggio, P.J., Powell, W.W., 1983. The Iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review* 48, 147-160.
- Edquist, C., 1997. *Systems of innovation: technologies, institutions and organisations*. Pinter, London.
- Edquist, C., 2002. *Innovation Policy - A systemic approach*.
- Elzinga, A., Jamison, A., 1995. Changing Policy Agendas in Science and Technology, in: Jasanoff, S., Markle, G.E., Peterson, J.C., Pinch, T. (Eds.), *Handbook of Science and Technology Studies*. Sage, London, pp. 572-597.
- Etzkowitz, H., Leydesdorff, L., 2000. The dynamics of innovation: from national systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy* 29, 109-123.
- Feller, I., Cozzens, S., 2007. *A Science of science and innovation policy research agenda*, Working Paper Series. School of Public Policy, Georgia Institute of Technology.
- Finnemore, M., 1993. International organizations as teachers of norms: The United Nations Educational, Scientific, and Cultural Organization and science policy. *International Organization* 47, 565-597.
- Freeman, C., 1977. Economics of research and development, in: Spiegel-Rösing, I., Price, D.D.S. (Eds.), *Science, Technology and Society: A Cross-Disciplinary Perspective*. Sage, London.
- Freeman, C., 1987. *Technology and economic performance: Lessons from Japan*. Pinter Publishers, London.
- Freeman, C., 1995. The "National system of innovation" in historical perspective. *Cambridge Journal of Economics*, 5-24.

- Freeman, C., 2002. Continental, national and sub-national innovation systems - complementarity and economic growth. *Research Policy* 31, 191-211.
- Freeman, C., Soete, L., 2009. Developing science, technology and innovation indicators: What we can learn from the past. *Research Policy* 38, 583-589.
- Gibbons, C.L., H. Nowotny, S. Schartzman, P. Scott and M. TROIW, 1994. *The new production of knowledge*. Sage Publications, London.
- Godin, B., 2000. Measuring science: is there "basic research" without statistics? , Project on the History and Sociology of S&T Statistics. Institut National de la Recherche Scientifique, Montréal.
- Godin, B., 2006. The linear model of innovation: The historical construction of an analytical framework. *Science, Technology & Human Values* 31.
- Godin, B., 2007. Science, accounting and statistics: The input–output framework. *Research Policy* 36, 670-690
- Godin, B., 2009. National innovation system (II). Industrialists and the origins of an idea, Working Paper No. 4. Project on the Intellectual History of Innovations, Quebec, Canada.
- Henriques, L., 2006. The dynamics of a national system of innovation and the role of the non-profit space: Portugal as a Research Laboratory, École Nationale Supérieure des Mines de Paris.
- Jacq, F., 1996. Pratiques scientifiques, formes d'organisation et représentations politiques de la science dans la France de l'après-guerre- La "politique de la science" comme énoncé collectif (1944-1962). I ' École Nationale Supérieure des Mines de Paris.
- Jang, Y., 2000. The worldwide founding of ministries of science and technology, 1950-1990. *Sociological Perspectives* 43, 247-270.
- Kline, S.J., Rosenberg, N., 1986. An overview of innovation, in: Landau, Rosenberg, N. (Eds.), *The Positive sum strategy: harnessing technology for economic growth*. National Academy Press, Washington DC.
- Lamont, M., Mallard, G., Guetzkow, J., 2006. Beyond blind faith: overcoming the obstacles to interdisciplinary evaluation. *Research Evaluation* 15, 43-55.
- Laranja, M., Uyarra, E., Flanagan, K., 2008. Policies for science, technology and innovation: translating rationales into regional policies in a multi-level setting. *Research Policy* 37, 823-835.
- Lepori, B., Barré, R., Filliatreau, G., 2008. New perspectives and challenges for the design and production of ST indicators. *Research Evaluation* 17, 33-44.
- Lepori, B., van den Besselaar, P., Dinges, M., Potì, B., Reale, E., Slipersæter, S., Thèves, J., van der Meulen, B., 2007. Comparing the evolution of national research policies: what patterns of change? *Science and Public Policy* 34, 372-388.
- Lundvall, B.-A., 1992. National systems of innovation. Towards a theory of innovation and interactive learning, in: Lundvall, B.-A. (Ed.).
- Lundvall, B.-A., Borrás, S., 2005. Science, technology and innovation policy in: Fagerberg, J., Mowery, D., Nelson, R.R. (Eds.), *The Oxford Handbook of Innovation*. Oxford University Press, Oxford.
- Marcussen, M., 2001. *The OECD in search of a role: Playing the idea game*, European Consortium for Political Research (ECRP), Grenoble.
- Martin, B.R., Irvine, J., 1992. Trends in public spending and related research: an international comparison. *Science and Public Policy* 19.

- Metcalfe, J.S., 1997. Technology systems and technology policy in an evolutionary framework, in: Archibugi, D., Michie, J. (Eds.), *Technology, Globalisation, and economic performance*. Cambridge University Press, Cambridge.
- Metcalfe, J.S., Georghiou, L., 1997. *Equilibrium and evolutionary foundations of technology policy*. Centre for Research on Innovation and Competition, The University of Manchester, Manchester.
- Nelson, R.R., 1959. The Simple economics of basic scientific research. *The Journal of Political Economy* 67, 297-306.
- Nelson, R.R., 1993. *National innovation systems. A comparative analysis*, 1 ed. Oxford University Press, New York, p. 539.
- OECD, 1966a. *Reviews of national science policy - Belgium*, Paris.
- OECD, 1966b. *Reviews of national science policy - France*, Paris.
- OECD, 1967a. *Politiques nationales de la science - Japon*. OECD, Paris.
- OECD, 1967b. *Politiques nationales de la science: Royaume Uni et Allemagne*, Paris.
- OECD, 1968. *Problèmes de politique scientifique - Séminaire de Jouy-en-Josas (France)*, in: OECD (Ed.), Paris.
- OECD, 1969. *Politiques nationales de la science -Italie*. OECD, Paris.
- OECD, 1970. *Politiques nationales de la science - Norvège*. OECD, Paris.
- OECD, 1971a. *Politiques nationales de la science - Suisse*. OECD, Paris.
- OECD, 1971b. *Reviews of national science policy - Spain*. OECD, Paris.
- OECD, 1973. *Politiques nationales de la science - Pays-Bas*. OECD, Paris.
- OECD, 1974. *Reviews of national science policy - Ireland*. OECD, Paris.
- OECD, 1981. *La politique scientifique et technologique pour les années 1980*, Paris.
- OECD, 1984. *Reviews of national science policy - Greece*. OECD, Paris.
- OECD, 1986. *National science policy reviews - Portugal*. OECD, Paris.
- OECD, 1991. *Choosing priorities in science and technology*, Paris.
- OECD, 1998. *Jobs strategy: technology, productivity, and job creation: Best policies practices*. OECD, Paris.
- Piganiol, P., Herz, K., Major, R., Ramsey, N.F., Schimdt, E.I., Schultz, T.W., Steacie, E.W.R., 1963. *Science and the policies of governments - The implications of science and technology for national and international affaires*. OECD, Paris.
- Polanyi, M., 1962. *The Republic of science - Its political and economic theory*. Minerva 1.
- Polanyi, M., 1966. *The tacit dimension*. Routledge & Keagan, London.
- Porter, T., Webb, M., 2007. *The role of the OECD in the orchestration of global knowledge networks*, Canadian Political Science Association Annual Meeting, Saskatoon, Saskatchewan, Canada.
- Rip, A., Meulen, B.V.d., 1996. The post-modern research system. *Science and Public Policy* 23, 343-352.
- Rip, A., Nederhof, A.J., 1986. Between dirigisme and laissez-faire: effects of implementing the science policy priority for biotechnology in the Netherlands. *Research Policy* 15, 253-268.
- Salomon, J.-J., 1977. Science policy studies and the development of science policy, in: Spiegel-Rösing, I., Price, D.de.Solla. (Eds.), *Science, Technology and Society*. Sage, London.

- Scott, A., 2007. Peer review and the relevance of science. *Futures* 39, 827-845.
- Sharif, N., 2006. Emergence and development of the national innovation systems concept. *Research Policy* 35, 745-766.
- Smith, B.L.R., 1990. *American science policy since World War II*, The Brookings Institution, Washington D.C.
- Smith, K., 2000. Innovation as a systemic phenomenon; Rethinking the role of policy. *Enterprise & Innovation Management Studies* 1, 73-102.
- UNESCO, 1977. *Méthode de détermination des priorités dans le domaine de la science et de la technologie*. UNESCO, Paris.
- von Hippel, E., 1988. *The sources of innovation*. Oxford University Press.
- Weinberg, A., 1963. Criteria for scientific choice, *Minerva*, 159-171.