Highly Qualified Personnel:
Should we Really Believe in Shortages?

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Project on the History and Sociology of S&T Statistics
Working Paper No. 15

Previous papers in the series:

1. B. Godin, *Outlines for a History of Science Measurement*.
2. B. Godin, *The Measure of Science and the Construction of a Statistical Territory: The Case of the National Capital Region (NCR)*.
3. B. Godin, *Measuring Science: Is There Basic Research Without Statistics?*
4. B. Godin, *Neglected Scientific Activities: The (Non) Measurement of Related Scientific Activities*.
5. H. Stead, *The Development of S&T Statistics in Canada: An Informal Account*.
6. B. Godin, *The Disappearance of Statistics on Basic Research in Canada: A Note*.
7. B. Godin, *Defining R&D: Is Research Always Systematic?*
8. B. Godin, *The Emergence of Science and Technology Indicators: Why Did Governments Supplement Statistics With Indicators?*
9. B. Godin, *The Number Makers: A Short History of Official Science and Technology Statistics*.
10. B. Godin, *Metadata: How Footnotes Make for Doubtful Numbers*.
11. B. Godin, *Innovation and Tradition: The Historical Contingency of R&D Statistical Classifications*.
12. B. Godin, *Taking Demand Seriously: OECD and the Role of Users in Science and Technology Statistics*.
13. B. Godin, *What's So Difficult with International Statistics? UNESCO and the Measurement of Scientific and Technological Activities*.
14. B. Godin, *Measuring Output: When Economics Drive Science and Technology Measurements*.

Highly Qualified Personnel: Should we Really Believe in Shortages?

The measurement of research and development (R&D) is composed of two basic sets of data: money spent on R&D and human resources devoted to R&D. Previous papers in this series have dealt at length with the former. For several people, however, above all some of the pioneers of science and technology statistics (C. Freeman, R.N. Anthony, W.H. Shapley, and C. Falk), human resources are much more appropriate than money as a measure of science and technology activities. [1] This idea goes back to the US National Research Council's (NRC) surveys on industrial research in the early 1930s. [2] As the US science adviser J.R. Steelman stated in 1947: "the ceiling on research and development activities is fixed by the availability of trained personnel, rather than by the amounts of money available. The limiting resource at the moment is manpower". [3]

Several problems concerning the measurement of scientific and technical personnel are similar to those concerning the measurement of R&D expenditures since both types of statistics share some basic categories and are broken down according to the same institutional classifications. [4] However, two methodological problems are specific to the

[1] R.N. Anthony (1951), *Selected Operating Data for Industrial Research Laboratories*, Harvard Business School, Boston (Mass.), pp. 3-4: "In view of these difficulties [accounting methods and definitions], we decided to collect only a few dollar figures (…) and to place most of our emphasis on the number of persons"; W.H. Shapley (1959), in NSF, *Methodological Aspects of Statistics on R&D: Costs and Manpower*, NSF 59-36, Washington, p. 13: "Manpower rather than dollars may be a preferable and more meaningful unit of measurement"; C. Freeman (1962), Research and Development: A Comparison Between British and American Industry, *National Institute Economic Review*, 20, May, p. 24: "The figures of scientific manpower are probably more reliable than those of expenditures"; C. Falk, and A. Fechter (1981), *The Importance of Scientific and Technical Personnel Data and Data Collection Methods Used in the United States*, Paper presented for the OECD Workshop on the Measurement of Stocks of Scientific and Technical Personnel, October 12-13, 1981, p. 2: "At the current time STP data seem to be the only feasible indicator of overall scientific and technical potential and capability and as such represent a most valuable, if not essential, tool for S&T policy formulation and planning".

[2] B. Godin (2002), The Number Makers: Fifty Years in the History of Official Statistics on Science and Technology, *Minerva*, in press.

[3] Steelman, J.R. (1947), *Science and Public Policy*, New York: Arno Press, 1980, p. 15.

[4] Godin, B. (2001), *Metadata: How Footnotes Make for Doubtful Numbers*, Montreal: OST; Godin (2001), *Tradition and Innovation: The Historical Contingency of R&D Statistical Classifications*, Montreal: OST.

measurement of human resources devoted to R&D. Firstly, there is the problem of definition: what is a scientist? [5] In fact, the response varies according to whether a country measures qualifications or occupations. Secondly, there is the problem of measurement: should we measure by head-counts or full-time equivalents (FTE)? [6] The answers to these questions were standardized in the OECD Frascati manual, although countries interpret them differently.

This paper is concerned with the origins of statistics on scientists and engineers in OECD countries and their relationship to science policy issues. [7] It argues that early debates about human resources in science and technology created two fictions: the shortages of scientists and engineers, and the brain drain. It shows how the discourses on personnel shortages and the brain drain owe their existence to statistics, and how statistics – with their deficiencies and methodological difficulties – generated controversies: incomplete statistics never prevented people taking firm position on scientific and technical human resources.

The first part of this paper demonstrates how human resources related to science and technology came to be measured as a result of World War II or, as some called it, the "war drain". [8] Throughout the post-war period, the United States was subject to a discourse on the shortages of scientists and engineers while Great Britain was subject to a discourse on the brain drain. This part of the paper seeks to understand how and why these discourses were developed. The second part extends the argument to (other European countries and) the OECD, showing how its preoccupation with the reconstruction of Europe after the war was the driving force behind its early efforts at measurement. The third part documents the

[5] NSF (1999), *Counting the S&E Workforce: It's Not That Easy*, Issue Brief, NSF 99-344, SRS Division, Washington.
[6] OECD (2000), *R&D Personnel Measured in Full-Time Equivalents*, DSTI/EAS/STP/NESTI (2000) 15; OECD (2001), *Assess Changes to Improve Collection of Headcount Data*, DSTI/EAS/STP/NESTI (2001)14/PART14; OECD (2001), *Measurement of FTE on R&D*, DSTI/EAS/STP/NESTI (2001) 14/PART16.
[7] To properly document the full range of issues involved would require a book length study. For present purposes, I concentrate only on the main episodes and the most influential countries.
[8] F.B. Jewett (1947), The Future of Scientific Research in Postwar World, reprinted in J.C. Burnham (ed.) (1971), *Science in America: Historical Reflections*, New York: Holt, Reinhart and Winston, p. 405.

recent shift in OECD measurement from statistics about researchers involved in R&D to indicators on the supply and demand of scientists and engineers.

Reminiscences of War

The measurement of scientific and technical personnel in OECD countries was from the start motivated by the consequences of World War II on the number of qualified personnel. The first collections and uses of statistics in public debates came mainly from the United States and Great Britain. Other countries – Canada for example – also documented the phenomenon, but nowhere was the impact of these debates more important than in the United States and the United Kingdom.

Deficits and Shortages in the American Workforce

World War II had an enormous impact on science in the United States. Not only had the war demonstrated the importance of government support for scientific research – a fact well documented in the literature –, but it also, according to some, slowed the production of scientists and engineers in the country. World War II has absorbed nearly all physically fit American graduate students into the armed forces. In 1945, V. Bush commented: “We have drawn too heavily for nonscientific purposes upon the great natural resource which resides in our young trained scientists and engineers. For the general good of the country too many such men have gone into uniform (…). There is thus an accumulating <u>deficit</u> of trained research personnel which will continue for many years”. [9]

Because it would take at least six years after the war ended before research scientists would begin to emerge from the graduate schools in significant numbers, one of Bush’s committees, [10] in collaboration with the American Institute of Physics, predicted (without giving details on the methodology used) a deficit of 150 000 bachelor’s degrees and 17 000

[9] V. Bush, (1945), *Science: The Endless Frontier*, North Stratford: Ayer Co., 1995, p. 24.
[10] Committee on Discovery and Development of Scientific Talent.

advanced degrees for 1955. [11] "Neither our allies nor, as far as is known, our enemies have permitted such condition to develop", stated the committee. [12]

Two years later, the Steelman report agreed with this assessment. Based on a large number of different sources, [13] J.R. Steelman estimated that the American "manpower pool today is smaller by 90 000 bachelors and 5 000 doctors of science than it would have been had pre-war trends continued". [14] The net loss to the country, however, was estimated to be 40 000 bachelors, and 7 600 PhDs. [15] Steelman's numbers were smaller than Bush's because the former estimated that normally only 90% of doctors and a third of bachelors enter careers in research or teaching.

For Steelman, these numbers were estimates of shortages rather than of deficits (which are larger), for they represented "the number of students who probably would have graduated in science and made careers in science if the war had not forced them out of school". [16] Two causes were identified for the shortages. Besides the wartime demands themselves, Steelman discussed the increase in demand for American R&D that began before the war and which was increased by the destruction and disruption of Europe: "The increase in demand occurred so sharply – expenditures tripled and quadrupled within a few years – than no possible training program could have turned out an adequate supply of scientists. It takes an average of ten years' training to prepare for independent scientific research". [17]

Now that the rhetorical framework had been set, it was not long before other American scientific institutions to follow suit, among them the National Science Foundation (NSF), [18]

[11] V. Bush (1945), *op. cit.* p. 158
[12] *Ibid*. p. 159.
[13] National Research Council, National Resources Planning Board (National Roster of Scientific and Specialized Personnel), Office of Education.
[14] Steelman, *op. cit*. p. 16.
[15] Steelman, volume 4, p. 14.
[16] *Ibid*. p. 3.
[17] *Ibidem*.
[18] The 1950s' literature on the topic is voluminous. The following list contains only a few important texts. For the United States, see: National Manpower Council (1953), *A Policy for Scientific and Professional Manpower*, New Yoirk: Columbia University Press; D. Wolfe (1954), *America's Resources of Specialized Talent: A Current Appraisal and Look Ahead*, Report of the Commission on Human Resources and Advanced

began adopting the same discourses. Raymond. H. Ewell, head of the Program Analysis Office at the NSF in the 1950s, and probably the first individual to perform an economic analysis linking R&D and GDP, launched the NSF discourse in 1955: “Figures indicate a requirement of 75 000 research scientists and engineers from 1954 to 1960, and a requirement for a net increase of 150 000 from 1954 to 1965. There is substantial doubt whether the required numbers of research scientists and engineers will be available”. [19]

Thereafter, the NSF developed discourses on the eminent shortage of scientists and engineers in the country (and enrolled industrialists in the crusade by surveying their lamentations on the lack of qualified personnel [20]). We can identify three steps in the construction of these discourses. Firstly, in the late 1950s, the NSF relied on predictions that had been calculated by others. In 1957, it compared the country’s actual needs in science and technology resources with what Steelman had predicted the country would need in 1957. [21] The organization observed that the country was far short of the goals that had been envisioned ten years earlier, at least with respect to basic research. The lesson was clear: the Federal Government must increase its support to basic research. Secondly, the NSF began developing its own predictions, by projecting past trends into the future. To facilitate this task, it launched an information program on the supply and demand of scientific and technical personnel, for which the Bureau of Labor Statistics conducted forecasting studies. [22] It projected a doubling of science and engineering doctorates by

Training, New York: Harper and Row; D.M. Blank and G.J. Stigler (1957), *The Demand and Supply of Scientific Personnel*, National Bureau of Economic Research, New York; A.A. Alchian, K.J. Arrow, and W.M. Capron (1958), *An Economic Analysis of the Market for Scientists and Engineers, Rand Corporation*, RM-2190-RC. For Great Britain, see: J. Alexander (1959), *Scientific Manpower*, London: Hilger and Watts; G.L. Payne (1960), *Britain’s Scientific and Technological Manpower*, London: Oxford University Press.

[19] R.H. Ewell (1955), Role of Research in Economic Growth, *Chemical and Engineering News*, 33 (29), p. 2982.

[20] See, for example: NSF (1956), *Science and Engineering in American Industry, 1953-54 Survey*, NSF 56-16, Washington, pp. 53-54; NSF (1955), *Shortages of Scientists and Engineers in Industrial Research*, Scientific Manpower Bulletin, no 6, August.

[21] National Science Foundation (1957), *Basic Research: A National Resource*, Washington, pp. 46-47.

[22] NSF (1961), *The Long-Range Demand for Scientific and Technical Personnel: A Methodological Study*, NSF 61-65, Washington; NSF (1963), *Scientists, Engineers, and Technicians in the 1960s: Requirements and Supply*, NSF 63-34, Washington.

1970. [23] Thirdly, the NSF developed its own tools – surveys and databases on science and engineering doctorates – with which it produced a regular series of statistics.

The first tool it used was a roster on scientific and specialized personnel created at the suggestion of the National Research Council (NRC) during World War II. The idea for a roster was itself inspired by similar registers by the British Royal Society and other professional societies. By 1939, the Royal Society register, which was soon taken over by the Ministry of Labor, had collected some 80 000 names of scientists. [24]

The American roster was intended to facilitate the recruitment of specialists for war research. [25] In 1940, the National Resources Planning Board (NRPB) established, following the recommendation of its Committee on Wartime Requirements for Specialized Personnel, the plan for the national roster and operated the latter jointly with the Civil Service Commission until it was transferred to the War Manpower Commission in 1942. [26] Several organizations collaborated in the effort, among them the NRC that set up, under Bush's request, an Office of Scientific Personnel. The NRC had in fact already begun compiling directories on specialized personnel several years before. [27] The roster was intended to "make proper contact between the right man and the right job (…) where acute manpower shortages have been found to exist". [28] "The task was an enormous one – to compile a list of all Americans with special technical competence, to record what those qualifications were, and to keep a current address and occupation for each person. (…) Questionnaires were sent out, using the memberships lists of professional societies and subscription lists of

[23] NSF (1961), *Investing in Scientific Progress*, NSF 61-27,Washington, p. 15; NSF (1967), *The Prospective Manpower Situation for Science and Engineering Staff in Universities and Colleges: 1969-1975*, Washington.
[24] C. Pursell, *op. cit*., p. 367.
[25] NRPB (1942), *National Roster of Scientific and Specialized Personnel*, Washington.
[26] The roster was again transferred to the Department of Labor in 1945. Other rosters were also established in the Office of Naval Research (ONR): one on top scientific personnel (1948) and another on engineering personnel (1949).
[27] B. Godin (2001), *The Number Makers: A Short History of Official Science and Technology Statistics*, Montreal: OST.
[28] NRPB (1942), *op. cit*. p. 1.

technical journals, and the data were coded and placed on punched cards for quick reference". [29] By 1944, the roster had detailed punch-card data on 690 000 individuals. [30]

Considered of little practical use by many, [31] and inoperative since 1947, the roster along with a national scientific register that had been operated by the Office of Education since 1950, was transferred to the NSF in 1952. [32] It then developed the roster further [33] as required by the law setting up the agency, and used it to produce statistical analyses fifteen years. [34] The NSF finally abandoned the roster in 1971, [35] by which time surveys have begun systematically replacing directories. Following a request by the Bureau of Budget, the NSF, jointly with the President's Committee on Scientists and Engineers that found itself handicapped by lack of data, [36] recommended a program for national information on scientific and technical personnel. [37] The NSF gradually developed a whole system of surveys – the Scientific and Technical Personnel Data System (STPDS) – for tracking the supply of graduates, their occupations and geographical mobility (Table 1). The system was revised in the early 1990s to better measure occupations, among other things. [38] Before then, taxicab drivers with advanced degrees in physics were officially classified as

[29] C. Pursell (1979), Science Agencies in World, War II: The OSRD and its Challenges, in N. Reingold, *The Sciences in the American Context*, Washington: Smithsonian, p. 367-368.

[30] R.C. Cochrane (1978), *The National Academy of Sciences: The First Hundred Years 1863-1963*, Washington: National Academy of Sciences, p. 406.

[31] "Those charged with recruiting chemists and physicists for OSRD and its contractors knew the outstanding men in each field already and through them got in touch with many young men of brilliant promise". J.P. Baxter (1946), *Scientists Against Time*, Boston: Little, Brown and Co., p. 127.

[32] National Science Board, *Minutes of the 5th meeting*, 6 April 1951; National Science Board, *Minutes of the 6th meeting*, 11 May 1951.

[33] NSF (1961), *The National Register of Scientific and Technical Personnel,* NSF 61-46, Washington; NSF (1964), *National Register of S&T Personnel*, NSF 64-16, Washington.

[34] See the series *American Science Manpower*, published from 1954 to 1970. For pre-NSF statistical studies based on the roster, see: NRPB (1941), *Statistical Survey of the Learned World*, Washington; L. Carmichael (1943), The Number of Scientific Men Engaged in War Work, *Science*, 98 (2537), pp. 144-145; Department of Labor (1946), *Directory of Colleges and Universities Offering Graduate Degrees and some Form of Graduate Aid*, Washington.

[35] National Science Board, *Minutes of the 142nd meeting*, 14-15 November 1971.

[36] President's Committee on Scientists and Engineers (1956), **Title**.

[37] NSF (1958), *A Program for National Information on Scientific and Technical Personnel*, NSF 58-28, NSF and President's Committee on Scientists and Engineers, Washington.

[38] NRC (1989), *Surveying the Nation's Scientists and Engineers: A Data System for the 1990's*, Washington; NSF (1989), *The Scientific and Technical Personnel Data System: The Plan for the Nineties*, SRS Division, NSF, Washington.

physicists, producing enormous counting differences with other agencies like the Bureau of Labor Statistics or the Census Bureau.

According to many, the NSF's data on scientists and engineers were and remain unique among OECD countries: [39]

> The number and distribution of scientists and engineers were recognized to be important indicators of a nation's S&T potential when the first S&T statistics were being designed in the 1960s. However, only the United States set up and has systematically maintained a coherent system for monitoring stocks and flows of scientists and engineers. Other countries have generally expressed a need for international data only in the context of short-term policy issues such as the brain drain or ageing.

Table 1.
NSF Surveys and Census

Survey	Frequency	First year for which data are available
Survey of Earned Doctorates	Annual	1957
National Survey of College Graduates	Biennial	1962
Survey of Graduate Students and Post-doctorates in Science and Engineering	Annual	1966
Integrated Postsecondary Education Data System Completions Survey	Annual	1966
Immigrant Scientists and Engineers	Annual	1968
Survey of Doctorate Recipients	Biennial	1973
National Survey of Recent College Graduates	Biennial	1976
Occupational Employment Statistics Survey	Triennial	1977

It was with such statistical data that the NSF lobbied for more resources year after year. H.A. Averch has documented the argumentative strategy as follows: [40]

1. Since the potential of scientific discoveries is unlimited, there should be a continually increasing flow of manpower for research;

[39] OECD (1994), *Statistics and Indicators for Innovation and Technology*, DSTI/STP/TIP (94)2/ANN1, p. 14.
[40] H.A. Averch (1985), *A Strategic Analysis of Science and Technology Policy*, Baltimore: Johns Hopkins University Press, chapter 4.

2. Market forces do not deliver researchers in sufficient quantity or quality to meet national needs;
3. Therefore, the government should secure enough money to supply the right number of scientists and engineers.

Enter statistics: the “right number” of scientists and engineers was to be determined by the statisticians and their users – the President’s Science Advisory Committee, [41] the National Academy of Sciences, [42] the Association of American Universities, [43] the Bureau of Labor Statistics, [44] … and the NSF. [45] These arguments worked for a while. Then, in 1989, the NSF published a highly controversial study forecasting a shortage of 675 000 scientists and engineers in the next two decades. [46] The study was swiftly and widely criticized for extrapolating from simplistic demographic trends. [47] The NRC recommended that: “The NSF should not produce or sponsor official forecasts of supply and demand of scientists and engineers (…). The NSF should limit itself to data collection and dissemination”. [48]

[41] *Meeting Manpower Needs in Science and Technology*, Washington, 1962.
[42] NRC (1985), *Engineering Education and Practice in the United States*, Study conducted at the request of the NSF, Washington.
[43] J.C. Vaughn and R.M. Rosenzweig (1990), Heading Off a PhD Shortage, *Issues in Science and Technology*, Winter: 66-73.
[44] See note 22. For a critical assessment, see: L. Hansen (1984), *Labor Market Conditions for Engineers: Is There a Shortage?*, National Research Council, Washington, pp. 75-98; W.L. Hansen (1965), Labor Force and Occupational Projections, Proceedings of the 18th Annual Winter Meeting, December 28 and 29, 1965, Industrial Relations Research Association, Madison, Wisconsin: 10-30.
[45] NSF (1969), *Science and Engineering Doctorate Supply and Utilization, 1968-1980*, NSF 69-37; NSF (1971), *1969 and 1980 Science and Engineering Doctorate Supply and Utilization*, NSF 71-20; NSF (1975), *Projections of Science and Engineering Doctorate Supply and Utilization, 1980 and 1985*, NSF 75-301; NSF (1979), *Projections of Science and Engineering Doctorate Supply and Utilization, 1982 and 1987*, NSF 79-303; NSF (1984), *Projected Responses of the Science, Engineering and Technicians Labor Market to Defense and Non-defense Needs: 1982-87*, NSF 84-304.
[46] NSF (1989), *Future Scarcity of Scientists and Engineers: Problems and Solutions*, Washington; NSF (1990), *The State of Academic Science and Engineering*, Washington., pp. 189-232.
[47] US House Subcommittee on Investigations and Oversight of the Committee on Science, Space and Technology (1992), *Projecting Scientific and Engineering Personnel Requirements for the 1990s*, 102nd Congress, 2nd session, April 8; National Research Council (2000), *Forecasting Demand and Supply of Doctoral Scientists and Engineers: Report of a Workshop on Methodology*, Washington. For a synthesis of the debate see: D.S. Greenberg (2001), *Science, Money, and Politics: Political Triumph and Ethical Erosion*, Chicago: University of Chicago Press, chapters 7-9.
[48] National Research Council (2000), Forecasting Demand and Supply of Doctoral Scientists and Engineers: Report of a Workshop on Methodology, *op. cit*, pp. 55-56.

Despite the warning, Congress recently asked the organization to predict how many high-tech workers the United States will need over the next decade. [49]

All in all, the success of American predictions on the supply and demand of scientists and engineers was about zero: [50] by 1968, all predictions of shortages had proved incorrect. But this did not deter the NSF nor any other organizations from pursuing and refining the same general discourses. When argument based on quantity lost their persuasive appeal, one turned to the alarming quality of researchers: there is always a shortage of exceptionally able scientists. [51] The rhetorical resources of scientists and their representatives are in fact infinite, especially when people are driven by political goals. As D.S. Greenberg recently commented: “Lacking any real political power (…) science employed desperate appeals which precision took second place to propaganda”. [52]

The British Brain Drain

The American debate on scientists and engineers was centered on shortages. The brain drain issue was inexistent in this country because the United States is a net importer of scientists and engineers. [53] Americans, for instance, spoke of brain circulation instead of brain drain. [54] The situation was different in Europe, however.

After the United States, concern over personnel shortages was greatest in Great Britain was the second most (followed by Canada [55]). [56] According to H.G. Johnson, the term brain

[49] *Science* (1998), Forecast: Fog Ahead on Job Front, 282, 4 December, p. 1795.
[50] Office of Technology Assessment (1985), *Demographic Trends and the Scientific and Engineering Work Force: A Technical Memorandum*, Washington; NRC (1984), *Labor-Market Conditions for Engineers: Is There a Shortage?*, Office of Scientific and Engineering Personnel, Washington; W.L. Hansen (1967), The Economics of Scientific and Engineering Manpower, *Journal of Human Resources*, 2 (2): 191-220.
[51] H.A. Averch, *op. cit*.
[52] D.S. Greenberg (2001), *Science, Money, and Politics: Political Triumph and Ethical Erosion*, Chicago: University of Chicago Press, p. 77.
[53] *The Brain Drain into the United States of Scientists, Engineers, and Physicians*, House of Representatives, Committee on Government Operations, 90th Congress, 1st Session, Washington: USGPO, 1967.
[54] NSF (1998), *International Mobility of Scientists and Engineers to the United States: Brain Drain or Brain Circulation*, Issue Brief, NSF 98-316, June 22.
[55] L. Parai (1965), *Immigration and Emigration of Professional and Skilled Manpower During the Post-War Period*, Special study no. 1, Economic Council of Canada: Ottawa.

drain originated in the United Kingdom because of government policies that kept salaries from arising too rapidly, resulting in the emigration of scientists to North America. [57] The British government even considered banning foreign recruitment advertising in the late 1960s. [58]

In the 1950s, the British Advisory Council on Science Policy (ACSP), through its committee on scientific manpower, had pioneered the collection of statistics on the supply of scientists and engineers in Great Britain. Its works involved not only assessing the then current supply of scientists and engineers but also forecasting the demand for them. The numbers produced were published regularly until 1963-64 and were followed by reports in 1966 and 1968 by the Committee on Manpower Resources for Science and Technology.

Early British Official Statistical Studies
on S&T Personnel

Scientific Man-Power, Report of a Committee Appointed by the Lord President of the Council (Barlow Committee), Cmd. 6824, 1946.

Report on the Recruitment of Scientists and Engineers by the Engineering Industry, ACSP, Committee on Scientific Manpower, 1955.

Scientific and Engineering Manpower in Great Britain, ACSP and Ministry of Labour & National Service, 1956.

Scientific and Engineering Manpower in Great Britain: 1959, ACSP, Committee on Scientific Manpower, Cmnd. 902, 1959.

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[56] For developing countries, see for example: S. Dedijer (1961), Why Did Daedalus Leave?, *Science*, 133, 30 June: 2047-2052; United Nations (1968), *Outflow of Trained Personnel from Developing Countries*, New York, 68-24459; Unesco (1969), *The Problem of Emigration of Scientists and Engineers*, Paris; Unesco (1971), *Scientists Abroad: A Study of the International Movement of Persons in Science and Technology*, COM.70/D.60/A, Paris; S. Watanabe (1969), The Brain Drain from Developing to Developed Countries, *International Labor Review*, pp. 401-433; Education and World Affairs (1970), *The International Migration of High-Level Manpower*, Committee on the International Migration of Talent, New York: Praeger.
[57] H.G. Johnson (1965), *The Economics of the Brain Drain: The Canadian Case*, Minerva, 3 (3): p. 299.
[58] *Nature* (2000), UK Discussed Ban on Foreign Job Ads in 1960s, 403, 13 January, p. 121.

The Long-Term Demand for Scientific Manpower, ACSP, Committee on Scientific Manpower, Cmnd. 1490, 1961.

Scientific and Technical Manpower in Great Britain: 1962, ACSP, Committee on Scientific Manpower, Cmnd. 2146, 1963.

Report of the 1965 Triennial Manpower survey of Engineers, Technologists, Scientists and Technical Supporting Staff, Committee on Manpower Resources for Science and Technology, Secretary of State for Education and Science and Ministry of Technology, Cmnd. 3103, 1966.

The Brain Drain, Report of the Working Group on Migration, Committee on Manpower Resources for Science and Technology, Secretary of State for Education and Science and Ministry of Technology, Cmnd. 3417, 1968.

Enquiry into the Flow of Candidates in Science and Technology into Higher Education, Committee on Manpower Resources for Science and Technology, Secretary of State for Education and Science and Ministry of Technology, Cmnd. 3541, 1968

The Flow into Employment of Scientists, Engineers and Technologists, Report of the Working Group on Manpower for Scientific Growth, Committee on Manpower Resources for Science and Technology, Secretary of State for Education and Science and Ministry of Technology, Cmnd. 3760, 1968.

The works of the ACSP, as well as a study by the Royal Society, [59] soon came under vehement criticism as soon as researchers began looking critically at it: "Its influence on policy was out of all proportion to the quality of its forecasts", commented K.G. Gannicott and M. Blaug. [60] "Instead of making out a convincing case for a shortage of scientists and technologists, with due attention to the swing from science and the brain drain which may have intensified it, the (…) Committee's efforts to develop an integrated picture of

[59] Royal Society (1963), *Emigration of Scientists from the United Kingdom*, Report of a Committee Appointed by the Council of the Royal Society, London: Royal Society.
[60] K.G. Gannicott and M. Blaug (1969), Manpower Forecasting since Robbins: A Science Lobby in Action, *Higher Education Review*, 2 (1): 56.

scientifically-qualified manpower is simply a mass of contradictions". [61] The main methodological limitations were as follows: [62]

Supply and demand:

- Uncritically accepting employers' estimates; [63]
- Projecting past trends into the future;
- Inadequately defining occupations (as an indicator of demand) and qualifications (as an indicator of supply) as well as the relationship between them;
- Confusing needs (or what ought to happen: the numbers required for the attainment of some economic targets) and demand (what actually occurs: the number who are offered employment);
- Ignoring the operations of the labor market;
- Using different methods in each survey;
- Providing insufficient details on methodology.

Brain Drain:

- Using only American immigration data;
- Not distinguishing between permanent and temporary employment abroad;
- Neglecting inflows.

These limitations were not specific the Great Britain. They were also documented for almost every national study on the brain drain. In fact, there were few statistics available to

[61] *Ibid*. p. 57.

[62] Besides Gannicott and Blaug, see: B. Thomas (1966), The International Circulation of Human Capital, *Minerva*, 5 (1): 479-506; H.G. Grubel and A.D. Scott (1966), The Immigration of Scientists and Engineers to the United States, 1949-61, *Journal of Political Economy*, 74 (4): 368-378; C.A. Moser and P.R.G. Layard (1968), Estimating the Need for Qualified Manpower in Britain, in B.J. McCormick (ed.), *Economics of Education*, Harmondsworth (Middlesex); V.A. Richardson (1969), A Measurement of Demand for Professional Engineers, *British Journal of Industrial Relations*, 7 (1): 52-70.

[63] S. Zuckerman once admitted: "One of the least reliable ways of finding out what industry wants is to go and ask industry", cited by Gannicott and Blaug, p. 59.

correctly document the phenomenon. For example, several national statistical studies on migration relied essentially on American data, namely data on emigration to the United States. [64] These were the only data available to measure the phenomenon. In using this data, however, countries like the United Kingdom were neglecting inflows into their own territory, thus probably inventing a phenomenon that did not really exist or overdramatizing a situation that was far from catastrophic.

Be it as it may, the British surveys had a considerable influence on work by the OECD. Alexander King, the first secretary of the ACSP committee on scientific manpower, soon became the director of the OEEC Office of Scientific and Technical Personnel (OSTP) and, later, the first director of the OECD Directorate of Scientific Affairs (DSA).

Internationalizing the Discourses

Two issues regarding the economic wll being and reconstruction of Europe challenged European bureaucrats after World War II: productivity and the supply of qualified human resources. These were the two domains where the OEEC – the predecessor of the OECD – invested most in terms of science and technology measurement. [65] The OECD therefore got involved in the measurement of personnel before it began measuring monetary investments in science and technology.

Documenting Gaps Between Europe, America and the USSR

The OEEC's early reflections on science and technology were conducted in several committees and authorities: the Manpower Committee (1948), Scientific and Technical Information (WP3) (1949), Scientific and Technical Matters (1951), Productivity and

[64] Some of NSF influential studies were: NSF (1958), *Immigration of Professional Workers to the United States, 1953-56*, Scientific Manpower Bulletin, NSF 58-4, Washington; NSF (1962), *Scientific Manpower From Abroad: United States Scientists and Engineers of Foreign Birth and Training*, NSF 62-24, Washington; NSF (1965), *Scientists and Engineers From Abroad*, NSF **65-1?**, Washington; NSF (1967), *Scientists and Engineers From Abroad, 1962-64*, NSF 67-3, Washington.

[65] B. Godin (2001), The Number Makers: A Short History of Official Science and Technology Statistics, *op.cit*.

Applied Research Committee (1952), Applied Research (195?), and the European Productivity Agency (1953). It is the Manpower Committee in particular that we owe the first systematic international measurements of science and technology. As early as 1951, it recommended to the Council the improvement of the comparability of manpower statistics in general. [66] As regards science and technology, it suggested that surveys be conducted in an effort to repair the recurring *lacunae* of current statistics: [67]

> Few member nations had adequate statistics on current manpower supply; fewer still on future manpower requirements. Furthermore, there were no international standards with regard to the statistical procedures required to produce such data.

The OEEC Manpower committee conducted the first international survey on scientific and technical personnel in 1954 and published its results in 1955. The Committee concluded that "on the whole, shortages do not at present seriously interfere with research or production". [68] But the report further specified that:

> Quantity is not the only factor in assessing requirements. Quality is equally important in this field. A merely numerical calculation of shortages could in fact lead to misunderstanding seeing that the shortage of a very small number of highly-qualified specialists may have very important effects on the launching of projects (p. 21).

The report recommended that countries improve their methods of measurement and supply data every two years (p. 22). The OEEC soon tried to persuade Member countries to add questions to their census: "The forthcoming general census which take place in many countries in 1960 offers an admirable opportunity to obtain information with regard to the qualification and employment of scientifically and technically trained persons". [69] In 1966, the OECD published its first analysis based on such data. [70]

[66] OEEC (1956), *Improvement of the Comparability of Manpower Statistics*, C (56) 59.
[67] OEEC (1960), *Forecasting Manpower Needs for the Age of Science*, Paris, p. 7.
[68] OECD (1955), *Shortages and Surpluses of Highly Qualified Scientists and Engineers in Western Europe*, Paris, p. 21.
[69] OEEC (1958), *Use of General Census to Gather Information on Scientific and Technical Personnel*, C(58)52, p. 22.
[70] OECD (1966), *The Education and Utilization of Highly Qualified Personnel: An Analysis of Census Data*, Inter-Governmental Conference on the Education and Utilization of Highly Qualified Personnel, DAS/EID/66.53.

An international conference on the organization and administration of applied research organized by the European Productivity Agency (EPA) in 1956 and devoted to the shortage of research workers made recommendations that were similar to those by the Manpower Committee. Regarding the 1954 survey, it reported: [71]

> It was difficult to assess shortages at present because some countries had not included questions of an appropriate nature in their census reports until about 1950, and so there was a limited basis for comparisons. National census figures also did not afford a means of determining the quality of the personnel in question.

The conference report qualified the available statistics as “sketchy” and the discussions on the topic as bedeviled by the “different interpretations given to educational qualifications and occupational terms (p. 11).” It recommended that the OEEC set up a dictionary of terms and encouraged detailed comparative surveys (pp. 11-12). The report nevertheless concluded, in contradiction to the conclusions of the 1954 survey: “It is certain that there is a general lack of qualified personnel” (p. 9).

Two years later, the second survey came to the same conclusion: “universal shortage is striking”, said the report using data that was hardly comparable between countries. For the OEEC, the results of the survey were: [72]

> a warning that countries of Western Europe, Canada and the United States are behind in their drive to produce scientists and engineers. The danger that this involves must not be underestimated. Technical progress, which is an essential factor in the improvement of living standards and security, depends upon the adequate supply of adequate personnel (…). The problem for many years to come will be to train enough qualified scientists and engineers. There will be no danger of training too many.

As a consequence, a working party on scientific and highly qualified manpower (WP25) was set up and a “vigorous program of action” developed. [73] This was motivated by the

[71] European Productivity Agency (1957), *Scientific Manpower for Applied Research: Shortage of Research Workers -How to Train and Use Them?*, OEEC: Paris, p. 8.
[72] OECD (1957), *The Problem of Scientific and Technical Manpower in Western Europe, Canada and the United States*, Paris, p. 5.
[73] OEEC (1957), *Creation of a Working Party on Scientific and Highly Qualified Manpower*, C(57)137.

recognition of a "fundamental change in the pattern of industry [due to] the development of new industries based on recent scientific discovery (…) with rich resources in the skill and ability of its people" (p. 4). The program of action was therefore "concerned with scientific manpower questions in general, basic education, university and technical high school training and industrial needs" (p. 3). The Secretariat also suggested, for the first time, a study on the "use of research funds in Member countries and the means to improve the allocation of these funds, with the goal of rationalising government research programs and, thereby, the management of human resources" (personal translation). [74]

OEEC/OECD Structures
Concerned with S&T Personnel

OEEC

Manpower Committee (1948)
WP25 (on Shortages of Highly Qualified and Technical Manpower) (1957)
Office of Scientific and Technical Personnel (OSTP) (1958)

OECD

Directorate of Scientific Affairs
    Committee on Scientific and Technical Personnel (CSTP) (1961)
    Education Committee (1970)
Directorate of Social Affairs, Manpower and Education (1974)

One year later (1958), the OEEC created the Office of Scientific and Technical Personnel (OSTP) as part of the European Productivity Agency (EPA). The Office, pursuing the work of its predecessor - the Working Party no. 25 - conducted a third survey on scientific and technical personnel in Members countries. [75] The report admitted that: "the problem of the definition of various types of scientific and technical personnel was of major concern to the

[74] OEEC (1957), *Note du Secrétaire général sur le document C(57)54*, C(57)66, p. 4.
[75] OECD (1963), *Resources of Scientific and Technical Personnel in the* OECD Area, Paris, p. 28.

experts" (p. 19). In the foreword to the publication, A. King nonetheless concluded that: [76] "although there are large gaps in the data presented in this report, the information assembled certainly represents one of the richest sources now available on the accumulation of stocks of qualified scientific and technical manpower in the OECD area (…)" (p. 5).

The survey found a growing difference between North America and Europe, and projected larger discrepancies for 1970: "Figures clearly reveal a growing difference between the two parts of the OECD area. While in 1952, the United States and Canada had 215 000 more first degrees in higher education than the European Member countries, this difference will most probably be 500 000 in 1970" (p. 28).

As similar gap between Europe and the USSR had been documented by the OEEC a few years before. [77] The study concluded that between 1954 and 1958, "the European countries have achieved less progress in the output of scientists and technologists from universities and equivalent institutions than the United States or Canada (…) [and] the Soviet Union has gained a clear lead (…). The relative positions will not, if present trends continue, be greatly changed by 1965" (p. 2). The rhetoric of this study (itself influenced by the NSF) [78] was carried over into the third survey.

The OSTP was abolished in 1961, but the Committee on Scientific and Technical Personnel continued its work in the 1960s. The committee would measure, for the first time in history, the migration of scientists and engineers between Member countries, the United States and Canada. Brain drain was a highly popular topic as we have seen. [79] The OECD had

[76] This kind of argument is documented in: B. Godin (2001), *Metadata: How Footnotes Make for Doubtful Numbers*, Montreal: OST.

[77] OEEC (1960), *Producing Scientists and Engineers: A Report on the Number of Graduate Scientists and Engineers produced in the OEEC Member Countries, Canada, the United States and the Soviet Union*, Paris, OSTP/60/414.

[78] N. De Witt (1955), *Soviet Professional Manpower: Its Education, Training, and Supply*, Washington: NSF; N. De Witt (1961), *Education and Professional Employment in the USSR*, NSF 61-40, Washington: NSF. L.A. Orleans (1961), *Professional Education in Communist China*, NSF 61-3, Washington: NSF.

[79] By 1967, S. Dedijer estimated that there were 3 000 titles recorded: S. Dedijer (1967), *Brain Drain or Brain Gain: A Bibliography on Migration of Scientists, Engineers, Doctors and Students*, Lund. The following references are to several international conferences that were organized at the time: US Advisory Commission on International Education Affairs/European Research Center (Lausanne, 1967): W. Adams, *The Brain Drain*,

previously documented some facets of this supposed brain drain with numbers produced for the Policy Conference on Economic Growth and Investment in Education held in 1961, [80] and in a study on R&D produced by C. Freeman and A. Young. [81] But the CSTP was now embarking on a huge project. In 1964, it appointed an ad hoc group to determine the feasibility of conducting a comprehensive study of the international movement of scientific and technical manpower. The group agreed that the "common impediment to taking adequate account of migration in policy decisions is the general lack of reliable information. Statistics (…) either do not exist at all or are seriously deficient in completeness, accuracy, and detail. The ad hoc studies that have been undertaken in a few countries are (…) too narrow in scope and too tentative in their conclusions to provide a sound basis for definitive policy discussions". [82] The committee concluded: "migration is necessarily an international activity that can best be studied on an international basis (…); the OEEC thus provides a suitable forum for a migration study". [83] A small steering group was subsequently appointed to establish guidelines and definitions, and to recommend methodology and sources of data. [84]

It took five years before the idea of the survey, first suggested in 1964, became reality. The report, two volumes and hundreds of pages long, was never published. [85] In general, data were partial in coverage (six countries) and difficult to process. Nevertheless, the OECD estimated that migration was overestimated and affected only a small part of the total

New York: Macmillan, 1968; Committee on Research Economics (Stockholm, 1973): *The Brain Drain Statistics*: Empirical Evidence and Guidelines, …, 1974; EEC/ESF (Strasbourg, 1980): *Employment Prospects and Mobility of Scientists in Europe*, …, 198**?**; NATO, NSF and US NRC (Lisbon, 1981): *The International Mobility of Scientists and Engineers*, …, 1982, NATO.

[80] OECD (1962), *International Flows of Students*, Policy Conference on Economic Growth and Investment in Education, volume 5, Paris.

[81] C. Freeman and A. Young (1965), *The Research and Development Effort in Western Europe, North America and the Soviet Union: An Experimental International Comparison of Research Expenditures and Manpower in 1962*, Paris: OECD, pp. 57-59.

[82] OECD (1964), *The International Movement of Scientific and Technical Manpower*, Paris, STP (64) 25, p. 2.

[83] *Ibid*, pp. 3-4.

[84] OEEC (1965), *The International Movement of Scientific and Technical Manpower*, Paris, STP (65) 1.

[85] OECD (1969), *The International Movement of Scientists and Engineers*, Paris, STP (69) 3. The document was written by Y. Fabian, G. Muzart and A. Young.

national stock of the scientific and technical work force: it is the elite who migrate. [86] This result was completely at odds with the discourse of Member countries.

The same message was conveyed in an important study on technological gaps, published in 1968. [87] The study documented, among other things, gaps between Europe and North America in the production of graduates, [88] but it also included a chapter on the brain drain. [89] This chapter brought together readily available (mainly of immigration to the United States) and showed that only a relatively small proportion of European scientists and engineers migrated to the United States. The proportion of loss to the United States was increasing, but when inflows were taken into account the net balance was about four times lower than the numbers (outflows) that usually appeared in British reports.

The OECD never pursued the work on the brain drain. In fact, in the 1970s the brain drain was no longer a central political issue. However, as the outcome of an international meeting on brain drain statistics arranged in Stockholm in 1973 by the Committee on Research Economics (**from which organization**?), Alison Young, from the OECD, acted as a consultant and drafted a proposal on guidelines for surveying international migration of highly qualified manpower. [90] Unfortunately, I have found no evidence of any use of the guidelines in the following years.

The OECD got involved considerably, however, in forecasting human resources in science and technology. These efforts were motivated by the realization that "policy makers would be better guided by a more comprehensive and strategic approach than by mere numbers on the shortages of scientists and engineers (**source**)". The OECD consequently organized

[86] OECD (1970), *International Movement of Scientists and Engineers*, Paris, STP (70) 20, p. 4.
[87] OECD (1968), *Gaps in Technology: General Report*, Paris.
[88] The study found that the overall educational effort of the United States was greater than that of Europe with respect to the production of (pure) scientists. With respect to engineers and "technologists", however, Europe surpassed the United States in both absolute and relative terms.
[89] OECD (1967), *A Note on the Brain Drain*, DAS/SPR/67.98.
[90] A. Young (1974), Guidelines for Surveying International Migration of Highly Qualified Manpower, in Committee on Research Economics, The Brain Drain Statistics: Empirical Evidence and Guidelines, *op. cit*. The specifications defined for the OECD survey served as a basis for the proposal. See: OECD (1965), *International Movement of Scientific and Technical Personnel*, SPT (65) 19.

symposia on methods of forecasting personnel. [91] These gave rise to important works on education planning in the 1960s and 1970s that mobilized the resources of the newly created Committee on education. [92] These education functions, however, were soon (1974) transferred to another directorate (Social Affairs, Manpower and Education), [93] and the Directorate of Science, Technology and Industry (DSTI) almost completely stopped dealing with scientific and technical personnel – except R&D human resources – until the 1990s.

From UNESCO to Canberra

The early OECD measurements of the scientific and technical workforce were not based on any international standards. The organization collected data from national governments that had their own definitions and collection methods. National data were therefore poorly comparable between countries. Some governments based their estimates on censuses, others on labor force surveys, still others on available and ready-made statistics (administrative records). In all these estimates, data were based on the educational qualifications of the population, as is still done in most surveys, and rarely on the occupations held by scientists and engineers. What surveys measured were graduates not jobs, supply not demand.

All these problems were identified and discussed in 1981 at an OECD workshop ("pushed and pulled by American initiatives" [94]) on the measurement of stocks of scientists and technical personnel. [95] Following the discussions, experimental questionnaires requesting

[91] OEEC (1960), Forecasting Manpower Needs for the Age of Science, *op.cit*; OECD (1962), *Employment Forecasting: International Seminar on Employment Forecasting Techniques*, Paris.
[92] OECD (1980), *Education Planning: An Historical Overview of OECD Work*, Paris; G.S. Papadopoulos (1994), *Education* 1960-*1990: The OECD Perspective*, Paris.
[93] In the 1980s, the Social Affairs, Manpower and Education Directorate (renamed the Directorate for Education, Employment, Labour and Social Affairs (DEELSA) in 1991) constructed its own indicators and started a publication based thereon: *Education at a Glance*. First edition: 1992.
[94] G. Westholm (1993), *Recent Developments in International Science and Technology Personnel Data Collection*, Draft Paper presented for the International Conference on Trends in Science and Technology Careers, Brussels, 28th-31st March, p. 4.
[95] OECD (1981), *Summary Record of the OECD Workshop on the Measurement of Stocks of Scientists and Technical Personnel*, DSTI/SPR/81.45.

data on total stocks of scientific and technical personnel were addressed to Member countries. [96] But the results were disappointing: "Only half a dozen countries responded and the quality and sparse data received did not allow any serious international comparisons to be made". [97] We had to wait until the early 1990s for OECD Member countries to define international standards, as they had done thirty years before with the Frascati manual. [98]

But it was really UNESCO that reawakened interest in scientific and technical personnel data at the international level. Very early on, in the 1960s, UNESCO began defining new categories of interest and collecting education data. The statistics were used, for example, by the OEEC in its study on gaps with the USSR. But the statistical series issued in the UNESCO Statistical Yearbooks had always been too aggregated for detailed analytical purposes. Then, in 1978, UNESCO adopted an important recommendation that defined scientific and technological activities (STA) in terms of three broad classes of activities: R&D, scientific and technological services (STS), and scientific and technical training and education (STET). In line with the recommendation, methodological guidelines on STET were published in 1982, [99] and guidelines on lifelong training discussed in 1989. [100] The guidelines on STET included only persons directly engaged in science and technology activities, and excluded those who were not, regardless of whether they had the qualifications for such work. Above all, the guidelines were never implemented through any substantial data collection: "due to the drastic reduction of personnel in the Division of Statistics, priorities had to be established and unfortunately, this area was not considered a

[96] OECD (1982), *International Survey of the Resources Devoted to R&D in 1979 by OECD Member Countries: Questionnaire*, DSTI/SPR/80.42.

[97] OECD (1992), *Workshop on the Measurement of Human S&T Resources: Conference Announcement*, DSTI/STII (2) 2, p. 1.

[98] In the 1960s, following gaps identified in data on scientific and technical personnel, the OECD Secretariat envisaged preparing a manual, but never did. See: OECD (1964), *Committee for Scientific Research: Programme of Work for 1966*, SR (65) 42, p. 23.

[99] UNESCO (1982), *Proposals for a Methodology of Data Collection on Scientific and Technological Education and Training at the Third Level*, CSR-S-15.

[100] UNESCO (1989), *Secretariat Background Paper to the Meeting of Experts on the Methodology of Data Collection on Lifelong Training of Scientists, Engineers and Technicians*, ST.89/CONF.602/3.

high priority". [101] UNESCO continued to center on R&D personnel rather than on the broader measurement of scientists and engineers. [102]

As for the OECD: until the 1993 edition, the Frascati manual limited the measurement of personnel to R&D – and to full-time equivalents (FTE) rather than head-counts. [103] The former, while a true measure of the volume of R&D, did not, however, allow them to counting the stocks and flows of physical persons and to compare science and technology statistics to population, education, and labor statistics, among others. The interest in the broader concept of science and technology personnel came from the Technology-Economy Program (TEP) in the early 1990s that highlighted, backed with scattered statistics, the key role of "human capital" in the innovation process. [104] Firmly deploring the lack of accurate statistical tools, TEP invited the DSTII (Scientific, Technological and Industrial Indicators Division) to prepare a methodological manual. The Division, in collaboration with Eurostat, therefore undertook a survey of existing data and national practices in measurement of scientific and technical personnel. [105] After examining several national and international publications, reports and statistics, it identified about a dozen different concepts concerning S&T human resources. [106] Most of these concepts differed in the way they covered occupation, qualification and field of study. Only a few countries (among them the United States) seemed to undertake some kind of regular human resources data collection. Above all, there was no clear category for highly qualified personnel category in any of the existing international classifications.

[101] UNESCO (1994), *General Background to the Meeting and Points for Discussion*, ST.94/CONF.603/5, p. 3. Guidelines were also envisaged on training statistics: UNESCO (1989), *Secretariat Background Paper to the Meeting of Experts on the Methodology of Data Collection on Lifelong Training of Scientists, Engineers and Technicians*, ST.89/CONF.602/3. The OECD produced such a manual: OECD (1997), *Manual for Better Training Statistics: Conceptual, Measurement and Survey Issues*, Paris.
[102] B. Godin (2001), *What's So Difficult About International Statistics? UNESCO and the Measurement of Scientific and Technological Activities*, Montreal: OST.
[103] OECD (1991), *Initial United States Proposals for Changes in the R&D Sections of the Frascati Manual tom Facilitate the Measurement of Total S&T Personnel*, DSTI/STII (91) 26.
[104] OECD (1992), *Technology and the Economy: The Key Relationships*, Paris, chapter 7.
[105] OECD (1993), *Results of the OECD/Eurostat Inventory of HRST Data Availability in OECD/EC Member Countries*, DSTI/EAS (93) 9; G. Westholm (1993), Recent Developments in International Science and Technology Personnel Data Collection, *op. cit.*

Simultaneously, the STIID asked R. Pearson from the Institute of Manpower Studies at the University of Sussex (Brighton) to prepare a draft manual on measuring scientific and technical human resources. [107] The explicit aim was to "identify possible future mismatches in the demand/supply equation". [108] The discussions engaged other OECD Directorates and agencies (mainly interested in education) as well as UNESCO and, more particularly, the European Union (DG XIII and Eurostat). Two workshops were held, one in 1992, [109] and another in 1993, [110] in which countries expressed general agreement with most of the proposed manual, although there were some debates occurred over issues like the inclusion of the humanities, the minimum level of S&T qualification, and the treatment of managers and the Armed Forces.

The manual introduced the concept of "Human Resources for Science and Technology" (HRST), with a rather wide definition embracing both qualifications – completed post-secondary education (level 5 and above) [111] – and occupation – employment in the S&T professions but without the equivalent qualifications. [112] It included the social sciences and humanities, but a system of "priorities" was established with the natural sciences and engineering situated at its core. [113] A similar priority was assigned to university (level 6) over technical training. [114] Students who were employed in any way and for however a short amount of time, were to be included, and students from abroad were to be distinguished systematically from their domestic counterparts.

[106] OECD (1993), *Measuring Human Resources Devoted to Science and Technology (HRST)*, DSTI/EAS (93) 17, p. 3.
[107] OECD (1992), *Draft Manual on the Measurement of S&T Human Resources*, DSTI/STII (92) 4.
[108] OECD (1992), Workshop on the Measurement of Human S&T Resources: Conference Announcement, *op. cit*. p. 1.
[109] OECD (1993), *Summary Record of the Workshop on the Measurement of S&T Human Resources*, DSTI/EAS/M (93) 2.
[110] OECD (1993), *Summary Record of the 1993 Workshop on the Measurement of S&T Human Resources*, DSTI/EAS/M (93) 4.
[111] ISCED: International Standard Classification of Education.
[112] ISCO: International Standard Classification of Occupations.
[113] "The Nordic group [of countries] had difficulties in accepting the use of the term "low priority" in connection with the humanities (…). It was agreed that the priorities terminology be replaced by coverage": OECD (1994), *NESTI: Summary Record of the Meeting Held on 18-20 April 1994 in Canberra*, Australia, DSTI/EAS/STP/NESTI/M (94) 1, p. 4.
[114] But the PhD-level could not be separately distinguished because of the identification difficulties.

Member countries adopted the manual for the measurement of HRST in 1994 in Canberra. The document was cleared for official publication in 1995. [115] The manual did not propose a collection of entirely new statistics, but offered guidelines on how various kinds of already existing data that could be exploited for constructing science and technology indicators. The Group of National Experts on Science and Technology Indicators (NESTI) itself emphasized that it was "a compromise between what is possible in the ideal world and what is realistic". [116]

Three stages in the measurement of human resources immediately followed the adoption of the manual:

- Surveys of HRST stocks: A first OECD/Eurostat pilot survey was conducted in 1995-96 to test the viability of the manual's data, concepts, and indicators; [117]
- Development of indicators on flows; [118]
- Analyses of the international mobility of highly skilled workers. [119]

On the basis of these experiences, a revision of the manual was begun in 2001. [120] A lot of problems were identified and future modifications to the manual suggested, especially on improving definitions and finding appropriate sources of data information: [121]

[115] OECD (1995), *Manual on the Measurement of Human Resources Devoted to S&T* (Canberra manual), OECD/GD (95) 77.
[116] OECD (1994), *Manual on the Measurement of Human Resources in Science and Technology: Discussion Paper*, DSTI/EAS/STP/NESTI (94) 3, p. 6.
[117] L. Hardy (1997), *Evaluation Report on the 1995/96 Pilot Data Collection on HRST Stocks*, DSTI/EAS/STP/NESTI (97) 3; Eurostat (1998), *Using the Community Labour Force Survey (LFS) as a Source of Data for Measuring the Stocks of HRST*, DSTI/EAS/STP/NESTI (98) 1.
[118] Eurostat (1996), *Basic Indicators for Describing the Flow of HRST: Full Report*, DSTI/EAS/STP/NESTI (96) 14; Eurostat (1997), *Basic Indicators for Describing the Flow of HRST: R&D, Methods and Data Analysis*, DSTI/EAS/STP/NESTI (97) 8; Eurostat (1998), *A Preliminary Analysis of the Flows From the Tertiary Education System and Stocks of HRST*, DSTI/EAS/STP/NESTI (98) 2; M. Akerblom (1999), *Mobility of Highly Qualified Manpower: A Feasibility Study on the Possibilities to Construct Internationally Comparable Indicators*, DSTI/EAS/STP/NESTI (99) 7.
[119] Seminar held in June 2001. Published in: OECD (2002), *International Mobility of Highly Skilled*, Paris.
[120] Eurostat, *The Canberra Manual: Some Preliminary Thoughts on the Revision of the Manual on the Measurement of Human Resources Devoted to Science and Technology*, DSTI/EAS/STP/NESTI/RD (99) 7.
[121] L. Hardy (1997), *op. cit*; L. Auriol and J. Sexton (2002), Human Resources in Science and Technology: Measurement Issues and International Mobility, in OECD, International Mobility of Highly Skilled, *op. cit*. 13-38.

- There is a relatively high level of national misunderstanding, misreporting and unusable data;
- National data come from different sources, and methodologies differ;
- Conversions from national systems to the standardized systems of ISCED and ISCO are very problematic;
- Coverage of qualification (particularly level 5) and occupation (persons working as HRST but not trained in HRST) lead to overestimations;
- There are difficulties in matching educational qualifications with occupations.

As can be seen from this short list, several of today's problems are highly similar to those of the 1960s. In fact, between the 1960 and 1990, no work had been conducted toward creating internationally standardized measurement of HRST. The OECD, under the influence of its Member countries, is in fact simply picking up were it left off over thirty years ago.

Conclusion

The early measurement of human resources in science and technology owes a great deal to war-related issues, first among them was the "shortage" of scientists and engineers after World War II, but also the gap preoccupations of Americans and Europeans with respect to the USRR during the Cold War and after. These latter preoccupations were great enough, in 1958, for the NSF to comment: "In recent years the need for information has been emphasized by considerations of national defense, and for this reason seems more pronounced than ever before in national history". [122]

As regard the comparative and international measurement of human resources in science and technology, this paper identified three phases. Firstly, OECD work in the 1950s on scientific and technical personnel was rooted in "the conviction that increased investment in

[122] NSF (1958), A Program for National Information on Scientific and Technical Personnel, *op. cit*. p. 3.

the training of scientific and technical personnel, and in the basic general education on which such training must be built, is an essential ingredient of forward-looking policy to promote economic and social development, such development being intimately linked with the quality of manpower in the Member countries and with the technical sophistication of their methods of production”. [123] The OEEC and the OECD conducted several international surveys aimed at specifically measuring the supply and demand of scientists and engineers. Then, in the 1970s and 1980s, the DSA (and its successor, the DSTI) restricted considerably its measurement of human resources: “All member countries are now committed to a policy of unprecedented expansion of their educational system (…). This imposes new tasks”, stated the OECD. [124] The DSTI therefore concentrated on R&D personnel and left the task of compiling education statistics to another Directorate. Science and technology personnel data would be gather only on an ad-hoc basis over the years, on the occasion of specific studies. Only in the 1990s, as the knowledge economy began generating attention (and buzzwords), did the organization’s statisticians again shift to measuring the supply and demand of scientists and engineers: “The move towards the knowledge-based economy has placed human capital in science and technology at the forefront of the policy debate across OECD countries, not just in the area of education and labour markets but also in science, technology and innovation policy”. [125] The current concept of “human capital” had in fact already been proposed in the 1960s, [126] along with the notion of “investment in human resources”, formulated in 1964 by the OECD study group on the economics of education. [127]

[123] OECD (1968), *Review of the Work of the Organization in the Field of Scientific and Technical Personnel*, C (68) 68, p. 1.

[124] *Ibid*. p. 2.

[125] OECD (2000), *Mobilising Human Resources for Innovation*, Paris, p. 3. See also: OECD (1996), *Measuring What People Know: Human Capital Accounting for the Knowledge Economy*, Paris; OECD (1998), *Human Capital Investment: An International Comparison*, CERI, Paris; OECD (2001), *The Well-being of Nations: the Role of Human and Social Capital*, Paris.

[126] G.S. Becker (1964), *Human Capital*, New York: National Bureau of Economic Research; T.M. Schultz (1968), *Investment in Human Capital*, in B.J. McCormick, Economics of Education, Penguin Books: Harmondsworth (Middlessex): 13-33; M. Blaug (1976), The Empirical Status of Human Capital Theory: A Slightly Jaundiced Survey, *The Journal of Economic Literature*, 14, pp. 827-853.

[127] OECD (1964), *The Residual Factor and Economic Growth*, Paris.

Over the last fifty years, no science and technology statistics has caused more debates and controversies than those on HRST. There were no shortage of myths, but the data were always too poor to permit any reliable measurement of personnel shortages or brain drain. The data were generally recognized as limited, but the charismatic mystique of numbers remained: "It does not seem that too much importance needs to be attached to this lack of comparability", suggested the OECD's second report on scientific and technical manpower in 1957. [128] Similarly, during the debates over the controversial NSF study published in 1989, R.C. Atkinson, president of the American Association for the Advancement of Science (AAAS), stated: "The models used to project supply and demand for scientists and engineers have been subject to criticism. But most of the dispute turns on *quantitative details* rather than the fundamental conclusion". [129] In his recent historical account of education at the OECD, G.S. Papadopoulos, former OECD director, summarized the bureaucrats' state of mind as follows: reports's « ultimate value lies not so much in the accuracy or otherwise of their quantitative analyses and predictions (…) as in the stimulus they provided for a more systematic approach to educational planning and in sensitising public opinion (…)". [130]

Some were doubtless more cautious in their methodologies and political discourses. In the early 1950s, for example, the Bureau of Labor Statistics measured the presumed loss of personnel owing to Reserve and Selective Service calls, and concluded: "factors other than calls to military duty caused the bulk of the separations [rate of research engineers and scientists]". [131] The Cold War, at least, was not responsible for the shortages. Others, like S. Zuckerman, made analytical clarifications like the following: "The term [brain drain] itself is a misnomer. In general, educated men throughout the ages have always moved from areas of lesser to areas of greater opportunity, where they expect to find better

[128] OECD (1957), The Problem of Scientific and Technical Manpower in Western Europe, Canada and the United States, *op. cit.* p. 9.
[129] R.C. Atkinson (1990), Supply and Demand for Scientists and Engineers: A National Crisis in the Making, *Science*, 248, 27 April, p. 427.
[130] G. Papadopoulos (1994), *op. cit.* p. 45.
[131] Bureau of Labor Statistics (1953), *Scientific R&D in American Industry: A Study of Manpower and Costs*, Bulletin no. 1148, Washington, p. 38.

resources with which they can apply their talents". [132] In commenting on the first draft manual on HRST, OECD Member countries themselves explicitly admitted that "too much attention was given [in chapter 2] to the brain drain". [133] At the second OECD workshop on HRST, Member Countries also "agreed that the manual should not deal extensively with the forecasts and projections as this was both a technically complex and politically sensitive issue. [134]

Nevertherless, politically charged discourses persisted unabated. While lamenting on the lack of appropriate statistics, the TEP document confidently proclaimed: there is "a risk of shortages of scientists and engineers in the future years". [135] Studies also appeared recently on shortages in specific sectors, like biotechnology [136] and the information and communication. [137] Finally, public debates over the so-called brain drain took place in United Kingdom [138] and Canada. [139] The arguments were the same as those of the 1960s, and the data just as poor. [140]

The rhetoric persisted because, as the first OECD survey stated: "There will be no danger of training too many". In their criticism of British forecasting, Gannicott and Blaug correctly identified the axiom guiding these discourses: there is always an unsatisfied need. "One cannot go wrong in putting [demand forecasts] forward as minimum estimates, since the real needs must exceed them". [141] "We cannot go wrong by producing too much". [142]

[132] S. Zuckerman, Scientist in the Arena, in A. de Reuck, M. Goldsmith and J. Knight (1968), *Decision Making in National Science Policy*, Boston: Little, Brown and Co., p. 14.
[133] OECD (1993), *Summary Record of the 1993 Workshop on the Measurement of S&T Human Resources*, DSTI/EAS/M (93) 4, p. 5.
[134] OECD (1994), *Manual on the Measurement of Human Resources in Science and Technology: Discussion Paper*, DSTI/EAS/STP/NESTI (94) 3, p. 7.
[135] OECD (1992), *Technology and the Economy: The Key Relationships*, Paris, p. 135.
[136] R. Pearson and D. Pearson (1983), *The Biotechnology Brain Drain*, IMS, Brighton.
[137] US Department of Commerce (1997), *America's New Deficit: The Shortage of Information Technology Workers*, Office of Technology Policy, Washington.
[138] ABRC (1985), *The Brain Drain: Summary of Findings of Enquiry*, London; Royal Society (1987), *The Migration of Scientists and Engineers to and from the UK*, London.
[139] OST (2000), *Les flux migratoires de personnel hautement qualifié*, Montreal.
[140] See, for example: W.J. Carrington and E. Detragiache (1998), *How Big Is the Brain Drain*?, International Monetary Fund, WP98102.
[141] K.G. Gannicott and M. Blaug (1969), *op. cit*. p. 63.
[142] *Ibid*. p. 65.

The British committees had “merely taken as an axiom that the country needs more scientists and technologists”. [143]

Forty years ago, the OECD concluded: “Because concern about the international movement of scientific and technical personnel has been aroused by the loss of highly qualified people, interest has been centred on immigration and many attempts have been made to count the people who have left”. [144] But “the situation is much more complicated than a simple examination of the US data would suggest”. [145] This paper suggested that it was the US statistics on the immigration of scientists and engineers into the United States in the 1960s that launched the brain drain debate in Europe, or at least sustained it for a while. Most countries tended to “confirm their axioms” using US statistics, creating “hysterical reactions” as A. Young have qualified the debates of the time. [146] What people forgot – or chose to ignore – was precisely the fact that these statistics only presented one side of the picture. In this case, numbers served to stir up controversies, rather than settle them.

[143] *Ibid*. p. 58.
[144] OEEC (1965), The International Movement of Scientific and Technical Manpower, *op. cit*. p. 6.
[145] OECD (1970), International Movement of Scientists and Engineers, *op. cit*. p. 3.
[146] A. Young (1974), Guidelines for Surveying International Migration of Highly Qualified Manpower, in Committee on Research Economics, The Brain Drain Statistics: Empirical Evidence and Guidelines, *op. cit*, p. 8.

Annex.
DSTI Workshops on S&T Manpower

1977 Ageing of Scientific and Technical Personnel

1981 Measurement of Stocks of Scientists and Technical Personnel

1988 Assessing the Availability of and Need for Research Manpower [147]

1992 Measurement of S&T Human Resources

1993 Measurement of S&T Human Resources

1999 Science and Technology Labour Markets

[147] Officially published as: OECD (1989), *Research Manpower: Managing Supply and Demand*, Paris.