Measuring Science:
Is There "Basic Research" Without Statistics?

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Measuring Science: Is There "Basic Research" Without Statistics?

Fundamental research is a central category of science policy and science measurement. Of all the concepts defined in the first edition of the Frascati manual, the OECD (Organization for Economic and Co-operation Development) methodological guide for official surveys on R&D, the first dealt with fundamental research. While a definition of research itself did not appear until the second edition in 1970, fundamental research was defined explicitly as follows:

> Work undertaken primarily for the advancement of scientific knowledge, without a specific practical application in view. [1]

In the last edition of the manual (1994), the definition is substantially the same as the one in 1963, although the term "basic" is now used instead of fundamental:

> Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. [2]

Between 1963 and 1994, therefore, all five editions of the manual carry essentially the same definition without any significant changes: basic research is research concerned with knowledge as contrasted with applied research, which is concerned with the application of knowledge. Over the same period, however, the definition has frequently been discussed, criticized, modified and, in some cases, even abandoned. How did the concept originate and why does it persist in discourses, policy documents and statistics despite almost unanimous dissatisfaction with it?

Certainly, the concept of basic research exists because a community defines itself according to it, because important sums of money are also devoted to it, and because it is a dimension of action (science policy). But the concept is, above all, a category. And, as often with a

[1] OECD (1963), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development*, Paris, p.12.
[2] OECD (1994), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris, p. 31.

category, it gets social and political existence through numbers. [3] It will be argued, in this paper, that the concept of basic research acquired political stability (partly) because of statistics. It helped academics and bureaucrats to convince politicians to fund basic research. However, as soon as the interests of politicians towards academic research changed, the concept of basic research came to be questioned. Statistics could not continue to "hold things together" to paraphrase A. Desrosières. [4]

Although the concept, whatever its name, existed for centuries in the discourses of philosophers and scientists, basic research was first defined explicitly in a taxonomy in 1934 by J. S. Huxley and later appropriated by V. Bush. The Bush report *Science: The Endless Frontier* [5] envisioned the National Science Foundation (NSF) as the main vehicle for funding basic research. But it was J.R. Steelman, I will argue, that was decisive in crystallizing the concept for political purposes. In 1947, H. Truman named the economist J. R. Steelman, then president of the Office of War and Mobilization Research, as Science Advisor, asking him to report on what should be done for science in the country. Ten months later, Steelman produced *Science and Public Policy*, [6] which became the basis of science and technology policy in the United States. This document, I will argue, served to institutionalize the current concept of basic research because the latter was <u>measured</u>, rather than being defined rhetorically as Bush did. Steelman performed the first surveys of science and technology resources that used precise definitions. Beginning in 1953, the survey became the instrument for regular NSF studies of resources devoted to research. Building on this model, the OECD followed suit in the early 1960's in order to feed its reflections on science policy.

This paper outlines the history of the concept of basic research as it relates to measurement, particularly from the 1930s onwards. [7] The research is part of a project on the history of

[3] Alonso, W., and P. Starr (1987), *The Politics of Numbers*, New York: Russell Sage; Desrosières, A. (1993), *La politique des grands nombres*, Paris: La Découverte ; A. Desrosières (1990), How to Make Things Which Hold Together: Social Science, Statistics and the State, in P. Wagner, B. Wittrock and R. Whitley (eds.), *Discourses on Society*, Kluwer Academic Publishing: 195-218.
[4] A. Desrosières (1990), *op. cit*.
[5] Bush, V. (1945), *Science: The Endless Frontier*, North Stratford: Ayer Co., 1995.
[6] Steelman, J.R. (1947), *Science and Public Policy*, New York: Arno Press, 1980.
[7] To the best of my knowledge, the literature contains only one article dealing with the history of the concept: Kline, R. (1995), Construing Technology as Applied Science: Public Rhetoric of Scientists and Engineers in the United States, 1880-1945, *ISIS*, 86: 194-221. Layton also touches on the topic from a technological point of view: Layton, E.T. (1976), American Ideologies of Science and Engineering, *Technology and Culture*, 17 (4): 688-700; Layton, E.T. (1974), Technology as Knowledge, *Technology and Culture*, 15 (1): 31-41.

science and technology statistics. It uses two methodologies. First, the main source of information comes from archival material. The main institutions involved in official science measurement in recent history - OECD, Unesco, the European Union – have all accepted to open their files to me from 1950 to 2000. This constitutes the core of the documents studied. To this, national sources were added when needed. For example, the NSF (and the National Science Board - NSB), as well as Canadian and British official publications were systematically studied over the same period. [8] Second, interviews were conducted with the main actors of the field. To date, nearly twenty persons have been interviewed from United States, United Kingdom, France, Canada, as well as the above three intergovernmental institutions. [9]

The first part of the paper presents and discusses the different labels and definitions of basic research that were used before the Bush report. This is a period of searching and fuzziness that Bush put an end to. The second part shows how the concept crystallized into a specific label and definition as a result of the NSF surveys and of the OECD Frascati Manual. The last part reviews the alternatives. It shows that even the promoters were dissatisfied with the concept but that extenuating factors prevented them – or so they believed – from changing it.

Emergence

The Ancients developed a hierarchy of the world in which *theoria* was valued over practice. This hierarchy rested on a network of dichotomies that were deeply rooted in

[8] I want to thank Mary-Ann Grosset from the OECD Documentation Center in Paris and Mary Carr from the Institute of European Studies in Florence. Also, the Canadian delegation at OECD, the personnel of the Institute of Statistics of Unesco, among them Denyse Levesley and Shiu-Kee Chu, as well as Rolf Lehming (Science Resources Studies Division) and Stephanie Bianci (Center of Documentation) from the NSF, and the personnel of the National Science Board (D.E. Chubin and S.E. Fannoney) deserves many thanks for their collaboration in helping for access to documents.

[9] I want to thank sincerely the following persons for having accepted to spend some time with me and for commenting on previous drafts of the present paper: A. King, C. Freeman, A. Young, G. Westrom, J.-J. Salomon, C.Falk, K. Arnow, P. Hemily, D. Gass, J. Bond, G. McColm, H. Stead, Al Seymour, H. Brooks, K. Smith, G. Muzart, M. Beckler, J. Dryden, A. Wycoff, K. Pavitt, G. Sirilli.

social practice and intellectual thought. [10] A similar hierarchy exists in the discourse of scientists: the superiority of pure over applied research. [11]

The concept of pure research originated in 1648, according to B. Cohen. [12] It was a term used by philosophers to distinguish between science or natural philosophy, that was motivated by the study of abstract notions, and the mixed "disciplines" or subjects, like mixed mathematics, that were concerned with concrete notions. [13] It came into regular use at the end of the 19th Century and was usually accompanied with the contrasting concept of applied research. In the 1930s, the term "fundamental" occasionally began appearing in place of "pure".

I will not deal here with the story of how the word was used by scientists in their discourses. Such a task would go well beyond the scope of the present paper. [14] I will rather concentrate on how the word and concept were inserted in taxonomies or kinds of research and on how they were related to measurement.

The first attempts at defining these terms systematically occurred in Britain in the 1930s, more precisely among those scientists interested in the social aspects of science – the "visible college" as G. Werskey called them, [15] among whom were the two British scientists, J. D. Bernal and J.S. Huxley.

J. D. Bernal was the first to perform a measurement of science in a Western country. [16] In *The Social Function of Science* (1939), Bernal estimated the money devoted to science in the United Kingdom using existing sources of data: government budgets, industrial data (from the Association of Scientific Workers) and University Grants Committee reports. He

[10] Arendt, H. (1958), *Condition de l'homme moderne*, Paris : Calmann-Lévy, 1983 ; Lloyd, G.E.R. (1966), *Polarity and Analogy: Two Types of Argumentation in Early Greek Thought*, Cambridge: Cambridge University Press; Lobkowicz, N. (1967), *Theory and Practice: History of a Concept From Aristotle to Marx*, London: University of Notre Dame.
[11] Hounshell, D.A. (1980), Edison and the Pure Science Ideal in the 19th Century America, *Science*, 207: 612-617; Roqué, X. (1997), Marie Curie and the Radium Industry: A Preliminary Sketch, *History and Technology*, 13 (4): 267-291.
[12] Cohen, I.B. (1948), *Science Servant of Men*, Boston: Little, Brown and Co, p. 56.
[13] Kline (1995), *op. cit*.
[14] *Ibidem*.
[15] Werskey, G. (1978), *The Visible College: The Collective Biography of British Scientific Socialists of the 1930s*, New York: Holt, Rinehart and Winston.
[16] There have doubtless been highly systematic attempts at measuring science and technology before the 1940s, but these were confined to Eastern Europe.

was also the first to suggest a type of measurement that became the main indicator of science and technology: Gross Expenditures on Research and Development (GERD) as a percentage of GDP. He compared the UK's performance with that of the United States and USSR and suggested that Britain should devote between one half and one percent of its national income to research. [17] The number was arrived at by comparing expenditures in other countries, among them the United States and the Soviet Union, which invested respectively 0,6% and 0,8%, while the UK spent only 0,1%. From these estimates, however, Bernal concluded: "The difficulties in assessing the precise sum annually expended on scientific research are practically insurmountable. It could only be done by changing the method of accounting of universities, Government Departments, and industrial firms". [18]

In his book, Bernal used the terms "pure" and "fundamental" interchangeably. He contrasted the ideal of science, or science as pure thought, not mainly with applied science but with the social use of science for meeting human needs. [19] When dealing with numbers, Bernal did not break the research budget down by types of research — such statistics were not available. "The real difficulty (…) in economic assessment of science is to draw the line between expenditures on pure and on applied science", Bernal said. [20] He could only present total numbers, sometimes broken down by sectors, but he could not figure out how much was allocated to basic research.

Five years earlier, J.S. Huxley (1934), who later became UNESCO's first Director-General (1947-48), introduced new terms and suggested the first formal taxonomy of research. The taxonomy had four categories: background, basic, ad hoc and development. [21] For Huxley, ad hoc meant applied research, and development meant more or less what we still mean by it today. [22] The first two categories defined pure research: background research is research "with no practical objective consciously in view", while basic research is "quite

[17] Bernal, J.D. (1939), *The Social Function of Science*, Cambridge (Mass.): MIT Press, 1973, p. 65.
[18] *Ibidem*, p. 62.
[19] *Ibidem*, pp. 3-7, 95-97.
[20] *Ibidem*, p. 62.
[21] Huxley, J.S. (1934), *Scientific Research and Social Needs*, London: Watts and Co.
[22] The term "development" appeared first in discourses of industrialists and the National Research Council. See: Godin, B. (2001), *Defining Research: Is Research Always Systematic?*, Project on the History and Sociology of S&T Statistics, Paper no. 5, OST: Montreal.

fundamental, but has some distant practical objective (…). Those two categories make up what is usually called pure science". [23]

Despite having these definitions in mind, however, Huxley did not conduct any measurements and his definitions were not widely adopted. [24] The terms pure, fundamental, background and basic frequently overlapped before V. Bush arrived on the scene. [25] Some analysts were also skeptical of the utility of the terms, and rejected them outright. For example, *Research: A National Resource* (1938), one of the first government measurement of science in America, explicitly refused to use any categories but research: "There is a disposition in many quarters to draw a distinction between pure, or fundamental, research and practical research (…). It did not seem wise in making this survey to draw this distinction". [26] The reasons offered were that fundamental and practical research interact and that both lead to practical and fundamental results. The Bush report itself, although it used the term basic research in the core of the text, also referred to pure research elsewhere in the document: in the Bowman committee report — Annex 3 of *Science: The Endless Frontier*— pure research was defined as "research without specific practical ends. It results in general knowledge and understanding of nature and its laws". [27]

Bush labored over definitions all of his life: "A principal problem confronting Bush was public confusion over terms like science, research and engineering, at least according to his views. Throughout the war and for many years afterwards, he tried to clarify their meanings to colleagues and to the public with only modest success". [28] In his well-known report, *Science: The Endless Frontier* (1945), Bush elected the term basic research and defined it as "research performed without thought of practical ends". [29] He estimated that the Nation invested nearly six times more in applied research than in basic research. [30] The numbers

[23] Huxley, J.S. (1934), *op. cit*., p. 253.
[24] Although he had some influence, as we will see shortly, on Bush (who borrowed the term "basic"), on Steelman (who adapted Huxley's typology) and on UNESCO and OECD (who called Huxley's basic research "oriented basic research").
[25] One even went as far as to used the three terms in the same page. See: Perazich, G., and P.M. Field (1940), *Reemployment Opportunities and Recent Changes in Industrial Techniques*, Works Progress Administration, National Research Project, Philadelphia, p. 3.
[26] National Resources Committee (1938), *Research: A National Resource*, New York: Arno Press, 1980, p. 6.
[27] Bush, V. (1945), *op. cit.*, p. 81.
[28] Reingold, N. (1987), V. Bush's New Deal for Research, *Historical Studies in the Physical Sciences*, 17 (2): 304.
[29] Bush (1945), *op. cit*., p. 18. According to Kline (1995), *op. cit*., pp. 216-217, the term originated from A. Kennelly (Harvard University, engineering) in the mid 1920s, and was popularized by industrialists.
[30] Bush (1945), *op. cit*., p. 20.

were arrived at by equating colleges and universities with basic research, and industrial and governmental research with applied research. More precise numbers appeared in appendices, such as ratios of pure research in different sectors – 5% in industry, 15% in government, and 70% in colleges and universities [31] – but the sources and methodology behind these figures were totally absent from the report.

With his report, Bush gave Huxley's term political flavor by putting basic research on governments' political agenda. He argued at length that governments should support basic research on the basis that it is the source of socioeconomic progress and the "pacemaker of technological progress. Basic research (…) creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science". [32] This is the first formal formulation of the linear model that preoccupied SSK researchers for decades. [33] To this rhetoric, the Bowman committee added:

> There is a perverse law governing research: under the pressure for immediate results, and unless deliberate policies are set up to guard against this, applied research invariably drives out pure. The moral is clear: it is pure research which deserves and requires special protection and specially assured support. [34]

Crystallization

Between 1930 and 1945 then, numerous labels were used for more or less the same concept: pure, fundamental, background and basic. The same label was sometimes even used to refer to different concepts: the term background research was a type of pure research for Huxley while for J. R. Steelman it represented what we now call "related scientific activities"; basic research, on the other hand, was for Huxley what we today call "oriented research". By integrating basic research into the NSF bill, Bush succeeded in imposing the term and its institutional definition.

[31] *Ibidem.*, p. 85.
[32] *Ibidem*, p. 19.
[33] Although Bush is often credited for "inventing" the linear model, scientists had been using it in public discourse since the end of the 19th century (for example, see: Rowland H. (1883), A Plea for Pure Science, in *The Physical Papers of Henry Augustus Rowland*, Baltimore: Johns Hopkins University Press, 1902: 593-613). Similarly, industrialists (Jewett, F.B (1937). Communication Engineering, *Science*, 85: 591-594) and government (National Resources Committee (1938), *op. cit.*: 6-8) used it in the thirties. The linear model is in fact the spontaneous philosophy of scientists.
[34] Bush (1945), *op. cit.*, p. 83.

Science: The Endless Frontier is usually considered the basis of science policy in the United States, particularly the basis for the funding of basic research. [35] This is only partly true. [36] Bush proposed the idea of an agency (NSF) that would be responsible for basic research but the rhetoric he used succeeded mainly with scientists and much less with policy makers: President H. Truman vetoed the NSF bill in 1947, following the recommendation of the Bureau of Budget against the organizational aspects which involved an independent Board. [37] Instead, he asked J. R. Steelman to prepare a report on what the government should do for science. The executive order stipulated that Steelman: [38]

1. Review the current and proposed scientific R&D activities conducted and financed by all government departments and independent establishments to ascertain: 1) the various fields of R&D and the objectives sought; 2) the type and number of personnel required for operating such programs; 3) the extent to and manner in which such R&D is conducted for the federal government by other profit and non-profit institutions; and 4) the costs of such activities.
2. Review using readily available sources: 1) the nature and scope of non-federal scientific R&D activities; 2) the type and number of personnel required for such activities; 3) the facilities for training new scientists; and 4) the amounts of money expended for such R&D.

Steelman can be credited, as much as Bush, for having initiated science policy in the United States. Several of the issues and problems with which science policy dealt over the next fifty years had already been identified by Steelman: research expenditures, support for basic research, defense research, human resources, the role of government, inter-departmental coordination, and the international dimension of science. In his inaugural address to the American Association for the Advancement of Science (AAAS) in 1948, Truman proposed five objectives that were drawn straight out of the Steelman report. [39]

[35] Smith, B.L.R. (1990), *American Science Policy Since World War II*, Washington: Brookings Institution.
[36] Hart, D.M. (1998), *Forged Consensus: Science, Technology and Economic Policy in the United States, 1921-1953*, Princeton: Princeton University Press; Blanpied, W.A. (1999), Science and Public Policy: The Steelman Report and the Politics of Post-World War II Science Policy, in *AAAS Science and Technology Policy Yearbook*, Washington: 305-320.
[37] England, J.M. (1982), *A Patron for Pure Science: The NSF'S Formative Years, 1945-1957*, Washington: NSF, p. 82. The veto of the NSF bill was only one manifestation of American politicians' reluctance to fund basic research before the 1950s. There were three other unsuccessful funding experiments in the 1920s and 1930s and a long struggle between V. Bush and Senator H. Kilgore between 1942 and 1948 on the appropriate role of the NSF. See Smith, 1990, *op. cit*.
[38] Steelman, J.R. (1947), *op. cit.*, pp. 70-71.
[39] Truman, H.S. (1948), *Address to the Centennial Anniversary*, AAAS Annual Meeting, Washington.

Moreover, Steelman developed three instruments that helped give basic research a more robust political existence. First, he conducted the first survey of resources devoted to R&D using precise categories, although these did not make it "possible to arrive at precisely accurate research expenditures" because of the different definitions and accounting practices employed by institutions. [40] In the questionnaire he sent to 70 industrial laboratories and 50 universities and foundations, he included a taxonomy of research that was inspired by Huxley's four categories: fundamental, background, applied and development. [41] Steelman did not retain Bush's term and preferred to talk of fundamental research in his taxonomy, though he regularly used "basic" in the text and defined fundamental research similarly as "theoretical analysis, exploration, or experimentation directed to the extension of knowledge of the general principles governing natural or social phenomena". [42] With this definition, he estimated that basic research accounted for about 4% of total R&D expenditure in the United States in 1947. [43]

Second, based on the numbers obtained in the survey, Steelman proposed quantified objectives for science policy. For example, he suggested that resources devoted to R&D be doubled in the next ten years and basic research quadrupled. [44] This kind of objectives, including another to which I shall presently turn, appeared, and still appears, in almost every science policy document of Western Countries in the following decades.

Third, Steelman introduced in science policy the main science indicator that is still used by governments today: R&D expenditures as a percentage of GDP. [45] Contrary to Bernal however, he did not justify how he arrived at the 1% goal for 1957. Nevertheless, President Truman subsequently incorporated an objective of 1% in his address to the AAAS.

While Bush developed an argument based on science's promise for the future, Steelman developed arguments based on historical statistics of R&D budgets. Of course, the latter also called on the future promises of science: "scientific progress is the basis for our progress against poverty and disease" [46] and basic research is "the quest for fundamental

[40] Steelman (1947), *op. cit.,* p. 73.
[41] *Ibidem*, pp. 299-314.
[42] *Ibidem*, p. 300.
[43] *Ibidem*, p. 12.
[44] *Ibidem*, p. 6.
[45] *Ibidem*, p. 6.
[46] *Ibidem*, p. 3.

knowledge from which all scientific progress stems", Steelman wrote, [47] recalling Bush's rhetoric. But he also developed an argument concerning the balance between basic science and applied research. [48] To that end, Steelman used two kinds of quantitative comparisons.

First, he made comparisons with other nations, among them the USSR that had invested $1,2 million on R&D in 1947, [49] which was slightly more than the Unites States ($1,1 million). It was Europe, however, that served as the main yardstick or target: "We can no longer rely as we once did upon the basic discoveries of Europe". [50] "We shall in the future have to rely upon our own efforts in the basic sciences": [51]

> As a people, our strength has laid in practical application of scientific principles, rather than in original discoveries. In the past, our country has made less than its proportionate contribution to the progress of basic science. Instead, we have imported our theory from abroad and concentrated on its application to concrete and immediate problems. [52]

One remark should be made about this rationale for investing in basic research. At the time, the fact that other nations were thought to invest more that the United States in basic research was explained by what has been called the "indifference thesis". Following Alexis de Tocqueville's *Democracy in America* (1845) in his chapter titled "Why the Americans are More Addicted to Practical than to Theoretical Science", some argued that the United States was more interested in applied science than basic research. [53] Reingold has aggressively contested this thesis. [54] He showed how historians (we should add policy makers, including Steelman) lacked critical scrutiny and easily reproduced scientists' complaints and views on colonial science as a golden age and Europe as a model of

[47] *Ibidem*, p. 21.
[48] The argument was already present in Bernal (1939), *op. cit*., pp. 329-330, but without quantitative evidence.
[49] Steelman (1947), *op. cit*., p. 5.
[50] *Ibidem*, p. 13.
[51] *Ibidem*, p. 4. A similar discourse was also developed in Bush (1945), *op. cit*.: "Our national preeminence in the fields of applied research and technology should not blind us to the truth that, with respect to pure research – the discovery of fundamental new knowledge and basic scientific principles - America has occupied a secondary place. Our spectacular development of the automobile, the airplane, and radio obscures the fact that they were all based on fundamental discoveries made in nineteenth-century Europe" (p. 78). "A Nation which depends upon others for its new scientific basic knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill" (p. 19). "We cannot any longer depend upon Europe as a major source of this scientific capital" (p. 6).
[52] Steelman (1947), *op.cit*., pp. 4-5.
[53] Shryock, R.H. (1948), American Indifference to Basic Research During the Nineteenth Century, *Archives Internationales d'Histoire des Sciences*, 28: 50-65.
[54] Reingold, N. (1971), American Indifference to Basic Research: A Reappraisal, in N. Reingold, *Science: American Style*, New Brunswick and London: Rutgers University Press, 1991: 54-75.

aristocratic sympathy for basic science. Reingold also argued that a nationalistic bias supported the discourses of the time: "Not only should the United States participate significantly in the great achievement known as science, but it should lead". [55]

The second kind of comparison Steelman made was between university budgets and those of other sectors. He showed that university research expenditures were far lower than government or industry expenditures, that is lower than applied research expenditures, which amounted to 90% of total R&D. [56] Moreover, he showed that university budgets as a percentage of total R&D had declined from 12% in 1930 to 4% in 1947. [57] Steelman urged the government to redress the balance in the "research triangle".

The NSF then seized the tools suggested by Steelman for selling basic research to the government and to the public. In 1950, Congress passed the controversial bill that created the NSF. [58] The law charged the NSF with funding basic research, but it also gave it, under the influence of the Bureau of Budget, [59] a role in science measurement. The NSF was authorized to "maintain a current register of scientific and technical personnel, and in other ways provide a central clearinghouse for the collection, interpretation, and analysis of data on scientific and technical resources in the United States". [60] In 1968, Congress mandated the NSF to report on the status and health of science and technology, [61] and, in 1982, it asked for a report on science indicators every two years. [62] This served as confirmation of the reputed quality of *Science and Engineering Indicators*, first published in 1973.

From the onset, sound data were identified at NSF as the main vehicle for assessing the state of science, as recommended by W.T. Golden in his memorandum to Congress. [63] Beginning with the first survey it conducted in 1953 – on federal government R&D expenditures -, the NSF defined basic research as research "which is directed toward the

[55] *Ibidem*, p. 63.
[56] Steelman (1947), *op. cit*., p. 21.
[57] *Ibidem*, p. 12.
[58] Twenty one bills were introduced in Congress between 1945 and 1950.
[59] England (1982), *op. cit*.
[60] Public Law 507 (1950) and Executive Order 10521 (1954).
[61] Public Law 90-407 (1968).
[62] Public Law 97-375 (1982).
[63] Golden, W.T. (1951), *Memorandum on Program for the National Science Foundation*, in W.A. Blanpied, Impacts of the Early Cold War on the Formulation of US Science Policy, Washington: AAAS: 68-72.

increase of knowledge in science". [64] One year later, the NSF added the following qualification in its survey: "It is research where the primary aim of the investigator is a fuller knowledge or understanding of the subject under study, rather that a practical application thereof". [65] These definitions had to be followed by the respondent to the questionnaire that classified research projects and money according to the suggested categories. With the definitions, developed for measurement purposes, and with the numbers originating from the surveys, the NSF fought for money and mustered several arguments in its favor.

The NSF reiterated to politicians the arguments already put forward by Bush and Steelman: knowledge is a cultural asset; university research is so basic that it is the source of all socioeconomic progress; a shortage of scientists prevents the Nation from harvesting all the benefits of science; the United-States is lagging behind its main competitor, the USSR; and a balance between applied and basic research is needed. All these arguments appeared in *Basic Research: A National Resource* (1957), a document written to convey in a non-technical manner the meaning of basic research. [66]

But two new kinds of argument were also put forward. First, *Basic Research: A National Resource* argued for a new way to strengthen basic research: convince industry to invest more in basic research than it actually does. [67] Indeed, NSF surveys showed that only a small percentage of industrial R&D was devoted to basic research. Second, the document stated that "the returns (of basic research) are so large that it is hardly necessary to justify or evaluate the investment" [68] and that, at any rate, "any attempt at immediate quantitative evaluation is impractical and hence not realistic". [69] Numbers were not judged useful. All that was necessary was to show the great contributions achieved by science and to present the important men who were associated with the discoveries. In line with this philosophy, the NSF regularly produced documents showing the unexpected but necessary contribution

[64] National Science Foundation (1953), *Federal Funds for Science: 1950-51 and 1951-1952*, Washington, p. 12.
[65] National Science Foundation (1954), *Federal Funds for Science: Fiscal Years 1953, 1954 and 1955*, Washington, p. 20.
[66] National Science Foundation (1957), *Basic Research: A National Resource*, Washington.
[67] *Ibidem*, pp. 37-38, 50-51.
[68] *Ibidem*, p. 61.
[69] *Ibidem*, p. 62.

of basic research to innovation, generally using case studies. [70] Besides *Basic Research: A National Resource*, the NSF published:

1961 Investing in Scientific Progress
1968 Technology in Retrospect and Critical Events in Science (TRACES).
1973 Interactions of Science and Technology in the Innovation Process.
1980 How Basic Research Reaps Unexpected Rewards.

This rhetoric served a particular purpose: to give university research a "political" identity it did not yet have. Indeed, the university contribution to national R&D was small, as Steelman had measured. In arguing that basic research was the basis of progress, the rhetoric made university research an item on the political agenda: "Educational institutions and other non profit organizations together performed only 10 percent of all R&D in the natural sciences. But (they) performed half of the Nation's basic research" claimed the NSF. [71]

This rhetoric was soon supported and reinforced by economists, among them economists at the RAND Corporation, the US Air Force's Think Tank. [72] Economists presented science as a public good, which had of course been advanced as a defining feature of science since the Republic of Science. [73] But economists qualified the public good using their own *jargon*: "Since Sputnik it has become almost trite to argue that we are not spending as much on basic scientific research as we should. But, though dollar figures have been suggested, they have not been based on economic analysis of what is meant by as much as we should". [74] To economists, science was a public good because knowledge could not be

[70] The practice was probably inspired by similar exercises at the Office of Naval Research (ONR), where A. T. Waterman, first director of NSF, was chief scientist in the 1940s. See Sapolsky, H.M. (1990), *Science and the Navy: The History of the Office of Naval Research*, Princeton: Princeton University Press, 83-85.
[71] NSF (1957), *op. cit*., p. 28.
[72] Nelson, R.R. (1959), The Simple Economics of Basic Scientific Research, *Journal of Political Economy*, 67: 297-306; Arrow, K.J. (1962), Economic Welfare and the Allocation of Resources for Invention, in National Bureau of Economic Research, *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton: Princeton University Press: 609-626.
[73] Hahn, R. (1971), *The Anatomy of a Scientific Institution: The Paris Academy of Sciences, 1966-1803*, Berkeley: University of California Press, pp. 35-37; Turner, F.M. (1980), Public Science in Britain, 1880-1919, *ISIS*, 71: 589-608; Stewart, L. (1992), *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660-1750*, Cambridge: Cambridge University Press; Golinski, J. (1992), Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820, Cambridge: Cambridge University Press.
[74] Nelson (1959), *op. cit*., p. 297.

(exclusively) appropriated by its producer, which therefore justified the need for government support.

When, at the beginning of the 1960s, the OECD began seriously considering the possibility of conducting measurements of science and technology, a large part of the work had already been done. Indeed, several countries had definitions that were in line with those of the NSF, as shown by two studies performed during that time, one by the Organization for European Economic Cooperation, [75] the OECD's predecessor, and the other by the OECD. [76] But few countries collected data on basic research. [77]

The OECD's involvement in science measurement was in fact a spin-off of its predecessor's interests in human resources. The OEEC had by then already performed three international surveys on scientific and technical manpower that had shown the limitations of making international comparisons. [78] When it decided in 1957 to broaden its analysis of science and technology and to measure monetary investments as well as human resources, it first set out to assess the state of the field. When the OECD was created and replaced the OEEC in 1961, the Directorate of Scientific Affairs (DSA) sent C. Freeman, of the National Institute of Economic and Social Research (London), who was then working on a survey of industrial research for the Federation of British Industries (FBI), on a mission in member countries. The aim was to look at available R&D statistics and to develop tools that would allow comparisons between countries [79] in an area that was increasingly seen as central to economic policy: science and technology. Freeman wrote the first edition of the OECD Frascati manual, which was approved by Member Countries in 1963. The NSF had considerably influenced the manual because the United States was far in advance of other countries in measurement. [80] In fact, the entire manual, and particularly the survey and definitions of concepts, was conceived according to the NSF's experience.

[75] OEEC (1961), *Government Expenditures on R&D in France and the United Kingdom*, EPA/AR/4209.
[76] OECD (1963), *Government Expenditures on R&D in the United States of America and Canada: Comparisons with France and the United Kingdom on Definitions Scope and Methods Concerning Measuremen*t, J.C. Gerritsen, J. Perlman, L.A. Seymour, G. McColm, DAS/PD/63.23.
[77] See OECD (1964), *Some Notes on Expenditures for Fundamental Research*, C.S-C1/CC/2/64/3.
[78] OEEC (1955), *Shortages and Surpluses of Highly Qualified Scientists and Engineers in Western Europe*, Paris; OEEC (1957), *The Problem of Scientific and Technical Manpower in Western Europe, Canada and the United States*, Paris; OECD (1963), *Resources of Scientific and Technical Personnel in the OECD Area*, Paris.
[79] For a survey of the difficulties at the time, see: Freeman, C, and A. Young, (1965), *The Research and Development Effort in Western Europe, North America and the Soviet Union: An Experimental International Comparison of Research Expenditures and Manpower in 1962*, Paris: OECD.
[80] This is admitted in the first edition of the Frascati Manual, OECD (1963), *op. cit*., p. 7.

The OEEC had mostly been interested in applied research, or at least in the application of research. [81] This was thought to be the key to economic development and had been its philosophy since its beginning in 1948. Basic research was not as important an issue for the OEEC as it was for the United States. One factor helps explain the OECD's new concern. Certain people in the organization, chief among them Alexander King, became increasingly interested in science policy. At the time, the understanding of research in terms of the classic linear model was taken for granted: innovation derived from applied research, which itself drew upon basic research. The aim of policies was therefore to increase funding of research in general, and basic research in particular. [82] Only later will the interest in basic research be to "control" or redirect the expenditures toward more mission-oriented research. [83] The research taxonomy that the OECD borrowed from the NSF for surveying research then allowed continuity with old and new concerns: it considered every kind of research, applied as well as basic research. There was something for everyone.

The OECD made two specific contributions to science measurement. Firstly, the organization generalized US definitions and surveys to all member countries, allowing therefore for the possibility of international comparisons. The first international survey was conducted in 1963-4, and the results published three years later. [84] Secondly, the OECD did more than simply copy the NSF: it put its own stamp on the field. Beyond the survey, the OECD developed a tool that helped crystallize the definition and the measurement of basic research: a standardized methodology manual now in its fifth edition. The Frascati manual suggested formal and precise definitions of concepts related to R&D activities, among them basic research. The definition that was suggested in the 1963 edition of the Frascati manual is still used by most countries today.

Contested Boundaries

Institutions and statistics are what gave stability to the fuzzy concept of basic research. Before the NSF and OECD, the concept of basic research was a free-floating idea, supported only by the rhetoric of scientists. Both organizations succeeded in "selling" basic

[81] OECD (1965), *Répertoire des activités de l'Agence européenne de productivité, 1953-1961*, Paris.
[82] Godin, B. (2001), Outlines for a History of Science Measurement, *Science, Technology and Human Values*, in print.
[83] But this concerns less university research than government laboratories and contracted-out research.
[84] OECD (1967), *A Study of Resources Devoted to R&D in OECD Members Countries in 1963/64: The Overall Level and Structure of R&D Efforts in OECD Member Countries* (volume I), Paris.

research as a category thanks to a specific tool: the survey and the numbers it generated. Important controversies raged beneath the consensus of an international community of state statisticians, however. Much effort is still devoted to keeping the concept of basic research on the agenda, a task that has occupied the NSF and OECD from the early 1960s on.

From the beginning, almost everyone had something to say against the definitions of basic research. Academics (particularly social scientists), governments and industry all rejected the definitions and suggested alternatives. Even the NSF and OECD never really seemed satisfied with the definitions. The criticisms centered around two elements. [85]

First and foremost, the definitions referred to the researcher's motives — mainly curiosity — and were thus said to be subjective. [86] The intentions of sponsors and users differed considerably and different numbers were generated depending on who classified the data: [87]

> Whether or not a particular project is placed under the basic research heading depends on the viewpoint of the persons consulted. For instance, university officials estimate that, during the academic year 1953-54, academic departments of colleges and universities and agricultural experiment stations received about $85 million for basic research from the Federal Government. But Federal officials estimate that they provided barely half that amount to the universities for the same purpose during the same period.
>
> A large part – perhaps the major part – of what industry regarded as basic research would be considered to be applied research or development in universities. [88]

Motives were also said to be subjective in the following sense: the classification of a research project often changes depending on the policy mood of the time: "Quite solidly justifiable mission-applicable work, labeled applied in the statistics of an earlier time, is now classified as basic, and vice versa. (…) Research support data reported by the agencies

[85] The arguments were developed at length at two conferences: National Science Foundation (1980), *Categories of Scientific Research*, Washington; Hensley, O.D. (1988), *The Classification of Research*, Lubbock: Texas Tech University Press.
[86] Kidd, C.V. (1959), Basic Research: Description versus Definition, *Science*, 129: 368-371.
[87] Some authors have recently shown that even charities had always expected more or less concrete results from their grants - grants generally reported to be basic research by the recipients; at the very least, foundations' motives were usually mixed, combining elements of basic and applied research. See: Kohler, R.E. (1991), *Partners in Science: Foundations and Natural Scientists 1900-1945*, Chicago: University of Chicago Press. See also: J. Schmookler (1962), Catastrophe and Utilitarianism in the Development of Basic Science, in R.A. Tyabout (ed.), *Economics of R&D*, Colombus: Ohio: 19-33.
[88] NSF (1957), *op. cit*., p. 25.

change in response to a number of fashions, forces and interpretations". [89] As early as 1938, the National Resources Committee observed the phenomenon and called it "window dressing": [90] "data are presented in the form which is supposed to be most conductive to favorable action by the Bureau of the Budget and congressional appropriation committees". [91]

In sum, the definition emphasized the researcher's intentions rather than the results: "In the standard definition, basic research is the pursuit of knowledge without thought of practical application. The first part is true – that science is intended to produce new discoveries – but the implication that this necessarily entails a sharp separation from thoughts of usefulness is just plain wrong". [92] The definition forgot, according to some, the results of research, its substantial content: [93] "Basic research discovers uniformities in nature and society and provides new understanding of previously identified uniformities. This conception departs from a prevailing tendency to define basic research in terms of the aims or intent of the investigators. It is a functional, not a motivational definition. It refers to what basic research objectively accomplishes, not to the motivation or intent of those engaged in that research". [94]

The problem to which these criticisms refer was already identified in 1929 by J. Dewey in *The Quest for Certainty*:

> There is a fatal ambiguity in the conception of philosophy as a purely theoretical or intellectual subject. The ambiguity lies in the fact that the conception is used to cover both the attitude of the inquirer, the thinker, and the character of the subject-matter dealt with. The engineer, the physician, the moralist deal with a subject-matter which is practical; one, that is, which concerns things to be done and the way of doing them. But as far as personal disposition and purpose is concerned, their inquiries are intellectual and cognitive. These men set out to find out certain

[89] National Science Board (1978), *Basic Research in the Mission Agencies: Agency Perspectives on the Conduct and Support of Basic Research*, Washington, p. 286-287.
[90] The first occurrence of the phenomenon in American history goes back to 1803 when President T. Jefferson asked Congress to support a purely scientific expedition for presumed commercial ends. See: Dupree, A.H. (1957), *Science in the Federal Government: A History of Policies and Activities to 1940*, New York: Harper and Row: p. 26.
[91] National Resources Committee (1938), *op. cit.*, p. 63.
[92] National Research Council (1995), *Allocating Federal Funds for Science and Technology*, Committee on Criteria for Federal Support of R&D, Washington: National Academy of Science, p. 77.
[93] Gruender, C.D. (1971), On Distinguishing Science and Technology, *Technology and Culture*, 12 (3): 456-463; OECD (1963), *Critères et Catégories de recherche*, C. Oger, DAS/PD/63.30 ; Nason, H.K. (1981), Distinctions Between Basic and Applied in Industrial Research, *Research Management*, May: 23-28.
[94] H. Brooks (1963), Basic Research and Potentials of Relevance, *American Behavioral Scientist*, 6: 87.

> things; in order to find them out, there has to be a purgation of personal desire and preference, and a willingness to subordinate them to the lead of the subject-matter inquired into. The mind must be purified as far as is humanly possible of bias and of that favoritism for one kind of conclusion rather than another which distorts observation and introduces an extraneous factor into reflection (…). It carries no implication (…) save that of intellectual honesty. [95]
>
> It is fair, then, to conclude that the question of the relations of theory and practice to each other, and of philosophy to both of them, has often been compromised by failure to maintain the distinction between the theoretical interest which is another name for intellectual candor and the theoretical interest which defines the nature of the subject-matter. [96]

Elsewhere in the book, Dewey presented the problem in terms of the following fallacy:

> Independence from any specified application is readily taken to be equivalent to independence from application as such (…). The fallacy is especially easy to fall into on the part of intellectual specialists (…). It is the origin of that idolatrous attitude toward universals so often recurring in the history of thought. [97]

A second frequently voiced criticism was that motives are only one of the dimensions of research. Research has multiple dimensions and any classification system with mutually exclusive categories tends to oversimplify the situation. Basic and applied research can be seen as complementary rather than opposing dimensions. Viewed this way, there is no clear-cut boundary between basic and applied research. Instead, there is a spectrum of activities, a continuum where both types of research overlap and mix. [98] Some even argued that there is such a thing as applied or technological research that is basic [99] (a contradiction

[95] Dewey, J. (1929), *The Quest for Certainty: A Study of the Relation of Knowledge and Action*, New York: Milton, Balch and Co, p. 67-68.
[96] *Ibidem*, pp. 68-69.
[97] *Ibidem*, p. 154.
[98] Wolfe, D. (1959), The Support of Basic Research: Summary of the Symposium, in *Symposium on Basic Research*, Washington: AAAS: 249-280; Brooks, H. (1967), Applied Research: Definitions, Concepts, Themes, in National Academy of Science, *Applied Science and Technological Progress*, Washington: 21-55.
[99] The term "fundamental technological research" seems to have appeared, to the best of my knowledge, in the 1960s both at the NSF (see D.O. Belanger, *Enabling American Innovation: Engineering and the National Science Foundation, West Lafayette: Purdue University Press*, 1998) and at the OECD (*Technological Forecasting in Perspective*, DAS/SPR/66.12, Paris, 1966). See also: Stokes, D.E. (1997), *Pasteur's Quadrant: Basic Science and Technological Innovation*, Washington: Brookings Institution; Stokes, D.E. (1982), Perceptions of the Nature of Basic and Applied Science in the United States, in A. Gerstenfeld, *Science Policy Perspectives: USA-Japan*, Academic Press: 1-18; Stokes, D.E. (1980), Making Sense of the Basic/Applied Distinction: Lessons From Public Policy Programs, in National Science Foundation, *Categories of Scientific Research*, Washington: 24-27; Branscomb, L.M. (1998), From Science Policy to Research Policy, in L.M. Branscomb and J.H. Keller, *Investing in Innovation: Creating a Research Innovation Policy That Works*, Cambridge (Mass.): MIT Press: 112-139; Branscomb, L.M. (1993), Targeting

in terms according to H. Brooks [100]). The British Government has even introduced the concept of basic technology in its budget documents. [101] All these reflections illustrate a long and continuing academic debate on the relationships between science and technology.[102]

Given the concept's malleability, several people concluded that the definition was essentially social [103] or political, [104] and at best needed to protect research from unrealizable expectations. [105] Some also argued that the definition rested on moral values. Brooks noted, for example, that "there has always been a kind of status hierarchy of the sciences, in order of decreasing abstractness and increasing immediacy of applicability (…). Historically a certain snobbery has always existed between pure and applied science". [106] Bernal also talked about snobbery, "a sign of the scientist aping the don and the gentleman. An applied

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Critical Technologies, in L.M. Branscomb (ed.), *Empowering Technology: Implementing a US Strategy*, Cambridge (Mass.): MIT Press: 36-63. Pioneers of the idea are historians like Layton (1974), *op. cit*., and Vincenti, W.G. (1990), *What Engineers Know and How They Know It*, Baltimore: Johns Hopkins University Press. For more references, see Staudenmaier, J.M. (1985), *Technology's Storytellers: Reweaving the Human Fabric*, Cambridge (Mass.): MIT Press: chapter 3.

[100] National Science Board, Minutes of the 91st Meeting, January 16-17 1964, NSB-64-4, Attachment 1, p. 4.

[101] DTI/OST (2000), *Science Budget 2001-02 to 2003-04*, London.

[102] The literature on the relationship between science and technology is voluminous. For a broad historical overview, see: Hall, A.R. (1974), What Did the Industrial Revolution in Britain Owe to Science?, in M. McKendrick, *Historical Perspectives: Studies in English Thought and Society*, London: Europa: 129-151; Keller, A. (1984), Has Science Created Technology?, *Minerva*, 22 (2): 160-182; Wise, G. (1985), Science and Technology, *OSIRIS*, 1: 229-246; Kranakis, E. (1990), Technology, Industry, and Scientific Development, in T. Frangsmyr (ed.), *Solomon's House Revisited: The Organization and Institutionalization of Science*, Canton: Science History Publications: 133-159; Gardner, P.L. (1994; 1995), The Relationship Between Technology and Science: Some Historical and Philosophical Reflections, *International Journal of Technology and Design Education*, Part I (4: 123-153) and Part II (5: 1-33). For a policy perspective, see: Rosenberg, N. (1991), Critical Issues in Science Policy Research, *Science and Public Policy*, 18 (6): 335-346; Rosenberg, N. (1982), How Exogenous is Science?, in N. Rosenberg, *Inside the Black Box: Technology and Economic*s, Cambridge: Cambridge University Press: 141-159; Pavitt, K. (1991), What Makes Basic Research Economically Useful?, *Research Policy*, 20: 109-119; Pavitt, K. (1989), *What Do We Know About the Usefulness of Science: The Case for Diversity*, SPRU Discussion Paper no. 65; Pavitt, K. (1987), The Objectives of Technology Policy, *Science and Public Policy*, 14 (4): 182-188; Brooks, H. (1994), The Relationship Between Science and Technology, *Research Policy*, 23: 477-486..

[103] N.W. Storer (1964), Basic Versus Applied Research: The Conflict Between Means and Ends in Science, *Indian Sociological Bulletin*, vol. 2 (1): 34-42.

[104] Cohen (1954), *op. cit*.; Shepard, H.A. (1956), Basic Research and the Social System of Pure Science, *Philosophy of Science*, 23 (1): 48-57; Reagan, 1967, *op. cit*.; Daniels, G.H. (1967), The Pure-Science Ideal and Democratic Culture, *Science*, 156: 1699-1705.; Falk, 1973, *op. cit*.; Layton, 1976, *op. cit*.; Toulmin, S. (1980), A Historical Reappraisal, in National Science Foundation (1980), *Categories of Scientific Research*, Washington: 9-13; Gieryn, T.F. (1983), Boundary-Work and the Demarcation of Science From Non-Science: Strains and Interests in Professional Ideologies of Scientists*, American Sociological Review*, 48: 781-795; Kline (1995), *op. cit*.

[105] Brooks (1967), *op. cit*., p. 25.

[106] *Ibidem*, p. 51.

scientists must needs appear somewhat as a tradesman; he risked losing his amateur status". [107]

People often denied that they make distinctions between the two types of research, but the arguments were generally fallacious. A common strategy used was the "yes, but…" argument. For example, A.T. Waterman, first director of NSF, noted that "mission-related research is highly desirable and necessary", [108] but recommended looking at "the impressive discoveries (made) solely in the interest of pure science" to appreciate the priority of basic research. [109] Similarly, W. Weaver, a member of the NSF's National Science Board from 1956 to 1960, wrote: "Both types of research are of the highest importance and it is silly to view one as more dignified and worthy of the other. (…) Yet the whole history of science shows most impressively that scientists who are motivated by curiosity, by a driving desire to know, are usually the ones who make the deepest, the most imaginative, and the most revolutionary discoveries". [110]

A symposium on basic research held in New York in 1959 and organized by the National Academy of Science (NAS), the American Association for the Advancement of Science (AAAS) and the Alfred P. Sloan Foundation concluded that no agreement existed on the definition of research: "none of these and no other proposed definition survived the criticism of the symposium participants" [111] As for an influential report from by the National Academy of Sciences submitted in 1965 to the House of Representatives: the report of the panel on basic research and national goals could only present the diversity of viewpoints rather than a consensus on questions regarding the level of funding basic research deserves from the Federal government. [112]

The alternatives suggested since these reflections have not generated consensus either. Brooks suggested classifying research according to its broadness or baseness. [113] Others proposed using terms that corresponded to end-results or use: targeted/non targeted,

[107] Bernal (1939), *op. cit*. p. 96.
[108] Waterman, A.T. (1965), The Changing Environment of Science, *Science*, 147, p. 15.
[109] *Ibidem*, p. 16.
[110] Weaver, W. (1960), A Great Age for Science, in Commission on National Goals, *Goals for Americans*, Columbia University, pp. 107-108.
[111] Wolfe (1959), *op. cit*., p. 257.
[112] National Academy of Sciences (1965), *Basic Research and National Goals*, Washington.
[113] Brooks, H. (1980), Basic and Applied Research, in National Science Foundation, *Categories of Scientific Research*, Washington: 14-18.

autonomous/exonomous, pure/oriented, basic/problem-solving. Ben Martin and J. Irvine, for their part, actualized the OECD concept of "oriented research", [114] and proposed the term "strategic". [115] Basic research would be distinguished according to whether it is 1) pure or curiosity-oriented, or 2) strategic: "basic research carried out with the expectation that it will produce a broad base of knowledge likely to form the background to the solution of recognized current or future practical problems". [116] Still others preferred abandoning the classification and suggested disaggregating research by sector only - university, government and industry. [117] None of these alternatives were unanimously considered advantageous: applied research can be as broad as basic research, [118] sectors are often multipurpose, [119] as evidenced, for example, by the presence of applied research in universities, [120] etc.

These are only some of the recent criticisms. The US Society for Research Administrators organized a conference in 1984 to study the topic again. [121] The US General Accounting Office (GAO) also looked at the question and proposed its own taxonomy separating fundamental research into basic and generic, and adding a mission-targeted category. [122] The Industrial Research Institute (IRI) created an ad hoc Committee on Research Definition that worked between 1971 and 1979. [123] IRI concluded that basic research was a category that firms did not use, and suggested replacing basic by exploratory, that is "research which

[114] The term "oriented research" came from the 1960s. According to the Freeman et al., fundamental research felled into two categories: free research that is driven by curiosity alone, and oriented research. See: OECD (1963), *Science, Economic Growth and Government Policy*, Paris, p. 64.

[115] Variations on this concept can be found in: G. Holton (1993), On the Jeffersonian Research Program, in *Science and Anti-Science*, Cambridge (Mass.): Harvard University Press, pp. 109-125; L.M. Branscomb (1999), The False Dichotomy: Scientific Creativity and Utility, *Issues in Science and Technology*, Fall, pp. 66-72; D. Stokes (1997), *op. cit*.

[116] Irvine, J., and B.R. Martin, *Foresight in Science: Picking the Winners*, London: Frances Pinter, 1984, p. 4.

[117] Reagan, M.D. (1967), Basic and Applied Research: A Meaningful Distinction?, Science, 155: 1383-1386.

[118] Langenberg, D.N. (1980), Distinctions Between Basic and Applied Research, in National Science Foundation (1980), *Categories of Scientific Research*, Washington: 32-36; David, E.E. (1980), Some Comments on Research Definitions, in National Science Foundation (1980), *Categories of Scientific Research*, Washington: 40-42; Falk, C. (1973), An Operational, Policy-Oriented Research Categorization Scheme, *Research Policy*, 2: 186-202.

[119] Brooks (1980), *op. cit*.

[120] M. Crow and C. Tucker (2001), The American Research University System as America's *de facto* Technology Policy, *Science and Public Policy*, 28 (1): 2-10; Rosenberg, N., and R. Nelson (1994), American Universities and Technical Advance in Industry, *Research Policy,* 3: 323-348.

[121] Hensley (1988), *op. cit*..

[122] General Accounting Office (1987), *US Science and Engineering Base: A Synthesis of Concerns About Budget and Policy Development*, Washington, pp. 29-30.

[123] Nason (1981), *op. cit*.; Brown, A.E. (1972), New Definitions for Industrial R&D, *Research Management*, September: 55-57.

generates or focuses knowledge to provide a concept and an information base for a new development program". [124]

How did the NSF and the OECD respond? The NSF took seriously discussions on the limitations of definitions and was regularly involved in clarification exercises. As early as 1953, it warned its readers against the limitations of the data:

> Greater caution must be used in interpreting amounts shown for the classifications by character of work [basic/applied] and by scientific category. The complex nature of most Government scientific research and development undertakings, involving as they often do a broad range of fields and disciplines of science and extending from purely basic to development, do not lend themselves easily to categorization. Judgments employed in making estimates are apt to vary from agency to agency. In addition, points of view of the reporting agencies tend to influence their judgments in certain directions. [125]
>
> The difficulties of classifying research and development activities by character of work and scientific field are somewhat greater than the original determination of what constitutes R&D in the first instance. As a result the distributions in this section are generally less reliable than amounts shown elsewhere in this report. (…) Because of these difficulties, the distributions should be taken as indications of relative orders of magnitude rather than accurate measures. [126]

The limitations were particularly acute in the case of industry. At the end of the eighties for example, only 62% of companies reported data on basic research. As a consequence, the NSF had to devise a new method to estimate basic research in industry. [127]

Secondly, the NSF reflected regularly on the problem: it organized a seminar in 1979 on categories of scientific research; [128] it studied definitions for tax purposes in the mid-eighties; [129] and, again in 1988, it created a task force on R&D taxonomy. [130] The task force suggested three categories instead of the standard two – basic and applied: fundamental,

[124] Industrial Research Institute (IRI) (1978), *Definitions of Research and Development*, New York. Thirty years later, IRI definitions are no more than labels: the institute uses NSF data on traditional basic research to talk of "directed" basic research and "discovery-type" research in industry. See: Larson, C.F. (2000), The Boom in Industry Research, *Issued in Science and Technology*, Summer: 27-31.
[125] NSF (1953), Federal Funds for Science: Federal Funds for Scientific R&D at Nonprofit Institutions, 1950-1951 and 1951-1952, Washington, p. 5.
[126] NSF (1953), *Federal Funds for Science: The Federal R&D Budget, Fiscal Years 1952 and 1953*, Washington, p. 8.
[127] The method concerned industry expenses: NSF (1990), *Estimating Basic and Applied R&D in Industry: A Preliminary Review of Survey Procedures*, NSF 90-322, Washington.
[128] NSF (1980), *op. cit*.
[129] Hertzfeld (1985), *Definitions of Research and Development for Tax Credit Legislation*, NSF: Syscon Corporation.
[130] National Science Foundation (1989), *Report of the Task Force on R&D Taxonomy*, Washington.

strategic and directed. [131] The definitions narrowed the scope of basic research by splitting it into two, fundamental and strategic (amounting to what is called basic research in industry). Also, the term "directed" significantly modified the sense of applied research so that it concerned what we usually call applied research and most of government research. None of these efforts, however, had any consequences for the NSF definitions and surveys.

Thirdly, the NSF representatives occasionally abandoned the dichotomy between basic and applied research. For instance, in the NSF's first annual report, J. B. Conant, chairman of the National Science Board (NSB), wrote: "we might do well to discard altogether the phrases applied research and fundamental research. In their place I should put the words programmatic research and uncommitted research". [132] Similarly, A.T. Waterman distinguished two kinds of basic research — free and mission-oriented: " Basic research activity may be subdivided into free research undertaken solely for its scientific promise, and mission-related basic research supported primarily because its results are expected to have immediate and foreseen practical usefulness". [133] These liberties on the part of individuals were rather exceptional, however, and, again, had no consequences. The "NSF's entire history resonates with the leitmotif of basic versus applied research". [134]

Finally, what really had a long lasting effect was the decision to use two definitions of basic research in the surveys instead of one. The first definition is the traditional one (see above, p. 11-12) and would thereafter be used in government and university surveys; the second was added specifically for the industrial survey: [135]

> Research projects which represent original investigation for the advancement of scientific knowledge and which do not have specific commercial objectives, although they may be in the fields of present or potential interest to the reporting company.

This was in fact the implicit recognition that only oriented research – and not basic research – existed in industry. If measured according to the first definition, little money would have been classified as being spent in basic research in industry.

[131] *Ibidem*, p. 3.
[132] National Science Foundation (1951), *First Annual Report: 1950-1951*, Washington, p. VIII.
[133] Waterman (1965), *op. cit*., p. 15.
[134] D.O. Belanger (1998), *op. cit*.; O.N. Larsen (1992), *Milestones and Millstones: Social Science at the NSF, 1945-1991*, New Bruswick: Transaction Publishers.
[135] National Science Foundation (1959), *Science and Engineering in American Industry: Report on a 1956 Survey*, Washington, 59-50, p. 14.

As for the OECD, research definitions were discussed for each revision of the Frascati manual. The first meeting in 1963 brought national experts from several countries, chief among which was the United States (NSF). K. S. Arnow [136] and K. Sanow [137] argued at length on the difficulties of defining appropriate concepts for surveys. Indeed, for some time the NSF devoted a full time person specifically to this task – K. S. Arnow. C. Oger from France (DGRST) discussed the limitations of a definition based exclusively on researchers' motives and suggested alternatives. [138] His suggestion appeared without discussion in an appendix to the manual.

Discussions continued over the following few years and resulted in the addition of a brief specification to the second edition of the manual. In 1970, and in line with a 1961 UNESCO document, [139] the OECD discussed a sub-classification of basic research according to whether it was pure or oriented. Pure basic research was defined as research in which "it is generally the scientific interest of the investigator which determines the subject studied". "In oriented basic research the organization employing the investigator will normally direct his work towards a field of present or potential scientific, economic or social interest". [140] Despite these specifications and clarifications, few countries produced numbers according to the new definitions.

Discussions resumed in 1973. C. Falk, of the NSF, proposed to the OECD a definition of research with a new dichotomy based on the presence or absence of constraints. He suggested "autonomous" when the researcher was virtually unconstrained and "exogenous" when external constraints were applied to his program. [141] He recommended that some form of survey be undertaken by the OECD to test the desirability and practicality of the definitions. He had no success: "the experts (…) did not feel that the time was ripe for a wholesale revision of this section of the manual. It was suggested that as an interim

[136] OECD (1963), *Some Conceptual Problems Arising in Surveys of Scientific Activities*, K.S. Arnow, DAS/PD/63.37.
[137] OECD (1963), *Survey of Industrial Research and Development in the United States: Its History, Character, Problems, and Analytical Uses of Data*, K. Sanow, DAS/PD/63.38.
[138] Oger, C. (1963), *op. cit*.
[139] Auger, P. (1961), *Tendances actuelles de la recherche scientifique*, Paris: UNESCO, p. 262.
[140] OECD (1970), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris, p. 10.
[141] OECD (1973), *The Sub-Division of the Research Classification: A Proposal and Future Options for OECD*, C. Falk, DAS/SPR/73.95/07.

measure the present division between basic and applied research might be suppressed". [142] The only modifications that member countries accepted – to appear in the 1981 edition of the Frascati manual - were that the discussion between pure and basic research was transferred to another chapter, separated from the conventional definitions.

Then, in 1992, two governments tried to introduce the term strategic research in the Frascati manual (United Kingdom and Australia): [143] "original investigation undertaken to acquire new knowledge which has not yet advanced to the state when eventual applications to its specific practical aim or objective can be clearly specified". [144] After "lively discussions", as the Portuguese delegate qualified the meeting, [145] they failed to win consensus. We read in the last edition of the Frascati manual that: "while it is recognized that an element of applied research can be described as strategic research, the lack of an agreed approach to its separate identification in Member countries prevents a recommendation at this stage". [146] In 2001, the question was on the agenda during the fifth revision of the Frascati manual. [147] This time, countries indicated a "strong interest in a better definition of basic research and a breakdown into pure and oriented basic research" but agreed that discussions be postponed and addresses in a new framework after they have advanced on policy and analytical ground. [148]

The 1992 debate at OECD centered, among other things, on where to locate strategic research. There were three options. First, subdivide the basic research category into pure and strategic as OECD suggests. Second, subdivide the applied research category into strategic and specific, as the British government does. Third, create an entirely new category (strategic research) as recommended by the Australian delegate. [149] In the end, "delegates generally agreed that strategic research was an interesting category for the

[142] OECD (1973), *Results of the Meeting of the Ad Hoc Group of Experts on R&D Statistics*, DAS/SPR/73.61, p. 8.

[143] This is only one of two discussions concerning the taxonomy of research. A new annex was also suggested but rejected. It concerned distinguishing between pure and "transfer" sciences. See: OECD (1991), DSTI/STII(91)27; OECD (1991), DST/STII(91)12.

[144] OECD (1992), DSTI/STP(92)16; OECD (1993), DSTI/EAS/STP/NESTI(93)10. Australia went so far as to delay the impression of the fifth edition of the Frascati Manual to influence, in vain, the debate.

[145] OECD (1993), DSTI/EAS/STP/NESTI/RD(93)5.

[146] OECD (1994), *op.cit.*, p. 69.

[147] OECD (2000a), *Review of the Frascati Manual: Classification by Type of Activity*, DSTI/EAS/STP/NESTI/RD(2000)4; OECD (2000b), *Ad Hoc Meeting on the Revision of the Frascati Manual R&D Classifications: Basic Research*, DSTI/EAS/STP/NESTI/RD(2000)24.

[148] OECD (2000), *Summary Record*, DSTI/EAS/STP/NESTI/M (2000) 1, p. 5.

[149] See OECD (1991), DSTI/STII(91)7.

purposes of S&T policy but most felt that it was very difficult to apply in statistical surveys". [150]

The UK is the only country to have openly debated the definitions and to have adopted an alternative to the OECD's definition of basic research for its surveys on R&D. Twice since the 1970s, the House of Lords Select Committee on Science and Technology has discussed the taxonomy of research. First, in response to the green paper on science. In the latter, *A Framework for Government R&D* (1971), Lord Rothschild chose a simple dichotomy (basic/applied) on the grounds that "much time can be lost in semantic arguments about the nature of basic research, its impact, accidental or otherwise, on applied research, and the difference between them". [151] In fact, Rothschild identified forty-five "varieties" or taxonomies of research in the literature. [152] The Select Committee discussed the policy document in 1972 and thought otherwise: the various definitions in existence obscured the real issue and there was need for an agreement on a standardized definition. [153] Upon analysis of the question, the Committee asked three Funding Councils (Environment, Agriculture, Medical) to submit statistics to the Lords using a more refined classification based on the so-called Zuckerman definition: basic, basic-strategic, oriented-strategic and applied. [154] The Committee recommended a special study of the problem with a view to drawing up standard definitions. [155]

In 1990, the Select Committee studied the question again in a session entirely devoted to R&D definitions. [156] It noted that the largest defect in OECD definitions concerned strategic research and recommended that: "the Frascati Manual should be amended to cater better for strategic research". [157] The Committee did not recommend creating a new category but rather locating strategic research in either the basic or applied category. There still remained the problem of deciding which category, however.

[150] OECD (1993), *Summary Record of the NESTI Meeting*, DSTI/EAS/STP/NESTI/M 93) 1, p. 5.
[151] HMSO (1971), *A Framework for Government Research and Development*, London, p. 3.
[152] Rothschild, L. (1972), Forty-Five Varieties of Research (and Development), *Nature*, 239: 373-378.
[153] HMSO (1972), *First Report from the Select Committee on Science and Technology*, London, pp. XIV-XV.
[154] HMSO (1961), *The Management and Control of R&D*, London: Office of the Minister of Science, pp. 7-8.
[155] *Ibidem*, p. 15.
[156] HMSO (1990), *Definitions of R&D*, Select Committee on Science and Technology, HL Paper 44, London.
[157] Ibidem, p. 12.

Today, UK is one of the few countries (together with Australia) that publish numbers using the oriented and strategic subclasses. [158] Since the 1985 edition of the *Annual Review of Government Funded R&D*, the British Government produces statistics according to the following classification: 1) basic-pure, 2) basic-oriented, 2) applied-strategic and 4) applied-specific. Strategic research is defined in the *Annual Review* as "applied research in a subject area which has not yet advanced to the stage where eventual applications can be clearly specified". [159] It differs however from the Select Committee's definition: "research undertaken with eventual practical applications in mind even though these cannot be clearly specified". [160]

In sum, despite official definitions (Frascati manual), governments use their own classification (UK) or do not use any. [161] Departments also have their own definitions: this is the case for Defense and Space, for example. [162] Finally, OECD itself deleted the question on basic research from the list of mandatory questions of the R&D questionnaire in the 1970s and rarely published numbers on basic research except for sector totals because of the bas quality of the data and because too many national governments fail to collect the necessary information. [163]

All in all, it seems that the current definition of basic research is not judged, by several people, a useful one for policy purposes, [164] at least not as much as the concept was in the 1950s during the NSF's crusade for government funding. For D. Stokes, for example, the definitions "have distorted the organization of the research community, the development of science policy, and the efforts to understand the course of scientific research"; [165] it "has

[158] See, for example: HMSO (1999), *Science, Engineering and Technology Statistics 1999*, London: DTI/OST.
[159] HMSO (1985), *Annual Review of Government Funded R&D*, London, p. 183.
[160] HMSO (1990), *op. cit*., p. 11.
[161] In fact, since the mid 1970s, governments started to delete the question in their surveys.
[162] NRC (1995), *op. cit*.; OECD (1993), *op. cit*., chapter 12; Averch, H.A. (1991), The Political Economy of R&D Taxonomies, *Research Policy*, 20: 179-194; HMSO (1990), *op. cit*.
[163] The only numbers appear in *Basic Science and Technology Statistics*, but missing data abound.
[164] Neither for industrialists (Nason, 1981), nor governments. According to the NSF itself, industrial representatives "prefer that the NSF not request two separate figures" (basic and applied), but "the Foundation considers it to be extremely important" to distinguish both (K. Sanow (1963), *Survey of Industrial R&D in the United States: Its History, Character, Problems, and Analytical Uses of Data*, paper presented at the OECD Frascati meeting, DAS/PD/63.38, p. 13. As regards governments representatives, the report of the second OECD users group that reported that the least popular of all the standard indicators were those concerning basic research, applied research and experimental development: OECD (1978), *Report of the Second Ad Hoc Review Group on R&D Statistics*, SPT (78) 6.
[165] Stokes (1982), *op. cit*., p. 2.

distorted the research agendas of the so-called mission agencies" because it has limited research support to pure applied research [166] and constrained NSF to pure basic research. [167] For L. Branscomb, NSF's "definitions are the source of much of the confusion over the appropriate role for government in the national scientific and technical enterprise". [168]

An important question remains: why, if numbers solidify concepts according to A. Desrosières, has the definition of basic research not gained strength over time? Why has the definition remained in the OECD methodological manual and in national surveys despite serious reservations? The reasons are many.

Firstly, because of statistics themselves. As seen in the discussions that took place during the OECD 1992 meeting of national experts, there has been a desire to preserve historical distinctions and the statistical series associated with it. As a result, experts were encouraged to move "toward how strategic research might be accommodated by drawing distinctions within the basic and applied categories, rather than by cutting across the categories". [169] There were associated practical reasons as well, such as accounting: institutions collect information for operational purposes, not for statistics.

Secondly, "there was also the semantic concern than strategic research might be confused with national and international security studies, or with research on strategic materials or technologies", or that "by reporting commercially relevant strategic research an OECD country might be seen by other governments as indirectly subsidizing goods exported by firms that benefited from the results of such research". [170]

Finally, there was fear, in the academic community, that governments would favor strategic over fundamental research: "The funding of fundamental research could be viewed by mission agencies as having no political advantage". (…) Hence, universities may be adversely affected or have to reclassify some research efforts in order to gain funding for projects". [171]

[166] *Ibidem*, p. 14.
[167] *Ibidem*, p. 15.
[168] Branscomb (1998), *op. cit*., p. 120.
[169] Stokes (1997), *op. cit*., p. 69.
[170] *Ibidem*. See also OECD (1991), DSTI/STII(91)7, footnote 1.
[171] NSF (1989), *op. cit*., p. 9; See also OECD (1991), DSTI/STII(91)7, paragraphs 9 and 10.

Notwithstanding all these reasons, a major factor that explains the concept's stability, at least at the OECD level, is a founding rule of the organization: all decisions have to be made by consensus. Since the concept of basic research has a relatively long history — a politically charged history no less —, since the definition was inscribed from the start in the Frascati manual, and since we possess a statistical series running back to the 1960s, it would take important arguments to counter the inertia.

Conclusion

Basic research is a central category for the measurement of science. Taxonomies have occupied academics, governments and statisticians for over fifty years. In the course of these efforts, the concept passed from a period where it was more or less well defined to a precise definition, for survey purposes, centered on the motivations of the researchers and the non-application of research results. The concept got institutionalized because organizations were specifically created for funding basic research, but also because of statistics. Without surveys and numbers the concept would probably never have congealed – or at least <u>not in the way it did</u> because the criticisms were too numerous and frequent.

The history of the concept is not a linear story, however. Even if Huxley and Bush launched the concept in taxonomies and the NSF appropriated and institutionalized it immediately, it remains that it does not deserve consensus among countries, institutions and individuals. The history of the concept and its measurement centers around three stages or periods. The first stage is one where what is referred to when talking of basic research takes different labels. Pure, fundamental and basic are used interchangeably to refer to a similar object - an object defined with related notions of knowledge, freedom and curiosity. The second stage is that of the institutionalization of the term and of the concept of "basic research". It emerged because Bush and Steelman argued politically, for the first, and quantitatively, for the second. It then got institutionalize by the NSF and the OECD. The survey was one of the main vehicle for this institutionalization. The third stage, partly overlapping with the second, is a stage where the concept is criticized and, sometimes, even abandoned by some, even if it persists at the NSF and OECD.

All in all, statistics were influential in helping to give basic research political identity and value. This lasted from 1947 (Steelman report) to the beginning of the seventies. The concept and its measurement remained relatively intimate as long as the interests of those of policy-makers and academics were served. "Things described by statistics are solid and hold together (…) to the extent that they are linked to hard social facts: institutions, laws, customs, etc". [172] "Clusters [statistics] are justified if they render action possible, if they create things which can act and which can be acted upon". [173] When interests began to clash in the seventies, the stabilizing force of statistics deteriorated. It was a time where oriented research began to be seen as far more important for policy-makers than basic research *per se*. Whether or not basic research was measured in a valid manner suddenly made difference. More and more people began to look seriously at the then current definitions used for statistical purposes in order to challenge them. The OECD was a platform where such discussions were held. Then, people started using new definitions and tried to produce appropriate numbers: strategic research (United Kingdom) and, later in the nineties, innovation. Today, basic research holds the second place, that is the residual, at least if one looks at statistics and the naming and ordering of categories of research: the basic (or pure)/applied dichotomy has been replaced by oriented/non-oriented in R&D statistics (broken down by socioeconomic objectives). [174] A complete reversal of the traditional hierarchy.

Contrary to what Lord Rotshchild thought, issues surrounding definitions are not merely semantic. The basic/applied dichotomy has led to numerous debates about where the responsibility for government funding ends and that for industry begins. Categorization is important, as the UK Select Committee argued, "because wrong orientation could have repercussions on funding". [175] Definitions often carry large sums of money. In fact, "once a class of research is identified as potentially helpful (…) a funding program usually follows". [176] This is why official definitions and statistics matter.

[172] A. Desrosières (1990), op. cit., p. 198.
[173] Ibid, p. 200.
[174] See: European Union (2001), *Statistics in Focus*, 2, p. 4; OECD (2001), *Main Science and Technology Indicators*, 1, Paris, p. 48.
[175] HMSO (1990), *op. cit*., pp. 11-12.
[176] Hensley (1988), *op. cit*., p. 9.

Annex

Taxonomies of R&D:

Huxley (1934)	background/basic/ad hoc/development
Bernal (1939)	pure (and fundamental)/applied
Bush (1945)	basic/applied
Bowman (in Bush, 1945)	pure/background/applied and development
Steelman (1947)	fundamental/background/applied/development
NSF (1953)	basic/applied/development
Carter and Williams (1959)	basic/background-applied/product-directed/development
OECD (1963)	fundamental/applied/development

Other labels used for basic research:

Autonomous (Falk, 1973)
Curiosity-driven (Irvine and Martin, 1984)
Exploratory (IRI, 1978)
Free (Waterman, 1965)
Intensive (Weisskopf, 1965)
Long term (Langenberg, 1980) [177]
Non-mission oriented (NAS, 196?)
Non-oriented (OECD, 1991) [178]
Non-programmatic (Carey, 19??)
Uncommitted (Conant, in NSF, 1951; Harvard Business School, 1953 [179])

Sub-classes for basic research:

Generic (GAO, 1987)
Objective (Office of the Minister for Science, 1961)
Oriented (UNESCO, 1961; OECD, 1970; UK Government, 1985)
Strategic (House of Lords, 1972; 1990; Irvine and Martin, 1984; NSF Task Force, 1989)

Extensions of the concept:

Basic technological research (Stokes, 1997; Branscomb, 1998; DTI/OST, 2000)

[177] D.N. Langenberg (1980), *Memorandum for Members of the National Science Board*, NSB-80-358, Wasington.
[178] *Main Science and Technology Indicators*.
[179] Dearborn, D.C., R.W. Knezmek, R.N. Anthony (1953), *Spending for Industrial Research, 1951-1952*, Graduate School of Business Administration, Harvard University. This survey was at the origin of the NSF's industrial survey.