The Most Cherished Indicator:
Gross Domestic Expenditures on R&D (GERD)

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Project on the History and Sociology of S&T Statistics
Working Paper No. 22

2003

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The Most Cherished Indicator:
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The OECD Frascati manual, now in its sixth edition, is the international standard for conducting national surveys on R&D. [1] It essentially develops two measurements of investment (or inputs) into science and technology: the financial resources invested in R&D, and the human resources devoted to these activities. To properly conduct surveys of R&D, the manual suggests precise definitions of R&D and which activities fall under this heading, as well as those that should be excluded.

Each of the two measures can be analyzed in terms of three dimensions. The first is the type or character of the research, which is either basic, applied or concerned with the development of products and processes. This is a fundamental classification scheme in science and technology measurement. [2] The second dimension is the sectors that finance or execute the research: government, university, industry or non-profit organizations. It is these institutions that are the object of measurement, and not the individuals of which they are composed. [3] Finally, in relation to this latter dimension, monetary and human resources are (ideally) classified by discipline in the case of universities (and non-profit organizations), by industrial sector or product in the case of firms, and by function or socioeconomic objective in the case of governments. [4]

The main indicator to come out of the Frascati manual is Gross Domestic Expenditure on R&D (GERD) – the sum of R&D expenditures in the following four economic sectors:

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[1] OECD (2003), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development*, Paris.
[2] B. Godin (2003), Measuring Science: Is There Basic Research Without Statistics?, *Social Science Information*, in press.
[3] B. Godin (2002), *Metadata: How Footnotes Make for Doubtful Numbers*, Project on the History and Sociology of S&T Statistics, Montreal.
[4] B. Godin (2002), *Innovation and Tradition: The Historical Contingency of R&D Statistical Classification*, Project on the History and Sociology of S&T Statistics, Montreal.

business, university, government and non-profit. [5] According to a recent survey by the OECD Secretariat, GERD is actually the most cherished indicator among OECD member countries, [6] despite the frequent suggestion that human resources are a better statistic, [7] and despite unanimous demand for output indicators. [8]

This paper explains where the indicator comes from. The first part presents early efforts to measure R&D on a national scale in order to determine a country's science or research budget. The second discusses how the NSF improved upon previous experiments, to the point where the OECD conventionalized the agency's choices and methodologies. The third part discusses the uses of the indicator, and the role the OECD played in its popularization.

The First Exercises on a National Budget

Statistics on R&D started to be collected in the early 1920s in the United States, then Canada and Great Britain. [9] The US National Research Council was a pioneer with its repertories of industrial laboratories. Several surveys and statistical analyses used the data coming out of these publications. Then, in the 1940s, government began surveying its own research activities.

Before the 1950s, measurement of R&D was usually conducted on individual sectors. Organizations surveyed either industrial or government R&D, for example, but very rarely aggregated the numbers to compute a "national research budget" (see Appendix). 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)

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[5] The measure includes R&D funded from abroad but excludes payments made abroad.
[6] OECD (1998), *How to Improve the MSTI: First Suggestions From Users*, DSTI/EAS/STP/NESTI/RD (98) 9.
[7] B. Godin (2002), *Highly Qualified Personnel: Should We Really Believe in Shortages,* Project on the History and Sociology of S&T Statistics, Montreal.
[8] B. Godin (2002), *Measuring Output: When Economics Drives Science and Technology Measurements,* Project on the History and Sociology of S&T Statistics, Montreal.
[9] B. Godin (2002), The Number Makers: Fifty Years of Science and Technology Official Statistics, *Minerva*, 40 (4), pp. 375-397.

compared to other economic activities, and at helping build a case for increased R&D resources.

J. D. Bernal was one of the first academics to perform measurement of science 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. [10] 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" (p. 57). "The difficulties in assessing the precise sum annually expended on scientific research are practically insurmountable. It could only be done by changing the method of accounting of universities, Government Departments, and industrial firms" (p. 62). 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" (p. 64).

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 (p. 65). 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" (p. 64). "The scale

[10] J. D. Bernal (1939), *The Social Function of Science*, Cambridge (Mass.): MIT Press, 1973, pp. 57-65.

of expenditure on science is probably less than one-tenth of what would be reasonable and desirable in any civilized country" (p. 65).

The next experiment to estimate a national budget was conducted in the United States by V. Bush. [11] Using primarily 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" (p. 85). 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 President's Scientific Research Board to innovate in this respect. In 1947, the Board published its report *Science and Public Policy*, which estimated, for the second time in as many years, a **national R&D budget**. [12] 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 (p. 73). 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%).

[11] V. Bush (1945), *Science: The Endless Frontier*, North Stratford: Ayer Co., 1995, pp. 85-89.

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 basic be quadrupled (p. 6). The Board also introduced into science policy the main science indicator 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. [13]

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. [14] Using many different sources, the Office of the Secretary of Defense (R&D) estimated that $3.75 billion, or over 1% of the Gross National Product, was spent on **research funds** in the United States in 1952. The report presented data regarding both sources of expenditures and performers of 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 system for R&D. The statistics showed that the federal government was responsible for 60% of the total, [15] industry 38% and non-profit institutions (including universities) 2%. With regard to the performers, industry conducted the majority of R&D (68%) – and half of this work was done for the federal government – followed by the federal government itself (21%) and non-profit and universities (11%).

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

An Accounting System for R&D

According to its mandate, the NSF started measuring R&D across all sectors of the economy with specific and separate surveys in 1953: government, industry, university and others. [16] Then, in 1956, it published its "first systematic effort to obtain a systematic across-the-board picture" [17] – at about the same time as Great Britain did. [18] It consisted of the sum of the results of the sectoral surveys for estimating **national funds**. [19] The NSF calculated that the national budget amounted to $5.4 billion in 1953. [20]

The NSF 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. [21] 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 output" (p. 1). 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" (p. 7).

In the same publication, the NSF innovated in another way over previous attempts to estimate the national budget: a matrix of financial flows between the sectors, as both sources and performers of R&D, was constructed (Table 1). Of sixteen possible financial relationships (four sectors as original sources, and also as ultimate users), ten emerged as

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[15] The Department of Defense and the Atomic Energy Commission were themselves responsible for 90% of the federal share.

[16] B. Godin (2002), The Number Makers: Fifty Years of Science and Technology Official Statistics, *Minerva*, 40 (4), pp. 375-297.

[17] NSF (1956), Expenditures for R&D in the United States: 1953, *Reviews of Data on R&D*, 1, NSF 56-28, Washington.

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

[19] 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.

[20] 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.

significant (major transactions). The matrix showed that the federal government sector was primarily a source of funds for research performed by all four sectors, while the industry sector combined the two functions, with a larger volume as performer. Such national transfer tables were thereafter published regularly in the bulletin series *Reviews of Data on R&D*,[22] until a specific and more extensive publication appeared in 1967[23]

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 conducted in the mid fifties at the NSF on the US research system[24] 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

[21] NSF (1961), R&D and the GNP, *Reviews of Data on R&D*, 26, NSF 61-9, p. 2.
[22] *Reviews of R&D Data*, Nos. 1 (1956), 16 (1959), 33 (1962), 41 (1963); *Reviews of Data on Science Resources*, no. 4 (1965).
[23] NSF (1967), *National Patterns of R&D Resources*, NSF 67-7, Washington.
[24] "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.

H. E. Stirner from the Operations Research Office at Johns Hopkins University. [25] 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". [26] Links with the System of National Accounts (SNA), a recently developed system then in vogue among economists and governments departments, [27] were therefore imagined: "The idea of national as well as business accounts is a fully accepted one. National income and product, money flows, and inter-industry accounts are well-known examples of accounting systems which enable us to perform analysis on many different types of problems. With the development and acceptance of the accounting system, data-gathering has progressed at a rapid pace". [28]

Soon, an important problem emerged from the matrix: the inconsistency between source and performer data, as reported by K. Arnow: "In the long run, over a period of years, the national totals for R&D expenditures derived from both approaches would show closely related and occasionally coinciding trend lines. For any given year, however, national totals based on the two approaches would probably differ". [29] The main reasons identified concerned the following:

- Sources:
    - Source organizations do not know the extent to which and when recipients of funds may use the money;
    - Sources do not always know whether they are making what may be called a final or through transfer to a performer or whether the recipient of the

[25] 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*, Washington: NSF, p. 37.
[26] K. Arnow (1959), National Accounts on R&D: The NSF Experience, *op. cit.* p. 61.
[27] S. S. Kuznets (1941), *National Income and its Composition, 1919-1938*, New York: NBER. The SNA, now in its fourth edition, was developed in the early 1950s and conventionalized at the world level by the United Nations: United Nations (1953), *A System of National Accounts and Supporting Tables*, Department of Economic Affairs, Statistical Office, New York; OECD (1958), *Standardized System of National Accounts*, Paris.
[28] H. E. Stirner (1959), A National Accounting System for Measuring the Intersectoral Flows of R&D Funds in the United States, *op. cit.* p. 32.
[29] K. Arnow (1959), National Accounts on R&D: The NSF Experience, *op. cit.* p. 59.

funds will distribute them further to other organizations which may be performers or redistributors.

- Performers:
  - Some of the amounts reported by the performers may represent funds which were not specifically allocated to R&D by the original source;
  - Performers do not always know the original source of money where the funds have passed through several hands before reaching them.

These limitations led to a decision that a system of R&D accounts should be based on performer reporting, since this offers the best available information on where R&D is going on. The NSF decision – as well as the matrix – became international standards with the adoption of the OECD Frascati manual by member countries in 1963.

The OECD was the source of the nomenclature used today to talk about the national research budget: **Gross Domestic Expenditure on R&D** (GERD). [30] In line with the SNA, and following the NSF, the manual recommended classifying R&D according to the following main economic sectors: business, government and private non-profit. [31] To these three sectors, the OECD, following the NSF again, added a fourth one: higher education. The following rationale was offered for the innovation: [32]

> 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.

The first edition of the OECD Frascati manual justified the classification of R&D data by economic sector as follows: it "corresponds in most respects to the definitions and classifications employed in other statistics of national income and expenditure, thus

[30] OECD (1963), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development*, Paris, pp. 34-36.
[31] Households, that is, the sector of that name in the SNA, was not considered by the manual.
[32] OECD (1963), The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development, *op. cit.* p. 22.

facilitating comparison with existing statistical series, such as gross national product, net output, investment in fixed assets and so forth".[33] A deliberate attempt, then, to link R&D to the economy.

The GERD is the sum of the R&D expenditures of the four economic sectors. It is not really a national budget, however, but "a total constructed from the results of several surveys each with its own questionnaire and slightly different specifications".[34] Some data come from a survey (industry), others are estimated with different mathematical formulas (university), still other are proxies (government).[35] 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 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 (…)".[36] Nevertheless, the OECD is responsible for the worldwide popularization of the GERD indicator and, above all, the GERD/GNP ratio.

The Mystique of Ranking

Linking R&D to economic growth has been one of the first tasks economists interested in science embarked on in the late 1950s and early 1960s. Growth accounting was the framework into which R&D was integrated into economists' theories.[37] However, as we discussed previously, scientists and official statisticians preceded these efforts with the GERD/GNP ratio.

According to the OECD, an indicator "that is particularly useful for making international comparisons is to compare R&D inputs with a corresponding economic series, for

[33] OECD (1963), The Measurement of Scientific and Technical Activities: Propose Standard Practice for Surveys of R&D, *op. cit.* p. 21.
[34] 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.
[35] B. Godin (2003), *Metadata: How Footnotes Makes for Doubtful Numbers*, Project on the History and Sociology of S&T Statistics, Montreal.
[36] Statistics Canada (2002), *Estimates of Total Expenditures on R&D in the Health Fields in Canada, 1988 to 2001*, 88F0006XIE2002007.
[37] B. Godin (2004), The New Economy: What the Concept Owes to the OECD, *Research Policy*, 33 (5), pp. 679-690.

example, by taking GERD as a percentage of GNP." [38] In fact, the American GERD/GNP ratio of the early 1960s, that is 3%, as mentioned in the first paragraphs of the first edition of the Frascati manual, became the ideal to which member countries would aim, and which the OECD would implicitly promote. [39]

The generalized use of the indicator at the OECD started in the early 1960s. The first such exercise was conducted by Freeman et al., and published by the OECD in 1963 for the first ministerial meeting on science. [40] The terms of future OECD statistical studies were fixed from that point on. The authors documented very rapid increase in R&D expenditures in the 1950s, greater than the rise in GNP (p. 22). They also showed a positive relationship between R&D and GNP: advanced industrial countries typically spent more than 1% of their GNP on R&D (p. 23). Finally, among the group of industrial countries, two groups were distinguished: high (over 1%) and low GERD/GNP (under 1%) (pp. 24-25).

The second exercise occurred as the result of the first international survey on R&D conducted in 1963-64. The analysis was presented at the second OECD ministerial meeting on science in 1966, and published officially in 1967. [41] The report was designed to examine the level and structure of R&D efforts in member countries. Three kinds of R&D data analysis were conducted – and these would become the standard used in the ensuing decades: 1) general measures or indicators in absolute (GERD) and in relative (GERD/GNP) terms, 2) breakdowns of R&D expenditures by economic sector, R&D objective and type of activity, and 3) specific analyses of economic sectors: government, business, higher education and non-profit.

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[38] OECD (1994), *The Measurement of Scientific and Technical Activities: Propose Standard Practice for Surveys of R&D*, Paris, p. 28.
[39] OECD (1963), The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of R&D, *op. cit*. p. 5. In fact, at the time of the first edition of the Frascati manual, the US GERD/GNP 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, *op. cit.*
[40] OECD (1963), *Science, Economic Growth and Government Policy*, Paris.
[41] OECD (1967), *A Study of Resources Devoted to R&D in OECD Member Countries in 1963/64: The Overall Level and Structure of R&D Efforts in OECD Member Countries*, Paris.

The OECD analysis of the first International Statistical Year (ISY) results was conducted using groups of countries, classified according to size and economic structure. The United States was chosen as the "arithmetic" standard (index = 1,000), and the graphs of the report pictured accordingly. The United States was put in its own category, followed by "sizable industrialized countries", "smaller industrialized countries", and "developing countries" (p. 8): [42]

1. United States;
2. France, Germany, Italy, Japan, United Kingdom;
3. Austria, Belgium, Canada, Netherlands, Norway, Sweden;
4. Greece, Ireland, Portugal, Spain, Turkey.

The report concentrated on the discrepancies between the United States and European countries. It showed that the United States' GERD was highest in absolute terms as well as per capita (p. 15), and that it had the most scientists and engineers working on R&D (p. 17). "There is a great difference between the amount of resources devoted to R&D in the United States and in other individual member countries. None of the latter spend more than one-tenth of the United States' expenditure on R&D…nor does any one of them employ more than one-third of the equivalent United States number of qualified scientists and technicians", reported the OECD (p. 19).

Finer analyses [43] were conducted at three levels. Firstly, the four basic sectors – government, non-profit, higher education and business enterprise – were analyzed. OECD measurements showed that "in all the sizable industrialized countries except France, about two-thirds of the GERD is spent in the business enterprise sector" (p. 23). "In the developing countries [of Europe] R&D efforts are, conversely, concentrated in the government sector" (p. 25). The OECD also showed that industrial R&D was highly concentrated: "83% of total industrial R&D is carried out by the 130 companies [mainly

[42] Other categorizations aiming to group European countries into broader economic entities more similar in size to the United States were also used: Western Europe and Common Market countries. But the same trends were observed: "The United States spends three times as much on R&D as Western Europe and six times as much as the Common Market" (p. 19).

American] with R&D programmes worth over $10 million each" (p. 43), and "government supports a higher proportion of R&D in selected industries [aircraft, electrical, chemical] in the United States than any other industrialized member country" (p. 51).

Secondly, R&D objectives were examined within three broad areas: 1) atomic, space and defense, 2) economic (manufacturing, extraction, utilities, agriculture, fishing, forestry), and 3) welfare and miscellaneous (health, hygiene, underdeveloped areas, higher education). The results showed, among other things, that two-thirds of the United States' total R&D resources were devoted to the first category (p. 28).

Finally, research activities were broken down by type – basic, applied and development. It was calculated that the United States (and the United Kingdom) spent more on development than any other category (p. 34). Also noteworthy was the fact that "the higher education sector is less important than might be expected, undertaking less than half of total basic research in the United Kingdom and the Netherlands, and less than two-thirds in all the other industrialized countries except Norway" (p. 34).

This kind of study continued with the next biennial surveys. In 1975, the OECD published its third study on international R&D statistics.[44] The quality of the data had considerably improved, at least with regard to detail. Although the social sciences and humanities were still excluded from the R&D survey, there were more refined classifications with regard to R&D by industry, scientific field and socioeconomic objective. Statistics were also a lot more numerous (and sophisticated!)[45] than in the 1967 report.

The numbers showed that the United States continued to be the largest R&D performer in the OECD area, "spending more than all the other responding countries taken together"

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[43] These looked at both the sources of funding for and the performers of R&D.
[44] OECD (1975), *Patterns of Resources Devoted to R&D in the OECD Area, 1963-1971*, Paris.
[45] OECD (1973), *Analyzing R&D Statistics by the Méthode des Correspondances: A First Experimental Approach*, DAS/SPR/73.92.

(p. 9). But the OECD comparisons were now conducted vis-à-vis five groups of countries, and not only versus the United States. The groupings were constructed on the basis of the performance of countries based on both GERD and GERD/GNP, and allowed the OECD to invent the concept of “R&D intensity” (pp. 14-15):

Group I:	*Large R&D and Highly R&D Intensive*
	France, Germany, Japan, United Kingdom, United States
Group II:	*Medium R&D and Highly R&D Intensive*
	Netherlands, Sweden, Switzerland
Group III:	*Medium R&D and R&D Intensive*
	Australia, Belgium, Canada, Italy
Group IV:	*Small R&D and R&D Intensive*
	Austria, Denmark, Finland, Ireland, Norway
Group V:	*Small R&D and other*
	Greece, Iceland, Portugal, Spain

The report documented a “leveling off” of R&D expenditures. The phenomenon was measured in two ways (pp. 19-21). Firstly, annual growth rates of GERD and R&D manpower were stable or declining in seven countries over the period 1963-1971. Secondly, GERD/GNP was stable or declining for nine countries, among them the United States. Three conclusions were drawn from the statistics (p. 23). Firstly, “the principal change since the publication of the results of the first ISY has been the absolute and relative decline in the resources devoted to R&D by the United States and the United Kingdom and the re-emergence of Japan and Germany as major R&D powers”. Secondly, differences between member countries narrowed slightly: “in 1963, nearly 60% of all OECD R&D scientists and engineers worked in the United States, as against about 20% in the (enlarged) Common Market and 20% elsewhere (of which 15% was in Japan). By 1971, the corresponding shares were: United States, less than 55%; Common Market, virtually no change; other countries, 25% (of which 20% was in Japan)”.

Thirdly, “there was a ‘leveling off’ in the amount of resources devoted to R&D in about half the countries in the survey”.

This was only one of the main issues of the OECD report. The other was its “stress on the role of the business enterprise sector” (p. 25) – because it is the “prime performer of R&D” (p. 47) – and the respective roles of (or balance between) public and private R&D (p. 85). The report noted a slight decrease in the share of government R&D funding, but a substantial increase in the percentage of GERD financed by business funds (p. 27). In most (fifteen) countries, the business enterprise sector was the most important sector for performance of R&D, performing about two-thirds of the national effort in Groups I and II, and over half in Group III (p. 47). Only Australia and Canada differed from this group, with about one-third of the R&D performed by industry. All in all, “over the period…countries seem to have drawn together (…): the role of industry increased in nine countries”, reported the OECD (p. 49).

The increasing interest in the business sector at the Directorate for Science, Technology and Industry (DSTI) was a direct consequence of the then-current debate on technological gaps. [46] One of the conclusions of the OECD study on the issue was that innovation was at the heart of discrepancies between the United States and Europe. [47] The obvious solution for national governments was to support industry’s’ efforts, and for the OECD to continue putting emphasis on industrial statistics. A specific analysis of industrial R&D trends published in 1979, and a *Science and Technology Indicators* series begun in 1984, would specifically contribute to the latter.

Trends in Industrial R&D (1979) continued the previous analyses on the leveling off of R&D funding, especially in “the new economic context since the energy crisis of 1973”. [48] The study was originally undertaken by an OECD group of experts examining “science

[46] B. Godin (2002), *Rhetorical Numbers*: *How the OECD Constructs Discourses on Science and Technology*, Project on the History and Sociology of S&T Statistics, Montreal.
[47] OECD (1970), *Gaps in Technology*, Paris.
[48] OECD (1979), *Trends in Industrial R&D in Selected member countries, 1967-1975*, Paris, p. 5.

and technology in the new economic context". [49] It concluded that "the new economic context does not seem to have had a major impact" (p. 16), since no change was observed in the overall level of industrial R&D, although a slight increase of 8% occurred between 1967 and 1975 (p. 14). Privately-funded industrial R&D grew by about 30% (p. 16), mainly before the crisis, but was offset by a decline in government support, above all in the United States. The report also noted a significant redistribution (and convergence) of industrial R&D in the OECD area, as efforts in the United States and the United Kingdom have declined, and those in Japan and Germany have increased (p. 17).

The core of the report, however, was devoted to analyzing trends in nine groups of manufacturing industries, each industry group being discussed in terms of its share of the three principal areas of performance: United States, EEC countries, and others, notably Japan. The study included only the main eleven OECD countries – classified into two groups: major and medium industrial R&D countries – because "they perform 97% of all industrial R&D in the OECD area" (p. 11), although a small final chapter (9 pages out of a total of 200 pages) discussed "small" countries.

The series *Science and Technology Indicators* (STI) followed, with three editions published in 1984, 1986 and 1989. The first edition dealt wholly with R&D, while the other two added some new indicators. These exercises were perfect examples of ranking countries and then assessing their efforts against the best performers. The series and its successor were a further step in the OECD' s philosophy of ranking countries using the GERD indicator.

The 1984 edition started with an overall view of R&D in the OECD area, in line with the 1975 report. The main results were threefold: 1) slower growth in R&D expenditures in the 1970s compared to the 1960s, although higher than 1970 GNP growth, 2) the United States remained the main performer of R&D, but its share of total R&D declined by 6% in the 1970s, while that of Japan increased by 4% and that of the European Community

[49] The main result of the group was published as: OECD (1980), *Technical Change and Economic Policy,* Paris.

remained relatively unchanged (slight gain of only 1%); 3) the share of government R&D in public budgets diminished in almost all countries, as did the share of the university sector.

Grouping of Countries in *STI* – 1984

High

Unites States, Japan, Germany, France, United Kingdom

Medium

Italy, Canada, Netherlands, Sweden, Switzerland, Australia, Belgium

Low

Austria, Norway, Denmark, Yugoslavia, Finland, New Zealand, Ireland

Others

Spain, Portugal, Turkey, Greece, Iceland

Following the general overview of the OECD area, four groups of countries were constructed according to their GERD, each group discussed in a separate chapter. This constituted the core of the report (260 pages out of a total of more than 330 pages), and was preceded by a short discussion on grouping exercises. The report refused to use any country as a yardstick or "norm" (p. 24):

> The United States is far from being a typical OECD country…Many authors simply take the resource indicator concerned for the United States and for one or two other major spenders as a "norm", as they are the technological leaders to whose R&D patterns the other countries should be aspiring in relative if not in absolute terms. However, here we shall take a different approach. For each R&D resource indicator we shall try and establish what the typical OECD country spends and then identify the exceptions. This "typical" OECD country is not defined in precise [*a priori* and unique] statistical terms [arithmetic average, median, etc.] but is based on observations of tables for individual indicators (industrial R&D, defense R&D, energy R&D).

Nevertheless, the OECD analyzed countries' performances according to groups labeled with normative names (high, medium and low GERD). While each group was treated separately, the overview chapter continued to compare countries and rank them, generally against the largest five, because "once we have identified and discussed what happened to R&D in these five countries [the United States, Japan, Germany, the United Kingdom and France] we have more or less explained what happened to R&D in the OECD area as a whole" (p. 20). Over and over again, the organization conducted its analysis with recurrent comparisons using expressions like "the largest spenders", and those in "first place", or "at the upper end of the range".

The OECD's grouping was founded on the following rationale: "it is only meaningful to make absolute comparisons between countries which devote broadly the same amounts to R&D in that they face the same degree of constraint in allocating resources" (p. 22). For the OECD, however, there remained more important groups (high GERD) than others (low GERD) and, within each of them, there were winners (generally the bigger countries) and losers (the smaller ones).

With the second edition of *STI* in 1986, grouping of countries was reduced to just three categories – large, medium, and small countries – and this grouping was not used in the analysis, but only in graphs (e.g.: p. 22) and tables (pp. 86ss). The dimension used for the grouping was country size, although this was not defined explicitly.

With regard to R&D, the main message of the report was similar to the previous one: 1) R&D funding increased by 3.5% annually between 1969 and 1981, 2) the United States lost a few percentage points between 1969 and 1983 (from 55% of OECD GERD to 46%); Japan gained several percentage points (from 11% of OECD GERD to 17%), but the European Community's position has not changed; 3) the business enterprise sector has taken over from the public sector as the main funder of R&D, with two-thirds of GERD, while the share of universities continued to decline. This last point (industry's increasing share of GERD) became a target which several countries thereafter suggested in their policy documents.

Grouping of Countries in *STI* – 1986

Large

United States, Japan, Germany, France, United Kingdom, Italy, Canada

Medium

Spain, Australia, Netherlands, Sweden, Belgium, Switzerland, Austria, Yugoslavia

Small

Denmark, Norway, Greece, Finland, Portugal, New Zealand, Ireland, Iceland

In this second edition, a new type of ranking appeared: industries were classified into three groups with regard to their R&D intensity: [50] high, medium or low. The first group corresponded to what the OECD called "high technology industries", that is, industries that spent over 4% of turnover on R&D. [51] This was one more ranking for which the performance of countries was evaluated in terms of share of high technology industries, growth, market share and trade balance.

The third edition of *STI* (1989) did not change very much, continuing the previous trends. The same message as in the previous two editions, and the same grouping as in the last report, prevailed. One characteristic of the previous reports, however, gained increased emphasis: the analysis and tables were regularly presented according to what the OECD

[50] The very first OECD statistical exercise on "research-intensive industries" is to be found in OECD (1963), *Science, Economic Growth and Government Policy*, Paris, pp. 28-35, and OECD (1970), *Gaps in Technology*, Paris, pp. 206-212 and 253-260. For criticisms of the indicator, see: L. Soete (1980), *The Impact of Technological Innovation on International Trade Patterns: The Evidence Reconsidered*, Science and Technology Indicators Conference, 15-19 September, Paris, OECD, STIC/80.33; K. S. Palda (1986), Technological Intensity: Concept and Measurement, *Research Policy*, 15, pp. 187-198; D. Felsenstein and R. Bar-El (1989), Measuring the Technological Intensity of the Industrial Sector: A Methodological and Empirical Approach, *Research Policy*, 18, pp. 239-252; J. R. Baldwin and G. Gellatly (1998), *Are There High-Tech Industries or Only High-Tech Firms? Evidence From New Technology-Based Firms*, Research Paper Series, No. 120, Statistics Canada.

[51] Aerospace, Computers, Electronics, Pharmaceuticals, Instruments, Electrical Machinery.

called geographical zones: OECD (in which the United States and Japan were separately identified, as well as the seven largest countries as a category or group), EEC, Nordic countries, and Others.

A fourth *STI* report was envisaged, but never completed. [52] In fact, after 1989, the DSTI statistical unit would never again publish official reports wholly devoted to the analysis of its R&D survey. Instead, it published regular statistical series (without analysis) on one hand (like *Main Science and Technology Indicators*), and on the other hand, contributed to the policy analyses conducted at the DSTI. The main contribution was the *Science and Technology Policy: Review and Outlook* series, and its successor – *Science, Technology and Industry Outlook*.

Treatment of the GERD in *STI* and
Science, Technology and Industry Outlook

		GERD
Science and Technology Indicators		
1984	407 pages	407 pages
1986	125 pages	63 pages
1989	137 pages	130 pages
Science, Technology and Industry Outlook		
1985	101 pages	None
1988	123 pages	None
1992	273 pages	20 pages
1994	341 pages	63 pages
1996	344 pages	12 pages
1998	328 pages	24 pages
2000	258 pages	12 pages

The first two editions of the series contained very few statistics. Policy trends and problems were treated mostly in qualitative language, although the first edition (1985)

[52] OECD (1989), *Summary Record of the NESTI Meeting*, STP (89) 27, p. 10.

included a very brief discussion of countries grouped according to GERD/GNP (p. 18), and the second (1988) contained a series of statistical tables, mainly on scientific papers, in an appendix. With the third edition (1992) and those following, however, an overview text reminiscent of the *STI* series was included as a separate chapter or section. It had the same structure, indicators and breakdowns as before, but less discussion broken down by country groups and rankings. In fact, what characterized the new series, above all from the 1996 edition on, was more diversity in the sources of statistics (other than just R&D numbers).

Conclusion

As early as 1967, the OECD warned countries against uncritical use of the GERD/GNP indicator: "Percentages of GNP devoted to R&D are useful in comparing a country's R&D effort with resources devoted to competing national objectives or to track its growth over time. International comparisons of GNP percentages are, however, not good yardsticks for science planning". [53] Certainly, "the percentage of GNP devoted to R&D varies directly with per capita GNP. [But] this appears to be true at the top and bottom of the scale" only. [54]

Again in 1975, the OECD stated: "Around the time of the publication of the first ISY results, many member countries were expanding their R&D efforts, and the percentage of GNP devoted to R&D was considered an important science policy indicator for which targets were to be set. This enthusiasm for GNP percentages has waned. For most, growth has seldom reached the more optimistic targets (notably the oft-quoted figure of 3% of GNP)". [55]

In fact, the indicator was not without its dangers. Firstly, as the OECD itself admitted, "international comparisons might lead to a situation where, for prestige reasons, countries

[53] OECD (1967), A Study of Resources Devoted to R&D in OECD member countries in 1963/64: The Overall Level and Structure of R&D Efforts in OECD member countries, *op. cit.* p. 15.
[54] *Ibid.* p. 19.
[55] OECD (1975), Patterns of Resources Devoted to R&D in the OECD Area, 1963-1971, *op. cit.* p. 23.

spend more on R&D than they need or can afford". [56] Secondly, the indicator said nothing about the relationship between the two variables: is the GNP of a country higher because it performs more R&D, or are R&D expenditures greater because of a higher GNP? [57]

> R&D expenditures and the gross national product show a high degree of correlation. The conclusion, of course, cannot be drawn that one of these is cause and the other effect – in our modern economy they are closely inter-linked and that is the most we can say. [58]

Finally, the indicator and the comparisons based upon it did not take diversity of countries or sectors into account. [59]

Despite these warnings, it was the OECD itself that contributed to the widespread use of the indicator. In every statistical publication, the indicator was calculated, discussed, and countries ranked according to it, because "it is memorable", [60] and is "the most popular one at the science policy and political levels, where simplification can be a virtue". [61] The OECD regularly compared countries within each of its policy series *Reviews of National Science Policy* [62] and *Science, Technology and Industry Outlook,* [63] and was emulated by others. For example, the United Nations and UNESCO developed specific GERD/GNP objectives for developing countries [64], as well as objectives for funding of developing countries by developed countries, [65] and national governments systematically introduced the GERD/GNP target into their policy objectives to argue for more and more R&D

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[56] OECD (1966), *Government and the Allocation of Resources to Science*, Paris, p. 50.
[57] B.R. Williams (1964), Research and Economic Growth: What Should We Expect?, *Minerva*, 3 (1), pp. 57-71; A. Holbrook (1991), The Influence of Scale Effects on International Comparisons of R&D Expenditures, *Science and Public Policy*, 18 (4), pp. 259-262.
[58] R. H. Ewell (1955), Role of Research in Economic Growth, *Chemical and Engineering News*, 33 (29), p. 2981. For similar warnings, see also: J.-J. Salomon (1967), Le retard technologique de l'Europe, *Esprit*, December, pp. 912-917.
[59] K. Smith (2002), Comparing Economic Performance in the Presence of Diversity, *Science and Public Policy*, 28 (4), pp. 267-276.
[60] OECD (1984), *Science and Technology Indicators*, Paris, p. 26.
[61] 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).
[62] The series covered every country, starting in 1962.
[63] See, for example: OECD (1985), *Science and Technology Policy Outlook*, Paris: pp. 20-21
[64] See, for example: United Nations (1960), *Declaracion de Caracas*, New York; United Nations (1971), *World Plan of Action for the Application of Science and Technology to Development*, New York, pp. 55-61.

resources, that is, the equivalent percentage to that in the United States. [66] A country not investing the "normal" or average percentage of GERD/GNP always aimed for higher ratios, generally those of the best-performing country: "the criterion most frequently used in assessing total national spending is probably that of international comparison, leading perhaps to a political decision that a higher target for science spending is necessary if the nation is to achieve its proper place in the international league-table". [67]

Thus, the OECD erred in 1974 when it wrote: "The search for "Magic Figures" of the 1960s, namely the percentage of GNP spent on R&D, has lost much of its momentum and relevance". [68] The indicator still remains the most cherished by governments today.

[65] United Nations (1971), *Science and Technology for Development*, New York.
[66] For an example, see R. Voyer (1999), Thirty Years of Canadian Science Policy: From 1.5 to 1.5, *Science and Public Policy*, 26 (4), pp. 277-282.
[67] OECD (1966), Government and the Allocation of Resources to Science, *op. cit.* p. 50.
[68] OECD (1974), The Research System, volume 3, Paris, p. 174.

Appendix

Coverage of Official R&D Surveys in Terms of Sectors

(First editions)

	Sectors				
	Industry	Govt.	Univ.	Others	Total
United States					
National Research Council	1933				
Works Progress Administration	1940				
National Resources Committee	1941	1938 [69]			
Bush (Bowman report)					1945
Kilgore		1945			
OSRD		1947			
Steelman Board					1947
Bureau of Budget		1950			
Harvard Business School	1952				
	1953				
Bureau of Labor Statistics	1953				
Department of Defense					1953
National Science Foundation	1956	1953		1956 [70]	1956
Canada					
National Research Council	1941				
Department of Reconstruction		1947			
Dominion Bureau of Statistics	1956	1960			
United Kingdom					
Federation of British Industries	1943				
ACSP					1956
DSIR	1958				

[69] Includes data on universities.
[70] Includes data on universities.