A Note on the Survey as an Instrument for Measuring Science and Technology

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A Note on the Survey as an Instrument for Measuring Science and Technology

Statistics are a wonderful tool for science policy, but they rarely come without limitations. Over the period 1960-2000, the OECD acknowledged the limitations of many of the statistics it produced, among them output indicators, and it listed them in a number of documents. According to the OECD, the cause of these limitations was the instrument used to produce them. [1]

But the OECD literature does not contain similar discussions regarding official (governmental) R&D surveys. Limitations are of course regularly discussed – and the revisions of the Frascati manual are specifically devoted to increasing the accuracy of surveys – but according to the OECD, the main limitation of R&D surveys is the lack of international comparability: countries have different practices that make comparisons difficult. Hence the publication of *Sources and Methods* documents devoted to reporting discrepancies in the data. [2] But the instrument itself – the survey – is always <u>taken for granted</u> and considered as the main if not the only reliable source of data on science and technology.

This paper argues that the survey, like any other instrument used in measuring features of the world, is a socially constructed apparatus with built-in limitations. To illustrate this argument, I examine three cases of discrepancy that I had mentioned in previous papers. The first two cases document the limitations of the survey as such by comparing results obtained through different surveys. The third case study compares the survey to another instrument for collecting data on science and technology, namely budgetary documents. In each case, I show the unintentional effects of the survey instrument upon official statistics.

[1] B. Godin (2001), *Measuring Output: When Economics Drive Science and Technology Measurement*, Montreal: OST.

Official Surveys Versus Academic Surveys

Most indicators on science and technology are derived from official (governmental) surveys. In fact, only governments have the resources for conducting regular surveys. But since there is rarely any replication, it is difficult to validate the statistics that are produced.

In the 1980s, A. Kleinknecht conducted a study assessing the quality of official R&D surveys. [3] He designed his own survey of industrial R&D and compared his results to those obtained by a government survey. He found large differences between the two types of surveys, mainly for small and medium sized (SME) enterprises (Table 1). The author measured four times more man/years devoted to R&D in SME than had been reported in the government survey. Overall, the official survey underestimated R&D by as much as 33%.

The reason offered for the differences was that SMEs 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, whereas the Frascati manual recommends measuring only formal R&D. [4] Non-budgeted R&D is the rule in SMEs: "in small firms, development work is often mixed with other activities". Indeed, Kleinknecht estimated that 33% of firms devoted less than one man/year to R&D, as mentioned above. But 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 [5] or innovation surveys. [6]

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[2] B. Godin (2001), *Metadata: How Footnotes Make Numbers Obsolete*, Montreal: OST.

[3] 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 laR&D dna les PMI-PME, *Économie et Statistique*, 271-272, pp. 77-85.

[4] The NSF had 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, which notes that 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, which discusses informal R&D in small companies.

[5] 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.

[6] See next section.

Table 1.
Numbers of Dutch Firms Performing R & D According to Three Sources, Detailed by Size Classes and by Manufacturing and Services

	Size classes (employees)						
	10 - 19	**20 - 49**	**50 - 99**	**100 – 199**	**200 - 499**	**>500**	**Totals**
Estimate by Central Statistical Office (CBS)							
Manufacturing	182	329	129	123	117	170	1,050
Services	312	245	67	37	50	55	766
Totals	494	574	196	160	167	225	1,816
Estimate based on R & D subsidy record							
Manufacturing	565	940	818	546	264	246	3,379
Services	897	688	567	267	258	152	2,829
Totals	1,462	1,628	1,385	813	522	398	6,208
SEO "medium" estimate							
Manufacturing	640	1,087	697	434	262	101	3,221
Services	1,400	1,044	522	280	152	44	3,442
Totals	2,040	2,131	1,219	714	414	145	6,663

How did Kleinknecht find the missing R&D in SME? He included a question specifically designed for firms with no formal department of R&D. This enabled SMEs to report even quite small-scale R&D work that they would not 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?" [7]

R&D Surveys versus Innovation Surveys

According to the OECD, the introduction of the innovation survey in the 1990s occasioned an important improvement in science and technology measurement. There was now a methodology capable of measuring not only the resources devoted to R&D, but also a number of activities related to innovation. Until then, R&D was used as a proxy for innovation, but now innovation could be measured directly.

Soon however, an embarrassing paradox occurred. Statistics from national R&D surveys did not correspond to those produced by innovation surveys. [8] The latter indicated significantly less R&D activity than did the standard R&D surveys because of methodological differences (Table 2). Nine sources of differences were identified, including: [9]

- Different populations frames: R&D surveys are often drawn from a special list of known (or potential) R&D performers. Innovation surveys are generally based on a population of businesses drawn from a statistical register.
- Different sampling methods: R&D surveys are censuses of businesses that undertake R&D; innovation surveys on the other hand are generally stratified random samples of businesses.
- Occasional R&D is often omitted from R&D surveys because it is too difficult, or too expensive, to obtain a list of occasional R&D performers.
- Industrial classification: large enterprise groups set up separate enterprises to perform their R&D, and do not have appropriate accounting systems to monitor expenditures.

[7] Kleinknecht (1987), *op. cit*. p. 254.

[8] OECD (2001), *Assess Whether There Are Changes Needed as a Result of the Comparison of R&D Data Collected in R&D and in Innovations Surveys*, DSTI/EAS/STP/NESTI (2001) 14/PART3; D. Francoz (2000), *Measuring R&D in R&D and Innovation Surveys: Analysis of Causes of Divergence in Nine OECD Countries*, DSTI/EAS/STP/NESTI (2000) 26; 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.

[9] At the OECD, these differences had been known since the 1980s. See: DSTI/IP/88.27

- Non-response: in about half the countries, responses rates of less than 50% were obtained in the innovation survey.

Table 2.
R & D Expenditure Measured in R & D Surveys and Innovation Surveys, France, 1997 [10]

Industry	R & D Expenditure from R & D Survey (US $m)	R & D Expenditure from Innovation Survey (US $m)
Food, beverages, tobacco	N/A	N/A
Textiles, clothing, footwear and leather	120	126
Wood and paper products	51	49
Printing, publishing and recorded media	4	14
Petroleum, coal, chemical and associated Product	3832	1894
Non-metallic mineral product	212	128
Metal product	497	455
Machinery and equipment	1230	879
Electric and electronic machinery	2551	2724
Precision instruments	1616	1171
Automobile	2027	1122
Other transports (mainly aeronautics and space)	2439	1039
Energy	524	575
Other manufacturing	111	78
Total manufacturing	15214	10254

In light of the above discrepancies, one might well ask: Is there one true instrument, and if so, which is it? Or one may infer, from the following statistician's statement, that neither instruments is perfect: "We should not seek at any price to secure the same measurement of R&D in both surveys, but rather understand and measure the divergences". [11] Efforts are nevertheless currently underway to obtain uniform figures. Two options are discussed. [12] The two surveys could be combined, as envisaged by Eurostat – the main user of the

[10] For similar data on Italy and Germany, see: G. Sirilli (1999), *Old and New Paradigms in the Measurement of R&D*, DSTI/EAS/STP/NESTI (99) 13; C. Grenzmann (2000), *Differences in the Results of the R&D Survey and Innovation Survey: Remark on the State of the Inquiry*, DSTI/EAS/STP/NESTI/RD (2000) 24.
[11] D. Francoz (2000), *Measuring R&D in R&D and Innovation Surveys: Analysis of Causes of Divergence in Nine OECD Countries*, DSTI/EAS/STP/NESTI (2000) 26, p. 5.
[12] OECD (2001), Assess Whether There Are Changes Needed as a Result of the Comparison of R&D Data Collected in R&D and in Innovations Surveys, *op.cit*. p. 3; OECD (2000), *Record of the NESTI Meeting*,

innovation survey results – or they could, at the very least, be conducted by the same agency, as the OECD seems to prefer.

Survey Data versus Budgetary Documents

There are actually two ways of measuring government-funded R&D. The first relies on the survey and measures expenditures, in other words the money that is actually spent. The second relies based on estimates drawn from budget documents and measures spending plans and intentions. Most governments use the second option, but both types of statistics are uncritically set along side each other in OECD international tables.

Recent studies have revealed that the data differ according to the method chosen: the amounts of government R&D funding reported by the performer (obtained from a survey), on the one hand, and the funder (derived from budgets), on the other, are never the same. A Norwegian study compared the results obtained from surveys with those estimated from budgets. [13] At the macro level, the two data sets gave roughly the same total amount of Government R&D expenditures. The deviation was only 1 million on a total of 8,9 billion NOK. But large deviations were observed at the more detailed level in the case of Defense, Education, and Health (Table 3). The main reasons for the discrepancies were the difficulty in interpreting the concept of development and the uneven treatment of related scientific activities (RSA), such as policy studies and evaluation.

In the United States, another study found an approximately 30% difference between the government-funded R&D reported in the performer-based businesses survey and the R&D reported by the funder in the government R&D survey (for the most recent numbers, see Table 4). [14] For 1995, for example, the NSF countered that: [15]

DSTI/EAS/STP/NEST/M (2000) 1, p. 8; Eurostat (2001), *Working Party Meeting on R&D and Innovation Statistics: Main Conclusions*, 19-20 April.

[13] O. Wiig (2000), *Problems in the Measurement of Government Budget Appropriations or Outlays for R&D (GBAORD)*, DSTI/EAS/STP/NESTI (2000) 25.

[14] NSF (1999), *Study on Federally Funded Industrial R&D: Summary of Findings from Company Interviews and Analyses of Collateral Data*, DSTI/EAS/STP/NESTI (99) 2; J.E. Jankowski (2001), *Relationship*

> Federal agencies reported $30,5 billion in total R&D obligations *provided* to industrial performers, compared with an estimated $21,7 billion in federal funding *reported* by industrial performers (…). Overall, government wide estimates equate to a "loss" of 31% of federally reported R&D support.

The gap was so large that the US Senate Committee on Commerce, Science, and Transportation asked the General Accounting Office (GAO) to review the procedure because of concerns over whether Members of Congress could truly rely on the NSF's data. [16] The most likely causes were identified as:

Table 3.
Government Budget Appropriations of Outlays for R & D (GBAORD) in 1998, by Ministry) Survey Results Compared with National GBAORD Figures (NIFU) and Deviation Between the Two Data Sets (Millions NOK)

Ministry	Ministry survey	GBAORD (NIFU)	Deviation
Ministry of Foreign Affairs	249	335	-86
Ministry of Education, Research and Church Affairs	4343	4090	253
Ministry of Justice and the Police	8	7	1
Ministry of Local Government and Regional Development	116	154	-38
Ministry of Health and Social Affairs	256	483	-227
Ministry of Children and Family Affairs	35	28	7
Ministry of Trade and Industry	1236	1188	48
Ministry of Fisheries	419	361	58
Ministry of Agriculture	470	348	122
Ministry of Transport and Communications	168	124	44
Ministry of the Environment	265	426	-161
Ministry of Labour and Government Administration	25	21	4
Ministry of Finance and Customs	45	57	-12
Ministry of Defence	1053	472	581
Ministry of Petroleum and Energy	201	263	-62
Sum ministries	8889	8357	532
Other	0	533	-533
Total GBAORD	8889	8890	-1

Between Data from R&D Funders and Performers, DSTI/EAS/STP/NESTI (2001) 14/PART7; OECD (2001), *Reconciling Performer and Funder R&D*, DSTI/EAS/STP/NESTI (2001) 13.

[15] NSF (1998), *Science and Engineering Indicators*, Washington, p. 4-44.

[16] GAO (2001), *R&D Funding: Reported Gap Between Data From Federal Agencies and Their R&D Performers Results From Noncomparable Data*, GAO-01-512R, Washington; M.E. Davey and R.E. Rowberg (2000), *Challenges in Collecting and Reporting Federal R&D Data*, Washington: Congressional Research Service.

- A definition problem associated with a shift in the concept of R&D procurement over the past decade: the defense budget may include expenditures which are not considered as R&D in the Frascati manual.
- Financing of R&D is sometimes provided by an intermediary, making it difficult for the performer to know the original source of funds.
- Contracts for R&D often extend beyond one year.

The congressional document, however, went beyond the methodological problems and indicated that for top R&D funding agency officials, NSF's data collection efforts were not a high priority, and therefore devoted few resources to collect them. A fact that called into question not only the NSF's decades of efforts, but also the quality of its data.

Table 4.
Comparison of Reported Federal R & D Activities With Performer-Reported Expenditures for Federal R & D ($ millions)

Year	Budget Authority	Total Obligations	Total Outlays	Total Performer-Reported Federal R&D Expenditures	Difference Between R & D Expenditures and Budget Authority	Difference Between R & D Expenditures and Outlays
1970	14,911	15,336	15,734	14,970	59	(764)
1975	19,039	19,039	19,551	18,437	(602)	(1,114)
1980	29,739	29,830	29,154	29,455	(284)	301
1985	49,887	48,360	44,171	52,128	2,241	7,957
1990	63,781	63,559	62,135	61,342	(2,439)	(793)
1991	65,898	61,295	61,130	60,564	(5,334)	(566)
1992	68,398	65,593	62,934	60,694	(7,704)	(2,240)
1993	69,884	67,314	65,241	60,323	(9,561)	(4,918)
1994	68,331	67,235	66,151	60,700	(7,631)	(5,451)
1995	68,791	68,187	66,371	63,102	(5,689)	(3,269)
1996	69,049	67,655	65,910	63,215	(5,834)	(2,695)
1997	71,653	69,830	68,897	64,865	(6,788)	(4,032)
1998 est.	73,639	72,114	69,849	66,636	(7,003)	(3,213)

At the suggestion of the United States, the OECD decided to include a paragraph in the next edition of the Frascati manual recognizing “the likelihood of differences in R&D expenditure totals between those estimated from the funders and those estimated from the performers of R&D”. [17] However, the OECD immediately added: “not too much emphasis should be put on this, as it might raise excessive suspicion on published R&D data (performer based)”.

Conclusion

A recent OECD mini survey indicated that Member countries used R&D data more frequently that other indicators, like output for example. [18] Whereas indicators based on GERD (Gross Expenditures on R&D) got over 80% of favorable responses, patents, technological balance of payments, and high technology trade balance got less than 50%. Three factors help explain the dominant role of the R&D survey in the measurement of science and technology:

- Legitimacy of the State: The legitimacy of the survey as a method of data collection is intimately linked to the legitimacy of the State itself. Governments have a relative monopoly on the survey because it is they who produce official national data and who define the standards. Governments therefore impose their own view of the world upon their users.
- Money: The survey concentrates on a statistic that is easy to measure, comparable with other government data and readily understood by every: money. As Daniel S. Greenberg recently argued: “A one-to-one relationship between money going in and science coming out has never been established. The volume of money, however, is countable, and comprehensible to scientists, politicians, and the public. Understood

[17] OECD (2001), Summary of the Main Conclusions of the Meeting on the Revision of the Frascati Manual held 9-11 May 2001, Annex to OECD (2001), *Summary Record*, DSTI/EAS/STP/NESTI/M (2001) 1, p. 15.
[18] OECD (1998), *How to Improve the Main Science and Technology Indicators: First Suggestions from Users*, DSTI/EAS/STP/NESTI/RD (98) 9.

by all is the necessity of money for the training and well-being of scientists and the nurturing and advance of science”. [19]

- First-mover advantage: R&D statistics were the first to be systematically developed by governments in the history of science and technology measurement. It will therefore take time and resources before other forms of statistics acquire a similar status.

Very few national statistical offices invested in measuring science and technology using instruments other than the survey. It was usually individual ministries and what I have elsewhere called elsewhere “clearing houses” that developed indicators using other sources of data. [20] When the multiple dimensions of science and technology are taken into considerations, statistical offices would seem to rely on a highly specific, and therefore limited, range of expertise.

[19] D.S. Greenberg (2001), *Science. Money, and Politics: Political Triumph and Ethical Erosion*, Chicago: University of Chicago Press, p. 59.
[20] B. Godin (2002), Outlines for a History of Science Measurement, *Science, Technology and Human Values*, in press.