Defining R&D:
Is Research Always Systematic?

Benoît Godin

3465, rue Durocher
Montréal (QUE)
Canada H2X 2C6

Project on the History and Sociology of S&T Statistics

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Defining R&D:
Is Research Always Systematic?

According to the Oxford Dictionary, the term "research" has French origins and appeared in the 16th century. [1] It is rooted in the term "search" invented in the 14th century and defined as "examine *thoroughly*". Research meant an "act of searching *closely and carefully*", or "intensive searching". It was first applied to science in 1639 as "scientific inquiry", but rarely used in that context before the end of the 19th century.

These definitions all included the essential idea of *systematicity.* Current definitions also focus on this idea. Whether one looks at 20th century dictionaries or international conventions on R&D, definitions of research always contain the idea of systematicity. The 1939 edition of the Webster dictionary, for example, defined research as "*diligent* inquiry or examination in seeking facts or principles", [2] while more recent definitions often specify "diligent *and systematic*". Similarly, the OECD's definition of research and development (R&D) uses the word "systematic" explicitly: R&D is "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". [3]

Despite these parallels, the current concept of "systematic" science is radically different from what it originally was. The purpose of this present paper is to discuss a change in the notion of research that occurred in the twentieth century, as a result of using a specific sense of "systematic". There are three parts to the thesis. First, the meaning of systematic in definitions of research has drifted from an emphasis on the *scientific method* to an emphasis on *institutionalized* research. Second, this drift is closely related to the (modern) instrument

[1] *Oxford Dictionary of English Etymology*, C.T. Onions (ed.), Oxford: Clarendon Press, 1966; *The Shorter Oxford English Dictionary*, W. Little, H.M. Fowler, J. Coulson, Oxford: Clarendon Press, 1959.
[2] *Webster's 20th Century Dictionary of English Language*, New York: Guild Inc., 1939.

used for measuring research and to its limitations, namely the survey. Third, the definition had important consequences on the numbers generated, the most important one being the undercounting of R&D.

Research Institutionalized

The OECD international standards on R&D suggest that governments measure institutional rather than individual research: it is institutions that should be surveyed, not their individual researchers. [4] The measurement of research is thus based on the classification of institutions by economic sector as defined in the National Accounting System (NAS). The original sectors included government, industry and households (individuals) but, for R&D statistics, the latter has been eliminated and the university sector added.

The OECD Frascati manual (1993) suggests two approaches for surveying R&D: one only surveys a *few* known R&D performers (or institutions), as most countries do, while the other surveys a random sample of all R&D performers:

> There are at least two feasible approaches for establishing the survey population of the business enterprise sector. One is to survey a sample drawn from the entire sector, choosing the sample on the basis of the company data available to the methodologists, such as employees and sales, by industry and region. The other is to try and survey only firms supporting R&D (para. 399, p. 107).

Until 1993, there was no precise standard for deciding which firms to include in the survey. Member countries therefore interpreted the text differently, making international comparisons difficult. This meant that small and medium sized firms (SME) were, usually, poorly surveyed because R&D was thought to be "a statistically rare event in smaller

[3] OECD (1993), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris: paragraph 57, p. 29.

[4] During the discussions in 2000 about the revision of the Frascati Manual, the OECD began, however, to look at how to measure R&D performed by consultants which amount to 13% of all current costs for R&D in the business sector in Sweden for example. See: DAS/EAS/STP/NESTI(2000)17; A. Sundstrom (2001), *Improve the Quality of R&D Personnel Data, Especially in Respect to Consultants*, DSTI/EAS/STP/NESTI (2001) 14/PART15.

units", i.e. not systematic. [5] In fact, the OECD distinguishes R&D according to whether it is continuous or *ad hoc*:

> 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 (para. 153, p. 51).

The manual recommends concentrating on continuous R&D only:

> 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. (para. 392, p. 105) 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 (para. 394, p. 106).

From these citations, one may conclude that systematic R&D is to be understood as research performed on an institutionalized and, above all, *continuous* basis. The main requirements to that end were put forward in the 1993 edition of the Frascati Manual, although they clearly reflected past and current practices of statisticians.

The Semantics of "Systematic"

The definition of research as an organized, formal and continuous activity is an important drift in the concept of research. One historical use of systematic in relation to research was associated with positivism that defined science as a search for comprehensive regularity and general law. [6] *Inductivism* was closely associated with this definition. This is, for example, the understanding given by the Canadian Department of Reconstruction and

[5] OECD (1981), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris: para. 243, p. 72.
[6] C. Hempel and P. Oppenheim (1948), Studies in the Logic of Confirmation, *Philosophy of Science*, 15 (135): 135-175.

Supply in its survey of government R&D in 1947: "(…) with the growth of modern scientific methods (…) which proceeds by observation and experiment, and by the *systematizing of the resulting facts and relationships into truth or laws*, the search for new knowledge, especially in the scientific and technical fields has become more and more institutionalized and professionalized". [7]

This meaning gave rise to and has been incorporated in the institutional definition of pure research as the general knowledge of nature and its laws: science as an activity that begins with observations and ends in truth and general laws. [8]

This meaning of systematic is closely related to a second one, that of *scientific method*. One can find it stated explicitly in UNESCO documents, for example. The first edition of the *Guide to the Collection of Statistics on Science and Technology* defined scientific research with four elements, among them was "the use of scientific methods, or work in a *systematic* way". [9] Elsewhere, we also read: "An activity can be said to be scientific, in fact, when it is based on a network of logical relationships which make it possible to obtain reproducible and measurable results. The methods used to obtain these results may be considered as techniques when the skills they employ are also systematic, when these skills are based on numerical measurements, and when the results which these measurements give are reliable". [10]

The model behind this understanding of research is, of course, the natural sciences that proceed by way of (laboratory) experimentation. [11] The model was so pervasive that "E"

[7] Department of Reconstruction and Supply (1947), *Research and Scientific Activity: Canadian Federal Expenditures 1938-1946*, Government of Canada: Ottawa: p. 5.
[8] V. Bush (1945), *Science: the Endless Frontier*, North Stratford: Ayer Company Publishers Inc., 1995: 81.
[9] UNESCO (1977), *Guide to the Collection of Statistics in Science and Technology*, Paris, p. 18; see also K. Messman (1977), *A Study of Key Concepts and Norms for the International Collection and Presentation of Science Statistics*, UNESCO: Paris, p. 20.
[10] J.-C. Bochet (1974), *The Quantitative Measurement of Scientific and Technological Activities Related to R&D Development*, CSR-S-2, Paris: UNESCO: p.1.
[11] Since the 1970 edition of the Frascati Manual, the OECD adds the adjective "experimental" to "development" to avoid a confusion between development, a phase of R&D, and the same term in economics, and to use the same term as Eastern European countries and UNESCO.

(for experimentation) sometimes replaced the "D" of R&D. [12] The model also suggested, for some time, the exclusion of the social sciences and humanities from the definition of research, because not "organized" research but individual.

Despite these meanings, UNESCO documents also contained the third and most recent meaning of systematic science found in OECD documents, but in more explicit terms:

> An activity to be considered at the international level of science statistics must be properly structured, i.e. it must meet the minimum requirements of a *systematic* activity such as: the person (s) exercising this activity must work during a significant number of hours per years; there must exist a programme of work; a certain amount of financial resources must be specifically allocated to the work.
>
> This means that diffused, discontinued or scattered S&T activities, i.e. activities carried out sporadically, or from time to time, within the various services of an institution, thus not meeting the above-mentionned minimum requirements of a systematic activity, should not be taken into account.
>
> There follows, therefore, that non-institutionalized, individual and/or discontinued, diffused or scattered activities are to be excluded for the presentation of international statistics". [13]

Where did this third meaning of systematic research come from? To the best of my knowledge, it came from industrialists, assisted by the US National Research Council. The more developed argumentation, however, came from the US Work Projects Administration (WPA), an organization created in 1935 and whose mandate was to provide jobs on which people could use their skills.

Industrial research underwent expansion after World War I. Most big firms became convinced of the necessity of investing in research and began building laboratories for the purpose of conducting R&D. [14] R&D had to be organized and systematized. The issue of

[12] This is the case for tax legislations in Canada and the United States. For the latter, see: H. R. Hertzfeld (1988), Definitions of R&D for Tax Purposes, in O.D. Hensley, *The Classification of Research*, Lubbock (Texas): Texas Tech University Press, pp. 136-137.
[13] K. Messman (1977), *op. cit.*, p. 10.
[14] On the emergence of industrial research, see: M.A. Dennis (1987), Accounting for Research: New Histories of Corporate Laboratories and the Social History of American Science, *Social Studies of Science*, 17: 479-518; J.K. Smith (1990), The Scientific Tradition in American Industrial Research, *Technology and Culture*, 31: 121-131. On statistics on industrial R&D for the beginning of the 20th century, see: D.E.H. Edgerton (1987), Science and Technology in British Business History, *Business History*, 29: 84-103; D.E.H. Edgerton and S.M. Horrocks (1994), British Industrial R&D Before 1945, *Economic History Review*, 47: 213-238; D.C.

"systematically" organizing industrial research was on every manager's mouth: *The Organization of Industrial Scientific Research* (C.E.K. Mees, Kodak), *The Organization of Scientific Research in Industry* (F.B. Jewett, ATT), *Organized Industrial Research* (C.D. Coolidge, General Electric), *Organized Knowledge and National Welfare* (P.G. Nutting, Westinghouse) are only some of the numerous titles by industrialists that appeared between 1915 and 1935.

The NRC was part of this "movement". Numerous discourses, similar in tone, were published in the Reprint and Circular Series of the NRC in the 1920s and 1930s. In 1932, for example, the NRC organized a conference in which industrialists, among them W.R. Whitney from General Electric, talked of *science as systematized knowledge and research as systematized search*, [15] and urged that "America must be foremost in *systematic, organized* research, or we shall be distanced by other countries". [16] The year after, M. Holland, from the NRC Division of Engineering and Industrial Research, in an analysis of the last biennial NRC survey of industrial research laboratories, concluded that: "scientific research has made of invention a *systematic*, highly efficient process". [17] The NRC was here recalling the new interests of industrialists in the organization of research in firms. It gave itself the task of promoting these ideas.

The close links between the NRC and industries goes back to the preparedness of the Council (1916). Industrialists were called for in First World War's research efforts coordinated by the NRC. After the War, the NRC, "impressed by the great importance of promoting the application of science to industry (…), took up the question of the

Mowery (1983), Industrial Research and Firm Size, Survival, and Growth in American Manufacturing, 1921-1946: An Assessment, *Journal of Economic History*, 43: 953-980; D. F. Noble (1977), *America by Design: Science, Technology and the Rise of Corporate Capitalism*, Oxford: Oxford University Press.

[15] W.R. Whitney and L.A. Hawkins (1932), Research in Pure Science, in M. Ross, M. Holland and W. Spraragen, *Profitable Practice in Industrial Research: Tested Principles of Research Laboratory Organization, Administration, and Operation*, New York: Harper and Brothers Publishers, p. 245. Whitney and Hawkins seem to oscillate between two meanings of systematic. On the one hand, is the meaning of generic facts and principles (p. 245) discovered by experiments (p. 249); on the other that of a system, mainly the European system of free men devoting their entire time to research with the assistance of students (pp. 247-248).

[16] *Ibid*, p. 253.

organization of industrial research, (…) and inaugurated an Industrial Research Section to consider the best methods of achieving such organization (…)." [18] "In the 1920s, the division had been a hotbed of activity, preaching to corporations the benefits of funding their own research. The campaign contributed to a fivefold increase from 1920 to 1931 in the number of US industrial labs". [19] The Division conducted special studies on industrial research, arranged visits of industrial research laboratories for executives, organized conferences on industrial research, helped set up the Industrial Research Institute – an organization that still exists today [20] – and compiled a biennial repertory of laboratories from 1920 to the mid 1950s. [21]

To the NRC we also owed one of the first historical analyses of industrial research in the United States. In its voluminous study on industrial research published in 1941 by the National Resources Planning Board, the NRC (and historian H.R. Bartlett from MIT) narrated the development of industrial research as follows: "until the twentieth century, industrial research remained largely a matter of the unorganized effort of individuals. Early in the 1900's a few companies *organized* separate research departments and began a systematic search not only for the solution of immediate problems of development and production, but also for new knowledge that would point the way to the future". [22]

The WPA took the idea and developed the most full-length argument defining research as systematic in the third sense. In 1935, the WPA started a project on *Reemployment Opportunities and Recent Changes in Industrial Techniques* "to inquire, with the

[17] M. Holland and W. Spraragen (1933), *Research in Hard Times*, Division of Engineering and Industrial Research, National Research Council, Washington, p. 13.
[18] NRC 1918-1919 report to the Council of National Defense; cited in A.L. Barrows, The Relationship of the NRC to Industrial Research, in National Research Council (1941), *Research: A National Resource II: Industrial Research*, National Resources Planning Board, Washington: USGPO, p. 367.
[19] G.P. Zachary (1997), *Endless Frontier: Vannevar Bush, Engineer of the American Century*, Cambridge (Mass.): MIT Press, 1999, p. 81.
[20] The Institute was launched in 1938 as the National Industrial Research Laboratories Institute, renamed the next year as the Industrial Research Institute. It became an independent organization in 1945.
[21] See A.L. Barrows (1941), *op. cit*; R.C. Cochrane, *The National Academy of Sciences: The First Hundred Years 1863-1963*, Washington: National Academy of Sciences, 1978: pp. 227-228, 288-291, 388-346.
[22] H.R. Bartlett, *The Development of Industrial Research in the United States*, in National Research Council (1941), *op. cit*., p. 19. A similar argumentation appeared in NRC's study of 1933 (Holland and Spraragen, *op. cit*., pp. 12-13), but it was but far less developed and articulated.

cooperation of industry, labor, and government, into the extent of recent changes in industrial techniques and to evaluate the effects of these changes on employment and unemployment". [23] Out of this project came, among sixty studies, measures of R&D in industry.

The WPA used NRC repertoires of industrial laboratories to assess the scope of industrial R&D and innovation in the country, and published its analysis in 1940. [24] The report 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" (p. xi). The authors contrasted colonial times when research was random, haphazard and unorganized because it was realized by independent inventors (pp. 46-47), with modern times when, between 1927 and 1938 for example, "the number of organizations reporting research laboratories has grown from about 900 to more that 1 700 affording employment to nearly 50 000 workers" (p. 40). 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" (p. 41). "The facilities available in these laboratories make it possible for the scientist to devote his time exclusively to work of a professional caliber. 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" (p. 43).

This is the rationale behind the current meaning of systematic in R&D definitions. Research is organized research, i.e. laboratory research. The meaning diffused rapidly in R&D surveys. For example, the first survey of industrial R&D in the United States conducted by the National Research Council in 1941 described industrial research as *"organized and*

[23] On this project and on the debate on technological unemployment, see: A.S. Bix (2000), *Inventing Ourselves Out of Jobs? America's Debate over Technological Unemployment, 1929-1981*, Baltimore: Johns Hopkins University Press, pp. 56-74.
[24] G. Perazich and P.M. Field (1940), *Industrial Research and Changing Technology*, Work Projects Administration, National Research Project, report no. M-4, Pennsylvania: Philadelphia.

systematic research for new scientific facts and principles (…) and presupposes the employment of men educated in the various scientific disciplines". [25] Similarly, the first survey of industrial R&D by the Federation of British Industries (FBI) defined research as "organized experimental investigations", [26] while the influential Harvard Business School one talked of "planned search for new knowledge". [27]

But it is the National Science Foundation (NSF) and the OECD that generalized the concept. As early as its first R&D survey in 1953 (concerned with non-profit institutions), the NSF defined research and development as "*systematic*, intensive study directed toward fuller knowledge of the subject studied and the *systematic* use of that knowledge for the production of useful materials, systems, methods, or processes". [28] This was an extension of the "industrial" definition (of the Harvard Business School) to other sectors. [29] The OECD followed with the 1970 edition of the Frascati Manual. [30]

Industrialized Research

Why did the third meaning of systematic prevail over others? Why privilege the organization rather than the method (or content) of research? To be sure, if one looks in dictionaries, systematic involves the idea of a system, and when the system concerns intellectual matters, systematic means deduction and logic. The everyday use, on the other hand, means to proceed with method. Organized and sustained are mentioned as pejorative meanings only.

I offer here three factors for explaining the appearance of the term systematic in the definition of research. The first is the influence of the industrial survey on R&D surveys in

[25] National Research Council (1941), *op. cit.*, p. 6.
[26] Federation of British Industries (FBI) (1947), *Scientific and Technical Research in British Industry*, London, p. 4.
[27] D.C. Dearborn, RW. Kneznek and R.N. Anthony (1953), *Spending for Industrial Research, 1951-1952*, Division of Research, Graduate School of Business Administration, Harvard University, p. 44.
[28] National Science Foundation (1953), *Federal Funds for Science*, Washington, p. 3.
[29] Surprisingly, the NSF never included the term "systematic" in its industrial survey.
[30] The OECD definition, with its reference to systematicity, only appeared in the second edition of the OECD Frascati Manual (1970), and not the first (1963).

general. The industrial survey influenced the whole methodology of questionnaires, including questionnaires for surveying government and university R&D, by equating the general notion of research with systematized research. The NRC was the main link here. Its Research Information Service inquired regularly into industrial research laboratories from 1920, and its repertoires of laboratories served for compiling the first statistics on industrial R&D, be it in NRC own surveys – the first in America – [31] or in those of the Work Projects Administration, the Bush report, [32] the Steelman report, [33] the Harvard Business School, [34] or the Bureau of Labor Statistics. [35] Then, the NSF took over and developed its whole surveys according to a questionnaire modeled on industrial R&D that had been contracted out in 1952 by the Department of Defense (DoD) to researchers at Harvard University Business School and to the Bureau of Labor Statistics. The former aimed "to recommend a definition of R&D that can be used for statistical and accounting purposes", [36] while the latter conducted the survey to "assist the military departments in locating possible contractors for R&D projects" (W.G. Whitman, chairman, Defense R&D Board). [37]

Second, statisticians recognized from the beginning that the activities surveyed and generally included in definitions of research varied considerably. Delimitations had to be drawn and conventions defined in order to measure research activities properly. One of the ways this was done was to exclude routine work from research by defining the latter as systematic activity. [38]

The third factor has to do with the costs of conducting a survey. Because there are ten of thousands of firms in a country, units surveyed have to be limited to manageable proportions. This was done by introducing a bias in industrial surveys: the survey identified

[31] M. Holland and W. Spraragen (1933), *op.cit.*; National Research Council (1941), *op. cit*.
[32] V. Bush (1945), *Science: The Endless Frontier*, North Stratford: Ayer Co. Publishers, 1995.
[33] J.R. Steelman (1947), *Science and Public Policy*, New York: Arno Press, 1980.
[34] D.C. Dearborn, R.W. Kneznek and R.N. Anthony (1953), *op.cit*; R.N. Anthony and J.S. Day (1952), *Management Controls in Industrial Research Organizations*, Boston: Harvard University Press.
[35] 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.
[36] D.C. Dearborn, R.W. Kneznek and R.N. Anthony (1953), *op. cit*.
[37] Bureau of Labor Statistics (1953), *op. cit*.
[38] See: B. Godin (2001), *op. cit*.

all major R&D performers, that is big firms with laboratories (organized research) and surveyed them all, but selected only a sample of smaller performers, when they did. This decision was also supported by the fact that only big firms had precise book-keeping practices on R&D because the activity could be located in a distinct and formal entity, the laboratory.

All three factors were at work in the influential Harvard Business School survey [39] that conditioned the NSF and subsequent OECD Member Countries' practices of surveying only big firms. The Harvard survey itself was an outgrowth of another one on research control practices in industrial laboratories. [40] The survey showed that firm size was one of the main variable explaining R&D investments. Consequently, the authors suggested: [41]

> 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.

Industrial research also led to a semantic innovation: the addition of "development" to "research" created the acronym we now know as R&D. Before the beginning of the present century, people simply spoke of science, sometimes of inquiry or investigation. Research was a term that became generalized after being used regularly by industries where "science" was often a contested term when applied to industry: industrial research blurred the boundaries between pure and applied. The term was rapidly incorporated in names of public institutions like the National *Research* Council (USA and Canada), and the Department of Scientific and Industrial *Research* (UK).

[39] D.C. Dearborn, R.W. Kneznek and R.N. Anthony (1953), *op. cit*.
[40] R.N. Anthony and J.S. Day (1952), *op. cit*. According to Anthony and Day (p. ix), the idea for this survey came from industrialists, among them J.M. Knox, Vice-President, Research Corporation, New York.
[41] R.N. Anthony and J.S. Day (1952), *op. cit*., pp. 6-7.

Development is a term first introduced in taxonomies of research by industry. The first NRC directory of industrial laboratories (1920) distinguished research and development (without breakdown because, so it argued, "no sharp boundary can be traced between them"). [42] The inspiration was clearly industrial since the whole inquiry was conducted with the aid of industrialists and professional societies, and since the NRC specified that it did not innovate but accepted the terms and numbers given by companies. It was not long before every manager talked of research and development: in the thirties, most annual report of companies brought both terms together. [43]

Government imitated the industrial practice with the creation of the US Office of Scientific Research and Development (OSRD) in 1941. Here, the category of development was coupled to that of research for two reasons. First, there were problems, during the war, with innovations getting rapidly into production. [44] As Stewart noted: [45]

> Between the completion of research and the initiation of a procurement program there was a substantial gap which the armed services were slow to fill. It was becoming increasingly apparent that for the research sponsored by NDRC (OSRD's predecessor) to become most effective, it was essential that the research group carry its projects through the intermediate phase represented by engineering development.

Indeed, firms experienced a lot of problems with production, and universities were often called on to help with development (pilot plants, large-scale testing). [46] Indeed, in 1943, as a partial response to those who push for operational research, [47] the OSRD created the Office of Field Service to bring research nearer to the military users. [48] With the OSRD, V. Bush thus succeeded in obtaining greater responsibilities than he had with its predecessor,

[42] NRC (1920), *Research Laboratories in Industrial Establishments of the United States of America*, Bulletin no 2, p. 2.
[43] For examples, see: M. Holland and W. Spraragen (1933), *op. cit*., pp. 9-11.
[44] C. Pursell (1979), Science Agencies in World War II: The OSRD and its Challenges, in N. Reingold, *The Sciences in the American Context: New Perspectives*, Washington: Smithsonian Inst. Press: p. 363.
[45] I. Stewart (1948), *Organizing Scientific Research for War*, New York: Arno Press, 1980, p. 35.
[46] L. Owens (1994), The Counterproductive Management of Science in the Second World War: Vannevar Bush and the OSRD, *Business History Review*, 68: pp. 553-555.
[47] E.P. Rau (2000), The Adoption of Operations Research in the United States During World War II, in A.C. Hughes and T.P. Hughes, *Systems, Experts, and Computers: The Systems Approach in Management and Engineering, World War II and After*, Cambridge (Mass.): MIT Press, pp 57-92.
[48] I. Stewart (1948), *op. cit*., p. 128.

the National Defense Research Committee (NDRC), namely responsibilities for development, procurement and liaison with the Army, besides research activities, [49] without getting involved in production *per se*, i.e. with respect of the frontiers between research and production.

Thanks to the OSRD, the "R&D" acronym spread to other organizations, first among them the Department of Defense (the *Research and Development* Board (1946), the position of Assistant Secretary of Defense for *R&D* (1953), the Air Force *R&D* Command (1950)), the Atomic Energy Act of 1946 that defined *R&D* in its own terms, the Senate that measured the government wartime effort in terms of *R&D* in 1945, [50] and the Bureau of Labor that integrated the acronym in its surveys in 1953, [51] as well as the National Science Foundation in the same year. [52] The concept also spread rapidly to the academic world, [53] then other countries [54], and international organizations (OECD, UNESCO).

The second reason why development came to be associated with research in statistics was that the former constitutes the bulk of research in industry and, for that reason, had to be identified as such. This is still the main purpose of the category today.

What Do R&D Surveys Count?

[49] *Ibid*, p. 527.
[50] H.M. Kilgore (1945), *The Government's Wartime Research and Development, 1940-44: Survey of Government Agencies*, Subcommittee on War Mobilization, Committee on Military Affairs, Washington.
[51] *Scientific Research and Development in American Industry: A Study of Manpower and Costs*, Department of Labor, Bureau of Labor Statistics, and Department of Defense (Research and Development Board), Washington, 1953.
[52] The acronym was so new that the NSF felt obliged to specify, in its first survey of industrial R&D: "The abbreviation "RD" is frequently used in this report to denote research and development (…)". NSF (1956), *Science and Engineering in American Industry: Final Report on a 1953-1954 Survey*, Washington, NSF 56-15, p. 1.
[53] D.C. Dearborn, R.W. Kneznek and R.N. Anthony (1953), *op. cit*.
[54] Dominion Bureau of Statistics (1956), *Industrial Research-Development Expenditures in Canada, 1955*, Ottawa; DSIR (1958), *Estimates of Resources Devoted to Scientific and Engineering R&D in British Manufacturing Industry, 1955*, London. The DSIR did not separate applied research and development but considered them as one category. In that sense, it followed Bush (1945), *op. cit*., and OSRD (1947), *Cost Analysis of R&D Work and Related Fiscal Information*, Budget and Finance Office, Washington.

Government statisticians think that the only valid instrument for measuring science is the survey. Any other instrument (bibliometrics, patents) is discredited from the start, conveniently overlooking the fact that surveys have their own limitations, a fact that would undermine the monopoly of science measurement by government statisticians.

In the eighties, A. Kleinknecht conducted a study assessing the quality of the measures produced by official R&D surveys. He designed his own survey of industrial R&D and compared his results with those obtained by a government survey. He found large differences between the two types of surveys, mainly for small and medium sized (SME) firms. The author measured four times more man/year devoted to R&D in SME than that which had been reported in the government survey. Overall, the official survey underestimated R&D by as much as 33%. [55]

The reason offered for the differences was that SME tend to conduct R&D in an informal way rather than on a continuous basis or in a department of the firm exclusively devoted to R&D. [56] Non-budgeted R&D is the rule in SME: "in small firms, development work is often mixed with other activities". Kleinknecht estimated that 33% of firms devoted less than one man/year to R&D. The number goes up to 50% of firms in the service industry. Since then, other studies have confirmed these results using data on R&D tax credit [57] or innovation surveys. [58]

[55] 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.

[56] The NSF has already identified the problem in the 1950s. See: NSF (1956), *Science and Engineering in American Industry: Final Report on a 1953-1954 Survey*, NSF 56-16, Washington: p. 89 presented a questionnaire sent specifically to firms conducting negligible R&D activities; and NSF (1960), *Research and Development in Industry, 1957*, NSF 60-49, Washington: pp. 97-98 discussed informal R&D in small companies.

[57] M.S. Lipsett and R.G. Lipsey (1995), Benchmarks, Yardsticks and New Places to Look for Industrial Innovation and Growth, *Science and Public Policy*, 22 (4): 259-265.

[58] OECD, DSTI/EAS/STP/NESTI(2000)26REV1 and DSTI/EAS/STP/NESTI/RD(2000)24; D. Francoz, *Achieving Reliable Results From Innovation Surveys: Methodological Lessons Learned From Experience in OECD Member Countries*, Communication presented to the Conference on Innovation and Enterprise Creation: Statistics and Indicators, Sophia Antipolis, 23-24 november 2000.

How did Kleinknecht find the missing R&D in SME? He included a question specifically designed for firms that have no formal department of R&D. This led SMEs to report even quite small-scale R&D work than they would have reported in the official survey: "if your enterprise does not have an R&D department, R&D activities might be carried out by other departments within your enterprise. For example: the sales department might develop a new product, or the production department might introduce improvements to a production process. Have any R&D activities been carried out within your enterprise even though you do not have a formal R&D department?". [59]

The OECD listened to these criticisms and accepted to discuss the issue during the 4th revision of the Frascati Manual. The French authorities suggested certain modifications. [60] Two options were discussed. One was to omit 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. In fact, the word systematic has never been defined explicitly in any edition of the Frascati manual. This was also rejected. However, and more importantly, a precise number was put forward and adopted for defining (core) R&D: one FTE (full-time equivalent) person working on R&D per year. Smaller efforts would have to be surveyed via other sources (i.e. innovation surveys). [61]

There are still conventions, however, preventing the full consideration of R&D expenditures. One such rule that we have not yet mentioned is the definition of a full-time researcher. According to the OECD, a full-time researcher is a person who devotes 90% of its activity to research. [62] Conversely, people whose research activity is less that 10% of their total work never figure in official calculations of research, although they spend time on research. This restriction has the effect of eliminating the proportion of scattered research incidental to professional activity and which, added together, can represent a large sum.

[59] Kleinknecht (1987), *op. cit*., p. 254.
[60] OECD (1991), *R&D and Innovation Surveys: Formal and Informal R&D*, DSTI/STII/(91)5 and annex 1.
[61] OECD (1993), *op. cit*., para. 393, p. 106.

Conclusion

Government and intergovernmental organizations developed a specific definition of research centered around the notion of systematic and institutionally organized research. They have done so to accommodate industry's definition of research and the inherent limitations of survey measurements.

Before this definition of research as systematic was standardized at the international level, two situations prevailed. First, definitions differed according to what government body preformed the survey (see annex). Second, and more often, research was "defined" with types or categories only (basic, applied, development) or merely a list of activities. This was the case for V. Bush's *Science: The Endless Frontier* (1945) and for J.R. Steelman's report (1947). [63] It was also the case for the first survey of the UK Department of Scientific and Industrial Research (1955), [64] and for the first edition of the Frascati Manual (1963).

Qualifying research as systematic had important consequences. By the middle of the 1950s, this new conception of research has spread to almost all institutions and countries, had modified the language (R&D) used to talk of research and, above all, had limited the scope of measurement to a specific set of research performers.

In fact, the concept of systematic research had considerably more influence than another innovation that appeared around the same time: the concept of scientific (and technical) activities (STA) invented in Canada and used for some time by the NSF. [65] Although UNESCO (1978) and the OECD (1981) tried to resuscitate the concept, it rarely succeeded

[62] OECD (1993), op. cit., para. 297, p.84.
[63] J.R. Steelman (1947), *op. cit*.
[64] DSIR (1958), *op. cit*.
[65] B. Godin, (2001), *op. cit*.

in broadening surveys to include activities other than R&D. Clearly, the only activities unaffected by the notion of systematicity are the measurements themselves.

Annex.

Some Definitions of Research

US National Resources Committee (1938):

Investigations in both the natural and social sciences, and their applications, including the collection, compilation, and analysis of statistical, mapping, and other data that will probably result in new knowledge of wider usefulness that aid in one administrative decision applying to a single case (p. 62).

US National Research Council (1941):

Organized and systematic search for new scientific facts and principles which may be applicable to the creation of new wealth, and presupposes the employment of men educated in the various scientific disciplines (p. 6).

US Atomic Energy Act (1946):

Theoretical analysis, exploration, and experimentation, and the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials, and processes (section 3e).

Canadian Department of Reconstruction and Supply (1947):

Purposeful seeking of knowledge or new ways of applying knowledge, through *careful* consideration, experimentation and study (p. 11).

Federation of British Industries (1947):

Organized experimental investigations into materials, processes and products, and scientific principles in connection to industry, and also development work, but excluding purely routine testing (p. 4).

Harvard School of Administration (1953):

Activities carried on by persons trained, either formally or by experience, in the disciplines and techniques of the physical sciences including related engineering, and the biological sciences including medicine by excluding psychology, if the purpose of such activity is to do one or more of the following things: 1) pursue a *planned* search for new knowledge, whether or not the search has reference to a specific application, 2) apply existing knowledge to problems involved in the creation of a new product or process, including

work required to evaluate possible uses, 3) apply existing knowledge to problems involved in the improvement of a present product or process (p. 92).

NSF (1953):

Systematic, intensive study directed toward fuller knowledge of the subject studied and the *systematic* use of that knowledge for the production of useful materials, systems, methods, or processes (p. 3).

OECD (1970):

Creative work undertaken on a *systematic* basis to increase the stock of scientific and technical knowledge [66] and to use this stock of knowledge to devise new applications (p. 31).

UNESCO (1978):

Any *systematic* and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications.

[66] "including knowledge of man, culture and society " was added in 1976.