4.11 FORESIGHT AND TECHNOLOGY ASSESSMENT AS COMPLEMENTING EVALUATION TOOLS

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4.11.1 Methodology

Traditionally, the evaluation of publicly funded research, technology and innovation programmes has been conceptualised as a hindsight exercise: what direct and indirect impacts were achieved? Were the policy targets attained? Was the target group reached? etc. This kind of ex post questioning, though, provides only to a limited extent answers to *strategic questions* like: what basic technical, scientific, economic or societal problems are calling for a policy intervention? On what functional assumptions would a policy programme's concept be based? Under which conditions would a programme be "strategically efficient"? Any attempt to answer such questions raises a whole series of methodical, conceptual and empirical problems, which must be solved in each case – one solution, nevertheless, becoming a promising model in recent years, is the *amplification and integration of evaluation procedures with foresight exercises and technology assessment.* Roughly, one can describe the basic concepts of foresight and of technology assessment in the following way:

- "Technology foresight is the systematic attempt to look into the longer-term future of science, technology, the economy and society, with the aim of identifying the areas of strategic research and the emerging of generic technologies likely to yield the greatest economic and social benefits" (Martin 1995, 140).
- Technology assessment, in very general terms, can be described as the anticipation of impacts and feedback in order to reduce the human and social costs of learning how to handle technology in society by trial and error. Behind this definition, a broad array of national traditions in technology assessment is hidden (see Schot/Rip 1997; Loveridge 1996).

4.11.2 General Description

Foresight [62]

Science and technology foresight exercises are becoming increasingly attractive for governments, national research agencies and businesses in their efforts at coping with the increasing complexity of new technologies and decision environments, in an increased techno-economic competition world-wide (see Martin 1995; Cameron et al. 1996; Grupp 1998). Since the 1990s, quite a number of major foresight exercises have been launched in many European countries.

The majority of experts consider foresight essentially as a collective and consultative process, with the process itself being equally or even more important than the outcome. Foresight exercises are ways of obtaining opinions, conflicting or otherwise, about future developments, most of which are already established. Foresight in this sense is an essential contributor to the creation, either collectively or individually, of models of the future. Such models are important because they are capable of creating synthesis, they are disruptive and interfere with current modes of thought, thus forming and shifting values.

Foresight is different from prognosis or prediction. Implicitly, it means taking an active role in shaping the future. As a possible result our prognosis of today may be falsified in the future because of a new orientation resulting from foresight. Elder attempts at a "planning" of the future by developing heuristic models (in the sense of futurology) were based on the assumption that the future is pre-defined as a linear continuation of present trends (Helmer 1966; Flechtheim 1968; Linstone 1999). Albeit these approaches largely failed due to the in-build simplification of the actual dynamics of social, economic and technological developments, some studies nevertheless evoked a vivid discussion about the future (e.g. Forrester 1971; Meadows et al. 1972).

In reality, future developments underlie reciprocal influences which cannot be assessed exhaustively in advance, thus not predicted. There is, nevertheless, a need to "monitor the future prospectively": the accelerating changes that individuals as well as societies have to adapt to socially and psychologically, make it necessary to anticipate these changes before they become reality (Helmer 1967). A *new understanding of foresight* gaining acceptance in the 1990s (starting with Irvine/Martin 1984) made clear that a targeted shaping of future developments is strictly limited and that the potential impacts of decisions can only

[62] This section is taken mainly from Kuhlmann 2001, based on Kuhlmann et al. 1999.

partially be estimated. Hence, the new approaches to foresight are striving for relatively "realistic" objectives (Cuhls 1998). In the context of policy-making, the most important intentions are

- to find out new demand and new possibilities as well as new ideas,
- to identify a choice of opportunities, to set priorities and to assess potential impacts and chances,
- to discuss desirable and undesirable futures,
- to prospect the potential impacts of current research and technology policy,
- to focus selectively on economic, technological, social and ecological areas as well as to start monitoring and detailed research in these fields.

A popular foresight approach is represented by the Delphi method originally developed in the USA in the 1960s (Gordon/Helmer 1964; Helmer 1983; Cuhls 1998): Delphi belongs to the subjective and intuitive methods of foresight. Issues are assessed, on which only unsure and incomplete knowledge exists. Delphi is based on a structured survey of expert groups and makes use of the implicit knowledge of participants. Hence, Delphi is both quantitative and qualitative. It includes explorative-predictive as well as normative elements (Irvine/Martin 1984). There is not a single method, but different variations in the application which all agree that Delphi implies an expert survey in two or more rounds. Starting from the second round, a feedback is given about the results of previous rounds: the same experts assess the same matters once more - influenced by the opinions of the other experts. Delphi facilitates a relatively strongly structured group communication process, revealing conflicting as well as consensus areas. Delphi-based foresight exercises, therefore, were used repeatedly and increasingly in the context of policymaking (Grupp 1998), building on their capacity to facilitate an alignment of actors' expectations through interactions (Sanz/Cabello 2000).

Results generated through Delphi processes are welcomed by many policymakers and strategists since they offer semi-quantitative data – which, nevertheless, like the older, naive future-planning exercises, can be misunderstood and misused as "facts" about the future. At the same time, with explicit professional methods of foresight, a broad variety of stakeholders can be involved: scientists, managers, consultancy firms, social organisations, etc. In this respect, strategic intelligence can be enforced (see EPUB "Tool Box", chapter 4). Through their participation, all these various actors get information, do their own intelligence building and feed back their perceptions (and values) into the system. Large explicit procedures are costly, but they improve the quality of the decision process also in another sense: allowing the reaction of various categories of "experts", they add dimensions of technology assessment and evaluation to the "pure" foresight exercise.

Technology Assessment[63]

Technology assessment, with its twin components of anticipation (of effects and impacts) and evaluation and feedback into decision-making, is done in various ways, depending on the key actors and the arenas (see e.g. Rip/Misa/Schot 1995; Smits et al. 1995; Loveridge 1996; Sundermann et al. 1999). Three strands, each with its own style, can be distinguished:

- Technology assessment in firms and in technological institutes, oriented towards mapping future technological developments and their value to the firm or institute, and used as an input in strategy development. *"Picking the winners" (or "avoiding the losers")* used to be the overriding orientation. This strand has developed relatively independently of "public domain" technology assessment, but links are emerging because of the need of firms to take possible societal impacts and public acceptance into account; biotechnology is the main example at the moment.
- Technology assessment for policy development and political decision-making about projects or programmes with a strong technological component (e.g. the electronic superhighway or modern agriculture) or important technologies (like genetic modification). One can call this *"public service" technology assessment*, and consider the U.S. Office of Technology Assessment (OTA) as the embodiment of this type of technology assessment. OTA has, during its lifetime, developed a robust approach to technology assessment studies, which can still be followed profitably. Other technology assessment bodies serving national parliaments and/or national governments were modelled on the OTA example, but have to attend to their specific situation and tend to include participatory technology assessment methods in addition to expert- and stakeholder-based approaches.
- *Agenda-building technology assessment* is the most recent strand. While it is particularly visible and more or less institutionalised in some European countries (Denmark, the

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Netherlands), participatory methods like consensus conferences are taken up all over the world. *De facto* agenda-building technology assessment has a longer history; for example, controversies over new projects or new technologies (and the studies and documents produced in the course of the controversy) induce learning (about potential impacts) and articulation (of the value of the technology). Agenda-building technology assessment merges into informed consultation processes to reach agreement on the value of new technology, as happens for instance through *Sozialpartnerschaft* in Austria.

Technology assessment is much more an advisory than a scientific research and policy-analytical activity. Increasingly, the *advisory activity includes participation*, and thus becomes joint agenda-building. One can compare this shift with the recognition, in foresight and evaluation exercises, of the importance and effects of the process as such, rather than just the data collection and analysis.

4.11.3 Policy instruments/interventions to evaluate with the method

Basically, it is useful to amplify evaluation procedures by combinations with foresight exercises and technology assessment if the evaluation is put in a *strategic perspective*, including the analysis of *users' and market expectations and needs*, understood as a critical frame conditions of a policy measure's potential success.

The interest of policymakers in such combinations is increasing, but there are only few examples of implemented systematic exercises yet. Thus, the following assessment of the potential use of new combinations for *different research and innovation policy instruments* is based rather on plausible consideration than on broad practical experience:

- *Financing R&D:* foresight exercises and technology assessment can help with *priority-setting* under the condition of scarce public budgets and competition for funding – evaluation might either assess funded research and innovation activities *ex post* in the light of foresight and technology assessment results by using them as a kind of benchmark, or rank envisaged funding themes *ex ante*.
- *Provision of R&D infrastructure:* foresight exercises and technology assessment can help to evaluate the actual or envisaged *priorities of research institutes*, by using the exercises' results as a benchmark (see example of Fraunhofer evaluation, below).
- *Technology Transfer/Innovation Diffusion*: foresight exercises and technology assessment can help to identify the quality and extent of the present or future demand for research results and technological developments, i.e. for the *likelihood of successful innovation*.
- *Standards, Regulations, IPRs:* foresight exercises and technology assessment can help to *characterise the need* for technical standards, regulations, and for the appropriateness of IPR regimes, in the light of identified present or future technical, social or economic risks and potentials, thus enlightening the evaluation of related policy measures.

4.11.4 Good practices examples

Example 1

Using technology foresight results in order to evaluate a research institution enables evaluators to get an overview of the fit between perceived future developments in science and technology world-wide and the performance portfolio of a given publicly (co-) funded research organisation. By constructing an adequate index the results of e.g. a Delphi study may be compared with the research activities and/or the staff competencies of a given sample of research units.

The following example provides some evidence of the applicability of this approach. In 1996, the German Chancellor and the Prime Minister of the federal "Länder" decided to evaluate all major research institutions which are jointly financed by the Federation and the Länder (i.e. the Fraunhofer-Gesellschaft; the Max-Planck-Gesellschaft; the Deutsche Forschungsgemeinschaft; the G.W. Leibniz-Gesellschaft; the Helmholtz-Gesellschaft). The strategic aim of the envisaged "system evaluations" of these organisations was not a detailed analysis of the research performance of their units, but the *assessment of the actual functioning* of these organisations in the context of the German "research landscape" as a part of the innovation system. International evaluation panels were formed in order to conduct these evaluations.

The Fraunhofer-Gesellschaft (FhG) is a semi-public contract research organisation consisting of 49 quite autonomous institutes, primarily active in the field of applied technological research. Among the most important issues of the FhG evaluation were questions like: Which technology-related markets promise the largest growth (world-wide and nationally)? Is FhG sufficiently represented in these markets? Does the technological portfolio of FhG fit with related technological developments world-wide?

The international panel in charge of the evaluation decided to employ – inter alia – the results of the German "Delphi '98" Study (Cuhls et al. 2002) as a benchmark for FhG's research and technology competencies. The report offered some 1,000 "visions" of "problem solutions" based on future scientific or technological achievements: in a Delphi process conducted on behalf of the German Ministry for Research (BMBF) these visions had been checked by some 1,000 experts from science, industry, and societal organisations. For each vision the "Delphi '98" Study presented information about its feasibility, the time horizon of its realisation, and also an assessment of the frame conditions fostering or hampering the realisation of a vision (e.g. the performance of the related public research infrastructure).

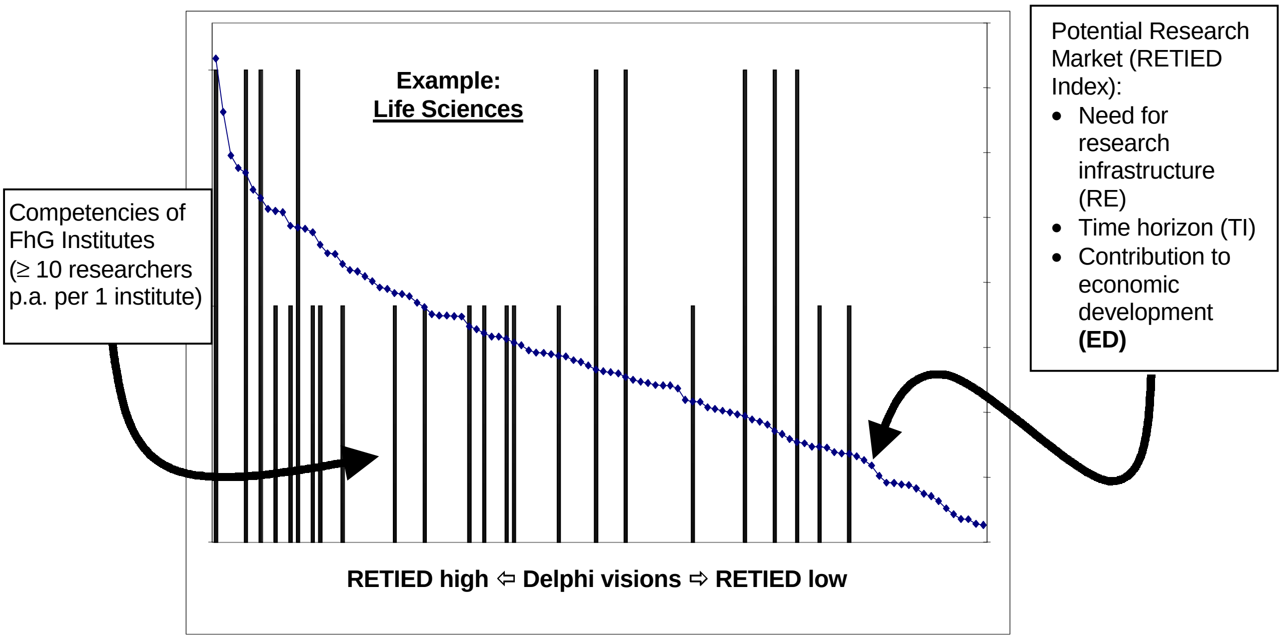
For the purpose of the FhG benchmarking, a "RETIED Index" was constructed, consisting of three Delphi criteria which were considered to be important for FhG, i.e. showing a future demand for R&D activities of the Fraunhofer institutes:

(1) necessity of an improvement of the research infrastructure (RE),
(2) time horizon of the realisation of a technological innovation (TI),
(3) contribution of an innovation to the economic development (ED).

Within each thematic sub-field (e.g. information and communication technologies, life sciences, environment and nature, mobility), the Delphi visions were sorted according to this index (see Figure 5, right hand).

As a next step the competencies of the Fraunhofer Society were assigned to the sorted visions: an internal group of Fraunhofer experts rated the competencies of FhG along various performance indicators (e.g. significant research competencies and personnel in at least one or two institutes) (see Figure 5, left hand).

Figure 5 Combining Foresight Results with Evaluation Purposes - Example: System Evaluation of the Fraunhofer Society (FhG)



Hereby a set of figures of "important visions" of future developments in science and technology was gained on the one hand and FhG-related competencies on the other. The matching of the two heterogeneous but inter-related strands of information revealed in an informative manner strengths and weaknesses of FhG's competencies vis-à-vis potential future research markets. The evaluation panel received these figures as a crucial input to the overall assessment of the adequacy of the given FhG portfolio.

Example 2:

Foresight methods might be further improved for the purpose of policy evaluation by combining it with technology assessment efforts. The German study *Technology at the Threshold of the 21st Century* (Grupp 1993), for example, was rather a foresight study, but indicated at the same time the relevance of extending foresight methods to technology assessment. The experts involved were assumed to have *some understanding of the potential – (non) desirable, (un-)intended – effects and impacts of new technology*. In other words, an informal technology assessment competence was required, profiting from exposure to foresight methods and experience.

4.11.5 Conditions for methodology application

Since the amplification of evaluation practices with foresight exercises and technology assessment is of an experimental character it is not advisable to fix a detailed set of conditions, operational steps, and data lay-outs for this methodological approach. There are, nevertheless *two basic conditions* of a useful implementation:

The envisaged evaluation procedure (programme or policy evaluation, institutional evaluation, *ex post* or *ex a*nte) must be embedded in *a strategic decision-making process*, calling for disposability of alternative perspectives.

Foresight exercises and technology assessments are costly. Their conduct just for the purpose of an evaluation would mean a considerable investment. Rather it is recommendable to *use the results of already available major foresight and assessment exercises in the context of evaluation*, the precondition of which is the willingness of policy authorities to initiate and support repeatedly the conduct of fresh exercises (e.g. regular exercises on a European scale).

4.11.6 Operational steps for method implementation

See section 4.11.5.

4.11.7 Data requirements/indicators

See section 4.11.5.

4.11.8 General Assessment of the scope and limits of the methodology

The amplification of research and innovation policy evaluation practices with foresight exercises and technology assessment helps to broaden the scope of actual or potential, intended or non-intended impacts and effects of public interventions.

Foresight and technology assessment can jointly contribute to strategic intelligence about future developments and their value. A difference in style and context will remain: Foresight aims to open up spaces for thinking about new possibilities, technology assessment is oriented to selecting or at least modifying and modulating developments. The link with evaluation, decisions and strategies implies that there will be more and more broadly based controversy than with foresight, which often remains limited to communities of experts.

Obviously, there are also *limits* of these methodologies. An important limitation of *foresight* is the well known fact that sudden science and technology breakthroughs often have not been foreseen by the majority of main-stream experts but were anticipated by a few unorthodox thinkers. This is a classical problem of foresight and other methods of "prospection": how to detect feeble signals or the minority views that could be revealed as the very precursors of the future? The paradoxical nature of foresight tools is that they aim at two conflicting goals: building consensus and preserving variety of visions.

The strengths and limitations of *technology assessment* cannot be identified unambiguously because of the variety in the contexts of use, and thus in goals and style. It is clear that there is renewed interest in technology assessment, and that this has to do with the increased possibilities of combining private-domain and public-domain technology assessment, and with the role of technology assessment in broader priority setting, technology road-mapping, and articulation of views about new technology.

Finally, since foresight and assessment are *complex combinations of methodologies in itself*, the scope of options and limitations of the hybrid combination with evaluation is inevitably huge. There are two basic limitations that should be mentioned explicitly:

The *cost of combining such complex efforts* (resources, time) are potentially high.

The *problem of the causal attribution* of potential scientific, technological, social or economic developments to a public policy measure under evaluative scrutiny – a basic problem of any policy evaluation – becomes even more an issue in this case.

4.11.9 Commented bibliography

On the combination of evaluation with foresight and technology assessment:

RTD Evaluation Toolbox, chapter 4: Distributed Techno-Economic Intelligence for Policymaking.

Grupp, H. (ed.) (1993): *Technologie am Beginn des 21*. Jahrhunderts, Heidelberg (Physica/Springer)

Kuhlmann, S. (2001) : *Management of Innovation Systems: The Role of Distributed Intelligence*. Apeldoorn/Antwerpen 2001 (Publisher Maklu; series "Nijmegen Lectures on Innovation Management"; edited by the Faculty of Policy Sciences, Nijmegen University)

Kuhlmann, S., Boekholt, P., Georghiou, L., Guy, K., Héraud, J.-A., Laredo. Ph., Lemola, T., Loveridge, D., Luukkonen, T., Polt, W., Rip, A., Sanz-Menendez, L., Smits, R. (1999): *Improving Distributed Intelligence in Complex Innovation Systems*. Brussels/Luxembourg (Office for Official Publications of the European Communities) (see also http://www.isi.fhg.de/ti/Final.pdf)

On the use and methodologies of foresight:

Cameron, H., Loveridge, D., Cabrera, J., Castanier, L., Presmanes, B., Vasquez, L., van der Meulen, B. (1996): *Technology Foresight - Perspectives for European and International Co-operation*, Manchester (PREST: Mimeo)

Cuhls, K. (1998): *Technikvorausschau in Japan. Ein Rückblick auf 30 Jahre Delphi-Expertenbefragungen*, Physica Verlag, Heidelberg

Cuhls, K., Blind, K.,Grupp, H., (2002): *Innovations for our Future. Delphi '98: New Foresight on Science and Technology*, Heidelberg, New York (Physica, Springer) (series 'Technology, Innovation and Policy' by the Fraunhofer Institute for Systems and Innovation Research, ISI)

Cuhls, K., Kuwahara, T. (1994): *Outlook for Japanese and German Future Technology. Comparing Technology Forecast Surveys*, Heidelberg (Physica/Springer Pub-lishers, Series "Technology, Innovation and Policy“, Vol. 1)

Flechtheim, O. K. (1968): *Futurologie - Möglichkeiten und Grenzen*, Frankfurt/M./ Berlin

Forrester, J. W. (1971*): Der teuflische Regelkreis. Das Globalmodell der Menschheitskrise*, Stuttgart

Gordon, T. J., Helmer, O. (1964): *Report on a Long-Range Forecasting Study*, Rand Corporation, Santa Monica/ California

Grupp, H. (1998) (ed.):; Special Issue on Recent National Foresight Activities, *Technological Forecasting & Social Change*, Vol. 57

Helmer, O. (1966)*: Social Technology*, Basic Books, New York/ London

Helmer, O. (1967): *Analysis of the Future: The Delphi method*, Rand Corporation, Santa Monica

Helmer, O. (1983): *Looking Forward. A Guide to Futures Research*, Beverly Hills/ London/ New Delhi

IPTS (2000): *The IPTS Futures Project. Synthesis Report*, Seville, European Commission : EUR 19038 EN.

Irvine, J., Martin, B. R. (1984): *Foresight in Science*, Picking the Winners, London/ Dover

Linstone, H. (1999): *Technological Forecasting and Social Change*, Vol. 62 (1999) p. 1-8

Loveridge, D. (guest ed.) (1996) ‘Special Publication on Technology Assessment’, *International Journal of Technology Management*; Vol. 11, Nos 5/6.

Martin, B. (1995): ‘Foresight in Science and Technology’, *Technology Analysis & Strategic Management* vol. 7, no. 2, 140.

Meadows, D. L., Meadows, D. H., Zahn, E., Milling, P. (1972): *The Limits To Growth*, Universe Books, New York

Sanz, L., Cabello, C. (2000): ‘Expectations and Learning as Principles of Shaping the Future’. In: N. Brown, B. Rappert and A. Webster (Eds): *Constested Futures: A Sociology of Prospective Science and Technology*. Aldershot: Ashgate

On the use and methodologies of technology assessment:

Rip, A., Misa, Th.J., Schot, J. (eds.) (1995): *Managing Technology in Society. The Approach of Constructive Technology Assessment*, London/New York (Pinter)

Schot, J., Rip, A. (1997): ‘The Past and the Future of Constructive Technology Assessment’, *Technological Forecasting and Social Change*, 54, 251-268

Smits R., Leyten, J., den Hertog, P. (1995): ‘Technology Assessment and technology policy in Europe: new concepts, new goals, new infrastructures’, *Policy Sciences*, 28, 272-299

Sundermann, K., Bröchler, S., Simonis, G. (eds.): *Handbuch Technikfolgenabschätzung*, Berlin 1999 (Sigma)