Scientometrics (2011) 87:389–398
DOI 10.1007/s11192-010-0308-3

European research policy and bibliometric indicators, 1990–2005

Henri Delanghe · Brian Sloan · Ugur Muldur

Received: 13 October 2010 / Published online: 19 November 2010

Abstract This paper describes and analyses the role played in the development of bibliometric indicators—and the use made of bibliometric indicators for policy purposes—by the European Commission's Directorate-General Research in the period 1990–2005.

Keywords European Commission · Research · Research policy · Framework programme · Evaluation · European paradox · Excellence · European research area

From input to output indicators

The post-World War II period can be divided into several periods as far as public science and technology (S&T) policies are concerned. Godin (2002), for instance, makes a distinction between a first period focusing on capacities and a second one focusing on research. S&T indicators reflect S&T policies: a particular set of S&T policies demands its own set of S&T indicators. That is why the post-war evolution in terms of S&T policies caused an evolution in terms of S&T indicators as well.

An important post-war evolution in terms of S&T indicators was that from input indicators to output indicators (OECD 2007). Input indicators concern, for instance, R&D investment and human resources. Output indicators concern, for instance, patents, the technology balance of payments (TBP), high-tech trade, and scientific publications. Input

The information and views expressed in this paper are those of the authors and do not necessarily reflect the official opinion of the European Commission.

H. Delanghe (✉) · B. Sloan · U. Muldur
European Commission, DG Research, Wetstraat 200, 1049 Brussels, Belgium
e-mail: Henri.Delanghe@ec.europa.eu

B. Sloan
e-mail: Brian.Sloan@ec.europa.eu

U. Muldur
e-mail: Ugur.Muldur@ec.europa.eu

indicators formed the core until the mid-1970s. A typical product of this period was the mainly input indicator-oriented Organisation for Economic Cooperation and Development (OECD) Frascati Manual. From the 1970s (US) and 1980s (other OECD member countries), increasing attention was paid to output indicators.

The main driver behind the development of output indicators was the fact that, by the 1970s/1980s, substantial amounts of money were being spent on research, which for accountability's sake needed to be justified, even more so once resources got scarce. Also between fields of science and within fields of science, evidence-based choices had to be made and funds allocated to areas with the largest added value from the perspective of growth and welfare. These factors fuelled the demand for output indicators (de Wijkerslooth de Weerdesteyn 1992; Moed et al. 1992).

The development of output indicators

With regard to the development of input indicators, the OECD followed—through, for instance, the 1963 Frascati Manual—where the United States (US) National Science Foundation (NSF) had pioneered since the 1930s (Godin 2001).

Output indicators, however, were initially developed through a fruitful dialectic exchange between the NSF and the OECD. The OECD made a start in the 1960s within the context of the debate on Europe lagging behind the US. In 1965, Christopher Freeman and Alison Young analysed for seven countries (Belgium, France, Germany, the Netherlands, the UK, the US and the USSR) statistics on investment (GERD), manpower engaged on research and development, and migration of scientists and engineers, as well as the TBP and patents. Though pioneering and experimental in its nature, it was the first document in industrialised countries to collect several indicators at once, both input and output ones (Freeman and Young 1965). Important OECD follow-up reports were 'Gaps in Technology' (1968) and 'The Conditions for Success in Technological Innovation' (1971) (Godin 2001).

Thereafter, the initiative shifted to the NSF—more precisely the US National Science Board—which in 1973 produced its epoch-making report 'Science Indicators, 1972'. The goal of this report was to provide a systematic objective picture of the overall state of US science. The report contained a large number of statistics on American scientific activities. A considerable part consisted of bibliometric indicators (National Science Board 1973; Elkana et al. 1978; Moed et al. 1992). The example set by the NSF was followed by a large number of countries in the second half of the 1980s and the first half of the 1990s.

After the publication of the NSF report, the OECD took on a more active role in the development of output indicators. The different editions of the OECD Frascati Manual reflect the evolution in the OECD's thinking. The first edition of the Frascati Manual (1963) adopted a sceptical tone but nevertheless discussed the potential of patent indicators and the TBP. The 1981 edition of the Frascati Manual adopted a more confident tone and contained a more extensive annex discussing different kinds of output indicators (Godin 2002).

From the early 1990s, the European Commission also became increasingly active in the development and use of various S&T output indicators, including not only bibliometric data, but also data on patents, technology alliances, innovation and high-tech trade (see "Institutional factors" section).

The case of bibliometric indicators

Where the paths of the NSF and the OECD diverged was in the use of bibliometric indicators. As already mentioned, the 1973 NSF report contained a large number of bibliometric indicators. This was not unnatural since the NSF was an academic funding agency. Yet surprisingly, given the dialectic exchange between the NSF and the OECD, bibliometric indicators never made it into OECD datasets (Godin 2002). Where output indicators are concerned the OECD still restricts itself mainly to patents, the TBP and high-tech trade. Nevertheless, since from at least the second half of the 1960s, the OECD did carry out a lot of preparatory work on bibliometric indicators including the development of a manual in the early 1990s (Godin 2002).

The reasons given by the OECD for not pursuing further bibliometric indicators were of a methodological nature (1989 supplement Frascati manual).Yet while it is true that in the 1980s, bibliometrics was a field in full development, other output indicators also faced methodological issues.

This may mean that other reasons played a role in the OECDs rejection of bibliometric indicators. Secondary reasons, according to Godin (2002), related to the economic mission of the OECD, the prominence of economists as producers/users of S&T indicators, the ease of measuring the economic dimensions of reality, and the state at that time of the field of bibliometrics. However, in Godin's view, the main reason was the fact that bibliometrics escaped the control of the national statistical agencies, and that these agencies therefore did not favour the use of such indicators.

Bibliometric indicators at the European Commission

While the OECD did not pursue bibliometric indicators, such indicators were adopted enthusiastically by the European Commission. Several reasons converged. The Commission created a strong institutional driver in the form of an indicator unit that was in close contact with the academic community and operating outside the milieu of the national statistical offices. Bibliometric indicators also helped address policy issues: bibliometric indicators underpinned the idea of the European paradox, one of the main ideas behind the expansion of the Framework Programmes (FPs); they served to illustrate the need for Europe to pursue scientific excellence; and the Directorate-General for Research had a long-standing interest in Member State S&T investment and performance and in indicators useful for obtaining an insight.

Institutional factors

There were two key phases of institutional change which helped to drive the development of bibliometric indicators.

The first, in the late 1980s and early 1990s was linked to the work of the Evaluation Unit of the then Commission Directorate-General XII (Research). The second phase, from 1995 to 2004, related to the work of a dedicated S&T indicator unit.

Phase 1—DG XII ex-post evaluation unit

This unit was responsible for conducting ex-post evaluations of the rapidly expanding FPs. By the late 1980s and early 1990s, DG XII was, because of the FPs, becoming an increasingly important research funding agency. In 1976, the Commission started funding shared cost R&D actions involving research centres and universities on a limited scale. In 1984, it launched its first Framework Programme, involving industry in addition to research centres and universities. In 1986, the Single European Act strengthened the Commission's role in the field of research stating the Community's aim in the field as "to strengthen the scientific and technological basis of European industry and to encourage it to become more competitive at an international level".

With the growing budget and the growing complexity of the funded actions, the interest in evaluation and evaluation indicators increased. In this context, the unit launched some pioneering efforts to use bibliometrics in an evaluation context. The unit also launched in 1989 a research programme called SPEAR, which aimed at encouraging the improvement and standardisation of evaluation methodologies. A SPEAR network forged close links with the academic community and led to some of the first reflections on the use and development of new indicators (and notably output indicators) for EU S&T policy (de Bruin et al. 1992; European Commission 1992a; D'Atri et al. 1992).

In the field of bibliometrics, the unit was able to engage with academic experts in the joint development of indicators. A good example of such collaboration was that with the Centre for Science and Technology Studies (CWTS) in Leiden, the Netherlands. By the late 1980s, early 1990s, CWTS had established itself as an important player in the field of bibliometrics. In 1988, for instance, Professor van Raan had edited a handbook on quantitative studies of science and technology including several bibliometric chapters (van Raan 1988). CWTS had also been selected by the Dutch government to provide input into a Dutch S&T observatory, like the Observatoire des Sciences et Techniques (OST) in France (de Wijkerslooth de Weerdesteyn 1992).

The collaboration between the European Commission and CWTS took the form of joint Commission-CWTS conferences on indicators. In 1991, for instance, there was the bibliometrics-oriented joint EC-CWTS Conference on "Science and Technology Indicators in a Policy Context". The purpose of the conference was to bring together international experts in the field of quantitative studies of science and technology, and policy makers to present practical applications of science and technology indicators and discuss the relationship between indicator research and science and technology studies in general with a special focus on the European Communities policy context (van Raan et al. 1992).

EC-CWTS collaboration also took the form of contracted studies. One such study—which pointed to the very initial nature of the take-up by the Commission of bibliometric indicators—concerned indicator demand and supply. The study consisted of two parts. The first part concerned the demand for bibliometric macro-indicators at the macro or regional level and assessed the types of (research or science) policy problems that could be addressed successfully by means of bibliometric indicators, the types of indicators needed to be constructed in order to answer those questions, and the types of databases required to collect the underlying bibliometric data. The second part of the study concerned the supply side. Potential producers of bibliometric macro-indicators were asked to indicate their ability to supply bibliometric indicators corresponding to the needs as specified in the first part of the study, with a focus on the costs involved and the conditions of access (Moed et al. 1992; European Commission 1992a).

This study illustrates how, from the very beginning, the European Commission was concerned about the ease of access to and use of bibliometric data. Very quickly, however, the emphasis shifted from the supply of bibliometric data to their use for policy purposes.

Phase 2—DG XII S&T indicators unit

In 1994–1995 a dedicated S&T Indicators Unit was created in DG XII. The aim of the unit was to produce analytical reports for EU S&T policy based on relevant statistics, and to develop new S&T indicators for policy use.

It was the issue of the coordination of EU Member States' S&T policies that stimulated the creation of the unit and also the publication of the first European S&T indicators report. For some years there had been relatively little progress on national policy coordination, but the subject was given a new impetus with the adoption in 1994 of the European Commission Communication on "Research and Technological Development: Achieving Coordination through Cooperation" (European Commission 1994a). The then EU Commissioner for Science, Research and Development, Professor Antonio Ruberti, recognized the need for a better information base on Member States' S&T investment and performance, and it was his personal commitment that led to the publication of the first European Report on Science and Technology Indicators (European Commission 1994b).

The new report, often referred to as "REIST" from the French acronym,[1] took much inspiration from the successful US NSF report "Science and Engineering Indicators". Its aim was to provide a policy-oriented analysis of a spectrum of S&T indicators for the 50 most technologically advanced countries. European countries could be compared with each other in terms of their S&T performance, and the EU as a whole could be benchmarked against other global players and regions. The S&T Indicators Unit went on to produce two further editions of REIST (in 1997 and in 2003), each time expanding the range of indicators and analyses (European Commission 1997, 2003).

REIST occupied an important niche, distinct from the reports of Eurostat and OECD, which built upon and added to their work. Unlike Eurostat and OECD, the report was not exclusively focussed on data from the official statistical system and therefore was able to provide a broader scope of indicators—particularly output indicators. It broke new ground by introducing data from other sources such as bibliometrics, patents, technology alliances, venture capital investments, firm-level data, and funding from the EU R&D Framework Programme. Moreover, through interacting with academic researchers, it also introduced innovative ways of analysing the data (e.g. science links in patents, publications by gender, composite indicators…).

In contrast to the broader coverage of the excellent OECD reports at the time, REIST was able to provide a dedicated focus on European S&T trends and their relationship with European policy developments.[2] This strong link with policy also distinguished the report from Eurostat's publications which focussed on presenting statistics and trends. REIST set out the European policy issues of the time, and analysed the data to draw out key messages for policy makers. In short it aimed to provide a bridge between statistics and EU policy.[3]

[1] "Rapport européen sur les indicateurs scientifiques et technologiques" (REIST).

[2] At the time, the OECD did not systematically present an "EU total" figure in all their graphs and tables. REIST provided EU totals for all indicators, which allowed the performance of the EU as a region to be compared with that of other major S&T players.

[3] An example of the impact of these publications is provided by Holbrook (1995), who reviewed the first REIST report. Holbrook noted that "the European Commission has produced a substantial volume of S&T program indicators modelled on the highly successful biennial S&T indicators reports issued by the National Science Foundation of the United States", admitted that, compared to the OECD, "the Europeans have the advantage of both money and legislation on their side" and that "one can always find things to criticise in a first edition", but concluded, nevertheless, that, in spite of the OECD's excellent track record in the field of

The S&T indicators unit, through its work on REIST, produced policy analyses using a number of different bibliometric indicators. These included publication and citation rates, co-authorship as a measure of intra- and extra-EU scientific cooperation, specialisation profiles, publications by individual research institution, and publications by gender.

In summary, the creation of the S&T Indicators Unit was a major catalyst in driving forward the use of bibliometrics to inform EU S&T policy and in international comparative studies. Some specific examples of this are outlined in detail in the next sections.

European paradox

An important argument underpinning the aforementioned growth of the Framework Programmes was that of the "European paradox". The idea of the European paradox was launched in 1994 through the executive summary of the first REIST which was published separately by Ugur Muldur and Luc Soete. One year later, the European Commission *Green Paper on Innovation* popularized the idea. These Commission publications argued that, compared to its investment in research, Europe was strong in scientific performance (and thus the production of new knowledge) but weak in transforming this new knowledge into innovation through new products and processes. One of the pieces of evidence presented in the paper was the number of publications per euro spent on non-business R&D. This ratio was slightly higher in Europe than in the US (Dosi et al. 2009).

Though the precise point the Commission wanted to make through the European Paradox concept (as explained in Chapter 4 of European Commission 1997) was often misunderstood, the idea generated much fruitful policy debate at the national and regional levels in the Member States. It also became the focal point of a vigorous academic debate that drove further developments in the field of bibliometrics. A good example is provided by the work of Dosi et al. (2005a, b, 2006, 2009), some of the most consistent critics of the European paradox idea. They argued that the bibliometric indicator used in the 1995 Green Paper was misleading since it took account only of the number of publications and not of research quality and thus disregarded the fact that only a small number of total publications have a significant effect on the advancement of knowledge. Based on an analysis of inter alia citations and the top 1% most cited publications, they concluded that "no overall 'European paradox' with a lead in science but weak 'downstream' links is observed. On the contrary, significant weaknesses reside precisely 'upstream', that is, the European system of scientific research lags behind the US in several areas. In turn, such a picture calls for strong science and higher education policies". This caused them to criticise the lack of support for basic research in the FPs (Dosi et al. 2009).

Excellence

In response to growing evidence on weaknesses affecting Europe's basic research (see "European paradox" section), the FPs put an increasing emphasis on excellence.

The need for scientific (and technological) excellence is embedded in the Treaty, which emphasizes the need for the Community to support research and technological development activities of high quality (Treaty, Art. 163). Yet it was only FP6 that for the first time

Footnote 3 continued
statistics and analysis, including in the field of S&T, "the staff at the OECD secretariat have good reason to be worried: they are no longer the only game in town".

posited excellence as a fundamental principle underpinning European funded research. The "scientific and technological excellence and the degree of innovation" was the first of a number of evaluation criteria common to all the programmes of FP6 and set out in the European Parliament and Council Regulations on the Rules for Participation (Article 10). Under FP7 as well, excellence retained its prime importance: it served inter alia to underpin the launching of the European Research Council.

With regard to excellence, indicator activity was ahead of policy. Already in the first indicator report (European Commission 1994b), an attempt was made to identify some of the top European research institutions. It was a very cautious attempt since rather than one single pan-European ranking, rankings were produced by country (of the 20 most active European research organisations in scientific publications in 6 large countries and of the 5 most active in 6 small countries); the rankings were based only on publication counts, not on citations; and much qualifying text was included.

By the publication of the second indicator report (European Commission 1997), a measure of confidence had been gained. A kind of pan-European ranking was produced which, however, still ensured the presence of each Member State. It included 28 institutions—the 3 most active research institutions in terms of Science Citation Index (SCI) publication output from the seven largest EU countries and the most active one from the smaller member countries—for which it listed the number of publications according to SCI and according to a survey, and which it ranked according to their mean expected citation rate.

In the third indicator report (European Commission 2003), rankings were once more produced by country—top 20 most important and activity publishing research institutions in large EU Member States and top 10 most important and actively publishing research institutions in smaller EU Member States. In order to avoid bias in favour of large institutions, the selection of institutions was based on discipline-specific rankings. The tables produced included the number of publications, the number of citations, the field normalised citation score, and field-specific information.

The same concern about scientific excellence underpinned the production, later on, of, for instance, the 'Mapping of Excellence' series of studies (e.g. European Commission 2004).

European research area

Bibliometric indicators also played a role in the implementation of the European Research Area concept. The achievement of the ERA is now the main objective of EU research policy. Simply put, the ERA involves a European 'internal market' for research, where researchers, technology and knowledge circulate freely, effective European-level coordination of national and regional research activities, programmes and policies takes place and new initiatives are implemented and funded at European level.

The ERA concept was launched formally in 2000 through the Commission Communication "Towards a European Research Area" and was provided with a new impetus in 2007 through the Commission Green Paper "The European Research Area: New Perspectives". Yet the historical origins of the concept date from much earlier, in fact from at least 1974. In the early 1970s, Commissioner Dahrendorf had identified coordination as the main role of the Commission in the field of research. Such coordination required a good understanding of and insight into the organisation, investment, and performance of Member State S&T systems. Bibliometric indicators helped to provide such insight.

By the publication of the 2000 ERA Communication, several attempts had already been made to obtain an insight into European scientific co-publication behaviour, and the role therein of the FP, using bibliometric indicators.

For example, in 1990, F. Narin and E. S. Whitlow conducted a study for the European Commission, covering the years 1977–1985. They utilised data on scientific publications, extracted from the SCI, produced by the Institute for Scientific Information (ISI). Essentially, they did not find noticeable effects of the Commission's activities. During the period 1977–1986, however, the Commission share of funding of European research was still modest: from 1.6% in 1977 rising to 1.9% by 1986. The Commission share of funding increased further to 3.4% by 1989. Moreover, many fields of science considered by Narin and Whitlow had only recently been targeted by the FP (European Commission 1990; de Bruin et al. 1992).

A follow-up study examined the publication patterns of scientists in Member States of the European Community and analysed whether there were any changes apparent in these patterns that could be interpreted in terms of effects of the R&D programmes set up by the Commission. The focus was on scientific output—measured through the number of scientific articles published—and international scientific cooperation—measured through co-authorships between scientists from different countries —, at the level of the Community as a whole, its individual Member States, and less favoured regions within the Community (European Commission 1992b; de Bruin et al. 1992).

The Commission retained its interest in the issue of scientific cooperation thereafter as well. The different editions of the REIST indicators reports included increasingly lengthy and sophisticated bibliometric analyses of scientific co-publication patterns. An FP-participant-based thematically focused analysis of scientific co-publication behaviour also constituted an important part of the FP7 ex-ante impact assessment (Glänzel and Debackere 2005; Muldur et al. 2006; Delanghe and Muldur 2007).

Conclusion

Bibliometric indicators found their way into a series of high-profile publications, such as, the 3 editions of the "European Report on Science and Technology Indicators" (1994, 1997 and 2003), "Europe in the Global Research Landscape", "Key Figures", and "Mapping of Excellence".

The interaction between policy needs, on the one hand, and academic advances in the field of bibliometrics, on the other hand, was crucial in shaping the development and use of bibliometric indicators. Since the early 1990s, the European Commission, in its preparation of EU S&T policies, and notably through the work of its S&T Indicators Unit, has been a serious user and promoter of bibliometrics. The preparation of new EU policy initiatives helped to drive the development of bibliometric indicators. Initiatives on ERA and scientific excellence led to the expanding use of bibliometric data by research institution and by field of science, as well as the use of co-publication measures to gain insights into patterns of transnational scientific cooperation. The deployment of such indicators in these policy contexts in turn generated vigorous academic debate, which further drove developments in the field of bibliometrics.

Two decades ago bibliometrics was treated with a certain degree of caution—notably by official statisticians, but also by some analysts. Perhaps the most significant change since then has been the mainstreaming of bibliometrics into S&T policy analysis, a trend observed not only in the European Commission, but also across many countries and international bodies. The European Commission continues to invest in the development of output indicators, including non-bibliometric ones, in accordance with its evolving policy priorities. A good example is the effort to develop a headline indicator on innovation in the context of the 2010 Innovation Union flagship initiative.

References

D'Atri, A., Péro, H., Removille, J., & Sand, F. (1992). Indicators for assessing industry oriented R&D programmes: Practices and trends at the European Commission. In: A. F. J. van Raan, R. E. de Bruin, H. F. Moed, A. J. Nederhof, & R. W. J. Tijssen (Eds.), *Science and technology in a policy context. Select Proceedings of the Joint EC-Leiden Conference on Science and Technology Indicators*, *Leiden*, *The Netherlands*, *23–25 October 1991* (pp. 521–539). Leiden, The Netherlands: DSWO Press, Leiden University.

de Bruin, R. E., Straathof, A., & Moed, H. F. (1992). Measuring the effects of European science policy: The assessment of scientific output and international scientific co-operation in CEC target fields, 1985–1990. In: A. F. J. van Raan, R. E. de Bruin, H. F. Moed, A. J. Nederhof & R. W. J. Tijssen (Eds.), *Science and technology in a policy context. Select Proceedings of the Joint EC-Leiden Conference on Science and Technology Indicators*, *Leiden*, *The Netherlands*, *23–25 October 1991* (pp. 453–467). Leiden, The Netherlands: DSWO Press, Leiden University.

de Wijkerslooth de Weerdesteyn, R.J. (1992). Opening address. In: A. F. J. van Raan, R. E. de Bruin, H. F. Moed, A. J. Nederhof & R. W. J. Tijssen (Eds.), *Science and technology in a policy context. Select Proceedings of the Joint EC-Leiden Conference on Science and Technology Indicators*, *Leiden*, *The Netherlands*, *23–25 October 1991* (xix–xxiii). Leiden, The Netherlands: DSWO Press, Leiden University.

Delanghe, H., & Muldur, U. (2007). Ex-ante impact assessment of research programmes—the experience of the European Union's 7th Framework Programme. *Science and Public Policy, 34*(3), 169–183.

Dosi, G., Llerena, P., & Sylos Labini, M. (2005a). *Evaluating and comparing the innovation performance of the United States and the European Union*. Expert Report Prepared for the Trend Chart Policy Workshop 2005, 29 June.

Dosi, G., Llerena, P., & Sylos Labini, M. (2005b). *Science-Technology-Industry Links and the "European Paradox": Some Notes on the Dynamics of Scientific and Technological Research in Europe.* LEM Working Paper Series 2005/02, May.

Dosi, G., Llerena, P., & Sylos Labini, M. (2006). The relationship between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox'. *Research Policy, 35*, 1450–1464.

Dosi, G., Llerena, P., & Sylos Labini, M. (2009). Does the 'European Paradox' still hold? Did it ever? In H. Delanghe, U. Muldur, & L. Soete (Eds.), *European science and technology policy: Towards integration or fragmentation?* (pp. 214–236). Cheltenham, UK: Edward Elgar.

Elkana, Y., Lederberg, J., Merton, R. K., Thackray, A., & Zuckerman, H. (1978). *Toward a metric of science: The advent of science indicators*. New York: Wiley.

European Commission (1990). *Measurement of scientific cooperation and coauthorship in CEC-related areas of science (EUR 12900) (F. Narin, E. S. Whitlow) (research evaluation).* Luxembourg: Office for Official Publications of the European Communities.

European Commission (1992a). *State of the art bibliometric macro-indicators. An overview of demand and supply (EUR 14582) (H. F. Moed, R. E. de Bruin, A. J. Nederhof, A. F. J. van Raan, R. J. W. Tijssen) (monitor spear).* Luxembourg: Office for Official Publications of the European Communities.

European Commission (1992b). *Measurement of national scientific output and international scientific cooperation in CEC-related areas of science during 1985–1990 (EUR 14581) (H. F. Moed, R. E. de Bruin, A. Straathof) (monitor spear).* Luxembourg: Office for Official Publications of the European Communities.

European Commission (1994a). *Research and technological development: Achieving coordination through cooperation.* COM (94) 438 Final, Brussels, 19 October.

European Commission (1994b). *The European report on science and technology indicators* (*EUR 15897*). Nuclear Science and Technology Series. Luxembourg: Office for Official Publications of the European Communities.

European Commission (1997). *Second European report on S&T indicators*, *1997—report* (*EUR 17639*). Nuclear Science and Technology Series. Luxembourg: Office for Official Publications of the European Communities.

European Commission (2003). *Third European report on science and technology indicators* (*EUR 20025*). Luxembourg: Office for Official Publications of the European Communities.

European Commission (2004). *Mapping of excellence in economics* (227 pp). Luxembourg: Office for Official Publications of the European Communities.

Freeman, C., & Young, A. (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.

Glänzel, W., & Debackere, K. (2005). *Bibliometric analysis for participants under the 5th European Framework Programme for Research and Technological Development* (Contract Number EVA6-CT-2005-0001)—final report.

Godin, B. (2001). *The emergence of science and technology indicators: Why did governments supplement statistics with indicators*? Project on the History and Sociology of S&T Statistics, Paper No. 8.

Godin, B. (2002). *Measuring output: When economics drives science and technology measurements*. Project on the History and Sociology of S&T Statistics, Working Paper No. 14.

Holbrook, A. (1995). OECD not the only game in town. *Science and Public Policy*, June, 213–214.

Moed, H. F., de Bruin, R. E., Nederhof, A. J., van Raan, A. F. J., & Tijssen, R. J. W. (1992). State-of-the-art of bibliometric macro-indicators: Demand side, In: A. F. J. van Raan, R. E. de Bruin, H. F. Moed, A. J. Nederhof & R. W. J. Tijssen (Eds.), *Science and technology in a policy context. Select Proceedings of the Joint EC-Leiden Conference on Science and Technology Indicators*, *Leiden*, *The Netherlands*, *23–25 October 1991* (pp. 1–16). Leiden, The Netherlands: DSWO Press, Leiden University.

Muldur, U., Corvers, F., Delanghe, H., et al. (2006). *A new deal for an effective European research policy—the design and impacts of the 7th Framework Programme*. Dordrecht, The Netherlands: Springer.

National Science Board (1973). *Science indicators 1972*. Washington, DC: National Science Board, National Science Foundation.

OECD (2007). *Assessing the socio-economic impacts of public investment in R&D*. DSTI/STP (2007-26). Paris: OECD.

van Raan, A. F. J. (Ed.) (1988). *Handbook of quantitative studies of science and technology*. North-Holland: Tokyo.

van Raan, A. F. J., de Bruin, R. E., Moed, H. F., Nederhof, A. J., & Tijssen, R. W. J. (Eds.) (1992). *Science and technology in a policy context. Select Proceedings of the Joint EC-Leiden Conference on Science and Technology Indicators*, *Leiden*, *The Netherlands*, *23–25 October 1991*. Leiden, The Netherlands: DSWO Press, Leiden University.