National Innovation System:
The System Approach in Historical Perspective

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Abstract

In the late 1980s, a new conceptual framework appeared in the science, technology and innovation studies: the National Innovation System. The framework suggests that the research system's ultimate goal is innovation, and that the system is part of a larger system composed of sectors like government, university and industry and their environment. The framework also emphasized the relationships between the components or sectors, as the "cause" that explains the performance of innovation systems.

Most authors agree that the framework came from researchers like C. Freeman, R. Nelson and B.-A. Lundvall. In this paper, I want to go further back in time and show what the "system approach" owes to the OECD and its very early works from the 1960s. This paper develops the idea that the system approach was fundamental to OECD work and that, although not using the term National Innovation System as such, the organization considerably influenced the above authors.

National Innovation System:
The System Approach in Historical Perspective [1]

Introduction

In the late 1980s, a new conceptual framework appeared in science, technology and innovation studies. It was one of the first frameworks since the linear model of innovation and the one of the first of a series of new policy frameworks to come: National Innovation System. [2] The National Innovation System framework suggests that the research system's ultimate goal is innovation and that the system is part of a larger system composed of sectors like government, university and industry and their environment. The framework also emphasized the relationships between the components or sectors as the "cause" explaining the performance of innovation systems.

Where does the idea of the National Innovation System come from? Most authors agree that it came from researchers like C. Freeman, R. Nelson and B.-A. Lundvall. [3] In this paper, I want to go further back in time and show what the "system approach" owes to the OECD and its very early works from the 1960s. Certainly, the OECD cannot be credited as sole source of the idea. In the 1960s, system dynamics among social scientists [4] and system analysis were pretty

[1] The author would like to thank four referees for their comments on the earlier version of this paper.
[2] Other frameworks were: Knowledge-base economy, Information Society, New Production of Knowledge (Mode1/Mode 2), Triple Helix.
[3] C. Freeman (1987), *Technology Policy and Economic Performance*, London: Pinter; G. Dosi et al. (1988), *Technical Change and Economic Theory*, Part V: National Innovation Systems, London: Pinter; B.-A., Lundvall (ed.) (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter; R. R. Nelson (ed.) (1993), *National Innovation Systems: A Comparative Analysis*, Oxford: Oxford University Press. See also: C. Edquist (ed.) (1997), *Systems of Innovation: Technologies, Institutions and Organizations*, London: Pinter; B. Amable, R. Barré and R. Boyer (1997), *Les systèmes d'innovation à l'ère de la globalisation*, Paris: Economica.
[4] On system dynamics, see the works of J.W. Forrester in the late 1960s. For an influential application, see: D.L. Meadows et al. (1972), *The Limits to Growth*, New York: Universe Books.

popular, the latter particularly in the United States at RAND. [5] Many researchers, particularly from management, began to use a system approach to study decisions and choices regarding science, technology and innovation. [6] Nevertheless, the OECD has been a very early and systematic user of the system approach, and an influential one among Member countries in matters of policy. By concentrating on the OECD, this paper adds a neglected piece of history to the literature. [7]

This paper is not a study of the concept of the National Innovation System itself, neither is it a critical analysis of its main rationale. R. Miettinen has conducted a very enlightened analysis that serves this purpose. [8] Rather, I want to develop the idea that a system approach was fundamental to OECD work and that, although not using the term National Innovation System as such, the organization considerably influenced the above authors (as much as they have influenced the organization).

[5] See: A. C. Hughes and T. P. Hughes (2000), *Systems, Experts, and Computers: the System Approach in Management and Engineering, World War II and After*, Cambridge (Mass.): MIT Press. For a sample of RAND's published analyses, see: C. Hitch (1955), An Appreciation of Systems Analysis, *Journal of the Operations Research Society of America*, November, pp. 466-481; C. Hitch (1958), Economics and Military Operations Research, *Review of Economics and Statistics*, 40 (3), pp. 199-209; B. Klein and W. Meckling (1958), Application of Operations Research to Development Decisions, *Operations Research*, 6 (3), pp. 352-363; E. S. Ouade (1969), *The Systems Approach and Public Policy*, Santa Monica (California): RAND Corporation.
[6] M. H. Halbert and R. L. Ackoff (1959), An Operations Research Study of the Dissemination of Scientific Information, in National Academy of Sciences/National Research Council, *Proceedings of the International Conference on Scientific Information*, Washington, Volume 1, pp. 97-130; R. E. Gibson (1964), A Systems Approach to Research Management, in J. R. Bright (ed.), *R&D and Technological Innovation*, Homewood (Illinois): R. D. Irwin, pp. 34-49; G. A. Lakhtin (1968), Operational Research Methods in the Management of Scientific Research, *Minerva*, Summer, pp. 524-540; R. L. Ackoff (1968), Operational Research and National Science Policy, in A. De Reuck, M. Goldsmith and J. Knight (eds.), *Decision Making in National Science Policy*, Boston: Little, Brown and Co., pp. 84-91.
[7] An old text from the 1800s was revived recently by B.-A. Lundvall, but unknown to the above authors at the time of their writings. This resuscitation is rather a rationalization: a search for ”fathers” after the fact.
[8] R. Miettinen (2002), *National Innovation System: Scientific Concept or Political Rhetoric*, Helsinki: Edita. See also N. Sharif (2006), Emergence and Development of the National Innovation System Concept, *Research Policy*, 35 (5), pp. 745-766.

The first part of the paper presents the emergence of the framework on National Innovation System in the OECD literature of the 1990s, [9] and its relationship to one of its competitors, the Knowledge-Based Economy framework. Two of th National Innovation System's limitations, as discussed at the OECD, are presented: lack of substance and statistics. [10] The first criticism is a severe one, and should be addressed, if true, to the entire system approach. The second criticism is, to a certain extent, real, at least as opposed to the early system approach. The second part of the paper goes back in history to trace the emergence of a system approach at OECD from the early 1960s onward. Three major documents are *Gaps in Technology* (1968-70), the Salomon report entitled *The Research System* published in three volumes between 1972 and 1974, and *Technical Change and Economic Policy* (1980). The third part looks at how a system approach entered into early statistics on science, via the Frascati manual.

This paper is based on documentary analysis. It uses archival material from the OECD, as deposited at the European Institute in Florence (Italy). It also makes use of the literature on statistics, particularly as it has links to the subject studied here, and as documented in Godin (2005).

National Innovation System at OECD

For several decades, (neoclassical) economists have been criticized for their failure to integrate institutions into their theories and econometric models. [11] Partly as a response to this situation, scholars in the field of science, technology and innovation studies invented the concept of a National Innovation System. However, the concept also owes a large debt to the old debate (1960s) on

[9] On the system approach at the European policy level, see the following publication, as well as the subsequent strategies of the European Commission which all carried a system approach: L. Soete and A. Arundel (eds.) (1993), *An Integrated Approach to European Innovation and Technology Diffusion Policy*, EIMS Series, Publication no. 15090, European Commission.
[10] Other limitations identified in the literature are: the focus on national aspects; the too broad approach; the difficulty to carry on effective transnational comparisons.

technological gaps and competitiveness, as illustrated in Freeman (1987) and his analysis of the Japanese system. [12] Since World War II, Europeans have been fascinated with the disparities in technological and economic performance between Europe and the United States and Japan. [13] The National Innovation System, with its emphasis on the ways institutions behave and relate to each other, offered a new rationale to explain these gaps.

According to R. R. Nelson, a National Innovation System "is a set of institutions whose interactions determine the innovative performance of national firms". [14] For B.-A. Lundvall, it "is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge". [15] These elements or institutions are firms, public laboratories and universities, but also financial institutions, the educational system, government regulatory bodies and others that interact together.

There are two families of authors in the literature on National Innovation System: those centering on the analysis of institutions (including institutional rules) and describing the ways countries have organized their National Innovation Systems, [16] and those who are more "conceptual", focusing on knowledge and the process of learning itself: learning-by-doing, learning-by-using, etc. [17] From the latter group, the concept of the knowledge economy, first suggested in the early 1960s, [18] re-emerged in the 1990s. [19]

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[11] R. R. Nelson (1981), Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures, *Journal of Economic Literature*, 19, pp. 1029-1064; R. R. Nelson and S. G. Winter (1977), In Search of a Useful Theory of Innovation, *Research Policy*, 6, pp. 36-76.
[12] C. Freeman (1987), Technology Policy and Economic Performance, *op. cit*.
[13] B. Godin (2002), Technological Gaps: An Important Episode in the Construction of Science and Technology Statistics, *Technology in Society*, 24, p. 387-413.
[14] R. R. Nelson (ed.) (1993), National Innovation Systems: A Comparative Analysis, *op. cit*. p. 4.
[15] B.-A. Lundvall (1992), Introduction, in B.-A., Lundvall (ed.), National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, *op. cit*. p. 2.
[16] R. R. Nelson (ed.) (1993), National Innovation Systems, *op. cit*.
[17] B.-A. Lundvall (ed.) (1992), National Systems of Innovation, *op. cit.*
[18] B. Godin (2008), The Knowledge Economy: Fritz Machlup's Construction of a Synthetic Concept, in H. Etzkowitz and R. Viale (eds.), *Proceedings of the 5th Triple Helix Conference*, Edward Elgar, Forthcoming.

It was to Lundvall – nominated deputy director of the OECD Directorate for Science, Technology and Industry (DSTI) in 1992 (until 1995) – that the OECD Secretariat entrusted its program on National Innovation Systems. In fact, the OECD always looked for conceptual frameworks to catch the attention of policy-makers (Godin, 2008). In the early 1990s, it was the framework on National Innovation System that was supposed to do the job: getting a better understanding of the significant differences between countries in terms of their capacity to innovate, and looking at how globalization and new trends in science, technology, and innovation affect national systems. [20] The program did not have the expected impact on policies. In a recent review paper, the OECD admitted: "there are still concerns in the policy making community that the National System of Innovation approach has too little operational value and is difficult to implement". [21]

Too little operational value, but also lack of substance, according to some. To D. Foray (France), the individual behind the resurgence of the concept of the knowledge-based economy, [22] the OECD work on the concept of National Innovation Systems is "neither strikingly original, nor rhetorically stirring", [23] and places too much emphasis on national institutions and economic growth, and not enough on the distribution of knowledge itself. However, Foray (and David) concluded similarly to Lundvall on a number of points, among them: "an efficient system of distribution and access to knowledge is a *sine qua non* condition for increasing the amount of innovative opportunities. Knowledge distribution is the crucial issue". [24]

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[19] Godin, B. (2006), The Knowledge-Based Economy: Conceptual Framework or Buzzword?, *Journal of Technology Transfer*, 31 (1), pp. 17-30.

[20] OECD (1992), *National Systems of Innovation: Definitions, Conceptual Foundations and Initial Steps in a Comparative Analysis*, DSTI/STP(92)15; OECD (1994), *National Innovation Systems: Work Plan for Pilot Case Studies*, DSTI/STP/TIP(94)16; OECD (1996), *National Innovation Systems: Proposals for Phase II*, DSTI/STP/TIP(96)11.

[21] OECD (2002), *Dynamising National Innovation Systems*, Paris, p. 11.

[22] D. Foray (2000), *L'économie de la connaissance*, Paris: La Découverte.

[23] P. David and D. Foray (1995), Assessing and Expanding the Science and Technology Knowledge Base, *STI Review*, 16, p. 14.

[24] *Ibid*. p. 40.

Thus, it seems that a central characteristic of a National Innovation System is the way knowledge is distributed and used. As K. Smith, author of the OECD methodological manual on innovation, put it: "The overall innovation performance of an economy depends not so much on how specific formal institutions (firms, research institutes, universities, etc.) perform, but on how they interact with each other". [25] Indeed, "knowledge is abundant but the ability to use it is scarce". [26]

Another consensual view of authors on National Innovation Systems was that statisticians simply did not have the appropriate tools to measure the concept. To Smith, the "system approaches have been notable more for their conceptual innovations, and the novelty of their approaches, rather than for quantification of empirical description". [27] "There are no straightforward routes to empirical system mapping: we have neither purpose-designed data sources, nor any obvious methodological approach. The challenge, therefore, is to use existing indicators and methods". [28] To Lundvall, "the most relevant performance indicators of National Innovation System should reflect the efficiency and effectiveness in producing, diffusing and exploiting economically useful knowledge. Such indicators are not well developed today". [29] Similarly, David and Foray suggested: "A system of innovation cannot be assessed only by comparing some absolute input measures such as research and development (R&D) expenditures, with output indicators, such as patents or high-tech products. Instead innovation systems must be assessed by reference to some measures of the use of that knowledge". [30] "The development of new quantitative and qualitative indicators

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[25] K. Smith (1995), Interactions in Knowledge Systems: Foundations, Policy Implications and Empirical Methods, *STI Review*, 16, p. 72.
[26] B.-A. Lundvall and B. Johnson (1994), The Learning Economy, *op. cit*. p. 31.
[27] K. Smith (1995), Interactions in Knowledge Systems: Foundations, Policy Implications and Empirical Methods, *op. cit*. p. 81.
[28] *Ibid*. p. 70.
[29] B.-A. Lundvall (1992), Introduction, *op. cit*. p. 6.
[30] P. David and D. Foray (1995), Assessing and Expanding the Science and Technology Knowledge Base, *op. cit*. p. 81.

(or the creative use of existing ones) is an urgent need in the formation of more effective science and technology policies". [31]

The OECD project on National Innovation System flirted with the idea of knowledge distribution and use, having even temporarily redefined the initial objectives of the project around knowledge access and distribution, whereas the original aims concerned institutional factors explaining the efficiency of National Innovation Systems. [32] The National Innovation System project also flirted with indicators on knowledge distribution, but rapidly concluded, "it has proved difficult to produce general indicators of the knowledge distribution power of a national innovation system". [33]

From the start, the OECD project identified the construction of indicators for measuring National Innovation Systems as a priority, [34] and indeed early on suggested a list of indicators to this end (see Appendix 1). [35] But the decision to build on existing work because of budgetary constraints [36] considerably limited the empirical novelty of the studies. Nevertheless, the project, conducted in two phases between 1994 and 2001, produced several reports that looked at flows and forms of transactions among institutions, among them: networks, clusters, and mobility of personnel (Table 1). [37]

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[31] *Ibid*. p. 82.
[32] Compare OECD (1993), Work on National Innovation Systems: Road Map, *op. cit*. with OECD (1994), National Innovation Systems: Work Plan for Pilot Case Studies, *op. cit.*
[33] OECD (1996), *National Innovation Systems: Proposals for Phase II*, DSTI/STP/TIP(96)11, p. 3.
[34] OECD (1993), *Work on National Innovation Systems: Road Map*, DSTI/STP(93)8.
[35] OECD (1997), *National Innovation Systems*, Paris, p. 45.
[36] OECD (1992), National Systems of Innovation: Definitions, Conceptual Foundations and Initial Steps in a Comparative Analysis, *op. cit*. p. 10.
[37] OECD (1995), *National Systems for Financing Innovation*, Paris; OECD (1997), National Innovation Systems, *op. cit*.; OECD (1999), *Managing National Innovation Systems*, Paris; OECD (1999), *Boosting Innovation: The Cluster Approach*, Paris; OECD (2001), *Innovative Networks: Co-Operation in National Innovation Systems*, Paris; OECD (2001), *Innovative Clusters: Drivers of National Innovation Systems*, Paris; OECD (2001), *Innovative People: Mobility of Skilled*

Table 1.

OECD Publications on National Innovation Systems

1995	*National Systems for Financing Innovation*.
1997	*National Innovation Systems*.
1999	*Managing National Innovation Systems*.
1999	*Boosting Innovation: The Cluster Approach*.
2001	*Innovative Networks: Co-Operation in National Innovation Systems*.
2001	*Innovative Clusters: Drivers of National Innovation Systems*.
2001	*Innovative People: Mobility of Skilled Personnel in National Innovation Systems*.
2002	*Dynamising National Innovation Systems*.
2005	*Governance of Innovation Systems*.

At the same time, the OECD endorsed the concept of the knowledge-based economy. The first step toward the generalized used of the concept of a knowledge-based economy at the OECD came in 1995, with a document written by the Canadian delegation for the ministerial meeting of the Committee on Science and Technology Policy (CSTP). The paper, including the knowledge-based economy concept in its title, discussed two themes: new growth theory and innovation performance. [38] On the first theme, the Secretariat suggested: [39]

> Economics has so far been unable to provide much understanding of the forces that drive long-term growth. At the heart of the old theory (neoclassical) is the production function, which says the output of the economy depends on the amount of production factors employed. It focuses on the traditional factors of labor, capital, materials and energy (…). The new growth theory, as developed by such economists as Romer,

Personnel in National Innovation Systems, Paris; OECD (2002), Dynamising National Innovation Systems, *op. cit*; OECD (2005), *Governance of Innovation Systems*, 3 volumes, Paris.

[38] OECD (1995), *The Implications of the Knowledge-Based Economy for Future Science and Technology Policies*, OCDE/GD(95)136.

[39] *Ibid*. p. 3.

> Grossman, Helpman and Lipsey, adds the knowledge base as another factor of production".

To the OECD, the work of the organization on National Innovation Systems built precisely on the new growth theory, since it looked at the "effective functioning of all the components of a national system of innovation". [40]

On the second theme – innovation – a dynamic National Innovation System was again suggested as the key to effectiveness. But understanding National Innovation Systems required "better measures of innovation performance and output indicators". [41] "Most current indicators of science and technology activities, such as R&D expenditures, patents, publications, citations, and the number of graduates, are not adequate to describe the dynamic system of knowledge development and acquisition. New measurements are needed to capture the state of the distribution of knowledge between key institutions and interactions between the institutions forming the National Innovation System, and the extent of innovation and diffusion". [42] This message was carried over into the 1995 ministerial declaration and recommendations: "there is need for Member countries to collaborate to develop a new generation of indicators which can measure innovative performance and other related output of a knowledge-based economy". [43]

From then on, two conceptual frameworks competed at the OECD for the attention of policy-makers: the National Innovation System and the analysis of its components and their interrelationships, and the Knowledge-Based Economy with its emphasis on the production, distribution and use of knowledge and its measurement. Both frameworks carried, to different degrees, a system approach that emerged in the 1960s.

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[40] *Ibid*. p. 4.
[41] *Ibid*. p. 5.
[42] *Ibid*. p. 6.

The System Approach

The OECD has been very influential on the development of science policy in Member countries. [44] The interest of the organization in these matters goes back to the OEEC, the predecessor to the OECD. [45] In 1958, the Council of Europe asked a Working Party (WP26) to examine the activities of the European Productivity Agency where the main activities for science were conducted. To the Council, there was a "scientific research crisis in Europe":

> Between the highly developed, science-based industries of the United States and the explosive development of Russian technology, Europe sits uneasily. (…) True, Europe has the great advantage of the tradition and maturity of its scientific institutions, and particularly those for fundamental research. (…) But this is not enough. (…) Europe has, as a region, been slow to exploit in production the discoveries of its laboratories. [46] It is no longer possible for each of its constituent countries to undertake the amount of research necessary for its security and prosperity. [47] [But] most of our governments have evolved little in the way of a coherent national science policy, while the concept of scientific research and development as an important and integral feature of company investment is foreign to the thought of most of European industry. [48]

Following the working party report, Dina Wilgress was asked by the Secretary-General to visit member countries to discover their approaches to science and technology. He reported: "It is in Western Europe that most of the great scientific discoveries have taken place (…) but in the race for scientific advance, the countries on the Continent of Europe stood comparatively still for more than two decades while the Soviet Union and North America forged ahead". [49] The sources

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[43] OECD (1996), Conference on New S&T Indicators for a Knowledge-Based Economy: Background Document, DSTI/STP/NESTI/GSS/TIP (96) 2, p. 2,

[44] J.J. Salomon (2000), L'OCDE et les politiques scientifiques, *Revue pour l'histoire du CNRS*, 3, 40-58.

[45] Organization for European Economic Co-operation.

[46] OEEC (1959), *A Programme for European Co-operation in Science and Technology*, C/WP26/W/4, p. 2.

[47] *Ibid*. pp. 2-3.

[48] *Ibid*. p. 3.

[49] OECD (1959), *Co-operation in Scientific and Technical Research*, C (59) 165, p. 14. Officially published in 1960.

of the problem were many: the educational system was “better fitted for turning out people trained in the liberal arts than in science and technology”; there were prejudices against those who work with their hands, and few applications of the results of science; there were also lack of resources for science, too great an emphasis on short-run profits and not enough on investment for the future, small-sized firms not so science-minded, and inadequacy of university facilities and technical training. Briefly stated, the components of the research system were not adapted to the then-new situation, nor well related to each other, nor oriented towards a common goal.

Table 2.

OECD Major Publications

Before the National Innovation System Series

(1960-1992)

1960	*Co-Operation in Scientific and Technical Research* (Wilgress report).
1963	*Science and the Policies of Governments* (Piganiol report).
1963	*Science, Economic Growth and Government Policy* (C. Freeman, R. Poignant, I. Svennilson).
1966	*Fundamental Research and the Policies of Governments*.
1966	*Government and the Allocation of Resources to Science*.
1966	*Government and Technical Innovation*.
1966	*The Social Sciences and the Politics of Governments*.
1968	*Fundamental Research and Universities* (B. David).
1968-70	*Gaps in Technology*.
1971	*The Conditions for Success in Technological Innovation* (K. Pavitt).
1972	*Science, Growth and Society* (Brooks report).
1972-1974	*The Research System* (Salomon report).
1980	*Technical Change and Economic Policy* (Delapalme report).
1981	*Science and Technology Policy for the 1980s*.
1988	*New Technologies in the 1990s: a Socio-economic Strategy* (Sundqvist report).
1991	*Choosing Priorities in Science and Technology*.
1991	*Technology in a Changing World*.
1992	*Technology and the Economy: the Key Relationships*.

It was in this context that the newly created OECD (1961), via a Directorate for Scientific Affairs, turned to the promotion of national science policies. From its creation in 1961 to the emergence of the literature on National Innovation Systems, the OECD produced several policy papers, and most of them carried a system approach (Table 2). This approach consisted in emphasizing the institutional and contextual aspects of research. To the OECD, research was a system composed of four sectors, or components, and embedded in a larger environment:

- Sectors: government, university, industry, non-profit.
- Economic environment.
- International environment.

The view that the research system is composed of four main sectors goes back to the very first analyses on science conducted by J. D. Bernal in the United Kingdom in 1939 [50] and in the United States in the 1940s. [51] Organizations and organized research (laboratories) were seen as the main drivers of growth, and were analytically classified into economic sectors. The same sectors, except for the university sector, were also used in the main classification of the System of National Accounts. The classification was soon conventionalized into statistics on R&D – as discussed below.

According to the OECD, science policy is concerned with the issues and problems of each of these sectors, and the relationships between the sectors. As the Piganiol

[50] J. D. Bernal (1939), *The Social Function of Science*, Cambridge (Mass.): MIT Press, 1973.
[51] V. Bush (1945), *Science: The Endless Frontier*, North Stratford: Ayer Co., 1995, pp. 85-89 President's Scientific Research Board (1947), *Science and Public Policy*, President's Scientific Research Board, Washington: USGPO.

committee (1963), set up by the Secretary-General to define the agenda of the organization in science policy matters, stated: "Science is not an autonomous activity but contributes to national safety, physical health, adequate nutrition, economic growth, improved living standards, and more leisure for the populations of the world". [52] "The scientist (…) has the opportunity to cooperate with the educator, the economist, and the political leader in deciding how science as a social asset can be furthered, and how a nation and the human community can best benefit from its fruits. Science, in a word, has become a public concern". [53]

Over the period 1960-1992, one of the OECD study that most explicitly carried a system approach was *The Research System*, published in three volumes between 1972 and 1974 under the direction of Jean-Jacques Salomon. The study looked at the research system in ten countries, large and small: organization, financing, application of science (or innovation), government research, university-industry relations, international dimensions, foundations. [54] Because research is not an autonomous system, so said the authors, the document "put emphasis on the institutional context in which research is conducted. One of the most delicate problem of science policy is how to influence the process by which scientific discoveries are transformed into useful applications and how to contribute, in some way or another, towards bringing the supply of science into closer harmony with the demand of society. [55] "The whole problem of university research consists in the break-up of its institutional framework (…). [56]

The study framed the central issue of the system approach in terms of a dichotomy between two periods, as the Piganiol report did: [57] the policy for

[52] OECD (1963), *Science and the Policies of Government*, Paris, p. 14.
[53] *Ibid*. p. 15.
[54] Volume 1: France, Germany, United Kingdom; Volume 2: Belgium, Netherlands, Norway, Sweden, Switzerland; Volume 3: Canada, United States.
[55] OECD (1972), *The Research System*, Volume 1, Paris, p. 16.
[56] *Ibid*. pp. 17-18.
[57] OECD (1963), *Science and the Policies of Government*, Paris, p. 18, See also the OECD Brooks report OECD (1972), *Science, Growth and Society*, Paris: OECD, p. 37. A. Elzinga and A. Jamison (1995), Changing Policy Agenda in Science and Technology, in S. Jasanoff et al. (eds.), *Handbook of Science and Technology Studies*, Thousand Oaks (Calif.): Sage, pp. 572-597.

science period as the expansion of research *per se,* versus the science for policy period where “developing national research potential [is] generally regarded as synonymous with national innovation potential”. [58] To the Salomon report:

> The needs of fundamental research depend primarily on the talent available and the fields opened up by the unsolved (or unformulated) problems of science itself. The needs of applied research and development, on the other hand, depend primarily on the problems which the industrial system sets itself. There is no hermetic seal between the first type of problem and the second, the terms of each being renewed or changed by the progress made by the other on the basis of a certain degree of osmosis between the university and industry and that is precisely why it is better to speak of a “research system” rather than a juxtaposition or hierarchy of different forms of research. [59]

To the report, again, “fundamental research will be required to respond more closely to the imperatives of selectivity dictated by the social, political and industrial context”. [60] “The new links which are now taking shape between science and society will no doubt be reflected in the long term in new patterns of organization”. [61]

As a major conclusion from the study, *The Research System* suggested: “Scientific and technological research, viewed from an institutional approach, cannot be separated from its political, economic, social and cultural context”. [62] “There is no single model, and each country must seek its own solutions”. [63]

Another influential report with regard to systemic conclusions at the OECD was *Gaps in Technology,* published in 1968-1970. In the 1960s, there were concerns in Europe that the continent was lagging the United States in term of

[58] OECD (1974), *The Research System*, Volume 3, Paris, p. 168.
[59] OECD (1972), The Research System, Volume 1, *op. cit*. p. 20.
[60] *Ibid*. p. 21.
[61] *Ibid*. p.22.
[62] OECD (1974), The Research System, Volume 3, *op. cit*. p. 197.
[63] *Ibid*. p. 199.

technological potential. [64] As the analysis of the first international survey on R&D concluded: "There is a great difference between the amount of resources devoted to R&D in the United States and in other individual member countries. None of the latter spend more than one-tenth of the United States' expenditure on R&D (…) nor does any one of them employ more than one-third of the equivalent United States number of qualified scientists and technicians". [65]

The OECD conducted a two-year study, collecting many statistics on the scientific and technological activities of both European countries and the United States. In the end, none of the statistics appeared conclusive in explaining economic performance. The OECD suggested that the causes of the gaps were not R&D *per se*: "scientific and technological capacity is clearly a prerequisite but it is not a sufficient basis for success". [66] The organization rather identified other factors in the "innovation system" as causes: capital availability, management, competence, attitudes, entrepreneurship, marketing skills, labour relations, education, and culture.

The conclusions of the OECD study were reinforced by a second study contracted to Joseph Ben-David. [67] Using several indicators, Ben-David documented a gap in the development of (applied and) fundamental research between Europe and the United States, and suggested that the origins of the gap went back to the beginning of the twentieth century: to the failure in Europe to develop adequate research organizations and effective entrepreneurship in the exploitation of science for practical purposes. Briefly stated, European universities were not oriented enough toward economic and social needs: academics still considered

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[64] B. Godin (2002), Technological Gaps: An Important Episode in the Construction of S&T Statistics, *op. cit.*

[65] OECD (1967), *The Overall Level and Structure of R&D Efforts in OECD Member Countries*, Paris, p. 19.

[66] OECD (1968), *Gaps in Technology: General Report*, Paris; OECD (1970), *Gaps in Technology: Comparisons Between Countries in Education, R&D, Technological Innovation, International Economic Exchanges*, Paris, p. 23.

[67] OECD (1968), *Fundamental Research and the Universities: Some Comments on International Differences*, Paris.

science essentially as a cultural good. To change the situation would, according to Ben-David, require long-term policies involving structural changes.

Now, what were those relationships essential to a performing research system? According to the OECD, there were five types of relationships. The first is between economic sectors, above all: government, university, industry. Here, a recurrent focus or target of policy proposals was the industrial sector as source of innovation and economic growth. The early OECD literature, through its early international surveys on R&D, was concerned with putting industrial research activities at the center of policies and arguing for devoting more government funding extramurally, namely to firms, and orienting fundamental research. Then, the organization put the emphasis on university-industry relationships for cross-fertilization of research. This was the 1980s. [68] Finally, and this is reflected in the current discourses, the organization urged universities to enter the marketplace and commercialize their inventions. From this emphasis on the industrial sector and the contribution of other sectors to innovation and economic growth, one can see how the research system at OECD was really an innovation system.

The second type of relationship in the "innovation system" was between basic and applied research, and here many OECD documents rejected the idea of innovation as a linear process starting with basic research and ending with commercialization. [69] As the background document to the first ministerial conference on science (1963) stated: there is no natural boundary between basic and applied research. "The real problem is that of linking these two types of research activity". [70] Similarly, to *The Research System*, it is "progressively more difficult to trace the line of demarcation between what is deemed to be fundamental and what is oriented or applied". [71] Science and technology are

[68] OECD (1984), *Industry and University: New Forms of Co-Operation and Communication*, Paris.
[69] B. Godin (2006), The Linear Model of Innovation: The Historical Construction of an Analytical Framework, *Science, Technology, and Human Values*, 31 (6), pp. 639-667.
[70] OCDE (1963), *Science, Economic Growth, and Government Policy*, Paris, p. 63.
[71] OECD (1972), The Research System, Volume 1, *op. cit*. p. 11.

intimately linked together. This was, in fact, the main reason the report gave for adopting a system approach: [72] "the special characteristic of modern scientific research is that it is developing in institutions which are no longer confined to the university environment". [73] "Scientific research is a continuous process (...) whose different element are so many links in a continuous and retro-active feed *system*". [74]

The third type of relationship in the "innovation system" regards policy itself. According to the OECD, policy was too fragmented and uncoordinated. As the Piganiol report stated in 1963: "There is a great need for studies of the several fields and ways in which science and policy interact, and there is a need above all for a continuing and intimate working relationship between officials responsible for science policy and other policy makers". [75] To the OECD, "national policies in other fields must take account of the achievements and expectations of science and technology": economic policy, social policy, military policy, foreign policy, aid policy. [76] To this end, the Piganiol report recommended the creation in each country of a national science Office whose tasks would be formulating a national policy, co-coordinating the various scientific activities, and integrating science policy with general policy. [77]

"A more comprehensive approach", namely "science policy as an integral factor in overall public policy", [78] was also the message of the Brooks report (1972), centered around social issues in science. To the OECD committee of experts, "purely economic solutions are insufficient". [79] "Science policy must be much more broadly conceived than in the past (…)": [80]

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[72] Such was the rationale already offered by Jean-Jacques Salomon (1970) in *Science et politique*, Paris: Seuil.
[73] OECD (1972), The Research System, Volume 1, *op. cit*., p. 12.
[74] *Ibid*. pp. 12-13.
[75] OECD (1963), Science and the Policies of Government, *op. cit*. p. 26-27.
[76] *Ibid*. p. 26.
[77] *Ibid*. p. 34.
[78] OECD (1972), *Science, Growth and Society*, Paris, p. 12.
[79] *Ibid*. p. 30.
[80] *Ibid*. p. 36.

> First, the different elements of science policies were usually treated independently of each other; second, science policies themselves were often treated in relative isolation from other policy decisions. [81] [Now], science and technology are an integral part of social and economic development, and we believe that this implies a much closer relationship between policies for science and technology and all socio-economic concerns and governmental responsibilities than has existed in the past . [82]

Again in 1980, in *Technical Change and Economic Policy*, concerned with the economic situation at the time in OECD countries, the Delapalme committee recommended a "better integration of the scientific and technical aspects of public policy, and the social and economic aspects", [83] and "much closer links regarding such government functions as providing for national defence, agricultural productivity, health, energy supply, and protecting the environment and human safety". [84] To the committee, "the organizations that propose and carry out science and technology policies tend to stand separate from offices at a comparable level concerned with the more legal and economic aspects of policy". [85]

The fourth type of relationship in the “innovation system” stressed by the OECD concerns the economic environment. From its very beginning, science policy at the OECD was definitely oriented toward innovation and economic progress. [86] This was the message of the Piganiol report [87] and the background document to the first ministerial meeting on science. To the latter, “the relationship between a national policy for economic development and a national policy for scientific research and development is one of the essential subjects for study (…)”. [88] What

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[81] *Ibid*. p. 47.
[82] *Ibid*. p. 96.
[83] OECD (1980), *Technical Change and Economic Policy*, Paris, p. 96.
[84] *Ibidem*.
[85] *Ibidem.*
[86] B. Godin (2005), *Measurement and Statistics on Science and Technology: 1920 to the Present*, London: Routledge.
[87] “A growing opportunity for science and technology lies in the field of economic development” (p. 16).
[88] OECD (1963), Science, Economic Growth and Government Policy, *op. cit*., p. 52.

was needed was a dialogue between those responsible for economic policy and those responsible for science policy. [89]

From 1980 on, the economic environment therefore became the central concern to the OECD. Because "science and technology policies have usually been defined and implemented independently of economic policies", [90] *Technical Change and Economic Policy* recommended that science and technology policies be better integrated to economic and social policies :

> If there is little justification for assuming limits to science and technology, there are limitations imposed by political, economic, social and moral factors which may retard, inhibit or paralyze both scientific discovery and technical innovation. [91] The most intractable problems lie not in the potential of science and technology as such, but rather in the capacity of our economic systems to make satisfactory use of this potential. [92]

The last type of relationship in the “innovation system” was international cooperation. This was the object of the very first policy document produced by the OECD (or OEEC at the time). International cooperation was, in fact, the *raison d’être* of the organization: “While scientists have co-operated on a regular basis without regard to national boundaries, there are few co-operations between governments in science and technology”. [93] “Each European country has an interest in assuring that Western Europe as a whole does not fall behind in the race for scientific advance between North America on the one hand and Russia and China on the other”. [94] “The OEEC is the only international organization that is in the position to develop co-operation between the countries of Europe (...)”. [95]

[89] *Ibid*. pp. 69-73.
[90] OECD (1980), Technical Change and Economic Policy, *op. cit.*, p. 12.
[91] *Ibid*, p. 93.
[92] *Ibidem*.
[93] OECD (1960), *Co-Operation in Scientific and Technical Research*, Paris, p. 12.
[94] *Ibid*.
[95] *Ibid*. p. 38.

In summary, the OECD documents produced since the early 1960s, three of them which have been studied more deeply here, were all concerned with developing a system approach to science policy. The research system was composed of several institutional sectors in relationship to each other and all oriented toward technological innovation. The industrial sector was embedded in an economic environment. The government sector was composed of different departments whose policies were related, but badly coordinated. The university sector had to orient its research potential more toward applied or oriented research and develop relationships with industry. On top was the OECD as a forum where countries collaborated to create a new object: science policy.

Measuring the Research System

Unlike the framework on National Innovation System, the system approach has the advantage of benefiting from statistics from its very beginning. As early as 1962, the OECD published the Frascati manual, which offered national statisticians methodological rules for surveys on R&D expenditures and manpower. [96] One of the main concepts of the manual was GERD (Gross Expenditures on R&D), defined as the sum of the expenditures from the four main economic sectors of the economy: government, university, industry, non-profit. [97] Each sector was measured, and the results aggregated to construct a national budget for research. But the statistics also served to analyze how each sector performed in terms of R&D activities and to measure the relationships as flows of funds between the sectors of the system. To this end, a matrix was suggested crossing sectors as sources of funds and sectors as performers of research activities, and identifying the transfers of funds between them.

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[96] B. Godin (2007), The Making of Statistical Standards: OECD and the Frascati Manual, 1962-2002, *Accounting, Organization, and Society*, forthcoming.

[97] OECD (1962), *Proposed Standard Practice for Surveys of Research and Development*, Paris, pp. 34-35.

The matrix is not directly the result of a system approach, [98] but it fitted the approach perfectly well, and helped make a "social fact" of it, as statistics did for the linear model of innovation (Godin, 2006). The idea comes from the US Department of Defense and its very first measurement of research funds in the United States in 1953. [99] The Office of the Secretary of Defense (R&D) estimated that $3.75 billion, or over 1% of the Gross National Product, was spent on research funds in the United States in 1952. The report presented data regarding both sources of expenditures and performers of research activities: "The purpose of this report is to present an over-all statistical picture of present and past trends in research, and to indicate the *relationships* between those who spend the money and those who do the work". The statistics showed that the federal government was responsible for 60% of total funding, [100] industry 38% and non-profit institutions (including universities) 2%. With regard to the performers, industry conducted the majority of R&D (68%) – and half of this work was done for the federal government – followed by the federal government itself (21%) and non-profit and universities (11%).

The Office's concepts of sources (of funds) and performers (of research activities) became the main categories of the National Science Foundation's accounting system for R&D. According to its mandate, the National Science Foundation started measuring R&D across all sectors of the economy with specific and separate surveys (or methods) in 1953: government, industry, university and others. [101] Then, in 1956, it published its "first systematic effort to obtain a systematic across-the-board picture" [102] – at about the same time as Great Britain

[98] Although economic input-output tables (or matrices), as originally developed by W. Leontief, and part of the System of National Accounts, are of a systemic nature and may have influenced the statistics on R&D.
[99] Department of Defense (1953), *The Growth of Scientific R&D*, Office of the Secretary of Defense (R&D), RDB 114/34, Washington.
[100] The Department of Defense and the Atomic Energy Commission were themselves responsible for 90% of the federal share.
[101] B. Godin (2002), The Number Makers: Fifty Years of Science and Technology Official Statistics, *Minerva*, 40 (4), pp. 375-297.
[102] National Science Foundation (1956), Expenditures for R&D in the United States: 1953, *Reviews of Data on R&D*, 1, NSF 56-28, Washington.

did. [103] It consisted of the sum of the results of the sectoral surveys for estimating national funds. The National Science Foundation calculated that the national budget amounted to $5.4 billion in 1953. [104]

In that same publication, the Foundation constructed a matrix of financial flows between the sectors, as both sources and performers of R&D (Table 3). Of sixteen possible financial relationships (four sectors as original sources, and also as ultimate users), ten emerged as significant (major transactions). The matrix showed that the federal government sector was primarily a source of funds for research performed by all four sectors, while the industry sector combined the two functions, with a larger volume as performer. Such national transfer tables were thereafter published regularly in the bulletin series *Reviews of Data on R&D*, [105] until a specific and more extensive publication appeared in 1967. [106]

The matrix was the result of deliberations conducted in the mid fifties at the National Science Foundation on the US research system [107] and demands to relate science and technology to the economy: "An accounting of R&D flow throughout the economy is of great interest at present (…) because of the increasing degree to which we recognize the relationship between R&D, technological innovation, economic growth and the economic sectors (…)", suggested H. E. Stirner from the Operations Research Office at Johns Hopkins University. [108] But "today, data on R&D funds and personnel are perhaps at the stage of growth in which national

[103] Advisory Council on Scientific Policy (1957), *Annual Report 1956-57*, Cmnd 278, HMSO: London.

[104] The data were preliminary and were revised in 1959. See: National Science Foundation (1959), Funds for R&D in the United States, 1953-59, *Reviews of Data on R&D*, 16, NSF 59-65.

[105] *Reviews of R&D Data*, Nos 16 (1959), 33 (1962), 41 (1963); *Reviews of Data on Science Resources*, no. 4 (1965).

[106] National Science Foundation (1967), *National Patterns of R&D Resources*, NSF 67-7, Washington.

[107] "Our country's dynamic research effort rests on the interrelationships – financial and non-financial – among organizations". K. Arnow (1959), National Accounts on R&D: The National Science Foundation Experience, in National Science Foundation, *Methodological Aspects of Statistics on Research and Development: Costs and Manpower*, NSF 59-36, Washington, p. 57.

[108] H. E. Stirner (1959), A National Accounting System for Measuring the Intersectoral Flows of R&D Funds in the United States, in National Science Foundation, *Methodological Aspects of Statistics on R&D: Costs and Manpower*, Washington: National Science Foundation, p. 37.

income data could be found in the 1920s". [109] Links with the System of National Accounts, a recently developed system then in vogue among economists and governments departments, [110] were therefore imagined: "The idea of national as well as business accounts is a fully accepted one. National income and product, money flows, and inter-industry accounts are well-known examples of accounting systems which enable us to perform analysis on many different types of problems. With the development and acceptance of the accounting system, data-gathering has progressed at a rapid pace". [111]

The National Science Foundation definitions – as well as the matrix – became international standards with the adoption of the OECD Frascati manual by member countries in 1963. The manual, written by C. Freeman after visiting countries where measurement was conducted, suggested collecting data on sectors for both intra-mural [112] and extra-mural activities, [113] and breaking down R&D data according to funder and performer. A matrix similar to that of the National Science Foundation was suggested as a useful way to determine the flows of funds between sectors. [114] From then on, the OECD produced regular studies analyzing the sectors and their performances. [115]

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[109] K. Arnow (1959), National Accounts on R&D: The NSF Experience, *op. cit*. p. 61.
[110] S. S. Kuznets (1941), *National Income and its Composition, 1919-1938*, New York: National Bureau of Economic Research. The System of National Accounts, now in its fourth edition, was developed in the early 1950s and conventionalized at the world level by the United Nations: United Nations (1953), *A System of National Accounts and Supporting Tables*, Department of Economic Affairs, Statistical Office, New York; OECD (1958), *Standardized System of National Accounts*, Paris.
[111] H. E. Stirner (1959), A National Accounting System for Measuring the Intersectoral Flows of R&D Funds in the United States, *op. cit*. p. 32.
[112] Intra-mural expenditures include all funds used for the performance of R&D *within* a particular organization or sector of the economy, whatever the sources of finance.
[113] Extra-mural expenditures include all funds spent for the performance of R&D *outside* a particular organization or sector of the economy, including abroad.
[114] OECD (1962), Proposed Standard Practice for Surveys of Research and Development, *op. cit*. pp. 35-36.
[115] OECD (1967), The Overall Level and Structure of R&D Efforts in OECD Member Countries, *op. cit*.; OECD (1971), *R&D in OECD Member Countries: Trends and Objectives*, Paris; OECD (1975), *Patterns of Resources Devoted to R&D in the OECD Area, 1963-1971*, Paris; OECD (1975), *Changing Priorities for Government R&D: An Experimental Study of Trends in the Objectives of Government R&D Funding in 12 OECD Member Countries, 1961-1972*, Paris; OECD (1979), *Trends in Industrial R&D in Selected OECD Countries, 1967-1975*, Paris; OECD (1979), *Trends in R&D in the Higher Education Sector in OECD Member Countries Since 1965 and Their Impact on National Basic Research Efforts*, SPT (79) 20 (unpublished).

Table 3.
Transfers of Funds Among the Four Sectors as Sources of R&D Funds and as R&D Performers, 1953
(in millions)

Sector		R&D PERFORMERS: Federal Government	Industry	Colleges and universities	Other institutions	Total
SOURCES of R&D FUNDS	Federal Government agencies	$970	$1,520	$280	$50	$2,810
	Industry		2,350	20		2,370
	Colleges and universities			130		130
	Other institutions			30	20	50
	Total	$970	$3,870	$460	$70	$5,370

In sum, the statistics on R&D served as the first tool to measure the "innovation system", the interrelationships between its components, and its links to the economy. Later, these statistics appeared limited for measuring the diversity and complexity of National Innovation Systems, and new ones were developed, among them the innovation survey. But few of the new statistics had the "strength" of the R&D statistics for "objectifying" the framework. [116] At the same time, the framework on National Innovation Systems itself became challenged by other frameworks.

Conclusion

Recently, B.-A. Lundvall resurrected an earlier paper from Chris Freeman as the first written contribution to the concept of National Innovation Systems. The

[116] By strength I mean 1) a consensus among countries, and 2) a historical series of data.

paper was produced for the OECD in 1982, but never published. [117] We have seen above that a system approach originated thirty years before the literature on National Innovation Systems. This was the approach of the experts composing the OECD committees.

Certainly Freeman contributed to the early approach. First, he had been advocating system analysis since the early 1960s: “There is no reason why these methodologies [operational research, system analysis and technological forecasting], developed for military purposes but already used with success in such fields as communication and energy, could not be adapted to the needs of civilian industrial technology”. [118] Second, he wrote the first edition of the Frascati manual, (co-) produced the background document to the first OECD ministerial conference on science, and acted as expert on many OECD committees whose reports appear in Table 2. In return, Freeman’s National Innovation System framework drew inspiration from, among others, three decades of OECD work and contributions of experts.

Where Freeman was quite influential was relative to a second systemic tradition in science and technology studies: technological systems. In the 1970s and 1980s, a whole literature concerned itself with (inter-industry) technology flows, [119] technological regimes and natural trajectories, [120] technological guideposts, [121]

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[117] C. Freeman (1982), *Technological Infrastructure and International Competitiveness*. Published with a forword from Lundvall in *Industrial and Corporate Change*, 13, 3, 2004, pp. 541-569. The history of the concept, according to Lundvall, goes from List (1841), then jumps to Freeman.

[118] OECD (1963), Science, Economic Growth and Government Policy, C. Freeman, R. Poignant and I. Svennilson, *op. cit*. p. 73; see also C. Freeman (1971), Technology Assessment and its Social Context, *Studium Generale*, 24, pp. 1038-1050.

[119] C. de Bresson and J. Townsend (1978), Notes on the Inter-Industry Flow of Technology in Post-War Britain, *Research Policy*, 7, pp. 48-60; N. Rosenberg (1979), Technological Interdependence in the American Economy, *Technology and Culture*, January, pp. 25-50; F. M. Scherer (1982), Inter-Industry Technology Flows in the United States, *Research Policy*, 11, pp. 227-245; K. Pavitt (1984), Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory, *Research Policy*, 13, pp. 343-373; M. Robson, J. Townsend and K. Pavitt (1988), Sectoral Patterns of Production and Use of Innovations in the UK, 1945-1983, *Research Policy*, 17, pp. 1-14;

[120] R. S. Nelson and S. D. Winter (1977), In Search of a Useful Theory of Innovation, *op. cit*.

technological paradigms, [122] and techno-economic networks. [123] This literature looked at technologies from a system of interrelated components perspective. [124] Freeman added his voice to the literature with two concepts. First, he talked of "technology systems" as families of innovations clustering in a system with wide effects on industries and services. [125] Then, he coined the term "techno-economic paradigm" as a cluster of technological systems with pervasive effects that change the mode of production and management of an economy. [126]

With these terms, Freeman developed a much-cited typology of innovation composed of four categories: incremental innovation, radical innovation, new technological system, techno-economic paradigm. [127] To Freeman, only the latter was equivalent to a revolution. And among the many generic technologies actually in existence, only electronics was of this type. This was precisely the rationale that the OECD needed to "sell" its new discourse on the information

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[121] D. Sahal (1981), *Patterns of Technological Innovation*, Reading, Mass.: Addison-Wesley Publishing Company; D. Sahal (1985), Technological Guideposts and Innovation Avenues, *Research Policy*, 14, pp. 61-82.

[122] G. Dosi (1982), Technological Paradigms and Technological Trajectories, *Research Policy*, 11 (1982), pp. 142-167.

[123] M. Callon et al. (1992), The Management and Evaluation of Technological Programs and the Dynamics of Techno-Economic Networks: the Case of the AFME, *Research Policy*, 21, pp. 215-236; G. Bell and M. Callon (1994), Techno-Economic Networks and Science and Technology Policy, *STI Review*, 14, pp. 67-126.

[124] The literature borrowed from economist J. Schumpeter's study of long waves, W. Leontief and input-output analyses, and historians. In fact, system was one of the most commonly discussed concepts among historians of technology who adopted a contextual approach. See, for example: T. P. Hughes (1983), *Networks of Power: Electrification in Western Society, 1880-1930*, Baltimore: Johns Hopkins University Press. For an early analysis of technological paradigms by a historian, see: E. W. Constant (1973), A Model for Technological Change Applied to the Turbojet Revolution, *Technology and Culture*, 14 (4), pp. 553-572.

[125] C. Freeman, J. Clark, and L. Soete (1982), New Technology Systems: an Alternative Approach to the Clustering of Innovations and the Growth of Industries, in *Unemployment and Technical Innovation*, Connecticut: Greenwood Press, pp. 64-81.

[126] C. Freeman (1987), Information Technology and Change in Techno-Economic Paradigm, in C. Freeman and L. Soete, *Technical Change and Full Employment*, Oxford: Basil Blackwell, pp. 49-69; C. Freeman and C. Perez (1988), Structural Crises of Adjustment, Business Cycles and Investment Behaviour, in G. Dosi et al., *Technical Change and Economic Theory*, London: Frances Pinter, pp. 38-66. See also: F. Kodama (1990), Can Changes in the Techno-Economic Paradigm Be Identified Through Empirical and Quantitative Study, *STI Review*, 7, pp. 101-129; F. Kodama (1991), Changing Global Perspectives: Japan, the USA and the New Industrial Order, *Science and Public Policy*, 19 (6), pp. 385-392.

economy to policy-makers and the public. [128] Freeman's analyses on electronics as revolution contributed to the then popular discourses on the information economy, or information society, at the OECD.

What, then, did the framework on National Innovation System add to the early system approach? Certainly, the issues studied and the types of relationships are more diverse and complex than those portrayed in the early approach: globalization of research activities, networks of collaborators, clusters, and the role of users are only some of the new terms added to the system approach in the 1990s. More fundamentally, however, the differences between the two periods are twofold. First, in its early years, the systemic view dealt above all with policy issues: the government was believed at that time to have a prime responsibility in the performance of the system. The role of government was its capacity to make the system work. But the policies had to be adapted and coordinated. That was the main message of OECD reports. With the National Innovation System, it would be rather the role of government as facilitator that would be emphasized. The message is directed towards the actors, or sectors, and focus on the need for greater "collaboration". Second, whereas the early system approach was centered on the research system and its links to other components or sub-systems, the National Innovation System framework is wholly centered on the firm as its main component, around which other sectors gravitate. The two approaches, however, put emphasis on technological innovation and its economic dimension, and urge all sectors to contribute to this goal – under their respective roles.

What the framework on National Innovation System certainly brought to a system approach that had existed for thirty years was a name or label. [129] Such labels are

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[127] On OECD use of the typology, see, among others: C. Freeman (1987), The Challenge of New Technologies, in OECD, *Interdependence and Co-operation in Tomorrow's World*, Paris, pp. 123-156; OECD (1988), *New Technologies in the 1990s: A Socio-Economic Strategy*, Chapter 1, Paris.

[128] B. Godin (2008), *The Information Economy: the History of a Concept through its Measurement, or How to Make Politically Relevant Indicators, 1949-2005*, History and Technology, Forthcoming.

[129] This is what happened in the 1960s, when people started talking about the linear model of innovation to name a theory on technological change that emerged in the 1940s. This phenomenon

important for academics as well as governments to highlight issues and bringing them to the intellectual or political agenda. Mode 1/Mode 2 and the Triple Helix are examples of academic labels used for increasing an issue's visibility – as well as a researcher's own visibility. [130] High-Technology, Knowledge-Based Economy, Information Economy or Society, and New Economy are examples of labels used by governments and the OECD to promote the case of science, technology and innovation and their consideration in the policy agenda of governments. [131] The National Innovation System is one such recent label invented as a conceptual framework that serves many purposes.

There is an irony in this story. The system approach suggested better theorizing of institutions, rules and culture and their integration into technological analyses. Innovation is not an autonomous activity but is embedded within the larger society. However, the approach had those institutions, rules and culture not only contributing to innovation, but (almost) totally defined (or analyzed) in terms of, and devoted to, innovation as commercialization of technological invention. This is one more consequence of the economic approach that has driven science, technology and innovation studies for nearly sixty years. [132]

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of labelling explains the difference in point of view between B. Godin and D. Edgerton on the history of the linear model of innovation. See D. Edgerton (2004), The Linear Model did not Exist, in K. Grandin, N. Worms, and S. Widmalm (eds.), *The Science-Industry Nexus: History, Policy, Implications*, Sagamore Beach: Science History Publications, pp. 31-57; B. Godin (2006), The Linear Model of Innovation: The Historical Construction of an Analytical Framework, *op. cit*.

[130] For critical analyses, see: B. Godin (1998), Writing Performative History: The New "New Atlantis", *Social Studies of Science*, 28 (3), pp. 465-483; T. Shinn (2002), The Triple Helix and New Production of Knowledge: Prepackaged Thinking in Science and Technology, *Social Studies of Science*, 32 (4), pp. 599-614. B.A. Lundvall recently imitated the strategy of the authors on the Triple Helix to re-launch the concept of National Innovation System in a special issue of *Research Policy*. See: B.-A. Lundvall, B. Johnson, E. S. Andersen and B. Dalum (2003), National Systems of Production, Innovation and Competence Building, *Research Policy*, 31, pp. 213-231.

[131] For critical analyses, see: B. Godin (2004), The Obsession for Competitiveness and its Impact on Statistics: The Construction of High-Technology Indicators, *Research Policy*, 33 (8), pp. 1217-1229; B. Godin (2004), The New Economy: What the Concept Owes to the OECD, *Research Policy*, 33, pp. 679-690; B. Godin (2006), The Knowledge-Based Economy: Conceptual Framework of Buzzword?, *op. cit*; B. Godin (2007), The Information Economy: the History of a Concept through its Measurement, or How to Make Politically Relevant Indicators, 1949-2005, *op. cit*.

[132] See: B. Godin (2006), *Statistics and STI Policy: How to Get Relevant Indicators*, Communication presented at the OECD Blue Sky II Conference "What Indicators for Science, Technology and Innovation Policies in the 21st Century?", Ottawa, Canada, 25-27 September

2006 [http://www.oecd.org/document/60/0,2340,en_2649_34409_37083516_1_1_1_1,00.html#Wednesday] (page consulted on October 25, 2006).

Appendix 1.

Indicators of Knowledge Flows in National Innovation Systems

(National Innovation Systems, OECD, 1997)

Type of knowledge flow	Main [source of] indicator
Industry alliances	
Inter-firm research cooperation	Firm surveys
	Literature-based counting
Industry/university interactions	
Cooperative industry/university R&D	university annual reports
Industry/University co-patents	patent record analysis
Industry/University co-publications	publications analysis
Industry use of university patents	citation analysis
Industry/University information-sharing	firm surveys
Industry/University institute interactions	
Cooperative industry/institute R&D	government reports
Industry/institute co-patents	patent record analysis
Industry/institute co-publications	publications analysis
Industry use of research institute patents	citation analysis
Industry/institute information-sharing	firm surveys
Technology diffusion	
Technology use by industry	firm surveys
Embodied technology diffusion	input-output analysis
Personnel mobility	
Movement of technical personnel among	labour market statistics
industry, university and research	university/institute reports