The Making of Statistical Standards:
The OECD and the Frascati Manual, 1962-2002

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Abstract

From its very beginning, science policy was defined according to the anticipated economic benefits of science. To contribute to this end, the OECD produced a methodological manual for national statisticians, aimed at conducting surveys of research and development. The Frascati manual (1962) offered a statistical, or accounting answer to three policy questions, or issues of the time: the allocation of resources to science, the balance between choices or priorities, and the efficiency of research.

This paper looks at how national accounting got into the measurement of scientific and technical activities. It discusses early national accounting exercises on science from the 1930s onward, and their influence on the OECD and its member countries. This paper suggests that accounting brought forth a specific definition of science and its measurement.

The Making of Statistical Standards:
The OECD and the Frascati Manual, 1962-2002

Introduction

In the 1950s, a new type of analysis appeared in the emerging field of science studies: accounting exercises. The analyses were of two kinds. A first one was growth accounting. Economists developed different techniques, among them econometric equations, most of them based on the concept of labor productivity, to estimate the contribution of science and technology to economic growth. Among the forerunners were J. Schmookler and M. Abramovitz. [1] In 1957, R. Solow formalized the analyses, using an equation called the production function. [2]

A second kind of accounting analyses was national accounting. Here, academics measured the "costs" of science and technology and its share in the national income or budget. The first and most influential such study was Machlup's *The Production and Distribution of Knowledge in the United States*, published in 1962. [3] But there were public organizations involved in such kinds of analyses as well, the first among them being the US National Science Foundation (NSF) and the OECD.

These measurements of science were quite different from the previous statistics produced from the 1860s onward. Then, what was measured were "men of science", or scientists, and their output: knowledge, or scientific publications. J. M Cattell, an American psychologist and editor of *Science* from 1895 to 1944, was the first systematic producer

[1] J. Schmookler (1952), The Changing Efficiency of the American Economy, 1869-1938, *Review of Economics and Statistics*, 34, pp. 214-231; M. Abramovitz (1956), Resource and Output Trends in the United States Since 1870, *American Economic Review*, 46, pp. 5-23; J. Kendrick (1956), Productivity Trends, Capital and Labor, *Review of Economics and Statistics*, 38, pp. 248-257.
[2] R. Solow (1957), Technical Change and the Aggregate Production Function, *Review of Economics and Statistics*, 39, pp. 312-320.
[3] F. Machlup (1962), *The Production and Distribution of Knowledge in the United States*, Princeton: Princeton University Press.

of statistics on men of science, based on data from a directory he started publishing regularly in 1906. [4] The systematic counting of scientific publications we owe to psychologists. At the same time as Cattell, psychologists started collecting data on the discipline's output, in order to contribute to the advancement of psychology as a science. [5]

This paper looks at national accounting of science, and at the OECD Frascati manual as a major contributor to the field. Adopted by member countries in 1963, the manual is a methodological document for conducting surveys on research and development (R&D). [6] It suggests definitions, classifications and indicators for national statisticians in order to compile comparable statistics among countries. According to the OECD, the manual "has probably been one of the most influential documents issued by this Directorate (…)". [7] It allowed the collection of standardized statistics among several countries, and made possible, for the first time in history, international comparisons on science. The manual is now in its sixth edition (2002), and is the standard used in national statistical offices.

Using archival material from the OECD, as deposited at the European University Institute in Florence, this paper shows what accounting for science owes to the manual, looking at its first forty years of existence (1962-2002). From its very beginning, science policy was defined according to the anticipated economic benefits of science. To contribute to this end, the Frascati manual offered a statistical, or accounting, answer to three policy questions or issues of the time: the allocation of resources (how much should government invest in science), the balance between choices or, priorities (where to invest), and efficiency (what are the results).

The first part of this paper traces the origins of national accounting for scientific activities. It discusses the main 20th Century developments leading to the Frascati

[4] B. Godin (2007), From Eugenics to Scientometrics: Galton, Cattell and Men of Science, *Social Studies of Science*, 37 (5), pp. 691-728.
[5] B. Godin (2006), On the Origins of Bibliometrics, *Scientometrics*, 68 (1), pp.109-133.
[6] OECD (1962), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development,* DAS/PD/62.47. Hereafter cited as FM.
[7] OECD (1979), *Notes by the Secretariat on the Revision of the Frascati Manual,* DSTI/SPR/79.37, p. iii.

manual. The second part looks at the manual's central statistic for allocating resources to science – Gross Expenditures on R&D (GERD) – and discusses what goes into the measurement of science. The third part looks at the use of statistics for "balancing" the science budget, while the last part looks at efficiency. This last part suggests that although the Frascati manual was entirely devoted to measuring inputs (investments in R&D), this was only the first stage toward input/output analyses.

The paper suggests that the real challenge of statistics on science is conceptual. In fact, mathematics is not a complicated issue here. More often than not, official statistics on science does not involve much sophisticated mathematics. It is essentially a descriptive statistics, although some statisticians have recently started constructing composites, with much controversy. The main difficulty is conceptual: defining the phenomena and events one wants to measure, drawing boundaries between what to include and what to exclude in the measurement, and constructing a relevant conceptual framework for policy-makers. These are the aspects that have driven the development of the OECD Frascati manual since the 1960s, and which are documented and analyzed here. A statistics never measures a phenomenon or event directly; it quantifies it. That is, it measures by way of a representation.

National Accounting

National accounting for science is part of a larger movement. National accounting for the economy appeared in England at the end of the 17th Century. Using data from various sources, among them population figures and tax records, William Petty and Gregory King produced the first estimates of national "income of the people". The aims were twofold: calculate the taxable capacity of the nation and effect policies, and compare the material strength or wealth of the country to that of rival nations. The two authors would soon be followed by others, first of all in England, but also in other countries like France (P. Boisguilbert, M. Vauban).

Prior to World War II, such exercises were mainly conducted by individual investigators. [8] Then, in 1932, with the impetus of the Great Depression and the need to devise macroeconomic policy, the US Congress gave the Department of Commerce a mandate to prepare a comprehensive set of national accounts. Economist Simon Kuznets, who had done considerable work with the National Bureau of Economic Research's early national accounting exercises in the 1920s, set the basic framework for what became the System of National Accounts. [9] Similar works in Great Britain, conducted by Richard Stone, [10] led to a standardized system conventionalized by international organizations like the United Nations and the OEEC (Organization for European Economic Co-Operation), and used in most countries of the world. [11]

While early national accounting exercises focused on measuring *incomes*, the System of National Accounts also collects information on the *production* (value) of goods and services in a country, and on their consumption. As C. S. Carson suggested, the central question for government with regard to the development of the accounts during the 1940s was: "Given government expenditures, how much of the total product will be left for civilian consumption?". [12] This focus on products had consequences on estimates of the national wealth: production was restricted to material production and to marketed (prices) production. It gave the indicator known as Gross National Product (GNP).

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[8] P. Deane (1955), The Implications of Early National Income Estimates for the Measurement of Long-Term Economic Growth in the United Kingdom, *Economic Development and Cultural Change*, 4 (1), Part I, pp. 3-38; P. Studenski (1958), *The Income of Nations: Theory, Measurement, and Analysis, Past and Present*, New York: New York University Press; N. Ruggles and R. Ruggles (1970), *The Design of Economic Accounts*, National Bureau of Economic Research, New York: Columbia University Press; J. W. Kendrick (1970), The Historical Development of National-Income Accounts, *History of Political Economy*, 2 (1), pp. 284-315; A. Sauvy (1970), Histoire de la comptabilité nationale, *Économie et Statistique*, 14, pp. 19-32; C. S. Carson (1975), The History of the United States National Income and Product Accounts: the Development of an Analytical Tool, *Review of Income and Wealth*, 21 (2), pp. 153-181; F. Fourquet (1980), *Les comptes de la puissance*, Paris: Encres; A. Vanoli (2002), *Une histoire de la comptabilité nationale*, Paris: La Découverte.

[9] S. S. Kuznets (1941), *National Income and its Composition, 1919-1938*, New York: NBER.

[10] T. Suzuki (2003), The Epistemology of Macroeconomic Reality: the Keynesian Revolution from an Accounting Point of View, *Accounting, Organizations and Society*, 28, pp. 471-517.

[11] 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; OEEC (1958), *Standardized System of National Accounts*, Paris.

[12] C. S. Carson (1975), The History of the United States National Income and Product Accounts, *op. cit.*, p. 169.

The System of National Accounts is a *representation* of the economic activity, as production and circulation, framed into an accounting framework (the exemplar of which is the firm). To a significant degree, the measurement of scientific activities has adopted this framework. Since the 1950s, official statistics on science, technology and innovation have been collected and presented in an accounting framework. The emblematic model for such an understanding is the OECD Frascati manual. The manual offers national statisticians definitions, classifications and methodologies for measuring the expenditures and human resources devoted to R&D.

How did an accounting framework get into science? Official statistics on R&D started to be collected in the early 1920s in the United States, then in Canada and Great Britain. [13] Before the 1950s, official measurement of R&D was usually conducted piecemeal. Organizations surveyed either industrial or government R&D, for example, but very rarely aggregated the numbers to compute a "national research budget". The first such efforts arose in Great Britain and the United States, and were aimed at assessing the share of expenditures that should be devoted to science (and basic science) compared to other economic activities, and at helping to build a case for increased R&D resources.

The British scientist J. D. Bernal was one of the first academics to perform measurement of science expenditures in a Western country. He was also one of the first to figure out how much was spent nationally on R&D – the **budget of science**, as he called it. 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. [14] He had a hard time compiling the budget, however, because "the sources of money used for science do not correspond closely to the separate categories of administration of scientific research". [15] "The difficulties in assessing the precise sum annually expended

[13] B. Godin (2005), *Measurement and Statistics on Science and Technology: 1920 to the Present*, London: Routledge.
[14] J. D. Bernal (1939) [1973], *The Social Function of Science*, Cambridge (Mass.): MIT Press, pp. 57-65.
[15] *Ibid*. p. 57.

on scientific research are practically insurmountable. It could only be done by changing the method of accounting of universities, Government Departments, and industrial firms". [16] The national science budget was nevertheless estimated at about four million pounds for 1934, and Bernal added: "The expenditure on science becomes ludicrous when we consider the enormous return in welfare which such a trifling expenditure can produce". [17]

Bernal also suggested a type of measurement that became the main indicator of science and technology: the research budget as a percentage of the national income. He compared the UK's performance with that of the United States and the USSR, and suggested that Britain should devote between one-half percent and one percent of its national income to research. [18] The number was arrived at by comparing expenditures in other countries, among them the United States which invested 0.6%, and the Soviet Union which invested 0.8%, while Great Britain spent only 0.1%. "This certainly seems a very low percentage and at least it could be said that any increase up to tenfold of the expenditure on science would not notably interfere with the immediate consumption of the community; as it is it represents only 3% of what is spent on tobacco, 2% of what is spent on drink, and 1% of what is spent on gambling in the country". [19] "The scale of expenditure on science is probably less than one-tenth of what would be reasonable and desirable in any civilized country". [20]

The source of Bernal's idea of a ratio is probably a very early calculation made by British economist L. Levi in 1869. [21] Using data from a circular sent to British scientific societies, Levi computed a ratio of incomes of scientific societies to national income of 0.04 %. Another such calculation before Bernal was that of E. B. Rosa, chief scientists at the US Bureau of Standards. In 1920, Rosa compiled, for the first time in American

[16] *Ibid*. p. 62.
[17] *Ibid*. p. 64.
[18] *Ibid*. p. 65.
[19] *Ibid*. p. 64.
[20] *Ibid*. p. 65.
[21] L. Levi (1869), On the Progress of Learned Societies, Illustrative of the Advancement of Science in the United Kingdom during the Last Thirty Years, in *Report of the 38th Meeting of the British Association for the Advancement of Science* (1868), London: John Murray, pp. 169-173.

history, a government budget for "research-education-development". [22] Rosa estimated that government's expenditures on research amounted to 1% of the federal budget. In the following year, J. M. Cattell, editor of *Science*, would use the ratio (1%) in his crusade for the advancement of science. [23] In the next decades, variants of the ratio took on names like research intensity, then technology intensity. [24]

The next experiment toward estimating a national budget was conducted in the United States by V. Bush in his well-known report to the President titled *Science: The Endless Frontier*. [25] Primarily using existing data sources, the Bowman committee – one of the four committees involved in the report – estimated the **national research budget** at $345 million (1940). These were very rough numbers, however: "since statistical information is necessarily fragmentary and dependent upon arbitrary definition, most of the estimates are subject to a very considerable margin of error". [26] The committee showed that industry contributed by far the largest portion of the national expenditure, but calculated that the government's expenditure expanded from $69 million in 1940 to $720 million in 1944. It also documented how applied, rather than basic, research benefited most from the investments (by a ratio of 6 to 1), and developed a rhetoric arguing that basic research deserved more resources from government.

The committee added data on national income in its table on total expenditures, and plotted R&D per capita of national income on a graph. But nowhere did the committee use the data to compute the research budget as a percentage of national income, as Bernal had. It was left to the US President's Scientific Research Board to innovate in this respect. In 1947, at the request of the US President, the Board published its report *Science and Public Policy*, which estimated, for the second time in as many years, a **national**

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[22] E. B. Rosa (1921), Expenditures and Revenues of the Federal Government, *Annals of the American Academy of Political and Social Sciences*, 95, May, pp. 26-33. See also: E. B. Rosa (1920), Scientific Research: The Economic Importance of the Scientific Work of the Government, *Journal of the Washington Academy of Science*, 10 (12), pp. 341-382.
[23] J. M. Cattell (1922), The Organization of Scientific Men, *The Scientific Monthly*, June, pp. 568-578.
[24] 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.
[25] V. Bush (1945) [1995], *Science: The Endless Frontier*, North Stratford: Ayer Co., pp. 85-89.
[26] *Ibid*. p. 85.

R&D budget. [27] With the help of a questionnaire it sent to 70 industrial laboratories and 50 universities and foundations, the Board in fact 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. [28] The Board estimated the US budget at $600 million (annually) on average for the period 1941-45. For 1947, the budget was estimated at $1.16 billion. The federal government was responsible for 54% of total R&D expenditures, followed by industry (39%), and universities (4%).

Based on the numbers obtained in the survey, the Board proposed quantified objectives for science policy. For example, it suggested that resources devoted to R&D be doubled in the next ten years, and that resources devoted to basic research be quadrupled. The Board also introduced into science policy the indicator first suggested by Bernal, and that is still used by governments today: R&D expenditures as a percentage of national income. Unlike Bernal however, the Board did not explain how it arrived at a 1% goal for 1957. Nevertheless, President Truman subsequently incorporated this objective into his address to the American Association for the Advancement of Science (AAAS) in 1948. [29]

The last exercise in constructing a total R&D figure, before the NSF entered the scene, came from the US Department of Defense in 1953. [30] Using many different sources, the Office of the Secretary of Defense for 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 work: "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 Office's concepts of sources (of funds) and performers (of research activities) would soon become the main categories of the NSF's accounting

[27] US President's Scientific Research Board (1947), *Science and Public Policy*, President's Scientific Research Board, Washington: USGPO, p. 9.
[28] *Ibid*. p. 73.
[29] H. S Truman (1948), *Address to the Centennial Anniversary*, AAAS Annual Meeting, Washington.
[30] Department of Defense (1953), *The Growth of Scientific R&D*, Office of the Secretary of Defense (R&D), RDB 114/34, Washington.

system for R&D. The statistics showed that the federal government, as a source of funds, was responsible for 60% of the total, [31] 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 institutions and universities (11%).

Then came the NSF. According to its mandate, the organization started measuring R&D across all sectors of the economy with specific and separate surveys in 1953: government, industry, university and non-profit. [32] Then, in 1956, it published its "first systematic effort to obtain a systematic across-the-board picture" [33] – one year before Great Britain did. [34] It consisted of the sum of the results of the sectoral surveys for estimating **national funds**. [35] The NSF calculated that the national budget amounted to $5.4 billion in 1953. [36]

The organization's analyses made extensive use of gross national product (GNP). For the NSF, this was its way to relate R&D to economic output: "despite the recognition of the influence of R&D on economic growth, it is difficult to measure this effect quantitatively", stated the NSF. [37] Therefore, this "analysis describes the manner in which R&D expenditures enter the gross national product in order to assist in establishing a basis for valid measures of the relationships of such expenditures to aggregate economic

[31] The Department of Defense and the Atomic Energy Commission were themselves responsible for 90% of the federal share.
[32] B. Godin (2002), The Number Makers: Fifty Years of Science and Technology Official Statistics, *Minerva*, 40 (4), pp. 375-297; B. Godin (2003), The Emergence of S&T Indicators: Why Did Governments Supplement Statistics with Indicators, *Research Policy*, 32 (4), pp. 679-691.
[33] NSF (1956), Expenditures for R&D in the United States: 1953, *Reviews of Data on R&D*, 1, NSF 56-28, Washington.
[34] Advisory Council on Scientific Policy (1957), *Annual Report 1956-57*, Cmnd 278, HMSO: London.
[35] The term "national" appeared for the first time only in 1963. See: NSF (1963), National Trends in R&D Funds, 1953-62, *Reviews of Data on R&D*, 41, NSF 63-40.
[36] The data were preliminary and were revised in 1959. See: NSF (1959), Funds for R&D in the United States, 1953-59, *Reviews of Data on R&D*, 16, NSF 59-65.
[37] NSF (1961), R&D and the GNP, *Reviews of Data on R&D*, 26, NSF 61-9, p. 2.

output".[38] The ratio of research funds to GNP was estimated at 1.5% for 1953, 2.6% for 1959 and 2.8% for 1962. The NSF remained careful, however, with regard to interpretation of the indicator: "Too little is presently known about the complex of events to ascribe a specified increase in gross national product directly to a given R&D expenditure".[39]

In the same publication, the NSF innovated in another way over previous attempts to estimate the national budget. Using the Department of Defense categories, the organization constructed a matrix of financial flows between the sectors, as both sources and performers of R&D (Table 1). 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 tables were thereafter published regularly in the NSF bulletin series *Reviews of Data on R&D*,[40] until a specific and more extensive publication appeared in 1967.[41]

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[38] *Ibid*. p. 1.
[39] *Ibid*. p. 7.
[40] *Reviews of R&D Data*, Nos. 1 (1956), 16 (1959), 33 (1962), 41 (1963); *Reviews of Data on Science Resources*, no. 4 (1965).
[41] NSF (1967), *National Patterns of R&D Resources*, NSF 67-7, Washington.

Table 1.

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

The matrix was the result of deliberations on the US research system conducted in the mid-fifties at the NSF[42] 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. [43] But "today, data on R&D funds and personnel are perhaps at the stage of growth in which national income data could be found in the 1920s". [44] Links with the System of National Accounts (SNA) 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

[42] "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 NSF Experience, in NSF, *Methodological Aspects of Statistics on Research and Development: Costs and Manpower*, NSF 59-36, Washington, p. 57.

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

[44] K. Arnow (1959), National Accounts on R&D: The NSF Experience, NSF, Methodological Aspects of Statistics on R&D: Costs and Manpower, *op. cit.*, p. 61.

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”. [45]

The NSF methodological guidelines – as well as the matrix – became international standards with the adoption of the OECD methodological manual by member countries in Frascati (Italy) in 1963.

The Frascati Manual

The Frascati manual is a methodological document aimed at national statisticians for collecting data on R&D. It proposed standardized definitions, classifications and a methodology for conducting R&D surveys. The first edition was prepared by British economist C. Freeman from the National Institute of Economic and Social Research (London), who was assigned at the time to improving the survey on industrial R&D conducted by the Federation of British Industries (FBI). Freeman was sent to the OECD by E. Rudd, from the British Department of Scientific and Industrial Research (DSIR). He visited the main countries where measurements were conducted. The manual owes a great deal to the NSF and its series of surveys in the early 1950s. [46]

The Frascati manual essentially developed three sets of guidelines. Firstly, norms were proposed for defining science as “systematic” research and demarcating research from other activities so these other activities could be excluded: research/related scientific activities, development/production, research/teaching. Secondly, the manual suggested classification of research activities according to 1) the sector that finances or executes the research: government, university, industry or non-profit organizations and, in relation to this latter dimension, 2) the type or character of the research, which is either basic, applied or concerned with the development of products and processes, 3) the activities classified by discipline in the case of universities (and non-profit organizations), by

[45] H. E. Stirner (1959), A National Accounting System for Measuring the Intersectoral Flows of R&D Funds in the United States, in NSF, Methodological Aspects of Statistics on R&D: Costs and Manpower, *op. cit*., p. 32.
[46] This is admitted in the first edition, FM (1962), p. 7.

industrial sector or product in the case of firms, and by functions or socioeconomic objectives in the case of governments. Finally, the manual suggested a basic statistic as an indicator for policy purposes.

Accounting for Science

The Frascati manual suggests collecting two types of statistics on science and technology: the financial resources invested in R&D, and the human resources devoted to these activities. The main indicator to come out of the manual is **Gross Domestic Expenditures on R&D** (GERD) – the sum of R&D expenditures in the four main economic sectors: business, university, government and non-profit. [47] The manual's specifications also allow one to follow the flow of funds between sectors (by way of a matrix), specifically between funders and performers of R&D.

GERD is the term invented by the OECD for measuring what was, before the 1960s, called national funds or budget. [48] In line with the System of National Accounts, and following the NSF, the manual recommended summing R&D according to the three main economic sectors: business, government and private non-profit, [49] to which the OECD, following the NSF again, added a fourth one: higher education. The following rationale was offered for the decision: [50]

> The definitions of the first three sectors are basically the same as in national accounts, but higher education is included as a separate main sector here because of the concentration of a large part of fundamental research activity in the universities and the crucial importance of these institutions in the formulation of an adequate national policy for R&D.

[47] The measure includes R&D funded from abroad, but excludes payments made abroad.
[48] FM (1962), pp. 34-36.
[49] Households, that is, the sector of that name in the System of National Accounts, was not considered by the manual.
[50] FM (1962), p. 22.

Why align R&D statistics with the system of national accounts? The first edition of the OECD Frascati manual stated that the classification of R&D data by economic sector "corresponds in most respects to the definitions and classifications employed in other statistics of national income and expenditure, thus facilitating comparison with existing statistical series, such as gross national product, net output, investment in fixed assets and so forth". [51]

The system of national accounts, now in its fourth edition, was developed in the early fifties and conventionalized at the world level by the United Nations. At the time, R&D was not recognized as a category of expenditures that deserved a specific mention in the national accounts. [52] In 1993 again, during the last revision of the system of national accounts, the United Nations rejected the idea of recognizing R&D "because it was felt that it opened the door to the whole area of intangible investment". [53] It decided instead to develop a functional classification of expenditures that would make items such as R&D visible in the system of national accounts by way of what was called "satellite accounts". [54] Despite its alignment with the system of national accounts, however, the Frascati manual still uses a different system of classification in a number of cases, including, for example, the coverage of each economic sector. [55]

The GERD, as statistics on national research, remains fragile. The first edition of the Frascati manual suggested that national "variations [in R&D statistics] may be gradually reduced" with standardization. [56] But the collection of statistics on R&D expenditures remains a very difficult exercise: not all units surveyed have an accounting system to track the specific expenses defined as composing R&D. The OECD regularly had to adjust or estimate national data to correct discrepancies. It also started a series called *Sources and Methods* documenting national differences with regard to OECD standards.

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[51] FM (1962), p. 21.
[52] Only institutions primarily engaged in research are singled out as a separate category.
[53] J. F. Minder (1991), *R&D in National Accounts*, OECD, DSTI/STII (91) 11, p. 3.
[54] See annex 11 of the 1994 edition of the Frascati manual.
[55] S. Peleg (2000), *Better Alignment of R&D Expenditures as in Frascati Manual with Existing Accounting Standards*, OECD/EAS/STP/NESTI (2000) 20; OECD (2001), *Better Alignment of the Frascati Manual with the System of National Accounts*, DSTI/EAS/STP/NESTI (2001)14/PART8.
[56] FM (1962), p. 6.

It finally developed a whole system of footnotes, allowing for the construction of comparable data among member countries while black-boxing the data's limitations. [57] Consequently, what one observes is increasing reliance with time on what official statisticians would call "sub-optimal" (or non-survey) techniques of measurement in member countries, to the point that the Frascati manual has started "standardizing" these techniques.

This is the case for R&D in the higher education sector. In the 1970s, the OECD launched a series of studies on its international surveys on R&D. [58] After having analyzed the data, the OECD refused to publish the report devoted to university R&D: [59] the data being qualified as "rather unsatisfactory" because of "serious conceptual and practical problems" that prevented reliable international comparisons. [60] How, for example, could a country spend twice as much as another on university research and yet report similar numbers of university personnel involved in R&D? Why did expenditures on basic research differ by a ratio of 1 to 2 between otherwise similar countries? The sources of the discrepancies were: [61] coverage of the university sector differed according to country (some institutions, like university hospitals and national research councils, were treated differently); estimates were used in place of surveys because they were cheaper, and coefficients derived from the estimates were little more than informed guesswork and were frequently out-of-date; general university funds were attributed either to the funder or to the performer; the level of aggregation (fields of science classification) was generally not detailed enough to warrant analysis; finally, there was a great deal of subjectivity involved in classifying research activities, according to a

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[57] B. Godin (2002), *Metadata: How Footnotes Make for Doubtful Numbers*, http://www.inrs-ucs.uquebec.ca/inc/CV/godin/metadata.pdf.

[58] OECD (1971), *R&D in OECD Member Countries: Trends and Objectives*; OECD (1975), *Patterns of Resources Devoted to R&D in the OECD Area, 1963-1971*; 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*; OECD (1979), *Trends in Industrial R&D in Selected OECD Countries, 1967-1975*; 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.

[59] 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, *op. cit.*

[60] *Ibid*, p. 1.

[61] Some of these were already well identified as early as 1969. See: OECD (1969), *The Financing and Performance of Fundamental Research in the OECD Member Countries*, DAS/SPR/69.19, p. 4.

basic/applied scheme that was "no longer used in certain countries, although policy makers still persist in requesting such data in spite of its many shortcomings" [62]

These difficulties led to a small-scale survey of national methods for measuring resources devoted to university research in 1981, [63] updated in 1983, [64] a workshop on the measurement of R&D in higher education in 1985 [65] and, as a follow-up, a supplement to the Frascati manual in 1989, [66] which was later incorporated into the manual as Appendix 3. The supplement recommended norms for coverage of the university sector, the activities and types of costs to be included in research, and the measurement of R&D personnel. Following editions of the Frascati manual "authorized" estimations of R&D expenditures based on techniques that the unpublished report disqualified: [67] estimates are used in place of surveys because they are cheaper, and coefficients derived from the estimates are little more than informed guesswork and are frequently out-of-date.

This was only the first example of deviating from the norm concerning the survey as the preferred instrument. [68] Government R&D was a second example. The OECD began collecting data on socioeconomic objectives of government funded R&D in the early 1970s, and introduced corresponding standards in the third edition of the Frascati manual (1975). [69] The method was in fact supplied by the European Commission. A work group of European statisticians was set up as early as 1968 by the Working Group on Scientific and Technical Research Policy in order to study central government funding of R&D. The purpose was to "indicate the main political goals of government when committing

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[62] OECD (1986), *Summary Record of the OECD Workshop on Science and Technology Indicators in the Higher Education Sector*, DSTI/SPR/85.60, p. 24.
[63] OECD (1981), *Comparison of National Methods of Measuring Resources Devoted to University Research*, DSTI/SPR/81.44.
[64] OECD (1984), *Comparison of National Methods of Measuring Resources Devoted to University Research*, DSTI/SPR/83.14.
[65] OECD (1985), *Summary Record of the OECD Workshop on Science and Technology Indicators in the Higher Education Sector*, DSTI/SPR/85.60.
[66] OECD (1989), *The Measurement of Scientific and Technical Activities: R&D Statistics and Output Measurement in the Higher Education Sector*, Paris.
[67] FM (1993), pp. 146ss.
[68] "While a certain amount of R&D data can be derived from published sources, there is no substitute for a special R&D survey", FM (1981), p. 22.
[69] The first two editions of the Frascati manual included preliminary and experimental classifications.

funds to R&D". [70] The implicit goal was to contribute to the "construction" of a European science policy and budget. To this end, the Commission adopted the *Nomenclature for the Analysis and Comparison of Science Programmes and Budgets* (NABS) in 1969 [71] produced by the group of experts, and published a statistical analysis based on the classification. [72]

In line with the spirit of the Brooks report, which had argued for changes in the objectives of government-funded R&D, [73] the OECD Directorate for Science, Technology and Industry (DSTI) adopted the European Commission's approach to obtaining appropriate statistics. [74] However, few governments actually conducted surveys of government R&D. [75] Most preferred to work with budget documents because, although less detailed and accurate than a survey, the information was easier and cheaper to obtain. [76] Among the methodology's advantages was speed, since the data were extracted directly from budget documents without having to wait for a survey. But it also had several limitations, [77] among them the fact that national data relied on different methodologies and concepts, and on different administrative systems. With regard to the classification, it reflected the intention to spend and not real expenditures. Contrary to early expectations, data were difficult to extract from budgets because they lacked the required level of detail: "the more detailed the questions are, the less accurate the data

[70] Eurostat (1991), *Background Information on the Revision of the NABS*, Room document to the Expert Conference to Prepare the Revision of the Frascati Manual for R&D Statistics, OECD.
[71] The first NABS was issued in 1969 and revised in 1975 (and included in the 1980 edition of the Frascati Manual) and again in 1983 (to include biotechnology and information technology, not as categories, but broken down across the whole range of objectives). In 1993, improvements were made in the Environment, Energy, and Industrial Production categories.
[72] CEC (1970), *Research and Development: Public Financing of R&D in the European Community Countries, 1967-1970*, BUR 4532, Brussels.
[73] OECD (1971), *Science, Growth and Society*, Paris.
[74] The first OECD (experimental) analysis of data by socioeconomic objectives was published in 1975: 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, 1962-1972, *op. cit*.
[75] Exceptions are Canada and the United Kingdom. Other countries either produced text analysis of budgets or estimate appropriations from budget documents. For methodologies used in European countries, see: Eurostat (1995), *Government R&D Appropriations: General University Funds*, DSTI/STP/NESTI/SUR (95) 3, pp. 2-3.
[76] Eurostat (2000), *Recommendations for Concepts and Methods of the Collection of Data on Government R&D Appropriations*, DSTI/EAS/STP/NESTI (97) 10, p. 3.
[77] Eurostat (2000), *The Frascati Manual and Identification of Some Problems in the Measurement of GBAORD*, DSTI/EAS/STP/NESTI (2000) 31.

become" because it was not always possible to define the specific NABS sub-level in the budget – budget items can be quite broad. [78] Finally, OECD statisticians were also confronted with a wide range of budgetary and national classification systems in member countries, over which they had relatively little control: [79]

> The unit classified varied considerably between countries (…) because national budget classification and procedures differ considerably. In some countries, such as Germany, the budget data are available in fine detail and can be attributed accurately between objectives. In others, such as the United Kingdom and Canada, the budgetary data are obtained from a survey of government funding agencies which is already based on an international classification. However, in others again such as France, the original series are mainly votes by ministry or agency.

To better harmonize national practices, a draft supplement to the Frascati manual specifically devoted to measurement of the socioeconomic objectives of government R&D was completed in 1978, [80] but was never issued as a separate publication. These data "play only a modest role in the general battery of science and technology indicators and do not merit a separate manual" stated the OECD. [81] Instead of a separate manual, the specifications were abridged and relegated to a chapter in the fourth edition of the Frascati manual. [82]

All in all, the GERD is not really a national budget, but "a total constructed from the results of several surveys each with its own questionnaire and slightly [one could rather say major] different specifications". [83] Some data come from a survey (industry), others are estimated using different mathematical formulas (university), still other are proxies (government). For this reason: "The GERD, like any other social or economic statistic, can only be approximately true (…). Sector estimates probably vary from 5 to 15% in

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[78] OECD (2000), *The Adequacy of GBAORD Data*, DSTI/EAS/STP/NESTI (2000) 18, p. 3.
[79] OECD (1990), *Improving OECD Data on Environment-Related R&D*, DSTI/IP (90) 25, p. 9.
[80] OECD (1978), *Draft Guidelines for Reporting Government R&D Funding by Socio-Economic Objectives: Proposed Supplement to the Frascati Manual*, DSTI/SPR/78.40.
[81] OECD (1991), *Classification by Socio-Economic Objectives*, DSTI/STII (91) 19, p. 9.
[82] In 1991, Australia again proposed that there should be a supplement to the manual dealing with detailed classification by socioeconomic objectives and fields of science. See: OECD (1992), *Summary Record of the Meeting of NESTI*, DSTI/STII/STP/NESTI/M (92) 1.
[83] D. L. Bosworth, R. A. Wilson and A. Young (1993), *Research and Development*, Reviews of United Kingdom Statistical Sources Series, vol. XXVI, London: Chapman and Hill, p. 29.

accuracy. The GERD serves as a general indicator of S&T and not as a detailed inventory of R&D (…). It is an estimate and as such can show trends (…)". [84]

Nonetheless, according to a recent survey by the OECD Secretariat, GERD is currently the most cherished indicator among OECD member countries, [85] despite the age-old suggestion that human resources are a better statistic. [86] Over the last forty years, the indicator has been used for several purposes, from rhetorically displaying national performance to lobbying for more funds for science to setting policy targets. The OECD was responsible for this worldwide popularization of the indicator. The OECD was also an ardent promoter of the GERD/GDP ratio as policy target. In fact, the American GERD/GDP ratio of the early 1960s, that is 3%, was mentioned in the first paragraphs of the first edition of the Frascati manual, and became the ideal to which member countries would aim. [87] In every OECD statistical publication, the indicator was calculated, discussed, and countries ranked according to it, because "it is memorable", [88] and is " the

[84] Statistics Canada (2002), *Estimates of Total Expenditures on R&D in the Health Fields in Canada, 1988 to 2001*, 88F0006XIE2002007.

[85] OECD (1998), *How to Improve the MSTI: First Suggestions From Users*, DSTI/EAS/STP/NESTI/RD (98) 9.

[86] R. N. Anthony (1951), Selected Operating Data for Industrial Research Laboratories, *op. cit*. pp. 3-4: "In view of these difficulties [accounting methods and definitions], we decided to collect only a few dollar figures (…) and to place most of our emphasis on the number of persons"; W. H. Shapley (1959), Problems of Definition, Concept, and Interpretation of R&D Statistics, in NSF, Methodological Aspects of Statistics on R&D: Costs and Manpower, *op. cit*. p. 13: "Manpower rather than dollars may be a preferable and more meaningful unit of measurement"; C. Freeman (1962), Research and Development: A Comparison Between British and American Industry, *National Institute Economic Review*, 20, May, p. 24: "The figures of scientific manpower are probably more reliable than those of expenditures"; C. Falk, and A. Fechter (1981), *The Importance of Scientific and Technical Personnel Data and Data Collection Methods Used in the United States*, Paper presented for the OECD Workshop on the Measurement of Stocks of Scientific and Technical Personnel, October 12-13, 1981, p. 2: "At the current time scientific and technical personnel data seem to be the only feasible indicator of overall scientific and technical potential and capability and as such represent a most valuable, if not essential, tool for S&T policy formulation and planning".

[87] FM (1963), p. 5. In fact, at the time of the first edition of the Frascati manual, the US GERD/GDP was 2.8%. See: NSF (1962), Trends in Funds and Personnel for R&D, 1953-61, *Reviews of Data on R&D*, 33, NSF 62-9, Washington; NSF (1963), National Trends in R&D Funds, 1953-62, *Reviews of Data on R&D*, 41, NSF 63-40.

[88] OECD (1984), *Science and Technology Indicators*, Paris, p. 26.

most popular one at the science policy and political levels, where simplification can be a virtue". [89]

What Accounting Measures?

Accounting and its methodology, or rather methodological difficulties, has had enormous impact on what was and could be measured. To properly understand the difficulties, one has to turn to history. The Frascati manual was the OECD's response to at least three methodological problems that prevented early statisticians from comparing surveys, drawing historical series or even believing in the numbers generated prior to the 1960s. The first problem concerned definitions of research. Two situations prevailed at the time. Firstly, more often than not, there was no definition of research at all, as was the case in the influential US National Research Council directory of industrial R&D. The first edition reported using a "liberal interpretation" that let each firm decide which activities counted as research: "all laboratories have been included which have supplied information and which by a liberal interpretation do any research work".[90] Consequently, any studies (and there were many) that used National Research Council numbers were of questionable quality: "the use of this information [National Research Council data] for statistical analysis has therefore presented several difficult problems and has necessarily placed some limitations on the accuracy of the tabulated material", warned a study from the US Works Progress Administration.[91] The US National Resources Planning Board used a similar practice in its survey of industrial R&D in 1941: the task of defining the scope of activities to be included under research was left to the respondent.[92] In Canada

[89] OECD (1992), *Science and Technology Policy: Review and Outlook 1991*, Paris, p. 111. The French translation reads as follows: "le plus prisé parmi les responsables de la politique scientifique et des hommes politiques, pour lesquels la simplification se pare parfois de certaines vertus" (p. 119).
[90] National Research Council, *Research Laboratories in Industrial Establishments of the United States of America*, Bulletin of the National Research Council, vol. 1, part 2, March 1920, p. 45.
[91] G. Perazich and P. M. Field (1940), *Industrial Research and Changing Technology*, Works Progress Administration, National Research Project, report no. M-4, Philadelphia, p. 52.
[92] National Resources Planning Board (1941), *Research: A National Resource (II): Industrial Research*, Washington: USGPO, p. 173.

as well, the first study by the Dominion Bureau of Statistics contained no definition of research. [93]

The second situation regarding definitions was the use of categories of research in lieu of a precise definition. Both the V. Bush[94] and US President's Scientific Research Board [95] reports, as well as the first survey from the British Department of Scientific and Industrial Research, [96] suggested categories that resembled each other (basic, applied and development) – but that were never in fact the same. As a rule, these categories served to help respondents decide what to include in their responses to the questionnaire, but disaggregated data were not available for calculating statistical breakdowns. Others, such as the US National Resources Committee, simply refused to use such categories because of the intrinsic connections between basic and applied research, which seemed to prevent any clear distinctions from being made. [97]

The second problem of pre-1960s R&D surveys, closely related to the problem of definition, concerned the demarcations of research and non-research activities. The main purpose of both the Harvard Business School study [98] and the US Bureau of Labor

[93] Dominion Bureau of Statistics (1941), *Survey of Scientific and Industrial Laboratories in Canada*, Ottawa.
[94] V. Bush (1945*)*, Science: The Endless Frontier, *op. cit*., pp. 81-83.
[95] President's Scientific Research Board (1947), Science and Public Policy, *op. cit*., pp. 300-301.
[96] DSIR (1958), *Estimates of Resources Devoted to Scientific and Engineering R&D in British Manufacturing Industry*, 1955, London, p. 8.
[97] National Resources Committee (1938), *Research: A National Resource (I): Relation of the Federal Government to Research*, Washington: USGPO, p. 6.
[98] D. C. Dearborn, R. W. Kneznek and R. N. Anthony (1953), *Spending for Industrial Research, 1951-1952*, Division of Research, Graduate School of Business Administration, Harvard University.

Statistics [99] survey, two influential studies of the early 1950s, was to propose a definition of R&D and to measure it. Two problems were identified: there were too many variations in what constituted R&D, so they claimed, and too many differences among firms on which expenses to include in R&D. Although routine work was almost always excluded, there were wide discrepancies at the frontier between development and production, and between scientific and non-scientific activities: testing, pilot plants, design, and market studies were sometimes included in research and at other times not. Indeed, companies had accounting practices that did not allow these activities to be easily separated. [100] K. Arnow, of the NSF, summarized the problem as follows:

> Even if all the organizations responding to the NSF's statistical inquiries shared, by some miracle, a common core of concepts and definitions, they might still not be able to furnish comparable data, since they draw on a diversity of budget documents, project reports, production records, and the like for estimating R&D expenditures. [101]

According to US accountant R. N. Anthony, author of the Harvard Business School survey, accounting practices could result in variations of up to 20% for numbers on industrial R&D. [102] Both the US Bureau of Census and the NSF also believed that only better accounting practices could correct such errors. [103]

A third and final problem of early R&D surveys concerned the population under study. We have noted how the National Research Council repertory was open to all firms who agreed to complete the questionnaire: "the National Research Council surveys were designed for the purpose of compiling a series of directories of research laboratories in

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[99] US Department of Labor, Bureau of Labor Statistics, Department of Defense (1953), *Scientific R&D in American Industry: A Study of Manpower and Costs*, Bulletin no. 1148, Washington.

[100] O. S. Gellein and M. S. Newman (1973), *Accounting for R&D Expenditures, American Institute of Certified Accountants*, New York; S. Fabricant, M. Schiff, J. G. San Miguel and S. L. Ansari (1975), *Accounting by Business Firms for Investments in R&D*, Report submitted to the NSF, New York University.

[101] K. Arnow (1959), National Accounts on R&D: The NSF Experience, in NSF, *Methodological Aspects of Statistics on Research and Development: Costs and Manpower*, NSF 59-36, Washington, p. 58.

[102] R. N. Anthony (1951), *Selected Operating Data: Industrial Research Laboratories*, Harvard Business School, Division of Research, Boston, p. 3.

[103] H. Wood, Some Landmarks in Future Goals of Statistics on R&D, in NSF (1959), *Methodological Aspects of Statistics on Research and Development: Costs and Manpower*, NSF 59-36, Washington, p. 52; NSF (1960), *Research and Development in Industry, 1957*, NSF 60-49, Washington, p. 99.

the United States. The schedules were therefore sent out without instructions which would have been necessary had it been intended to use the data for purposes of statistical analysis". [104] When statisticians finally began addressing the problem, however, their methodologies differed: some limited the survey to distinct laboratories, [105] others sent the questionnaire on a consolidated company basis, [106] and still others concentrated on big firms to "speed up results". [107] There were no real standards.

All in all, the absence of norms made survey comparisons impossible before the 1960s, which resulted in statistics that were often of limited value. The US President's Scientific Research Board wrote that it was "not possible to arrive at precisely accurate research expenditures" because of three limitations: 1) variations in definition, 2) variations in accounting practices, and 3) the absence of a clear division between science and other research activities. [108] Similarly, the NSF admitted that the industrial R&D surveys it conducted before 1957 were not comparable to those it conducted after that date. [109]

The Frascati manual aimed to improve the situation with precise definitions. Surprisingly, the first edition carried no definition of research at all. Research was rather contrasted to routine work:

> The guiding line to distinguish R&D activity from non-research activity is the presence or absence of an element of novelty or innovation. Insofar as the activity follows an established routine pattern it is not R&D. Insofar as it departs from routine and breaks new ground, it qualifies as R&D (p. 16).

The manual therefore put emphasis on discussing precisely what routine activities were – not in order to measure them, but to exclude them from measurement. [110] The first edition

[104] G. Perazich and P. M. Field (1940), Industrial Research and Changing Technology, *op. cit.* p. 52.
[105] R. N. Anthony (1951), Selected Operating Data: Industrial Research Laboratories, *op. cit.* p. 42.
[106] D. C. Dearborn, R. W. Kneznek and R. N. Anthony (1953), Spending for Industrial Research, 1951-1952, *op. cit.* p. 43.
[107] Dominion Bureau of Statistics (1956), *Industrial Research-Development Expenditures in Canada, 1955*, Ottawa, p. 22.
[108] President's Scientific Research Board (1947), Science and Public Policy, *op. cit.* pp. 73, 301.
[109] NSF (1960), Funds for R&D: Industry 1957, *op. cit*. pp. 97-100
[110] As a UNESCO document once reported, there have never been any positive criteria for defining related scientific activities. See J.-C. Bochet, *The Quantitative Measurement of Scientific and Technological Activities Related to R&D Development*, CSR-S-2, Paris: UNESCO, 1974, p. 2.

dealt extensively with boundaries (frontiers) between routine work and R&D. It distinguished R&D from two other types of activities: related scientific activities and non-scientific activities (of which industrial production was perhaps the most important). It is here that the main differences were said to exist between member countries. According to the 1962 edition, related scientific activities fall into four classes: 1) scientific information (including publications), 2) training and education, 3) data collection, and 4) testing and standardization. Non-scientific activities are of three kinds: 1) legal and administrative work for patents, 2) testing and analysis, and 3) other technical services (see Appendix).

Not measuring related scientific activities was a decision as important as measuring R&D. As UNESCO constantly reminded national statisticians, related scientific activities includes important scientific and technological activities. [111] These activities cover, for example, information, data collection, testing and standardization. Without these activities, several R&D activities would not be possible, or at least not possible in their current form: "the optimal use of scientific and technological information depends on the way it is generated, processed, stored, disseminated, and used". [112] In some countries, related scientific activities amount to over one-third of all scientific and technological activities. The Frascati manual also recognized the centrality of these activities to a country: [113]

> R&D activities are only one part of a broad spectrum of scientific activities which include scientific information activities, training and education, general purpose data collection, and (general purpose) testing and standardization. Indeed, in some countries one or more of these related scientific activities may claim a larger share of material and human resources than R&D. It may well be desirable for such countries to begin their statistical inquiries by surveying one or more of these areas rather than R&D.

[111] K. Messman (1975), *A Study of Key Concepts and Norms for the International Collection and Presentation of Science Statistics*, COM-75/WS/26, UNESCO, pp. 33-34.
[112] UNESCO, *Guide to Statistics on Scientific and Technological Information and Documentation (STID)*, ST-84/WS/18, Paris, 1984, p. 5.
[113] FM (1962), p. 13.

The first edition of the manual suggested measuring these activities, but separately, [114] while the following editions recommended excluding them unless they serve R&D directly. [115] The rationale for the non-treatment of these activities was offered as early as the first edition: "It is not possible here to make a detailed standard recommendation for related scientific activities (…). The objective of this manual is to attain international comparability in the narrower field of R&D (…). Arising from this experience, further international standards can be elaborated by the OECD for related activities". [116] The recommendation for standards was soon abandoned, however, despite talks about extending the Frascati manual to related scientific activities as early as 1964: [117] "We are not concerned here with the problem of measuring R&D related activities," stated the manual, "but with the conventions to be used to exclude them when measuring R&D activities". [118]

Such an understanding of what scientific activities are was in line with a "moral" hierarchy in vogue for decades: "The facilities available in the laboratories make it possible for the scientist to devote his time exclusively to *work of a professional caliber* [R&D]. He is not required to perform *routine* tasks of testing and experimentation but is provided with *clerical and laboratory assistants* who carry on this work". [119] No argument was needed to convince people of this hierarchy. It was taken for granted by almost everybody that "soft" activities like market studies or design, for example, were not part of science. This was the general understanding of the time. [120]

[114] The Frascati manual nevertheless recommended that: "All calculation of deductions for non-research activities of research organizations, and of additions for R&D activities of non-research organizations should be made explicit, that is to say, recorded both by individual respondents and by those compiling national totals from the data furnished by individual respondents. Furthermore, whenever possible, related scientific activities such as documentation and routine testing, should be measured simultaneously with R&D and reported separately". FM (1962), p. 14.
[115] Starting with FM (1970), p. 17.
[116] FM (1962), pp. 14-15.
[117] OECD (1964), *Committee for Scientific Research: Programme of Work for 1965*, SR (64) 33, pp. 12 and 18; OECD (1964), *Committee for Scientific Research: Programme of Work for 1966*, SR (65) 42, p. 23.
[118] FM (1962), p. 14.
[119] G. Perazich and P. M. Field (1940), Industrial Research and Changing Technology, *op. cit*. p. 43.
[120] For an historical point of view, see: S. Shapin (1989), The Invisible Technician, *American Scientist*, 77, pp. 554-563.

Having delimited what was not considered research in the first edition, the OECD turned to a precise definition of research in the second edition: R&D is "creative work undertaken on a *systematic* basis to increase the stock of scientific and technical knowledge, and the use of this stock of knowledge to devise new applications". [121] The idea of systematicness comes from the industrial R&D surveys conducted in the United States since the 1940s. [122] It equated research with organizations or industries that had experimental laboratories, or "organized" research facilities. The US Works Progress Administration report, for example, began with the following fact: "The *systematic* application of scientific knowledge and methods to research in the production problems of industry has in the last two decades assumed major proportions". [123] The authors contrasted colonial times, when research was random, haphazard and unorganized because it was realized by independent inventors, [124] with modern times when, between 1927 and 1938 for example, "the number of organizations reporting research laboratories has grown from about 900 to more than 1,700 affording employment to nearly 50,000 workers". [125] And the report continued: "Industry can no longer rely on random discoveries, and it became necessary to organize the *systematic* accumulation and flow of new knowledge. This prerequisite for the rise of industrial research to its present proportions was being met by the formation of large corporations with ample funds available for investment in research". [126]

[121] FM (1970), p. 8.
[122] National Research Council (1941), *Research: A National Resource (II): Industrial Research*, National Resource Planning Board, Washington: USGPO; D. C. Dearborn, R. W. Kneznek and R. N. Anthony (1953), Spending for Industrial Research, 1951-1952, *op. cit*.
[123] G. Perazich and P. M. Field (1940), Industrial Research and Changing Technology, *op. cit*. p. xi.
[124] *Ibid*. pp. 46-47.
[125] *Ibid*. pp. 40.
[126] *Ibid*. pp. 41. This was, in fact, the common understanding about the emergence of industrial research for at least two decades (1920): "The starting and development of most manufacturing businesses depended upon discoveries and inventions made by some individual or group of individuals who developed their original discoveries into an industrial process". This was more often than not accidental. "With the increasing complexity of industry and the parallel growth in the amount of technical and scientific information necessitating greater specialization, the work of investigation and development formerly performed by an individual, has been delegated to special departments of the organization, one example of which is the modern industrial research laboratory". C. E. K. Mees (1920), *The Organization of Industrial Scientific Research*, New York: McGraw Hill, p. 5-6.

Similarly, the Harvard Business School study has shown that firm size was one of the main variables explaining R&D investment. Consequently, the authors suggested limiting the samples to larger units: [127]

> The fact that there are almost 3,000 industrial research organizations can be misleading. Most of them are small. (…) Over half employ less than 15 persons each, counting both technical and non-technical personnel. Many of these small laboratories are engaged primarily in activities, such as quality control, which are not research or development.
>
> [Therefore] this report is primarily concerned with industrial laboratories employing somewhat more than 15 persons.

To the OECD, systematic research meant research conducted on a regular basis. However, it was 1993 before there was an explicit OECD rationale. In fact, the word "systematic" had never been defined explicitly in any edition of the Frascati manual. During the fourth revision of the manual in 1991, then, the French delegate suggested certain modifications to the definition of research. [128] Two options were discussed. One was the omission of references to "systematic" in the definition of R&D. This was rejected because it was felt that the term was useful in excluding non-R&D activities. The other option was to qualify "systematic" as "permanent and organized" in the definition of R&D. This option was also rejected. However, a precise number was proposed and adopted for defining (core) R&D: a minimum of one full-time equivalent person working

[127] R. N. Anthony and J. S. Day (1952), *Management Controls in Industrial Research Organizations*, Cambridge (Mass.): Harvard University Press, pp. 6-7.
[128] OECD (1991), *R&D and Innovation Surveys: Formal and Informal R&D*, DSTI/STII/(91)5 and annex 1.

on R&D per year. [129] From then on, the manual began distinguishing R&D according to whether it is continuous or *ad hoc*: [130]

> R&D by business enterprises may be organized in a number of ways. Core R&D may be carried out in units attached to establishments or in central units serving several establishments of an enterprise. In some cases, separate legal entities may be established to provide R&D services for one or more related legal entities. *Ad hoc* R&D, on the other hand, is usually carried out in an operational department of a business such as the design, quality or production department.

In 1993, the manual explicitly recommended concentrating on continuous R&D only: [131]

> R&D has two elements. R&D carried out in formal R&D departments and R&D of an informal nature carried out in units for which it is not the main activity. In theory, surveys should identify and measure all financial and personnel resources devoted to all R&D activities. It is recognised that in practice it may not be possible to survey all R&D activities and that it may be necessary to make a distinction between "significant" R&D activities which are surveyed regularly and "marginal" ones which are too small and/or dispersed to be included in R&D surveys. (…) This is mainly a problem in the business enterprise sector where it may be difficult or costly to break out all the ad hoc R&D of small companies.

This meant that a part of R&D, that part conducted by small and medium-sized enterprises, would continue to be poorly surveyed because R&D was thought to be "a statistically rare event in smaller units", i.e.: not systematic. [132] And indeed, surveys conducted by academics have documented how official R&D figures underestimate R&D by undercounting small and medium-sized enterprises, by at least 30%. [133] The definition of research as systematic research has also restricted the coverage of the sciences surveyed. The Frascati manual was restricted to the natural and engineering sciences until the third edition. In 1976, the manual included the social and human sciences for the first

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[129] FM (1994), p. 106.
[130] *Ibid*. p. 51.
[131] *Ibid.* pp. 105-106.
[132] FM (1981), p. 72.
[133] A. Kleinknecht (1987), Measuring R&D in Small Firms: How Much Are We Missing?, *The Journal of Industrial Economic*, 36 (2): 253-256; A. Kleinknecht and J. O. N. Reijnen (1991), More evidence on the undercounting of Small Firm R&D, *Research Policy*, 20: 579-587. For similar numbers in France, see: S. Lhuillery and P. Templé (1994), L'organisation de la R&D dans les PMI-PME, *Économie et Statistique*, 271-272, pp. 77-85. For Italy, see : E. Santarelli and A. Sterlacchini (1990), Innovation, Formal vs Informal R&D and Firm Size, *Small Business Economics*, 2, pp. 223-228.

time. [134] The social sciences and humanities have been excluded from definitions and measurements because they were considered as not organized (systematic) but individual research. Even after being included, "some deviations from the standards may still have to be accepted", stated the OECD Frascati manual. [135] Today, the bias continues in other OECD methodological manuals, [136] where a system of "priorities" is established with the natural sciences and engineering situated at its core. [137]

When official definitions and surveys began to cover the social sciences and humanities, [138] the conventions designed for the natural sciences in the previous decade were strictly applied to these new disciplines. Therefore, activities such as data collection and scientific and technical information – among them the production of statistics – which are the raw material of the social sciences and humanities, and which are an integral part of research in these disciplines, were excluded because they were considered as related scientific activities. [139] Similarly, economic studies and market research were never considered as research activities by industry surveys. [140]

That research came to be equated with systematized research or large organizations with dedicated laboratories [141] is due partly to methodological difficulties of accounting and the costs of conducting a survey. Because there are tens of thousands of firms in a country, units surveyed have to be limited to manageable proportions. This was done by

[134] The definition of R&D was modified as follows, and an appendix specifically dealing with these sciences was added: "R&D may be defined as creative work undertaken on a *systematic* basis to increase the stock of scientific and technical knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications". FM (1976), p. 29.
[135] FM (1981), p. 17.
[136] OECD (1995), *Manual on the Measurement of Human Resources Devoted to S&T*, OECD/GD (95) 77.
[137] "The Nordic group [of countries] had difficulties in accepting the use of the term "low priority" in connection with the humanities (…). It was agreed that the priorities terminology be replaced by coverage": OECD (1994), *NESTI: Summary Record of the Meeting Held on 18-20 April 1994 in Canberra*, Australia, DSTI/EAS/STP/NESTI/M (94) 1, p. 4.
[138] Today, nine OECD countries still do not include the social sciences and humanities in their surveys.
[139] P. Lefer (1971), *The Measurement of Scientific Activities in the Social Sciences and Humanities*, UNESCO: Paris, CSR-S-1; OECD (1970), *The Measurement of Scientific Activities: Notes on a Proposed Standard Practice for Surveys of Research in the Social Sciences and Humanities*, DAS/SPR/70.40, Paris.
[140] In the case of industrial R&D, the exception was: D. C. Dearborn, R. W. Kneznek and R. N. Anthony (1953), Spending for Industrial Research, 1951-1952, *op. cit*.
[141] On academics' use of the idea, see: J. Schmookler (1959), Bigness, Fewness, and Research, *Journal of Political Economy*, 67 (6), pp. 628-632; F. Machlup (1962), *The Production and Distribution of Knowledge in the United States*, Princeton: Princeton University Press, pp. 82-83.

introducing a bias in industrial surveys: the survey identified all major R&D performers, that is, big firms with laboratories (or “organized” research) and surveyed them all, but selected only a sample of smaller performers, when they selected any. This decision was also supported by the fact that only big firms had precise book-keeping practices on R&D since the activity could be located in a distinct and formal entity, the laboratory.

Accounting and Science Policy

That the OECD developed a methodological manual on R&D had to do with policy. As the NSF suggested in 1951: "A sound policy must rest on a sound foundation of fact". [142] And again in 1952: "The necessary first step in policy development is the assembly of an adequate body of fact". [143] Such a rationale for the collection and analysis of data was also offered at OECD in the early 1960s when discussions on science policy emerged. Science was now becoming recognized as a factor in economic growth, at least by OECD bureaucrats. In order that science might optimally contribute to progress, however, science policies had to be developed. And to inform the latter, statistics were essential, so thought the organization: "Informed policy decisions (…) must be based on accurate information about the extent and forms of investment in research, technological development, and scientific education", argued the OECD's Piganiol report. [144] "Provision for compilation of data is an indispensable prerequisite to formulating an effective national policy for science". [145] Freeman would repeat similar needs in the following years, among others in a 1963 study for the first ministerial conference on science: "most countries have more reliable statistics on their poultry and egg production than on their scientific effort and their output of discoveries and inventions". (…) The statistics available for analysis of technical change may be compared with those for national income before the Keynesian revolution". [146]

What were the policy decisions for which data were so necessary? There were three, and all were framed within the vocabulary of neoclassical economics, even in evolutionary economists' hands. [147] The first was the allocation of resources to R&D, or what economists call the **optimum** level of resources: "Assessing what is in some sense the

[142] NSF, *First Annual Report, 1950-51*, Washington: USGPO, p. 13.
[143] NSF, *Second Annual Report, Fiscal Year 1952*, Washington: USGPO, p. 5.
[144] OECD (1963), Science and the Policies of Government, *op. cit*. p. 24.
[145] OECD (1963), Science and the Policies of Government, *op. cit*. p. 24.
[146] OECD (1963), *Science, Economic Growth and Government Policy*, Paris, pp. 21-22; the same quotation (more or less) can be found on p. 5 of the first edition of the Frascati manual.
[147] For a summary of neoclassical economists' view on science policy, see: S. Metcalfe (1995), The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives, in P. Stoneman (ed.), Handbook of the Economics of Innovation and Technological Change, Oxford: Blackwell, pp. 408-512, especially pp. 408-447.

"right" or "optimum" level of allocation of resources".[148] As discussed above, the GERD was developed to serve this end, and the ratio GERD/GDP became a policy target.

The second policy decision was the balance between choices or priorities, or what economists call **equilibrium**. To many, decisions about research funding were analyzed in terms of tensions between freedom and control, between big science and little science, between socioeconomic objectives, between scientific fields, between basic and applied research.[149] To the OECD, statistics was the solution to the issue, and a system of classification for statistical breakdowns was proposed.

The first edition of the Frascati manual suggested classifying R&D by dimensions. One of the central dimensions was concerned with economic sectors, as discussed above. Other classifications concerned each of the sectors. The manual's recommended system of classification is peculiar in that each economic sector of the system of national accounts has its own classification. Whereas in most official surveys the units are analyzed according to a common system of classifications (every individual of a population, for example, is classified according to the same age structure), here the main economic sectors of the system of national accounts were distinguished and classified separately. The business sector was classified (and the statistics broken down) according to industry, the university (and private non-profit) sector according to fields of science or scientific disciplines, and the government sector according to socioeconomic objectives.

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[148] C. Freeman and A. Young (1965), The Research and Development Effort in Western Europe, North America and the Soviet Union, *op. cit.*, p. 15.

[149] Bernal, J. D. (1939), *The Social Function of Science*, Cambridge (Mass.): MIT Press, 1973; US President's Scientific Research Board (1947), *Science and Public Policy*, Washington: USGPO; T. Parsons (1948), Social Science: A Basic National Resource, paper submitted to the Social Science Research Council, reprinted in S.Z. Klausner and V.M. Lidz (1986), *The Nationalization of the Social Sciences*, Philadelphia: University of Pennsylvania Press, 41-112, p. 109; A.M. Weinberg (1963/1964), Criteria for Scientific Choice, *Minerva* , 1(2), pp. 159-171 and 3 (1), pp. 3-14; S. Toulmin (1964), The Complexity of Scientific Choice: A Stocktaking, *Minerva*, 2 (3), pp. 343-359; National Research Council (1965), *Basic Research and National Goals*, Washington: National Academy Press; National Research Council (1967), *Applied Science and Technological Progress*, Washington: National Academy Press; B.L.R. Smith (1966), The Concept of Scientific Choice, *American Behavioral Scientist*, 9, pp. 27-36; C. Freeman (1969), National Science Policy, *Physics Bulletin*, 20, pp. 265-270; H. Krauch (1971/1972), Priorities for Research and Technological Development, *Research Policy*, 1, pp. 28-39; H. Brooks (1978), The Problem of Research Priorities, *Daedalus*, 107, pp. 171-190.

The principal recommendations regarding these classifications were made in the first edition of the Frascati manual, and have been regularly updated since 1970.

Although each economic sector has its own classification, there is one more classification recommended in the manual, and it applies across all economic sectors. It concerns whether R&D is basic, applied or development, and has been an issue discussed over forty years at OECD. [150] Since Condorcet, a magic number of 20 is often suggested as the percentage of R&D funds that should be devoted nationally to basic research, and such a target was proposed to the OECD early on. [151] Such a ratio depends on statistical breakdowns of research funds between basic research, applied research and development. Former NSF director D.N. Langenberg once explained how the Foundation "must retain some ability to characterize, even to quantify, the state of the balance between basic and applied research across the Foundation. It must do so in order to manage the balance properly and to assure the Congress and the scientific and engineering community that it is doing so". [152]

Of all the concepts defined in the first edition of the Frascati manual, the first dealt with fundamental research. While a definition of research itself did not appear until the second edition, fundamental research was defined explicitly as follows: [153]

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

In the last edition of the manual, the definition is substantially the same as the one in 1962, although the term "basic" is now used instead of fundamental: [154]

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[150] The first discussions on the balance between basic and applied research are to be found in Bernal (1939), Bush (1945) and the US PSRB (1947). For the OECD, see: B. Godin (2005), Measurement and Statistics on Science and Technology: 1920 to the Present, *op. cit.*, pp. 298-302.
[151] OECD (1966), *Fundamental Research and the Policies of Government*, Paris, p. 32-33.
[152] D.N. Langenberg (1980), *Memorandum for Members of the National Science Board*, NSB-80-358, Wasington, p. 4.
[153] FM (1962), p.12.
[154] FM (2002), p. 77.

> 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.

Between 1962 and 2002, therefore, all six editions of the manual carried 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 and, in some cases, even abandoned.

The concept of basic research and its contrast with applied research has a long history that goes back to the nineteenth century, and the integration of the dichotomy into taxonomies used for statistical surveys comes from the British scientists J. S. Huxley and J. D. Bernal. [155] V. Bush appropriated the taxonomy for the statistics of his report *Science: the Endless Frontier*, as did the US President's Scientific Research Board. But it was the NSF that gave the concept of basic research its influential definition with its very first R&D surveys. [156]

The first OECD meeting of national experts on the Frascati manual held in 1963 brought together people and groups from several countries, chief among which was the NSF. K. S. Arnow [157] and K. Sanow [158] discussed at length 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). At the meeting, C. Oger from France (*Direction générale de la recherche, de la science et de la technologie*) discussed the limitations of a definition of fundamental research based exclusively on researchers' motives, and suggested alternatives. [159] In fact, the main criticism of the concept concerned – and still concerns – its subjectivity: whether a project is classified as basic or

[155] Huxley, J. S. (1934), *Scientific Research and Social Needs*, London: Watts and Co.; Bernal, J. D. (1939), The Social Function of Science, *op. cit*.
[156] B. Godin (2003), Measuring Science: Is There Basic Research Without Statistics?, *Social Science Information*, 42 (1), pp. 57-90.
[157] K. S. Arnow (1963), *Some Conceptual Problems Arising in Surveys of Scientific Activities*, OECD, DAS/PD/63.37.
[158] K. Sanow (1963), *Survey of Industrial Research and Development in the United States: Its History, Character, Problems, and Analytical Uses of Data*, OECD, DAS/PD/63.38.
[159] C. Oger (1963), *Critères et Catégories de recherche*, OECD, DAS/PD/63.30.

applied is still up to the survey respondent. [160] Oger's suggestion (crossing categories of research according to three criteria: aims, results and types of work) appeared without discussion in an appendix to the first edition of the Frascati manual.

Discussions continued over the following few years, resulting in the addition of a brief text to the second edition of the manual. In 1970, the manual discussed a sub-classification of basic research according to whether it was pure or oriented. [161] 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 toward a field of present or potential scientific, economic or social interest". [162]

Discussions resumed in 1973. C. Falk, of the National Science Foundation, 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 the research program. [163] 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 measure the present division between basic

[160] Researchers tend to qualify their research as basic, while providers of funds prefer to call it applied or oriented.

[161] To the best of my knowledge, the term "oriented research" came from P. Auger (1961), *Tendances actuelles de la recherche scientifique*, Paris: UNESCO, p. 262. The OECD rapidly appropriated the concept in two publications. First, in a document produced for the first ministerial conference on science in 1963, C. Freeman et al. suggested that fundamental research fell into two categories – free research that is driven by curiosity alone, and oriented research (OECD (1963), Science, Economic Growth and Policy, *op. cit*. p. 64). Second, in the second edition of the Frascati manual, the OECD defined oriented research as follows: "In oriented basic research the organization employing the investigator will normally direct his work toward a field of present or potential scientific, economic or social interest": FM (1970), p. 10. A precursor to the concept is Huxley's definition of basic research (J. S. Huxley (1934), *Scientific Research and Social Needs*, London: Watts and Co.) and the definition of basic research offered to firms in the NSF surveys of industrial research: "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": National Science Foundation (1959), *Science and Engineering in American Industry: Report on a 1956 Survey*, Washington, NSF 59-50, p. 14.

[162] FM(1970), p. 10.

[163] C. Falk (1973), *The Sub-Division of the Research Classification: A Proposal and Future Options for OECD*, OECD, DAS/SPR/73.95/07.

and applied research might be suppressed". [164] However, the only modifications that member countries accepted – to appear in the 1981 edition of the Frascati manual – were that the discussion of the difference between pure and basic research was transferred to another chapter, separated from the conventional definitions.

Then, in 1992, the delegates from United Kingdom and Australia tried to introduce the term "strategic research" into the Frascati manual – the Australian going so far as to delay publication of the Frascati manual: [165] strategic research was "original investigation undertaken to acquire new knowledge which has not yet advanced to the stage when eventual applications to its specific practical aim or objective can be clearly specified". [166] After "lively discussions", as the Portuguese delegate described the meeting, [167] they failed to win consensus. We read in the 1993 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". [168]

The 1992 debate at the OECD centered on, among other things, where to locate strategic research. There were three options. First, subdivide the basic research category into pure and strategic, as the OECD had suggested. Second, subdivide the applied research category into strategic and specific, as the British government did. Third, create an entirely new category (strategic research) as recommended by the Australian delegate. [169] In the end, "delegates generally agreed that strategic research was an interesting category

[164] OECD (1973), *Results of the Meeting of the Ad Hoc Group of Experts on R&D Statistics*, DAS/SPR/73.61, p. 8.
[165] This is only one of two discussions concerning the taxonomy of research at the time. A new appendix was also suggested but rejected. It concerned distinguishing between pure and "transfer" sciences. See OECD (1991), *Distinction Between Pure and Transfer Sciences*, DST/STII(91)12; OECD (1991), *The Pure and Transfer Sciences*, DSTI/STII(91)27.
[166] OECD (1992), *Frascati Manual – 1992*, DSTI/STP(92)16; OECD (1993), *The Importance of Strategic Research Revisited*, DSTI/EAS/STP/NESTI(93)10.
[167] OECD (1993), *Treatment of Strategic Research in the Final Version of Frascati Manual - 1992*, DSTI/EAS/STP/NESTI/RD(93)5.
[168] FM (1994), p. 69.
[169] See OECD (1991), *Ventilation fonctionnelle de la R-D par type d'activité*, DSTI/STII(91)7.

for the purposes of science and technology policy but most felt that it was very difficult to apply in statistical surveys". [170]

In 2000, the question was on the agenda again during the fifth revision of the Frascati manual. [171] 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 addressed in a new framework after they had advanced on policy and analytical ground. [172] To this end, a workshop was held in Oslo (Norway) in 2001 as part of a project related to the financing of basic research, entitled *Steering and Funding Research Institutions*. [173] The final report of the project, however, completely evaded the question and did not discuss definitions. The rationale given by the OECD was the following: "the key question is not to find a new conceptual definition for basic research, but to define its scope sufficiently broadly to cover the whole range of research types needed to establish a sound body of knowledge to achieve socio-economic advances". [174]

The result of all this was that, beginning in the mid-1970s, governments started to delete the question on basic research from their surveys. Today, only half of OECD member countries collect data on basic research. The OECD itself deleted the question on basic research from the list of mandatory questions on the R&D questionnaire, and rarely published numbers on basic research except for sector totals because of the low quality of the data, and because too many national governments failed to collect the necessary information. [175] Beginning with the 1981 edition, the manual also added reservations on the classification because it was qualified as subjective. [176] All in all, it seems that the

[170] OECD (1993), *Summary Record of the NESTI Meeting*, DSTI/EAS/STP/NESTI/M(93) 1, p. 5.
[171] 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.
[172] OECD (2000), *Summary Record*, DSTI/EAS/STP/NESTI/M (2000) 1, p. 5.
[173] OECD (2002), *Workshop on Basic Research: Policy Relevant Definitions and Measurement: Summary Report*, http://www.oecd.org/dataoecd/61/8/2676067.pdf.
[174] OECD (2003), *Governance of Public Research: Toward Better Practices*, Paris, p. 101.
[175] The only numbers appear in the *Basic Science and Technology Statistics* series, but missing data abound.
[176] FM (1981), p. 21.

current statistical breakdown of research, and the numbers generated, are not judged by several people to be useful for balancing the budget. [177] As W. H. Shapley, from the US Bureau of Budget, once suggested: "breakdowns do not tell anything about balance (…). Two programs are not in "balance" in any meaningful sense just because the same number of dollars happens to be applied to them in some particular year". [178] Equally, as the Frascati manual itself admits, classifications are "not detailed enough to be of use to one significant class of potential users of R&D data (…) [because] this manual is essentially designed to measure national R&D efforts (…). [179]

The Efficiency of Research

We suggested that there were three policy decisions that required data, according to the OECD. The first was the allocation of resources to R&D. The second was balancing the budget. There was a third one, defined again according to neoclassical economics, namely determining the **efficiency**, or effectiveness of research. The first edition of the Frascati manual set the stage for measuring efficiency by using an input-output approach as a framework for science statistics. Certainly the manual was entirely concerned with proposing standards for the measurement of inputs. But this was only a first stage. [180] Despite this focus, the manual discussed output and inserted a chapter (section) specifically dedicated to its measurement because "in order really to assess R&D efficiency, some measures of output should be found". [181] However, stated the manual, "measures of output have not yet reached the stage of development at which it is possible

[177] Neither are they by industrialists (see: H. K. Nason (1981), Distinctions Between Basic and Applied in Industrial Research, *Research Management*, May, pp. 23-28). 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 Research and Development in the United States: Its History, Character, Problems, and Analytical Uses of Data, *op. cit*. p. 13). With regard to government representatives, the second OECD users group 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*, STP (78) 6.
[178] W. H. Shapley (1959), Problems of Definition, Concept, and Interpretation of R&D Statistics, in NSF, Methodological Aspects of Statistics on R&D: Costs and Manpower, *op. cit*. p. 14.
[179] FM (1981), p. 21.
[180] FM (1962), p. 11.
[181] *Ibid*.

to advance any proposals for standardization". [182] "It seems inevitable that for some time to come it will not be possible to undertake macro-economic analysis and to make international comparisons on the basis of the measurement of output (…). This is an important limitation". [183]

Nevertheless, from its very first edition, the Frascati manual suggested that a complete set of statistics and indicators, covering both input and output, was necessary in order to properly measure science. The output indicators suggested were patents and payments for patents, licensing and technical know-how. [184] By 1981, the manual included an appendix specifically devoted to output, and discussed a larger number of indicators, namely innovations, patents, technological payments, high-technology trade, and productivity. The tone of the manual had also changed. While recognizing that there still remained problems of measurement, it stated that: "Problems posed by the use of such data should not lead to their rejection as they are, for the moment, the only data which are available to measure output". [185]

Freeman continued to advocate an input-output framework in the following years, to OECD and UNESCO officials among others. "There is no nationally agreed system of output measurement, still less any international system", stated Freeman in 1969 in a study on output conducted for UNESCO. "Nor does it seem likely that there will be any such system for some time to come. At the most, it may be hoped that more systematic statistics might become possible in a decade or two". [186] The dream persisted, however, because "it is only by measuring innovations (…) that the efficiency of the [science] system (…) can be assessed", continued Freeman. [187] "The output of all stages of R&D

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[182] FM (1962), p. 37.
[183] FM (1962), pp. 37-38.
[184] An early statistical analysis of two indicators was conducted by the director of the OCED statistical unit and presented at the Frascati meeting in 1963. See: Y. Fabian (1963), *Note on the Measurement of the Output of R&D Activities*, DAS/PD/63.48.
[185] OECD (1981), The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development, *op. cit*. p. 131.
[186] C. Freeman (1969), *Measurement of Output of Research and Experimental Development*, UNESCO, ST/S/16, p. 8.
[187] *Ibid*. p. 25.

activity is a flow of information and the final output of the whole system is innovations – new products, processes and systems". [188]

To Freeman, "the argument that the whole output of R&D is in principle not definable is unacceptable (…). If we cannot measure all of it because of a variety of practical difficulties, this does not mean that it may not be useful to measure part of it. The GNP does not measure the whole of the production activity of any country, largely because of the practical difficulties of measuring certain types of work. The measurement of R&D inputs omits important areas of research and inventive activity. But this does not mean than GNP or R&D input measures are useless". [189] And what about the relationship between input and output? "The argument that the input/output relationship is too arbitrary and uncertain in R&D activity to justify any attempts to improve efficiency or effectiveness (…) rests largely on the view that unpredictable accidents are so characteristic of the process that rationality in management is impossible to attain (…). The logical fallacy lies in assuming that, because accidental features are present in individual cases, it is therefore impossible to make useful statistical generalizations about a class of phenomena". [190]

Armed with such a "convincing" rationale, the Frascati manual continued, edition after edition, to suggest an input-output framework of science (under Paragraph 1.4) as well as offering its readers an appendix discussing output indicators. It also continued to argue for the development of output indicators as follows: "At present, only R&D inputs are included in official R&D statistics and, thus, in the body of this manual. This is regrettable since we are more interested in R&D because of the new knowledge and inventions which result from it than in the activity itself". [191]

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[188] *Ibid*. p. 27.
[189] *Ibid*. pp. 10-11.
[190] *Ibid*. p. 11.
[191] FM (1981), p. 17.

Things began to change in 1976. According to the OECD, the manual "has reached maturity" [192] and the Secretariat began looking at other indicators than R&D expenditures. In December, the OECD Committee for Scientific and Technological Policy organized a meeting of national experts on R&D statistics in order to prepare the work of the second *ad hoc* review group on statistics. The OECD Secretariat submitted the question of indicators to the group: "Science indicators are a relatively new concept following in the wake of the long-established economic indicators and the more recent social indicators. So far, the main work on this topic has been done in the United States where the National Science Board of the NSF has published two reports: *Science Indicators 1972* (issued 1973) and *Science Indicators 1974* (issued 1975)". [193] The background document to the meeting analyzed in depth the indicators that appeared in *Science Indicators*, and compared them to the statistics available and to those that could be collected, and at what cost. [194] The group was asked "to draw some lessons for future work in member countries and possibly at OECD".

The final report of the review group suggested a three-stage program for the development of new indicators: [195]

- Short-term: input indicators (like industrial R&D by product group).
- Medium-term: manpower indicators (like occupations of scientists and engineers).
- Long-term: output (productivity, technological balance of payments, patents) and innovation indicators, as well as indicators on government support to industrial R&D.

A few months later, in November 1978, the OECD Directorate for Science, Technology and Industry responded to the *ad hoc* review group report and made proposals to member

[192] *Ibid*., p. 3.
[193] OECD (1976), *Science and Technology Indicators*, DSTI/SPR/76.43, p. 3.
[194] See particularly the annex of OECD (1976), Science and Technology Indicators, *op. cit*.
[195] OECD (1978), Report of the Second Ad Hoc Review Group on R&D Statistics, STP (78) 6, pp. 17-21.

countries. [196] It suggested limiting indicators to those most frequently requested by users of statistics, i.e.: input indicators. The decision was dictated by the need to accelerate the dissemination of data – a limitation already identified by the first *ad hoc* review group on statistics. It was nevertheless suggested that a database be created, from which a report based on indicators would be published every two years. The report would "be modeled to some extent on the NSF *Science Indicators* reports". [197]

The Canadian delegate, H. Stead, judged these proposals too timid. He suggested that the Frascati manual be revised in order to turn it into an indicator manual that would cover more aspects or dimensions of science than R&D. [198] The first part would match more or less the current content of the manual, while the second part would deal with other indicators, namely scientific and technical personnel, related scientific activities, outputs and high-technology trade. His suggestions were rejected as premature, [199] but the Introduction to the manual was rewritten for the 1981 edition in order to place R&D statistics in the larger context of indicators. In this introductory chapter, the OECD also introduced the concept of "Science and Technological Activities", arising from the recently-adopted UNESCO recommendation. According to UNESCO, science and technological activities are: [200]

> systematic activities which are closely concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology. These include such activities as R&D, scientific and technical training and education (STET), scientific and technological services (STS).

[196] OECD (1978), *General Background Document for the 1978 Meeting of the Group of National Experts on R&D Statistics*, DSTI/SPR/78.39 and annex.
[197] *Ibid*. p. 8.
[198] *Ibid*. pp. 16-17.
[199] OECD (1979), *Summary of the Meeting of NESTI*, STP (79) 2, p. 4. The question would be discussed again in 1988: "The delegates discussed whether one or more OECD manuals should be developed for measuring scientific and technological activities. They concluded that the revised Frascati manual should continue to deal essentially with R&D activities and that separate manuals in the *Measurement of Scientific and Technical Activities* series should be developed for S&T output and impact indicators which are derived from entirely different sources from R&D statistics": OECD (1988), *Summary of the Meeting of NESTI*, STP (88) 2.
[200] UNESCO (1978), *Recommendation Concerning the International Standardization of Statistics on Science and Technology*, Paris, p. 2.

Certainly the concept of "scientific activities" had already been present in the Frascati manual since 1962, and that of scientific and technical activities in the title of the manual. But now, a short discussion appeared in an introductory chapter "addressed principally to non-experts and (…) designed to put them in the picture". [201] The purpose, however, was not to measure science and technological activities but, again, "to distinguish R&D, which is being measured, from scientific and technical training and education and scientific and technological services which are not". [202] It had correspondingly few consequences on the standard definition of science and its measurement.

Table 2.

The OECD R&D Family of Manuals

1963	*The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development* (Frascati manual).
1990	*Proposed Standard Practice for the Collection and Interpretation of Data on the Technological Balance of Payments*.
1992	*Proposed Guidelines for Collecting and Interpreting Technological Innovation Data* (Oslo manual).
1994	*Data on Patents and Their Utilization as Science and Technology Indicators*.
1995	*Manual on the Measurement of Human Resources in Science and Technology* (Canberra manual).

What did have consequences, however, was the concept of innovation, introduced in the same edition (1981). Of all science and technological activities, innovation is the only activity in the history of OECD statistics on science and technology that was given a certain autonomy and a status equivalent to R&D. In 1997, in collaboration with the

[201] FM (1981), p. 13.
[202] *Ibid*. p. 15.

European Union (Eurostat), the OECD published a manual devoted specifically to the measurement of innovation – the Oslo manual – the first draft of which was distributed in 1992. [203]

Thereafter, and starting with the 1993 edition, an annex on new indicators was added to the Frascati manual, as well as a table presenting the OECD new "family" of methodological manuals on measuring science, among them three manuals on output indicators. (Table 2). [204] By that time, the OECD had definitely extended its measurement from input to output, and the Frascati manual was only one of the proposed international standards for measuring science.

Conclusion

Accounting and the Frascati manual were the statistical answer or policy tool to contribute to the anticipated economic benefits of science. At the OECD, these benefits had to do with economic growth. In 1961, the organization and member countries adopted a 50% growth target. All divisions of the organization aligned themselves with the objective, first among them the Directorate for Scientific Affairs. [205] With regard to R&D, a whole program of work on the economics of science was developed. The Committee for Scientific Research (CSR) of the Directorate for Scientific Affairs recommended that the OECD Secretariat "give considerable emphasis in its future program to the economic aspects of scientific research and technology". [206]

The committee proposal was based on the fact that there "is an increasing recognition of the role played by the so-called third factor [technical progress] in explaining increases in GNP". [207] But, the committee continued, "the economist is unable to integrate scientific

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[203] OECD/Eurostat (1997), *Proposed Guidelines for Collecting and Interpreting Technological Innovation Data* (Oslo Manual), Paris.
[204] To this table, we could add a working paper on bibliometrics: Y. Okubo (1997), *Bibliometric Indicators and Analysis of Research Systems: Methods and Examples*, OECD/GD (97) 41. This document, however, was not really a methodological manual.
[205] OECD (1962), *The 50 Per Cent Growth Target*, CES/62.08, Paris.
[206] OECD (1962), *Economics of Research and Technology*, SR (62) 15, p. 1.
[207] *Ibid*. p. 2.

considerations into his concepts and policies because science is based largely on a culture which is anti-economic". [208] Thus, the OECD gave itself the task of filling the gap. To this end, the organization developed a research program on the economy of science that led to a statement on science in relation to economic growth as a background document for the first ministerial conference held in 1963. [209] The document contained one of the first international comparisons of R&D efforts in several countries based on existing statistics, conducted by Freeman *et al*. [210]

The committee went further than simply recommending the collection of statistics. It also suggested that the OECD conduct studies on the relationships between investment in R&D and economic growth. Indeed, "comprehensive and comparable information on R&D activity are the key to [1] a clearer understanding of the links between science, technology and economic growth, [2] a more rational formulation of policy in government, industry and the universities, [3] useful comparisons, exchange of experience, and policy formation internationally". [211] The main obstacle to this suggestion was identified as being the inadequacy of available data. [212] To enlighten policy, the committee thus supported the development of a methodological manual. [213]

The OECD had been responsible for a major achievement in the field of science measurement, that of conventionalizing a specific and particular vision of science as research accounting. The importance of this contribution is considered so great, by the OECD itself, that: "if the OECD were to close its doors tomorrow, the drying up of its

[208] *Ibid*. p. 5.
[209] OECD (1963), Science, Economic Growth and Government Policy, *op. cit*.
[210] The year before, S. Dedijer (Sweden) had published the first such comparison: S. Dedijer (1962), Measuring the Growth of Science, *Science*, 138, 16 November, pp. 781-788. Two other international statistical comparisons, again based on existing statistics, would soon follow: A. Kramish (1963), *Research and Development in the Common Market vis-à-vis the UK, US and USSR*, report prepared by the RAND Corporation for the Action Committee for a United Europe (under the chairmanship of J. Monnet); C. Freeman and A. Young (1965), The Research and Development Effort in Western Europe, North America and the Soviet Union, *op. cit.*
[211] OECD (1963), *A Progress and Policy Report*, SR (63) 33, pp. 4-5.
[212] OECD (1962), Economics of Research and Technology, *op. cit*., p. 10.
[213] OECD (1962), *Draft 1963 Programme and Budget*, SR (62) 26, p. 19.

statistics would probably make a quicker and bigger impact on the outside world than would the abandonment of any of its other activities". [214]

An important aspect of the OECD's accounting was that it occurred without any opposition from member countries. This is quite different from the history of other standards and statistics. Dissemination of the French meter outside France, for example, has not been an easy task, and the meter is still not universally used today. [215] Similarly, the standardization of time units for a while saw its English proponents opposed to the French. [216]

At least three factors contributed to the easy acceptance of the Frascati manual and its accounting conception among OECD countries. Firstly, few countries collected data on science in the early 1960s. The OECD offered a ready-made model for those who had not yet developed the necessary instruments. For the few countries that already collected data, mainly the United States, Canada and Great-Britain, the manual reflected their own practices fairly well: it carried a community of views that they already shared. Secondly, the accounting was proposed by an international organization and not by a specific country, as in the case of the meter or the time unit, for example. This was perceived as evidence of neutrality, although the United States exercised overwhelming influence. Thirdly, the OECD introduced the manual with a step-by-step strategy. First step: as with the first edition, the document began as an internal document only (1962). It would not be published officially before the third edition (1976). Second step: the manual was tested (1963-64) in a large number of countries. Third step: it was revised in light of the experience gained from the surveys. Regular revisions followed, the manual being in its sixth edition now. The philosophy of the OECD was explicitly stated in 1962 in the following terms: [217]

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[214] OECD (1994), *Statistics and Indicators for Innovation and Technology*, DSTI/STP/TIP (94) 2, p. 3.
[215] D. Guedj (2000), *Le mètre du monde*, Paris: Seuil.
[216] E. Zerubavel (1982), The Standardization of Time: A Socio-Historical Perspective, *American Journal of Sociology*, 88 (1), pp. 1-23.
[217] FM (1962), p. 2.

> It would be unrealistic and unwise to expect certain Member governments to adapt completely and immediately their present system of definition and classification of research and development activity to a proposed standard system of the OECD. However, it should perhaps be possible for governments to present the results of their surveys following a proposed OECD system, in addition to following their own national systems. Furthermore, governments could take account of a proposed OECD system when they are considering changes in their own system. Finally, those government who have yet to undertake statistical surveys of R&D activity could take account of, and even adopt, a proposed OECD system.

An additional factor explaining the relative consensus of OECD member countries with regard to accounting was the involvement of national statisticians in the construction of OECD statistics and methodological manuals. This took three forms. Firstly, the creation of a group of National Experts on Science and Technology Indicators (NESTI) to guide OECD activities. Secondly, the setting up of regular *ad hoc* review groups on science statistics to align OECD statistical work to users' needs. Thirdly, the active collaboration of member countries in developing specific indicators.

In the end, the Frascati manual was the product of a large number of influences: ideological, political, administrative, historical and individual. First, the manual owes its existence to the early policy demand for statistics. It was the OECD Directorate for Scientific Affairs that pushed and piloted the whole operation. It did this, secondly, with a view to orienting policies, and therefore the statistics, toward accounting. Third, the manual is the product of official statisticians who hold a specific view of the field and who "control" its measurement (via the national survey). Fourth, it owes most of its concepts to previous experiments in measurement, chief among them that of the National Science Foundation. The NSF was an influential source of ideas for several concepts like systematic research, basic research and the GERD matrix, but UNESCO, the United Nations, and the European Commission also played an important role, in classifications for example. Finally, one individual was behind several of these early developments – the manual but also the (economic) analyses of the time –: the economist Freeman. Besides writing the first edition of the Frascati manual (1962), Freeman would produce one of the first international statistical comparisons of R&D for the first ministerial conference on science (1963). This analysis would be very influential on subsequent OECD studies of technological gaps. Freeman would also produce the first methodological comparison of methodologies used in different countries for measuring science (1965). In this study, he inaugurated the use of multiple indicators for measuring science and technology. Finally, Freeman would contribute to the diffusion of OECD norms and methods on accounting to developing countries: he wrote the UNESCO manual for the measurement of scientific and technical activities (1969). [218]

We suggested at the beginning of this paper that a representation always decides how things are measured. In light of the history of the OECD Frascati manual, we can see how, in turn, a statistics constructs a specific representation through the way it quantifies. Over the last sixty years, the representation of science, as developed through statistics among governmental and international organizations, has been very influential. It has given policy-makers an accounting framework, which has really defined the way science policy has been constructed: managing science through the anticipated economic benefits of research, as measured by statistics. [219]

[218] UNESCO (1969), *The Measurement of Scientific and Technological Activities: Proposals for the Collection of Statistics on Science and Technology on an Internationally Uniform Basis*, COM.69/XVI-15 A, Paris.
[219] B. Godin (2009), *Making Science, Technology and Innovation Policy: Conceptual Frameworks as Narratives, 1945-2005*, Edward Elgar, Forthcoming.

Appendix.

Activities to be Excluded From R&D

(Frascati Manual)

1963

1) related activities
2) non-scientific activities

1970

1) related activities
2) industrial production and distribution of goods and services and the various allied technical services

1976

3) activities using the disciplines of the social sciences such as market studies

1981

1) education and training
2) other related scientific and technological activities
3) other industrial activities

1993

1) R&D administration and indirect support activities

Related activities

1963

1) scientific information
2) training and education
3) data collection
4) testing and standardization

1970

1) scientific education
2) scientific and technical information
3) general purpose data collection
4) testing and standardization
5) feasibility studies for engineering projects
6) specialized medical care
7) patent and license work

1976

1) policy related studies

1981

1) scientific and technical information services
2) general purpose data collection
3) testing and standardization
4) feasibility studies
5) specialized medical care
6) patent and license work
7) policy related studies

1993

1) routine software development

Non-scientific activities

1963

1) legal and administrative work for patents
2) routine testing and analysis,
3) other technical services

Industrial production

1963

1) prototypes and trial production
2) design and drawing
3) pilot plant

1970

1) prototypes
2) pilot plant
3) trial production, trouble-shooting and engineering follow-through

1976

1) prototypes
2) pilot plant
3) trial production, trouble-shooting and engineering follow-through

1981

1) innovation
2) production and related technical services (see specific cases)

1993

1) innovation
2) production and related technical services (see specific cases)

Innovation

1981

1) new product marketing
2) patent work
3) financial and organizational changes
4) final product or design engineering
5) tooling and industrial engineering
6) manufacturing start-up
7) demonstration

1993

1) tooling and industrial engineering
2) manufacturing start-up and preproduction development
3) marketing for new products
4) acquisition of disembodied technology
5) acquisition of embodied technology
6) design
7) demonstration

Specific cases

1981

1) prototypes
2) pilot plants
3) very costly pilot plants and prototypes
4) trial production
5) trouble-shooting
6) feed-back R&D

1993

1) industrial design
2) tooling and industrial engineering

Administration and other supporting activities

1993

1) purely R&D financing activities
2) indirect supporting activities