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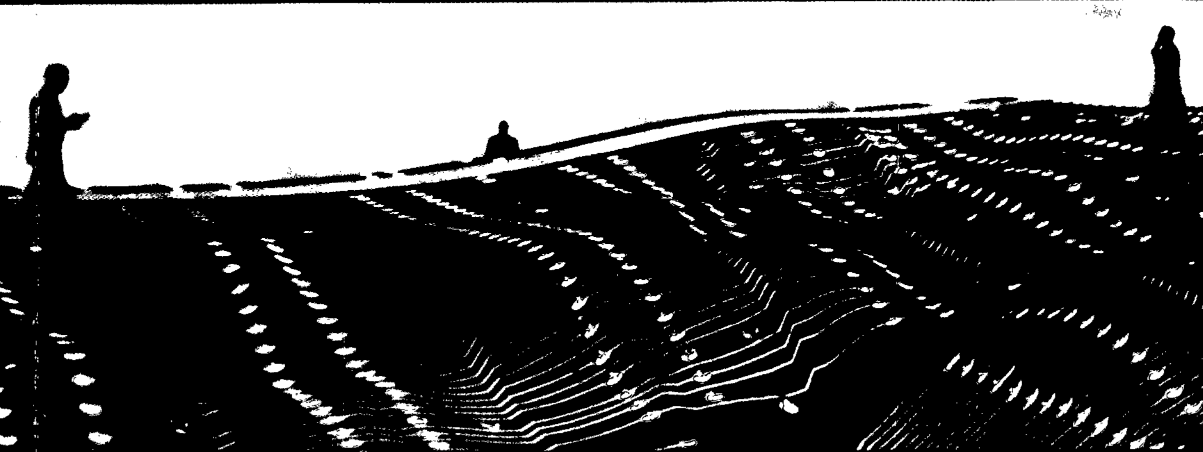
TECHNOLOGY FORESIGHT



International Practice in

TECHNOLOGY FORESIGHT

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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International Practice in

TECHNOLOGY FORESIGHT

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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Foreword

Until not too long ago, people believed that economic growth resulted only from the accumulation of production factors, such as capital and labour. A landmark study conducted by E. F. Denison in the 1960s addressed the issue of what factors led to the remarkable expansion experienced by the United States economy at that time. The underlying idea behind was not only to analyse the past, but also to identify critical factors to be stressed in future economic policies. Denison's research concluded that economic growth was related to three main factors. Two of them were, indeed, physical and human capital formation. The third factor was then called "advance of knowledge" and its application to production. Today we call it technological innovation. By that time, technological progress was considered as given, unaffected by economic policies or political decisions. Later on, in the 1980s, researchers found that governments could indeed influence the speed of the innovation process and its economic impact through a wide range of policies. The last decades were marked by the dramatic impact of numerous technological innovations, which entailed sharp changes in economic structures and in our daily life.

In our view, productivity growth spurred by innovation and technological change is the main driving force in the process of economic growth, both in industrialized and developing countries, and its contribution will increase in the future. UNIDO has embarked in an interactive discussion among member States and different actors about economic policy formulation, particularly geared to identifying the determinants of innovation and technological progress in developing countries. Our aim is to stimulate the elaboration and dissemination of methodologies and studies to map out the ensuing challenges and opportunities. Technology foresight is one of the most promising means of doing this, as the experience of industrial countries and corporations eloquently shows.

Through regional initiatives, UNIDO promotes the idea of technology foresight as a tool for forward looking strategic decision-making and policy formulation that will improve the conditions for innovation and induce economic growth, thus enhancing the quality of life in developing countries and economies in transition.

I am very pleased to present a selection of expert papers prepared under the UNIDO Regional Initiative on Technology Foresight for Central and Eastern

Europe and the Newly Independent States. This book provides a comprehensive overview of the international experience in technology foresight and offers an incentive for governments and industry to promote and support technology foresight for shaping the future.

Carlos Magariños

Abbreviations [technology foresight CEE/NIS]

ACARD	Advisory Council on Applied Research and Development (United Kingdom)
AiG	Confederation of Industrial Research Associations (Germany)
AII	Adriatic and Ionian Initiative
APEC	Asia-Pacific Economic Cooperation
ASTEC	Australian Science, Technology and Engineering Council
ASTPP	Advanced Science and Technology Policy Planning (European Commission)
BMBF	Federal Ministry of Education and Research (Germany)
BMFT	Federal Ministry for Research and Technology (Germany)
BMWi	Federal Ministry of Economics and Technology
CEDEFOP	European Foundation for the Promotion of Vocational Training (Germany)
CEE	Central and Eastern Europe
CEI	Central European Initiative
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
DFG	German Research Association
DSS	decision support system
EC	European Community
EU	European Union
ESTO	European Science and Technology Observatory Network
FOA	Sweden's Defence Research Establishment
FP5	Fifth Framework Programme (European Commission)
GDP	gross domestic product
GERD	gross expenditure on research and development
ICS	International Centre for Science and High Technology
ICT	information and communications technology
IFP	OECD International Futures Programme
IPTS	Institute for Prospective Technological Studies (European Community)
ISI	Fraunhofer Institute for Systems and Innovation Research (Germany)
ITA	Institute for Technology Assessment (Austria)
ITECH	Institute for New Technologies of the United Nations University
IVA	Royal Swedish Academy of Engineering Sciences
JRC	Joint Research Centre (European Community)
MITI	Ministry of International Trade and Industry (Japan)
NIS	National Innovation System (Poland)
NIS	newly independent States
NISTEP	National Institute of Science and Technology Policy (Japan)
NPOR	National Programme of Oriented Research (Czech Republic)
NRDP	National Research and Development Policy of the Czech Republic
NUTEK	Swedish National Board for Industrial and Technical Development
OECD	Organisation for Economic Cooperation and Development

OSCE	Organisation for Security and Cooperation in Europe
OST	Office of Science and Technology (United Kingdom)
PEST	politics, economics, social factors and technological change
PREST	Policy Research in Engineering, Science and Technology (United Kingdom)
R&D	research and development
S&T	science and technology
SMEs	small and medium enterprises
SPRU	Science and Technology Policy Research (United Kingdom)
STA	Science and Technology Agency (Japan)
SWOT	strengths, weaknesses, opportunities and threats
TEAM	Techno-Economic Analysis Network for the Mediterranean (European Commission)
TEP	Hungarian Technology Foresight Programme
TFP	Technology Foresight Programme (United Kingdom)
UNDP	United Nations Development Programme

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Contents

Introduction

In the era of globalization, the key to economic success lies in continuous innovation to achieve ever-higher productivity and thus enhanced competitiveness. Higher productivity calls for new technologies. Thus, technology innovation is decisive for increased competitiveness and economic and social development. There is corresponding concern about the interaction between economic competitiveness and a number of social factors such as unemployment and working conditions, inequality and social cohesion, environment and sustainability and risks associated with new technologies. Therefore there is a need for new technology and industrial policies that balance competitiveness against unemployment, inequality, sustainability and risk. This requires new policy-making tools and technology foresight is prominent among them.

Technology foresight is a relatively new mechanism for strategic decision-making. Its wide application in certain countries dates back to the beginning of the 1990s. It is also highly regarded as a tool for anticipating future market demand and designing development strategies for transnational companies.

Meanwhile, technology foresight is being increasingly recognized worldwide as a powerful instrument for establishing common views on future development strategies among policy-making bodies, bridging the present with the future. One of its unique features is the participation of a large number of stakeholders, namely, government, science, industry and civil society. The application of technology foresight has become crucially important in strengthening the transition process in Central and Eastern European States and newly independent States and narrowing their competitive gap in the global economy. Although technology development planning was traditionally carried out by Governments, the change of socio-economic systems in those States has necessitated the introduction of the new approach encapsulated in technology foresight processes. Applied at the national and regional levels, those processes would allow those States to benefit from the globalization process and integration of their economies in the global market. Compared with the other Central and Eastern European States and newly independent States, Hungary adopted technology foresight early on. A few other States, such as the Czech Republic, Poland and Slovenia, have undertaken the first steps towards promoting technology foresight at the national level.

Technology foresight programmes should be instrumental in providing assistance to Central and Eastern European States and newly independent States with economies in transition that would lead to more sustainable and innovative development aimed at fostering economic, environmental and social benefits at the national and regional levels. Such programmes should stem from the real needs of those States in national capacity-building for technology foresight, as well as in shaping regional long-term development vision.

To build awareness of the usefulness of technology foresight in designing strategies for technological development, sharing current thinking on technology foresight with a focus on the Central and Eastern European States and newly independent States and establishing the basis for cooperation, a Regional Conference on Technology Foresight for Central and Eastern Europe and the Newly Independent States was held in Vienna on 4 and 5 April 2001. The Conference was organized jointly by UNIDO and the Permanent Mission of Hungary to the International Organizations in Vienna.

In particular, the Conference was aimed at reviewing and evaluating the need for and advantages of technology foresight methodologies in the Central and Eastern European and newly independent States. The Conference participants focused on creating a platform for the exchange of knowledge on the application of technology foresight in those States, taking into account the methodologies and techniques available in the different States and regions.

The Conference was attended by participants representing most States in Central and Eastern Europe, the newly independent States, States in other regions, international organizations, transnational companies and the private sector, as well as leading international experts in technology foresight.

The Conference underlined the importance of technology foresight in shaping the future of countries with economies in transition in the era of globalization.

The Conference participants examined a number of issues related to the application of technology foresight in Central and Eastern European and newly independent States, such as:

(a) Assisting decision makers in identifying competitive advantages in the global economy;

(b) Helping to anticipate the needs of society, including issues related to the quality of life and the development of visions and strategies;

(c) Identifying future critical technologies and increasing the focus on research and development programmes in order to optimize available resources;

(d) Indicating the range of methodologies that are available and best suited to the Central and Eastern European and newly independent States for national and regional applications; and

(e) Highlighting the regional dimension in the context of ongoing European integration.

The Conference examined those issues utilizing the knowledge of experts associated with the technology foresight exercises in Central and Eastern

European and newly independent States (the Czech Republic, Hungary, Poland, the Russian Federation and Ukraine). The Conference participants were informed about the experiences gained in carrying out technology foresight exercises in selected market economies (Austria, France, Germany, Sweden and the United Kingdom of Great Britain and Northern Ireland) and the practice of transnational companies in technology foresight promotion. It evaluated the methodologies, challenges, opportunities and impact of relevant European initiatives.

The present publication contains the experts' papers covering three aspects:

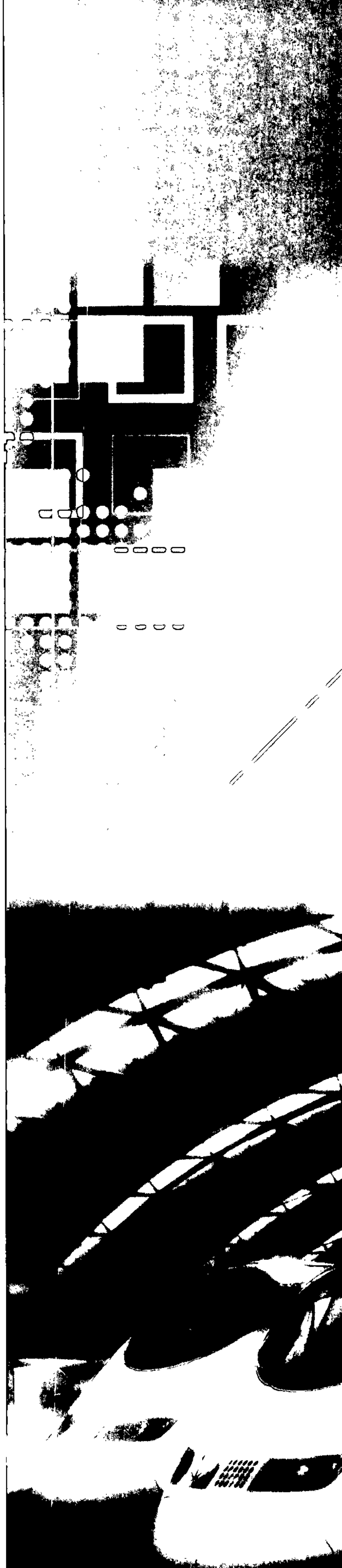
(a) Challenges to countries with economies in transition and benefits for technology foresight;

(b) Regional and national experiences in technology foresight;

(c) Technology foresight methodologies and applications.

Session I.

Challenges for transition economies: benefits from technology foresight



1 Technology foresight in a rapidly globalizing economy

Ben R. Martin*

Abstract

What are the key global driving forces influencing the economy and society today? And what are the challenges that these pose for technology policy? The four key drivers of change in the economy over coming decades can be summarized as the four "Cs". Increasing competition, increasing constraints on public expenditure, increasing complexity and the increasing importance of scientific and technological competencies

In a rapidly globalizing economy, the transition to a "knowledge-based economy" poses important challenges for technology and research. The concept of technology foresight offers a tool for the strategic management of research and technology. Technology foresight has evolved from its origins in the United States and has been widely used in Japan over the last 30 years in both the public and private sectors. It spread extensively during the 1990s and is now employed in many industrialized nations. To understand the content and the importance of technology foresight for emerging economies, it is worthwhile examining the experiences in Japan, the United States, the Netherlands, Germany, France and particularly the United Kingdom with their respective foresight programmes. These programmes highlight the role of technology foresight in "wiring up" the national or regional system of innovation and hence in enhancing competitiveness in a globalizing and increasingly knowledge-intensive economy.

There is widespread and growing recognition that technology foresight represents a useful tool to aid decision-making in relation to research and technology policy, whether at the national or regional level or at a more micro-level. Japan, after 30 years of experience, still makes extensive use of foresight. In other countries, foresight began to take root since the beginning of the 1990s.There has been marked progress in Germany where foresight now is quite firmly established. The Netherlands, France and the United Kingdom have also undertaken foresight exercises and are starting to gain some of the process benefits discussed earlier, such as better communication between all the relevant stakeholders, the creation of networks, and extending time horizons in relation to decision-making.

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No individual foresight approach is perfect. Each has its own strengths and weaknesses. If the aim is to achieve a long-term holistic overview of technology in a country with a large number of experts on technology and innovation, then the Delphi survey is well suited to the task. However, in other circumstances, such as applying technology foresight at the company level or for an indvidual sector, another approach may be more appropriate.

Individual countries or organizations may adopt quite different approaches. Japan, Germany, the United Kingdom (initially, at least) and France have made use of large-scale Delphi surveys in their holistic foresight exercises. In the Netherlands and Australia, the Delphi method has not been employed; instead, the emphasis has been on other approaches, such as panel discussions and brainstorming, commissioned studies, and creating or tapping networks.

One question that is sometimes asked in countries contemplating whether to become involved in foresight for the first time (given that the costs are far from negligible) is the following: "If Japan and other major countries are engaging in foresight exercises and making the results public, can we not just purchase their results and act upon them?" The short answer is "No". There are two main reasons for this. First, each country has its own particular strengths and weaknesses in industry and in science and technology. This means that the choices made, for example, by Japan will not necessarily be the same as those made by a country like Australia or Hungary. Second, the benefits associated with the process of carrying out foresight exercises are at least as important as the direct outputs (priorities, policies or whatever).

We have seen how the growing spread of foresight may herald the emergence of a new "social contract" between science and society. After several decades during which governments and the public were fairly relaxed about exact benefits they would ultimately derive from science and when they would occur, now they are coming to expect more direct and specific benefits in return for the considerable investments that they make in science. Foresight is a tool for helping to achieve this, and perhaps also for "wiring up" the national or regional innovation system so that it can learn and innovate more effectively.

Foreword

This paper[1] begins by examining the challenges posed for technology and research in a rapidly globalizing economy and by the transition to a "knowledge-based economy". It then examines the concept of technology foresight, looking at how it offers a tool for the strategic management of research and

[1]Earlier versions of this paper were given at the National Institute of Science and Technology Policy (NISTEP), Tokyo, 18 January 1999; at the International Conference on Forward Thinking: Keys to the Future in Education and Research", organized by the German Federal Ministry of Education and Research (BMBF) and held in Hamburg on 14-15 June 1999; at the Asia-Pacific Economic Cooperation (APEC) Centre for Technology Foresight, Bangkok, 21 June 1999; at the International Symposium on Frontiers of Science and the National Natural Science Foundation of China (NSFC) Priority Setting, Beijing, 23-25 August 1999; and at the Swedish/European Union International Seminar on Foresight for a Competitive and Sustainable Europe, Stockholm, 20 March 2001. It draws upon various international reviews of foresight including Irvine and Martin (1984); Martin and Irvine (1989); Cuhls et al. (1993); Martin (1993, 1995a, 1995b, 1996, 1997); Cameron et al. (1996); and Martin and Johnston (1999). See also the special issue of Technological Forecasting and Social Change, Vol. 60 (1999).

technology. It describes how technology foresight has evolved from its origins in the United States of America. Widely used in Japan over the last 30 years in both the public and private sectors, it spread extensively during the 1990s and is now employed in many industrialized nations. The paper considers experiences in Japan, the United States, the Netherlands, Germany, France and particularly the United Kingdom of Great Britain and Northern Ireland with their respective technology foresight programmes. The paper highlights the role of technology foresight in "wiring up" the national or regional system of innovation and hence in enhancing competitiveness in a globalizing and increasingly knowledge-intensive economy.

Introduction

The broad aim of technology foresight is to identify emerging generic technologies likely to yield the greatest economic and social benefits. During the 1990s, technology foresight became much more widespread. Japan had been engaging in extensive foresight activities since 1970,[2] and there were several foresight initiatives in France in the early 1980s. Later that decade, countries such as Sweden, Canada and Australia also began to experiment with technology foresight. However, prior to 1990, there was comparatively little technology foresight in the United States, the United Kingdom and Germany. Around 1990, the situation began to change with the Netherlands,[3] the United States,[4] Australia,[5] Germany,[6] the United Kingdom,[7] France[8] and various other countries launching major foresight exercises.

In this paper, we first summarize the economic and political background to this increasing interest in technology foresight. We identify some of the key "drivers" of change in an era of globalization, competition and a shift towards a more knowledge-intensive economy and society. Next, we consider what is foresight and why it is needed. We then analyse its historical evolution, focusing on developments in Japan, the United States, the Netherlands, Germany and France before examining in more detail the United Kingdom Foresight Programme. We end with some general conclusions about the role and nature of foresight, in particular its role in "wiring up" the national or regional system of innovation, enabling it to learn and innovate more effectively.

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[2]Such activities were not normally described in Japan as "foresight" but as "forecasting" or "long-term strategic planning" or other similar terminology.

[3]See van Dijk (1991) and van der Meulen (1996 and 1999).

[4]See Mogee (1991).

[5]See, e.g., CSIRO (1991), ASTEC (1994), Pitman (1994) and Martin and Johnston (1998).

[6]See Cuhls et al. (1993), Breiner et al. (1994) and Cuhls et al. (1996).

[7]See Georghiou (1996) and Martin and Johnston (1998).

[8]See, e.g., Quevreux (1994) and Heraud (1996).

Global driving forces and the challenges for technology policy

Some of the main drivers of change in the global economy over coming decades can be summarized in terms of the "four Cs":

- Increasing competition;
- Increasing constraints on public expenditure;
- Increasing complexity; and
- Increasing importance of scientific and technological competencies.

As we shall see, these factors also underlie the upsurge of interest in foresight, giving rise to its emergence as a global concept and policy tool. Let us consider each of these four driving forces briefly in turn.

Increasing competition

There is widespread recognition that we live in an increasingly competitive world. Over the last 10 years or so, many more market-economy "players" have emerged—in Asia, in Central and Eastern Europe, in Latin America and elsewhere. This has greatly increased the level of economic competition between countries as well as companies. At the same time, we are witnessing huge (and perhaps historically unprecedented) variations in labour costs (e.g., by a factor of 100 or more between Germany and China). These are occurring at a time when companies can much more easily shift resources and production between countries to benefit from lower costs or other advantageous local resources. For the richer and more industrialized countries, the key to success lies in continuous innovation to achieve ever-higher productivity and thus enhanced competitiveness.

In this era of competition and increasingly rapid change, new technology is playing a growing role in relation to economic and social development. As we move towards the knowledge-based economy, industrial competitiveness is coming to depend to a greater degree on new technologies and innovation. However, emerging technologies and the strategic research which underpins them are often too far removed from the market, too risky or too expensive for industry to take sole responsibility for their support. Governments must assume at least part of the financial responsibility. Yet (as we describe below) Governments cannot afford to fund all areas of research and technology which their scientists or industrialists would like them to support. Choices have to be made, and technology foresight offers a process to help make those choices.

There is increasing concern about the interaction between economic competitiveness and a number of social factors such as unemployment and working conditions, inequality and social cohesion, environment and sustainability, and new risks (those associated with the introduction of new technologies) and their distribution across different sectors of society compared with the distribution of benefits. There is therefore a need for new national science and technology (S&T) policies that balance competitiveness against unemployment, inequality, sustainability, risk and so on. This requires new policy tools such as technology foresight.

Constraints on public expenditure

Governments in many countries have been experiencing significant public expenditure constraints because of the need to balance their budgets (for example, to meet the Maastricht criteria for European monetary union). Those constraints are likely to grow over time for a number of reasons including demography and the ageing population, and the increasing costs of—and rising expectations concerning—health care, education and social welfare. Another possible factor is that we may have reached the politically acceptable limits to tax-raising; if a Government attempts to extract taxes above a certain level, companies or more affluent individuals may take their business off-shore, to a country where the tax system is not so burdensome, something which has been made much easier by new technology and the growing use of electronic transactions.

These constraints on public spending will result in increasing demands for greater accountability and for better "value for money" from all areas of government spending. In the case of research and technology, this requires new policy tools, along with a better justification for government funding of research and technology. We also need policies to develop technologies to deliver health care, education and social welfare more effectively.

Because of these trends and the escalating cost of research and technological development, no Government can afford to do everything in research and technology, not even the richest. Governments now realize that they must be more selective—they must have explicit policies and clearer priorities for research and technology. Choices have to be made. In the past, those choices tended to be made tacitly—they just "emerged" from the policy process. The question now is whether we should continue with this approach, or whether we should attempt to devise a more systematic procedure for priority setting in relation to technology and research. Foresight offers a tool (but not a panacea) for helping to identify those priorities.

Increasing complexity

The trend towards growing complexity is driven by greater coupling and closer interactions of systems of a variety of forms, including interactions between:

- Local, national, regional and global systems—for example, between national systems and the European Union, and between each of these and world bodies such as the World Trade Organization (WTO);

- Research and technology, on the one hand, and the economy, politics, culture and environment on the other (as described in the section on increasing competition above);
- Public and private sectors in such areas as health care and transport;
- Different technologies—here, Kodama's notion of technology fusion[9] is particularly important. Often the most important radical innovations arise when two or more previously separate streams of technology come together and "fuse";
- Different producers of knowledge—according to the thesis of Gibbons et al.,[10] in the "Mode 2" form of knowledge production, a far wider range of knowledge producers is involved and there is considerable blurring of the institutional boundaries between them (e.g., between the industrial and university sectors).

As a result of these growing interactions between systems of different forms, there is a need for the following:

- A better understanding of complex systems;
- Flexible policies, responses and systems;
- Policy tools linking different partners and their needs, values and so on;
- Increased and more effective networks, partnerships and collaboration;
- A clear division of responsibility between national, regional and global bodies and their respective policies.

As we shall see below, technology foresight provides a process for addressing several of these issues in a systematic, open and collaborative manner.

Increasing importance of scientific and technological competencies

The final point in our list of key drivers of change in the global economy is the increasing importance of scientific and technological competencies. Here, one can distinguish between knowledge and skills. As argued above, scientific and technological knowledge is becoming a strategic resource for companies and countries. It is also increasingly vital to improving the quality of life. As many science policy studies have demonstrated,[11] at least as important as codified knowledge (encapsulated in textbooks, scientific papers, patents and so on) is tacit knowledge. Such tacit knowledge is not easily transferred; generally it requires people or organizations to be brought

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[9]Kodama (1992).

[10]Gibbons et al. (1994).

[11]See, for example, Faulkner and Senker (1995)

together, ideally with individuals working together at the same location for a period of time. Again, technology foresight can forge the connections that help bring this about.

Scientific and technological skills or expertise are also becoming ever more important in relation to wealth creation and improvements in the quality of life. Here, matters are complicated by the fact that new technologies not only demand new skills, they also make old skills obsolete (arguably, at an increasing rate). This points to the need for continuous learning, both at the level of the individual (with a shift away from the notion that the individual is educated only in the first 20 years or so of life to one of "lifetime learning", a shift in which new technologies can make a major contribution), and at the organizational level (with the creation of the "learning organization"). In addition, because of the growing complexity and interaction of systems described above, we need new generic or system-wide skills—skills such as interdisciplinary approaches, team-working, networking and collaborating, all of which can be fostered or exchanged through the technology foresight process.

The changing social contract between S&T and society

As has been argued elsewhere,[12] what the above factors may be producing is a shift in the "social contract" between science and technology, on the one hand, and the State or Government, on the other. In the 40 years after the end of the Second World War, the "science-push" model exerted a dominant influence on funding policy for research. According to this model, advances in basic research give rise to opportunities in applied research which, in turn, make possible the development of new technologies and innovations. Society, therefore, supported basic research in the expectation that it would ultimately generate benefits in the form of wealth, health and national security, but Governments were fairly relaxed about exactly what form those benefits might take and when they might occur. Now, faced with increasing industrial competition, tighter financial constraints and demands for accountability, Governments are expecting more specific benefits in return for continued investments in research. Foresight represents one way of linking the interests of the scientific community in pursuing the most promising research opportunities with the needs of industry and society in relation to new technology and innovation.

This leads us to another reason why Governments have become involved in foresight—namely, that the successful use and exploitation of science and technology depends increasingly on the creation of effective networks between industry, universities and government research laboratories. Foresight can help to establish and strengthen those links. As is argued later

[12]See, for example, Guston and Keniston (1994), de la Mothe and Halliwell (1997) and Martin and Etzkowitz (2001).

in this paper, this might be seen as part of the process of "wiring up" the national or regional innovation system so that it can learn and innovate more effectively.

Foresight-definition and rationale

In this section, the following definition of "foresight" is used:

> Foresight is the process involved in systematically attempting to look into the longer-term future of science, technology, the economy, the environment and society with the aim of identifying the emerging generic technologies and the underpinning areas of strategic research likely to yield the greatest economic and social benefits.

There are six important aspects to this definition. First, foresight is not a technique (or even a set of techniques) but a process that, if well designed, brings together key participants from different stakeholder groups (the scientific community, government, industry, non-governmental organizations and other public interest or consumer groups) to discuss what sort of world they would like to create in coming decades. Second, the attempts to look into the future must be systematic to come under the heading of "foresight". Third, those attempts must be concerned with the longer term—by which we mean a typical horizon of 10 or more years (and generally in the range between 5 and 30 years). Fourth, successful foresight involves balancing science or technology "push" with market "pull"—in other words, identifying likely demands relating to the economy and society as well as potential scientific and technological opportunities. Fifth, the focus is on the prompt identification of emerging generic technologies[13]—in other words, technologies that are still at a pre-competitive stage in their development and where there is consequently a legitimate case for government funding. Last, attention must be given to the likely social benefits (or adverse consequences) of new technologies (including the impact on the environment) and not just their impact on industry and the economy.

It is important to stress that foresight is not the same as technology forecasting. Technology forecasting, after enjoying some popularity in the 1960s and early 1970s, fell somewhat into disrepute following the general failure to foresee the 1973 oil crisis and its effects. During the second half of the 1980s, interest shifted to foresight or *la prospective*.[14] This has a different philosophical starting-point from that of traditional predictive or extrapolative forecasting. The latter assumes that there is one, unique future. It is then the task of the forecaster to predict, as accurately as possible, what this will

[13]A generic technology may be defined as "a technology the exploration of which will yield benefits for several sectors of the economy or society" (Martin, 1993, p. 51).

[14]The approach of *la prospective* has been pioneered by Godet (e.g., 1986 and 2001) and others in France.

be. By contrast, with foresight and *la prospective* one assumes that there are numerous (or infinite) possible futures. Exactly which one we will arrive at depends upon the choices made today. In other words, foresight involves a more active attitude towards the future; countries, organizations and indeed individuals have the power to shape the future through the decisions they take today.

As has been argued above, there is a widespread recognition that emerging generic technologies are likely to have a revolutionary impact on industry, the economy, society and the environment over coming decades. These technologies are heavily dependent for their development on advances in science. If one can identify emerging technologies at an early stage, Governments and others can target resources on the strategic research areas needed to ensure rapid and effective development. The aim of foresight is to identify potentially important emerging technologies at as early a stage as possible, and to facilitate their subsequent development and exploitation.

Historical evolution of foresight

Technology forecasting first came to prominence in the late 1950s in the United States defence sector and in work by consultants such as the RAND Corporation. The latter were responsible for developing some of the principal tools of technology forecasting, such as the Delphi questionnaire survey[15] and scenario analysis. Large forecasting exercises were carried out during the 1960s by the United States Navy and by the United States Air Force. Technology forecasting was also taken up by private companies (e.g., in the energy sector).[16] However, the next developments, and the emergence of what we now term "foresight", took place in Japan.

Technology foresight in Japan

Towards the end of the 1960s, Japan decided that technology forecasting represented a potentially useful policy tool and a team was sent to the United States to consult with experts. In 1970, the Science and Technology Agency (STA) undertook its first 30-year forecast of the future of science and technology. The aim was to construct a holistic overview encompassing all science and technology, thus providing decision makers in both public and private sectors with the background intelligence on long-term trends needed for broad direction-setting. Several thousand experts from industry, universities and government organizations were surveyed (using a Delphi questionnaire) about possible innovations or technological developments,

[15]The essential feature of a Delphi survey is that respondents have a second chance to give their views in the light of opinions expressed by everyone else.

[16]For further details, see Irvine and Martin (1984).

when they were likely to occur, their importance and the probable constraints on their realization. The results from the first round of the survey were synthesized and fed back to the same experts who in the second round of the Delphi exercise were given an opportunity to confirm or modify their views. These 30-year forecasts have since been repeated approximately every five years up to the present.

The results from these surveys are seen as having two main uses: (*a*) compiling background data for research and development (R&D) planning, in particular providing an overview of longer-term technological trends and identifying important emerging technologies; and (*b*) monitoring current science and technology, including the level of current Japanese R&D activities in relation to those in other countries, highlighting areas where there is an emerging need for international collaboration, and identifying factors constraining technological development. The results have formed one of the inputs to decisions by the Council for Science and Technology of Japan on future government science and technology policy. They also represent background intelligence for other government ministries and for industry.

A few years ago, Japan's National Institute of Science and Technology Policy (NISTEP) carried out a survey of companies to assess how much use they made of the results from the fourth Delphi exercise. Out of nearly 250 respondents, 59 per cent considered the results were "very important" and a further 36 per cent judged them "worthwhile". The main uses of the STA results include "planning for R&D and business projects" (72 per cent), "analysing medium-term technological trends" (61 per cent) and "analysis of the specific content of the topics surveyed" (60 per cent). NISTEP also assessed the accuracy of the results from the first Delphi survey in 1970. They found that 64 per cent of topics had been fully or partially realized in the intervening 20 years. Given the long time-horizon and the fact that this was the first Delphi survey in Japan, these figures are particularly encouraging. Where the forecasts had proved inaccurate, this was often not so much in relation to technological developments but as a result of subsequent political or social changes.[17]

Three points should be stressed regarding Japan. First, the Japanese recognize that the main value from foresight is often not so much the direct outputs (forecasts, and subsequent policies based upon them) but the process benefits of foresight. These process benefits can be summarized as the "five Cs"—communication, concentration on the longer term, coordination, consensus, and commitment. Second, the STA surveys constitute just one of a wide range of foresight activities in Japan. Third, most of the other foresight exercises use techniques other than Delphi surveys, such as expert panels, brainstorming, scenarios, commissioned studies from consultants and so on. For example, the Ministry of International Trade and Industry (MITI) periodically produces "10-year visions" as well as organizing numerous other fore-

[17]Kuwahara (1994).

sight efforts. At the next level down (meso-level foresight), industrial associations and informal ad hoc groupings of companies perform or commission a variety of foresight exercises for specific industrial or technological sectors. Finally, a lot of micro-level foresight is carried out within individual firms, with the major science-based companies devoting considerable effort to forecasts specific to particular product ranges or processes.[18]

Technology foresight in the United States

In the United States, the Department of Defense has continued to be an enthusiastic user of technology foresight. For example, the United States Air Force has carried out some of the largest and most systematic foresight exercises. In the civil sector, one of the main approaches to foresight has been a series of reviews of individual scientific fields. In the 1960s and early 1970s, a dozen of these field surveys were carried out. Several more were conducted during the 1980s and 1990s by the National Research Council. In all of these, the approach was similar, with most of the work being done by a large committee of eminent scientists and a few industrialists. The resulting reports each set out the exciting scientific opportunities available in that field. However, with one or two exceptions, the reports shied away from identifying priorities. They also gave relatively little attention to "demand-pull" considerations, and they almost invariably ended up by asking the Federal Government to double the budget for that field over the next few years. As a result, they generally had little direct impact on the Federal Government.[19]

Prior to 1990, the prevailing belief in the United States was that the Federal Government did not need an explicit technology policy; the country, it was argued, was rich enough to aspire to leadership in all areas of science and technology. This meant that the demand for foresight in the public sector was generally less than elsewhere. However, at the end of the 1980s, there appears to have been a sea-change in attitudes as a result of increasing concern about United States competitiveness, particularly in relation to Japan. The emerging recognition that the United States needed to have a coherent technology policy largely explains the upsurge in interest in foresight during the early 1990s.

The favoured approach to foresight in the United States during this period was to draw up lists of critical technologies (i.e., those critical to the future of the United States economy or to national security). The Department of Defense carried out several such exercises, while others were conducted by the Department of Commerce, the Council on Competitiveness and the Office of Science and Technology Policy. In addition, various industrial consortia (e.g., aerospace and computer systems) drew up more specific lists of

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[18]See Irvine and Martin (1984) and Martin and Irvine (1989) for further details.

[19]These and various other United States foresight initiatives such as the Five-Year Outlooks and the Research Briefing are described elsewhere (ibid.).

critical technologies for their sectors and often produced "road-maps", setting out how each of these was to be developed. The methodology in all these exercises involved starting with an initial long list of emerging technologies, identifying explicit selection criteria, and then using those criteria to produce a short list (typically of around 10-20) of the most important technologies. These exercises provoked much discussion but were criticized for making only limited use of data, for involving relatively few people in the scientific and industrial communities, and for identifying technologies that are too broad for specific policy decisions.[20]

Technology foresight in the Netherlands

Technology foresight in the Netherlands has taken a different form from that in other European countries. Among its characteristics are a high degree of decentralization, the use of a range of methods (although not Delphi surveys), close integration with existing policy processes and structures, and a focus on specific fields (as opposed to the holistic foresight exercises of the three large European countries). Technology foresight also has a longer history in the Netherlands than in the United Kingdom or Germany. It had its origins in attempts during the 1970s to examine and strengthen the relationship between science and society. Since 1980, the sector councils (for agriculture, environment and health) have carried out various foresight activities. In the 1990s, the Foresight Steering Committee (described below) assumed responsibility for coordinating these activities.

The Ministry of Economic Affairs began to carry out technology foresight in 1990.[21] Rather than looking at the whole of technology, these exercises were based on a few critical technologies. Three fields were analysed in 1990 (e.g., chip cards) and another three in 1992 (e.g., signal processing). The objectives were to produce an input to technology policy, to provide small and medium enterprises (SMEs) with an early warning of opportunities and threats, and to create networks. There are four main steps in the foresight process: (*a*) consultation to draw up a short list of technologies to be examined; (*b*) analysis to identify the key players, potential bottlenecks and opportunities; (*c*) a strategic conference to bring together the stakeholders, to test the preliminary results, to create consensus and to generate commitment to implementing the results; and (*d*) follow-up (e.g., launching a pilot project or creating a new institute).

For each field, consultants produced reports on how the technology might be exploited, in particular by SMEs. A range of mechanisms was used to implement the results including the creation of networks, improvements to the knowledge infrastructure, new training courses and publications. SMEs were the main target group, but the problem here is that the most innova-

[20]See, for example, Mogee (1991) and Martin (1993).
[21]van Dijk (1991).

tive SMEs are generally already aware of the new technology, while less innovative ones tend not to be involved in the foresight process nor to be very influenced by the results. In order to evaluate the effectiveness of the first exercise, a questionnaire was sent two years later to participants. Of these, 75 per cent had found the information generated "very valuable", and a similar number had made new contacts as a result of participating. In addition, 60 per cent had taken follow-up action (e.g., developing a new product).[22]

A number of lessons emerge from these exercises. First, they require much effort and the follow-up activities take a lot of time to organize, largely because of the need to identify a "product champion" responsible for implementing the results. Second, because SMEs are such an important component of Netherlands industry, it is vital to involve them, yet there are considerable difficulties in doing so because of the wide range in their technological and innovative capabilities. Third, the choice of foresight methodology depends on the objectives—an approach appropriate for identifying resource allocation priorities may be ineffective at stimulating companies to take advantage of the economic opportunities.[23]

The Ministry of Education and Science also became involved in foresight, setting up a Foresight Steering Committee in 1992.[24] It had two tasks: (*a*) to initiate, support and coordinate foresight exercises; and (*b*) to provide advice to the Ministry on options for science and technology policy. Among the areas in which foresight exercises were initiated were chemistry, transport and infrastructure, agriculture, energy, nanotechnology, informatics, educational research, legal research, economic research, social sciences, and health. The methodology normally involved a preliminary selection of topics based on an overview of the committee members and requests from outside organizations. The foresight process was designed to ensure both close cooperation with key policy makers, and that priorities were based on an assessment of potential contributions of science and technology to society. The design of the foresight process also took account of the characteristics of the research field-for example, whether it is concentrated in a few laboratories or highly fragmented.

The main conclusions to emerge from these foresight activities are threefold. First, designing a foresight process geared to a specific field has two advantages: (*a*) it makes implementation far easier; and (*b*) it provides greater flexibility in dealing with specific issues and problems. Second, the main problems encountered involve: (*a*) setting priorities and "posteriorities" (i.e., negative priorities), especially at the national level; and (*b*) the fact that budgetary cuts tend to induce distrust in foresight. Third, the scenario methodology forces participants to think beyond their usual framework and ad hoc problems.[25]

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[22]Netherlands Ministry of Economic Affairs (1994).

[23]Martin (1996a).

[24]This section draws on van der Meulen (1996 and 1999). Later in the 1990s, the Ministry of Agriculture also became involved in foresight.

[25]Ibid.

Technology foresight in Germany

The attitude towards foresight in Germany changed appreciably after 1990.[26] Until then, there was comparatively little research or technology foresight. The reasons included the stipulation in the federal constitution that science should be autonomous, the political climate under the Christian Democrat Government, and the country's federal structure with the division of responsibility for research between the Länder and the Federal Government. However, around 1990 there was a major policy change that brought about the launching of various foresight activities by the Government. The reasons for that change include problems associated with unification, recession and the structural crisis, and the renewed emphasis on technology foresight in other countries.[27]

Since 1990, several foresight exercises have been completed. In the exercise known as "Technology at the Threshold of the 21st Century", the first step was a review by the Fraunhofer Institute for Systems and Innovation Research (ISI) of the lists of "critical technologies" drawn up in the United States and the results of other foreign foresight initiatives. Next, a long list was prepared of 86 technologies with potential economic or social utility over the next 10 to 15 years. Using a relevance tree approach, experts from the Federal Ministry of Education and Research (BMBF) agencies *(Projektträger)* evaluated each technology in terms of such criteria as timing, economic importance and non-economic benefits, identifying the most important ones for Germany in terms of each criterion.[28]

In another initiative, ISI collaborated with NISTEP in Japan which was conducting the fifth STA 30-year forecast. The first step was to translate the Japanese Delphi topics into German.[29] The topics were sent to a large sample of experts from industry, universities and government. Comparison of the German and Japanese responses showed close agreement on the likely timing of advances, suggesting that the Delphi approach can be used reasonably consistently across countries. Where there were differences between the two sets of results was over the relative importance of individual topics and likely constraints. Since both these are closely linked to the respective national research systems, such differences are not unexpected. Another result to emerge was confirmation of the earlier Japanese finding that experts in a particular sub-field sometimes put forward unduly optimistic views. One strength of the Delphi approach is that such a bias can be identified and taken into account.[30]

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[26]This section draws on Grupp (1996).

[27]Cuhls et al. (1996).

[28]However, they were unable to arrive at a single list of priorities (see Grupp, 1994a; 1994b).

[29]This proved a non-trivial task; after a preliminary translation by professional translators, German experts had to check each topic to ensure that its meaning had been accurately reproduced.

[30]Grupp (1994a; 1994c; 1996).

Although the exercise was reasonably successful, in particular, enabling the views of German and Japanese experts to be compared, the approach had some weaknesses. The two countries therefore carried out a "mini-Delphi" exercise to develop an improved methodology. Among the changes were for the two countries to select the topics jointly, the distinguishing of different categories of importance (to science and technology, on the one hand, and to the economy, the environment and society on the other), and the inclusion of questions on the conditions to foster innovation. The findings from this exercise included the following:

(*a*) The mini-Delphi is an important methodological tool;

(*b*) International selection of the Delphi topics is recommended for such joint exercises;

(*c*) Questions relating to market demand should be included in discussions of S&T policy;

(*d*) Delphi surveys should seek qualitative as well as quantitative information—for example, views on alternative solutions to particular problems.[31]

Foresight in Germany has had an impact at several levels. First, at the federal level, it has influenced budget priorities within the Federal Ministry of Education and Research (BMBF), although technology foresight is just one of many inputs. It has also played a role in strategic talks with industry and large research organizations. Second, a number of State Governments have carried out investigations of the regional implications of the national foresight results. Third, in industry, there have been more specific foresight exercises carried out by industrial associations. A pharmaceutical company has also conducted a Delphi survey of several thousand doctors, and a number of other companies are known to have performed in-house foresight activities. Lastly, foresight has had a wider impact on German society. The results have been published and widely discussed in the media. This has helped generate a more positive debate on future technologies, with distinctions being made between individual technologies and whether each of them is desirable or not.

Technology foresight in France

In France, there were several interesting foresight initiatives in the early 1980s under a socialist Government which gave high priority to technology as a means to achieving economic and social progress. For example, in 1981 there was a major technology consultation exercise in which 1,200 experts were involved and which yielded reports on five priority fields together with an overview report.[32] A year later, the National Colloquium on Research and

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[31]Subsequently, Germany collaborated with Japan in the latter's sixth Delphi exercise in the late 1990s.

[32]Irvine and Martin (1994).

Technology was held which, together with various regional meetings, involved 3,000 people. It identified half a dozen key technologies and the Government subsequently launched national "mobilizing" programmes[33] to promote these. Regular foresight was then used to steer or redirect these national programmes during the 1980s. Other examples of foresight include an exercise by the Centre National de la Recherche Scientifique (CNRS) in 1984 to identify 20 strategic themes and the Prospective 2005 conference organized by CNRS and the Planning Commissariat in 1985.[34]

However, after the change of government in 1986, interest in foresight declined until 1994 when a Delphi survey on future technologies was launched by the Ministry for Higher Education and Research.[35] This was carried out in parallel with another foresight experiment by the Ministry of Industry to identify key technologies,[36] an exercise which gave more emphasis to the needs of industry and society and rather less to science and technology push. The Delphi survey used many of the same questions as the earlier Japanese and German surveys so that the views of French experts could be compared with those of the Germans and Japanese.[37] Among the aims were to see if a Delphi survey would work in France, to establish whether experts would participate, and to find out whether decision makers would be influenced by the results.

Questionnaires were sent to over 3,000 experts drawn fairly equally from industry, universities and public research organizations, and covering 15 sectors. Among the questions considered in analysing the results were the level of consensus among experts and, conversely, whether there were groups of experts with distinctly different views, and whether experts held different views from those slightly less knowledgeable on that topic. A comparison of the results with those from the Japanese and German surveys revealed that French experts held very similar views on the timing of technological developments or innovations to their German and Japanese counterparts.

In some sectors, there was also consensus on the relative importance of individual topics. For example, in life sciences, the list of 10 developments judged most important by French experts was very similar to that for the Germans, and likewise for the materials sector. However, for all the sectors combined, there was very little overlap between the top 10 most important topics for each country (with only one topic common to all three lists). Topics on which there was most difference between Japan and the two European countries include domestic robots, exploitation of the oceans and the development of supersonic passenger planes, differences which would seem to reflect economic and other national specificities.

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[33]The term "mobilizing" indicates the emphasis given to mobilizing the industrial and scientific communities to work together in pursuit of national goals.

[34]Martin and Irvine (1989).

[35]This section draws on Heraud (1996b).

[36]This "key technologies" exercise was repeated five years later.

[37]Quevreux (1994).

In the question on which nation is currently the technological world leader, there were interesting differences, with French experts having a surprising tendency to regard the United States as pre-eminent, while the Germans were more predisposed to see the Japanese as leaders. The question dealing with likely technological constraints also revealed national differences; for the French, the sector with the least constraints was agriculture, for the Germans transport, and for the Japanese architecture and construction. Lastly, the question on which topics most required international collaboration again revealed a lack of agreement between France and Germany, a finding with potential implications for the European Union's R&D policy.[38]

One weakness often cited in relation to Delphi surveys is that they artificially create consensus and can, as a result, give rise to misguided policies. However, the French exercise showed that one can use the Delphi results to identify groups of experts with systematically different views. For example, experts employed in large firms tend, on average, to be less optimistic on the timing of particular developments than those working in SMEs. Finally, as in other countries, the national exercise has encouraged lower-level foresight activities. For example, a regional foresight exercise was conducted in the Bordeaux region, exploring the implications of the national results for that area.

Technology foresight in other countries

In the latter part of the 1980s, foresight began to spread to other countries, such as Sweden, Canada, Australia and Norway. In Sweden, for example, there were foresight initiatives by the Council for Planning and Coordination of Research, the National Board for Technical Development, the Royal Academy of Engineering Sciences, the Defence Research Institute and in industry. Their experiences and those of organizations in Canada, Australia and Norway are described elsewhere.[39] More recently, foresight has spread further afield, for example, to Hungary.

The United Kingdom Foresight Programme

In 1983, the United Kingdom Cabinet Office and the Advisory Council on Applied Research and Development (ACARD) commissioned the Science Policy Research Unit[40] (SPRU) to carry out a study on the approaches adopted to identifying exploitable areas of science in France, Germany, the United States and Japan in both government and industry. The resulting SPRU report[41] advocated that the United Kingdom should learn from overseas experiences with

[38]Heraud (1996a).

[39]See, for example, Martin and Irvine (1989).

[40]The organization's name was changed in 1998 to SPRU-Science and Technology Policy Research.

[41]The report to ACARD was subsequently published as a book; see Irvine and Martin (1984).

foresight, and in particular from Japan, and should try foresight on an experimental basis. Unfortunately, 1983 was not a propitious time to suggest that the United Kingdom Government should assume a new responsibility—Mrs. Thatcher being keen to reduce the role of government rather than to add to it! Although some of the ideas were subsequently taken up in an ACARD report,[42] the SPRU study had little immediate impact on policy in the United Kingdom.

By 1992, however, the philosophy of the United Kingdom Government towards technology policy had changed following the replacement of Margaret Thatcher by John Major as Prime Minister, and the Cabinet Office commissioned a new study from SPRU. This reviewed technology foresight activities in the United Kingdom, and provided a brief update of developments in Germany and the United States (building upon an extensive review of foresight conducted by SPRU for the Government of the Netherlands in 1987-1989).[43] It also identified a number of foresight options for the United Kingdom.[44] Now the timing was right; the United Kingdom had a new minister for science and technology, the first of cabinet rank for thirty years, who was trying to produce a government White Paper on science, engineering and technology, the first such policy document for 20 years. He was looking for a big new idea and was persuaded that foresight should be that big new idea!

The following year, the White Paper was published,[45] setting out the need to link the United Kingdom science base more effectively to wealth creation and improvements in the quality of life. It argued that researchers who receive funds from the public purse have a duty to identify potential users or beneficiaries of their research, and to explore with them their longer-term needs in relation to science and technology. To achieve these aims, the White Paper proposed a large-scale Technology Foresight Programme.

The United Kingdom Technology Foresight Programme (TFP) was launched later in 1993 with a budget of approximately £1 million. The aims were (*a*) to increase United Kingdom competitiveness, (*b*) to create partnerships between industry, the science base and government, (*c*) to identify exploitable technologies over the next 10-20 years, and (*d*) to focus the attention of researchers on market opportunities and hence to make better use of the science base. The Programme was organized by the Office of Science and Technology (OST) in cooperation with other government departments, and involved extensive use of consultants.[46] It was overseen by a Steering Group made up of leading figures from industry, universities and government. In addition, 15 panels (again consisting of experts from industry, academia and government) directed the foresight efforts in different sectors.

[42]ACARD (1986).
[43]Martin and Irvine (1989); also published as Irvine and Martin (1989).
[44]Martin (1993). (The report was written in 1992 but was published in 1993.)
[45]Office of Science and Technology (1993).
[46]See Georghiou (1996) for further details.

The Programme had three main phases. In the first, "pre-foresight", stage, a number of "Focus on Foresight" seminars were held to explain to the industrial and scientific communities what foresight is, why it is important and why they should take part, and to seek their views on how best to carry it out. As a result of their feedback, a substantial change was made to the methodological approach, with less reliance on the Delphi survey than originally envisaged. This sent a signal to the wider community that the Foresight Programme was not just being imposed on them from above but that they were being invited to play a role in shaping it from the outset, a signal that helped generate enthusiasm for taking part. A "co-nomination" exercise was also conducted in which experts were asked to identify other experts in their area. The resulting database was used in helping to determine the membership of the 15 sector panels, and in constructing a pool of experts on whom each panel could draw for information and advice.

The second stage was the main foresight phase. In this, panels began by holding discussions to set the scene in their sector and to identify strengths and weaknesses. They also consulted with their pool of 60-100 experts, as well as engaging in wider consultation through regional and topical workshops. In addition, a major Delphi survey was carried out with questionnaires being sent to some 7,000 experts. All these information sources were drawn upon by panels in identifying technological priorities for their sector. Each panel produced a preliminary report which was circulated for comment and then revised. The structure of each panel report was broadly similar. They began by analysing the sector in terms of its scope, characteristics, contribution to gross domestic product (GDP) and so on, before benchmarking United Kingdom strengths and weaknesses. They identified the main trends, driving forces, barriers and challenges, and analysed a range of scenarios. Next, they examined a range of technological opportunities for making contributions to wealth creation or improved quality of life. Each report then narrowed these down to a list of priorities together with a set of key recommendations for their implementation and for future technology foresight in the sector.

The Steering Group synthesized the findings of the 15 panels, identifying a total of 27 generic technological priorities (i.e., priorities emerging from two or more panels) which they grouped into six categories:

- Harnessing future communications and computing (example priorities include information management and the modelling, simulation and prediction of complex systems);
- From genes to new organisms, processes and products (e.g., bioinformatics, and health and lifestyle);
- New materials, synthesis and processing (e.g., catalysis, and chemical and biological synthesis);
- Getting it right: precision and control in management (e.g., management and business process engineering, and security and privacy technology);

- A cleaner world (e.g., environmentally sustainable technology, and product and manufacturing life-cycle analysis);
- Social trends and the impact of new technology (e.g., demographic change, and social impact in the workplace and the home).

They also analysed the main bottlenecks likely to impede the exploitation of those new technologies, arriving at 18 generic infrastructural priorities grouped under five headings:

- The skills base (e.g., communication skills and business awareness);
- The science base (e.g., incentives for multidisciplinary research and for industrial involvement);
- The communications infrastructure (e.g., promoting the information superhighway and gathering overseas scientific and technological intelligence);
- The financial infrastructure (e.g., long-term funding for innovative R&D and special incentives for SMEs);
- The wider policy and regulatory environment (e.g., intellectual property rights and scientifically based standards).

The Steering Group's report concluded with over 60 recommendations for "taking foresight forward". Some of these focused on the three main types of stakeholders—government departments, the science and engineering base, and the private sector. Others related to five types of key activities: (*a*) maintaining the networks and panels, (*b*) infrastructural issues, (*c*) focusing on Europe and the global dimension, (*d*) focusing on partnership, and (*e*) monitoring the outputs.

The third phase of the Programme—that of "post-foresight" or implementation—had a number of components including: (*a*) shaping new government R&D priorities (in ministries, Research Councils and the Higher Education Founding Councils); (*b*) influencing company R&D strategies; (*c*) improving partnerships between industry and the science base; (*d*) influencing wider government policy (e.g., towards regulation); and (*e*) drawing lessons for the second Foresight Programme (which took place in 1999-2001). The process benefits of the Foresight Programme (in particular, the "five Cs" discussed in relation to Japan previously) were particularly important, corresponding as they each did to areas of previous weakness in the United Kingdom. In addition, the Government established a Foresight Challenge Fund of some £30 million which, with matching funds (in fact, rather greater amounts) from the private sector, funded two dozen foresight projects based on partnerships between public-sector research organizations and firms. The spending patterns of the Research Councils were appreciably altered in the light of the priorities emerging from the Foresight Programme, and the same is true (although to a lesser extent in certain cases) of the government departments which fund R&D. There was also an impact on industry, with some companies drawing upon information and particularly the contacts that they had made during the Foresight Programme and with others engaging in their own foresight exercises.[47]

In 1997, the new Labour Government, after a positive review of foresight, decided to continue and indeed to strengthen foresight. In the second Foresight Programme, which began in 1999 and for which the main phase will shortly be completed, efforts were made to learn from the first exercise. The new Programme has also aimed for harder targets—getting foresight into company boardrooms, financial institutions and SMEs. In addition, more emphasis has been given to social considerations such as the ageing population and crime prevention. Although the Delphi component was dropped, one innovation has been the construction of a digital "knowledge pool"—a managed database of foresight material collected from all round the world as well as produced during the United Kingdom programme. Lastly, to help give the programme wider visibility, there has been a change in title. It is now called "foresight" rather than "technology foresight" on the grounds that it is as much to do with foreseeing changing markets and social and environmental needs as with new technologies. With these improvements, it is hoped that foresight will become more widely accepted, embedded and successful in the United Kingdom.

Foresight for "wiring up" the national system of innovation

One reason for the adoption of foresight by a growing number of countries over the last decade or so is linked to a central concept to emerge from science policy research over the last decade or so—the notion of the national (or regional) system of innovation.[48] Such a system is seen as being made up of a number of actors—firms, government laboratories, universities and so on. However, the most important element is not so much the individual actors as the links between them. A national innovation system made up of actors which are not necessarily particularly strong but where the links between them are well developed may operate more effectively (in terms of learning and in generating innovations) than another system in which the actors are stronger but the links between them are weak. If the concept of the national (or regional) innovation system is a valid one, then the question for policy makers is how to create and strengthen the links between the various components of the system. Foresight, as we have seen above, offers a tool for achieving this—for getting the individual components of the national innovation system to communicate with each other, to discuss issues of longer-term common interest, to coordinate their respective strategies, and

[47]For example, the author recently worked with a major financial institution in the City of London to carry out a Delphi-based foresight exercise.

[48]See, for example, Freeman (1987), Lundvall (1992) and Nelson (1993).

in some cases to collaborate. In short, foresight provides a means for "wiring up" the national or regional system of innovation.[49]

There is an intriguing analogy here with the development of the infant brain which needs stimuli to develop links between the neurons and thus to "wire up" the brain, enabling it subsequently to learn faster and more efficiently.[50] Likewise, for the national system of innovation, there need to be processes and incentives to develop links between the various actors. The more the wiring up takes place between the component parts, the more effective the national innovation system as a whole becomes in terms of learning and innovating. Foresight provides a means to achieve this.

Conclusion

What general conclusions can be drawn from the above analysis? First, there is widespread and growing recognition that technology foresight represents a useful tool to aid decision-making in relation to research and technology policy, whether at the national or regional level or at a more micro-level. Japan, after 30 years of experience, still makes extensive use of foresight. In other countries, foresight has begun to take root since the start of the 1990s. There has been marked progress in Germany where foresight is now quite firmly established. The Netherlands, France and the United Kingdom have also undertaken foresight exercises and are starting to gain some of the process benefits discussed earlier, such as better communication between all the relevant stakeholders, the creation of networks, and the stretching of time-horizons in relation to decision-making.

Second, no individual foresight approach is perfect. Each has its own strengths and weaknesses. If the aim is to achieve a long-term holistic overview of technology in a country with a large number of experts on technology and innovation, then a Delphi survey is well suited to the task. However, in other circumstances such as technology foresight at the company level or for an industrial sector, another approach may be more appropriate.

A third and closely related conclusion is that individual countries or organizations may adopt quite different approaches. Japan, Germany, the United Kingdom (initially, at least) and France have made use of large-scale Delphi surveys in their holistic foresight exercises. In the Netherlands and Australia, the Delphi method has not been employed; instead, the emphasis has been on other approaches, such as panel discussions and brainstorming, commissioned studies, and creating or tapping networks. Such approaches are also often favoured in meso- and micro-level foresight by companies.

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[49]Martin and Johnston (1999).

[50]Martin (2001).

One question that is sometimes asked in countries contemplating whether to become involved in foresight for the first time (given that the costs are far from negligible) is the following: "If Japan and other major countries are engaging in foresight and making the results public, can we not just purchase their results and act upon them?" The short answer is "No". There are two main reasons for this. First, each country has its own particular strengths and weaknesses in industry and in science and technology. This means that the choices made, for example, by Japan will not necessarily be the same as those made by a country like Australia or Hungary. Second, as has been stressed earlier, the benefits associated with the process of carrying out foresight are at least as important as the direct outputs (priorities, policies or whatever).

Finally, we have seen how the growing spread of foresight may herald the emergence of a new social contract between science and society. After several decades during which Governments and the public were fairly relaxed about the exact benefits they would ultimately derive from science and when they would occur, now they are coming to expect more direct and specific benefits in return for the considerable investments that they make in science. Foresight is a tool for helping to achieve this, and perhaps also for "wiring up" the national or regional innovation system so that it can learn and innovate more effectively.

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2 Technology foresight as a tool for European Union integration and enlargement

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Abstract

Many aspects of the development of technological and scientific knowledge present strong challenges to the economic system, to employment, education, our values and, last but not least, to our way of life. Social and economic developments, ethical questions and attitudes all will influence the development of technologies. Technology foresight attempts to permanently evaluate these challenges and identify for policy makers possible problems and opportunities. In recent years, one can observe a wide range of foresight activities developed at a national level. The results of those exercises, as well as the processes by which they have been developed have stimulated the creation of some level of national consensus about S&T policy directions and instruments in many countries.

In an attempt to progressively consolidate a European scientific and technological policy, the European Union recently launched a series of proposals to reinforce the European Research Area. To create a common vision of challenges and opportunities that could underpin this policy, the European Union has launched some major foresight initiatives and is attempting to strengthen the networking and exchange of best practices between the member States and pre-accession countries. The Futures Project of the Institute of Prospective Technological Studies (IPTS) and the recent Futures for Enlargement project are examples of foresight exercises with such a supranational character. They intend to stimulate regional cooperation within the European Union.

The Futures Project

The technological, economic and political landscape of Europe is undergoing profound and dramatic changes. Information and communications technologies are developing at a ferocious pace. Together with breakthroughs in life

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sciences, these technologies are transforming the way we live and the way we work, while the single currency, the enlargement of the EU, demographic changes, sustainability concerns and the wider context of globalization are transforming our economy. Each of these "trend" breaks is in itself a challenge. The fact that they will occur simultaneously and strongly interact with each other over the next 10 years is even more challenging for most policy areas and in particular policies relating to technology, competitiveness and employment.

Launched in 1998, with its first phase finished in early 2000, the IPTS Futures Project aimed to examine the individual and combined effects of these technological, economic, political and social drivers. The Futures Project especially set out to explore possibilities in technology, competitiveness and employment with a time horizon of 2010.

To address these issues in depth and with a cross-sector perspective, the Project brought together nearly 200 experts and policy makers drawn from industry, academia and government to take part in a series of brainstorming sessions, seminars and workshops during 1999.

In 1999 four panels of experts (that had started working in 1998) produced panel reports on the following issues: demographic and social trends; information and communication technologies and the information society; life sciences and the frontiers of life; natural resources and the environment. The results of the work of the panels were presented and extensively discussed at a seminar in Brussels in July 1999 in which more than 80 experts took part.

In the second half of 1999, the Project expanded on the policy consequences of the issues raised by those four initial panels and produced the technology, employment and competitiveness "maps" described below.

The technology map is a European level analysis of six technology sectors: information and communications technologies, life sciences, energy, environmental and clean production technologies, materials and related technologies, and transport technologies. The analysis examines a selection of technologies in each sector and focuses on the timetable for commercialization, the strength or weakness of Europe and the relative importance of the technologies for economic and social development.

Four key themes for the coming years are analysed in the employment map. First, the European workforce will age significantly and start to shrink. Second, fast technological change, especially in information and communications technologies, will create hard to match demands for technology related skills. Third, the transition to a "mosaic society" will increase demands for personal services. Many jobs will be created, but what kinds of jobs? Fourth, Europe faces a potential knowledge paradox, in which new patterns of flexibility in work contracts may lead to under-investment in human resources. The result could put a brake on Europe's competitiveness and growth in the emerging knowledge economy.

The competitiveness map analyses the main challenges and opportunities for Europe's economy with the time horizon of 2010 in order to indicate areas that will require the attention of European policy in the next few years.

In the first part, emerging areas of growth of the European economy are identified, taking into account consumption trends and production strengths and potentials. The map concentrates on the geographic distribution of economic activities, both within Europe and globally. In this respect, the accession of new member States represents a particularly important driver of change. Finally, the map analyses the organizational challenges at firm and market level in responding to a globalized and increasingly digitized economy.

In parallel to the work on the maps, the Futures Project focused on three cross-cutting issues—enlargement, knowledge and training, and the societal bill—which will play a role in the way Europe will look in 2010. Enlargement will substantially change the economy and governance of the European Union. Knowledge and learning are key drivers of the so-called knowledge society. The societal bill focuses on the next 10 years of European public finance, which is going to confront a number of major choices on how to finance pensions systems, social protection, health-care systems, education and necessary investments for an environmentally sustainable society.

Finally, the Futures Project commissioned several short review papers on social issues that might affect the different policy areas. These papers were published in the *Futures Series*.

The thematic network on foresight in pre-accession countries

The IPTS designed its Enlargement Project as an instrument for improving the level of information about the pre-accession countries in the European Commission, and for strengthening cooperative activities between the EU member States and the candidate countries as well as among themselves.

One of the main activities is organizing prospective seminars on S&T policy and its possible impact on socio-economic development as a means of establishing dialogue on techno-economic issues relevant to EU enlargement.

In particular, the Enlargement Project supports European decision makers with foresight activities in their efforts to promote technological, economic and social development in Eastern Europe, to enforce the integration process and to improve the environmental situation in the whole of Europe. The Enlargement Project so far has worked mainly through networks and by stimulating prospective dialogues.

The main line of work during the year 2000 focused on exchanging "best practices" between EU member countries and the pre-accession countries. Three issues were tackled during that period:

- Awareness building on national foresight in the pre-accession countries and the EU;
- Exchange of experiences on foresight methodologies;
- Foresight on regional issues: the Baltic Sea as a European sea.

Enlargement Futures Project

At a high-level meeting in Tallinn (September 2000) participants suggested that IPTS launch a major foresight exercise, very similar to the Futures Project, with the aim of identifying the common challenges to the enlargement process over a time horizon of 2010. The project should have a duration of two years.

Beginning in October 2000, the IPTS worked on the Enlargement Futures Project and set up the Steering Group which will pilot the development of the Project over the following two years. The Steering Group brainstormed and defined the areas of work, and suggested experts for the different issues.

The Steering Group's brainstorming produced more than 80 different proposals, issues and challenges which were organized in the following four themes for analysis in the first phase of the project:

- Economic transformation;
- Knowledge, technologies and learning capabilities;
- Employment and societal change;
- Sustainability, environment and natural resources.

The objectives of the thematic panels are to provide a list of important social, economic and technological issues of change in pre-accession countries for the time horizon of 2010, and to develop a description of the plausible final stage of the selected issues. Preliminary results will be discussed at a seminar in Prague (Czech Republic) in September 2001. The panel's work will be presented at a high-level meeting in Bled, Slovenia, at the end of 2001.

In the following sections, some of the issues raised in the report, "The Wider Picture: Enlargement and Cohesion in Europe," are discussed.

The challenges of enlargement

Democratic and political transformation

Despite their diversity, all pre-accession countries have full EU membership as a common policy objective. This entails a number of shared features for economic, social and political transformation in these countries.

The Central and Eastern European (CEE) countries are experiencing a complicated process of transforming their former political systems into democratic ones. The biggest challenge is the establishment of an efficient governance system which is transparent and credible. Other challenges will come from the integration of the "*acquis communautaire*".

Economic transformation

Economic restructuring on an appropriate scale and scope is a basic prerequisite for full integration of the pre-accession countries into the European

Union. The economic transformation of former socialist pre-accession countries targets restructuring centralized economies into open market economies. The main thrust of the reform so far is related to the establishment of a new legal framework with the corresponding institutions, as well as carrying out structural reforms.

The structural reform of the economy has included privatization of State-owned companies and public property, modernization of enterprises, including the introduction of new technologies, the development of new forms of management and financial and economic principles.

Industrial restructuring is not yet completed. Most pre-accession countries have achieved a profound reorganization of their industries and enterprises, including the establishment of new industrial structures, market integration with some EU-based companies, changes in ownership, etc. Rapid growth has been achieved in sectors that have already undergone phases of restructuring and modernization, or have received foreign direct investment flows (e.g., car industry, food processing, telecommunications, and the software and personal computer industry). Trust in the governance system and belief in its efficiency are central to a continued flow of foreign direct investment. Domestic investment has been slow to develop. Again, while the issue of confidence in the governance system is closely linked to this development, it is not the only one. Domestic financial groups have been slow to evolve in most countries in transition. There is a risk of the emergence of a "dual economy" of modern, foreign-owned plants and a backward domestic industrial basis. There is a need to provide domestic enterprises with the opportunity to learn and participate in knowledge creation processes, and for them to develop their own specific innovation systems.

One can also find significant differences between pre-accession countries. Countries with a strong engineering tradition are on the way towards a more R&D intensive structure of production, services and trade. Other countries are following a strategy of development based on low-tech, labour-intensive and low-wage industry. These trends raise the critical issue of how to manage the cohesion process to maintain stability of growth and not to widen the gap between those countries with different rates of economic development. This also raises the issue of uneven regional development within the enlarged EU.

Development of the information society

The global challenges of the information society and the knowledge-based economy require special attention in the process of European integration. While proceeding with political, economic and social changes, pre-accession countries will have to try to reap the opportunities for economic growth and competitiveness which developments in information and communications technology present.

The EU/CEE Information Society Forum has signalled some basic common challenges for these countries: weakness of the regulatory framework (for example in data protection, intellectual property rights, security); diffusion of information and telecommunication technologies in SMEs and in the public sector; and training and education with new technologies.

Given the very fast pace of technological developments, this represents a major challenge. But it could also present countries with an opportunity to "leapfrog" countries that have invested heavily in older generations of technology.

A big challenge for the years to come is to avoid "info-exclusion", and a further splitting of society and regions into "info-poor" and "info-rich". Affordable access to information networks is a precondition for business participation in the digital economy, and for citizen participation in the information society.

Wide awareness building, life-long learning and the introduction of education in information and communications technology and new multimedia tools in the school curricula are some basic steps for meeting the challenges of the information society and the new digital economy. Furthermore, the development of new applications and their wide use in all areas of social, economic and political life will challenge all European countries, and pre-accession countries in particular.

Agriculture

Agriculture, with its high share of GDP and the workforce, is important for all pre-accession countries, and its future will influence most of the 15 EU countries. The future of this sector is a key issue with respect to rural development. Industrial and service activities are essentially concentrated in the main cities, indicating the risk of a severe development gap between rural areas and urban centres. There is also a high degree of diversity among the agricultural sectors of the accession countries. This applies not only to productivity, which in the most advanced countries is 10 times higher than in the least productive ones, but also to patterns of specialization. Some countries are strongly specialized in one agricultural sector, such as forestry, presenting specific problems and opportunities with respect to the pulp, paper and furniture industries. Similarly to industrial development, reinforcing the establishment of new, complementary patterns of specialization in agriculture in both the CEE countries and the 15 EU countries, should be considered as an option for the longer term.

The inevitable decline of agricultural employment in certain CEE countries, if not skilfully managed, could displace millions of people from low productivity agriculture. The phenomenon of rural-urban migration impacting overcrowded cities and the risk of major migratory movements within the future EU are highly probable if the process of transformation of agriculture is not tackled properly.

Transport and energy: mobility and sustainability in a larger Europe

The traditional service and infrastructure sectors are important in countries such as Cyprus and Malta, but are historically underdeveloped in CEE countries. The latter are transforming their service sectors and are on the way to building a modern infrastructure. It is expected that consumer services such as retailing, repair and tourism will continue to expand in line with the growing income of private households in CEE countries.

Special challenges arise from the growing needs to upgrade and introduce structural changes in transport and energy. So far, policy has focused on international transport connections; however, local and regional transport will require substantial investments to increase accessibility to markets and movement of people. Increasing integration and increasing volume of material flows as many of the pre-accession country regions grow, are undoubtedly going to create major bottlenecks in transport networks.

Growth in transport will also have a significant effect on CO_2 emissions. About one third of those emissions originate in the transport sector. A relatively aged vehicle supply is only increasing the emissions levels.

The energy infrastructure of the pre-accession countries will undergo drastic changes. The existing installations/power plants are generally outdated and do not comply with the environmental standards of the European Union. The problem is aggravated by the fact that the existing power plants are mostly coal-fired and thus increase CO_2 emissions. Gas and oil reserves in the region are small. However, the trend in the energy sector towards higher efficiency and lower prices for gas powered plants in combination with environmental concerns may lead to a change from coal to gas in compliance with EU standards.

The more favourable economic situation in the pre-accession countries will lead to an increase in electricity demand. To satisfy the demand by 2010 an increase of installed capacity of approximately 50 per cent is necessary. This requires substantial investment, not considering the need for replacement of the ageing nuclear facilities.

Nuclear power plants provide a significant contribution to total electricity generation. Current discussions on the security of nuclear power indicate that there will be increasing pressure to close these plants in the future.

Human resources and education: preparing for the "knowledge-based" society

The level of education, training and skills of human beings is essential for the sound and sustainable development of society. These factors represent the most important determinant of economic growth and a major source of innovation. A democratic society needs educated and well-informed citizens.

Recent data point out that the proportion of the population with secondary and vocational education in CEE countries is comparable with the average level in Organisation for Economic Cooperation and Development (OECD) countries. However, the share of such employees in the labour force is below the level of many OECD countries. Due to an imbalance of supply and demand of different skills, most CEE countries have a growing shortage of skills in some areas (e.g., business administration, commercial services and engineering skills in advanced technologies). The educational system is progressively taking care of this imbalance for new generations. However, tackling the imbalance in today's labour force will require a major effort of retraining and on-the-job training of the working population and of those who were left unemployed during the transition.

In some CEE countries increasing student numbers are observed without the corresponding increases in the number of teachers. Many young people have continued their education due to uncertain employment prospects during the transition. The level of enrolment in tertiary education has increased dramatically. However, this has also coincided with a dramatic reduction of government expenditures, which has left the educational system in a very difficult position. There are great concerns as to the quality, content and structure of education and training in the coming years.

Social trends

Since 1989, social security systems in CEE countries have gone through radical changes and are facing complex challenges related to the drop in economic output, rapidly rising unemployment and inflation. Labour markets have undergone shifts in the structure of employment, increased flexibility of labour law, introduction of self-employment, active labour market policies and reform of labour relations.

Rapidly growing unemployment is one of the most serious social problems. People starting their career, people with a lower level of education, people aged over 45 and minorities are particularly exposed to the risk of unemployment. There are also significant regional differences in the levels of unemployment in all CEE countries.

CEE countries have started to adopt EU norms concerning health and safety in the workplace, protection of workers' rights, free movement of workers, equal rights for both sexes, etc. Major changes have also been introduced in the health and social security systems, including changes in the institutional setting, introduction of various forms of private insurance and tightened eligibility rules and lowered benefit levels. CEE countries need substantial resources to improve the quality of health care and to overcome the lack of medical technology and shortages of medicines.

Major challenges for the coming decade are the restrictions due to budgetary constraints on one side, and the prevention of social exclusion caused by high levels of unemployment and deepening poverty, on the other.

The risk of uneven regional development inside CEE counties and the appearance of isolated, underdeveloped towns or regions with high levels of unemployment, skill mismatches and ageing populations should also be considered.

Conclusion

The specific challenges outlined in this paper for pre-accession countries in their process of transformation, transition and integration into the EU are only a first attempt to sketch the type of issues which are likely to be raised in the Enlargement Futures Project.

This brief overview also illustrates the highly interrelated nature of the policy challenges. There is no doubt that the Enlargement Futures Project will further emphasize the complexity of the challenges. Many of the observations made focus on the challenges of a group of countries (mainly CEE countries). The geographic spread of pre-accession countries and the variety in their historical development will necessitate further refinement and focus during the development of the Project.

3 Technology foresight for strategic decision-making

Philippe Bourgeois*

Abstract

Since the Second World War, technology has been a powerful engine driving economic development. During the 1980s, economists of the new growth theory school showed that science and technology were important determinants of economic growth.

Rapid technological change and the development of global markets for technology-based products have created an unstable environment for countries and companies. The increasing sophistication and complexity of technology used in a wide range of products has made it more and more difficult for even the largest corporations to anticipate these changes.

Public authorities and the business community need a specific tool to predict technological change, to define their strategy, and to take the best decisions. Technological foresight is one such tool.

Many countries involved in the science and technology priority-setting process use technology foresight. It can be defined as a systematic process to identify key future technologies in order to aid in policy-making, planning, and decision-taking. Although the objectives of national technology foresight studies differ, one or more of the following are found in most studies: to create a common vision for society, to identify future technologies, to guide future technological development, and to provide "intelligence" for SMEs.

The economic, institutional and cultural context of each country influences the definition of objectives in technology foresight studies. In addition, the choice between an "industrial vision" and a "science vision" of technological development characterizes these studies. The French Technological Foresight study is one example. Ordered by the Minister of Industry, the choice of an "industrial vision" required a short-term time horizon and a market-driven approach.

Technology foresight is highly complex due to the wide scope of research, the lack of a precise definition of the concept of technology, the arbitrary nature of selection criteria, and the inherent risk of overlooking a significant technology. Nevertheless, technology foresight is necessary, and even indispensable, to guide both public authorities and private companies in the strategic decision making process.

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The world is in the midst of a technological revolution. Electronic, information and communication technologies and biotechnology now shape society, and people are able to communicate at any time and from anywhere in the world.

Both public authorities and private companies are affected by this revolution. Since the end of the Second World War, public authorities have become increasingly interested in technology, first for reasons of national security, prestige and independence, and then, during the 1980s, because of the role of technology as a major element of economic growth. During that period, economists proposed a new growth theory in which science and technology were perceived as essential parameters of growth and State aid for the development of emerging technologies was justified, notably to ensure a satisfactory rate of growth.

The private sector also realized that the technological revolution had to be taken into account in the definition and implementation of its strategy. Although technological development was considered to be a risk, it was also perceived as an opportunity. The risk for a company is the emergence of another more advanced technology that makes a recently adopted technology obsolete. The opportunity for companies that anticipate change is to offer new products or use new processes, or both, before its competitors, in order to achieve a decisive competitive advantage.

Although various definitions of technology foresight have been proposed, the following seems to provide the best description of the process:

> Technology foresight involves systematic attempts to look at the long-term future of science and technology with a view to identifying emerging generic technologies and the underpinning areas of strategic research that are likely to yield the greatest economic and social benefit.

Such a definition has several implications, as follows:

(*a*) Studies should be systematic and methodical to guarantee the quality of the exercise and results and to avoid subjectivity;

(*b*) Studies should have a long-term perspective, often 10 years, but possibly ranging between 5 and 30 years;

(*c*) Technology foresight is a process rather than a set of techniques, and involves consultation with and interaction between the scientific community, business and policy makers;

(*d*) One focus is on the identification of emerging generic technologies, that is, technologies that will benefit several economic sectors or society as a whole. Such technologies are still at a pre-competitive stage and can be targeted for selective funding to ensure rapid development;

(*e*) Strategic research also plays a key role, including basic research aimed at creating a broad knowledge base that can be used to develop solutions designed to meet current and future practical needs;

(*f*) The social benefit of new technologies, and not only the benefit for industry and the economy, should also be considered.

Strategic decision-making and technology foresight

Because of the important role of technology in the changing economic and social context, tools are needed to help decision makers determine their strategy for future growth. Both public authorities and private companies, including small and medium-scale enterprises, are increasingly recognizing the need for technology foresight studies to guide the decision-making process.

A new economic context

Interaction between technological progress and economic development has always been an important feature of human history. Competitiveness is an indicator of a healthy economy, and is reflected in employment figures, the balance of payments and living standards. It is now widely agreed that technology plays a key role in the development and improvement of products and the manufacturing process. Public authorities and private companies cannot ignore that factor. However, financial resources for technological development are limited in both the public and private sectors.

New needs of public authorities and the private sector

Most of the major decisions made by public authorities and private companies involve technology. However, the accelerating rate of change, especially in information and communication technologies and biotechnology, entails increasing uncertainty about the results of those decisions. New tools adapted to those conditions are required, especially since strategic choice is unavoidable in a climate of limited financial resources for technological development.

The links between economic growth, innovation, employment, quality of life and technology have been a subject of inquiry since economics emerged as an organized discipline. Adam Smith observed in *The Wealth of Nations* that invention, capital growth per worker and advances in industrial organization were linked. Public authorities and the business community cannot ignore those links.

Public authorities are responsible for the good health of the economy, and notably for economic growth, innovation and living standards. During the last decade, Governments have had to take financial constraints into account. The best allocation of limited resources has therefore become a major objective of economic policy.

Companies are essential players in economic development. They create wealth and employment. They innovate new products, new processes and new organizations. As the political and economic environment changes rapidly, both the public authorities and the private sector must therefore be prepared to meet the challenge arising from such a process of change.

Rapid technological change and the development of global markets for technology-based products have created an unstable environment for public authorities and companies. The increasing sophistication and complexity of the technology used in a wide range of products has made it more and more difficult to take enlightened decisions. Technology foresight is a useful tool to help decision makers.

Technology foresight approach

The term "technology foresight" covers many areas and activities. The economic, institutional and cultural context of each country may influence the definition of objectives in technology foresight studies, as will be seen, below, in considering a study conducted in France. Nevertheless, most studies include one or more of the following objectives:

(*a*) Creating a common vision for society;

(*b*) Identifying key future technologies;

(*c*) Guiding future technological development;

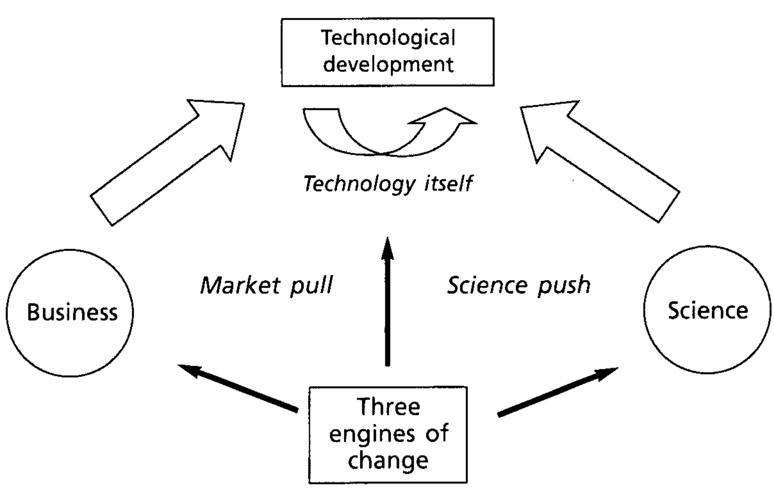
(*d*) Providing "intelligence" for small and medium-scale enterprises.

Once the objectives have been defined, an overall conceptual framework is required to determine the appropriate methodology for the study.

Technological development

Briefly, three engines guide technological change, as reflected in figure I below.

Figure I. Engines of technological development



In industrial countries, science is a powerful engine of technological development. New knowledge creates the opportunity for new products and processes. Biotechnology has developed through advances in science and there are strong links between the progress achieved in those two areas.

The second engine is technology itself. Moore's Law, according to which the processing power of electronic components doubles every 18 months, provides a good description of the dynamic process of technological development.

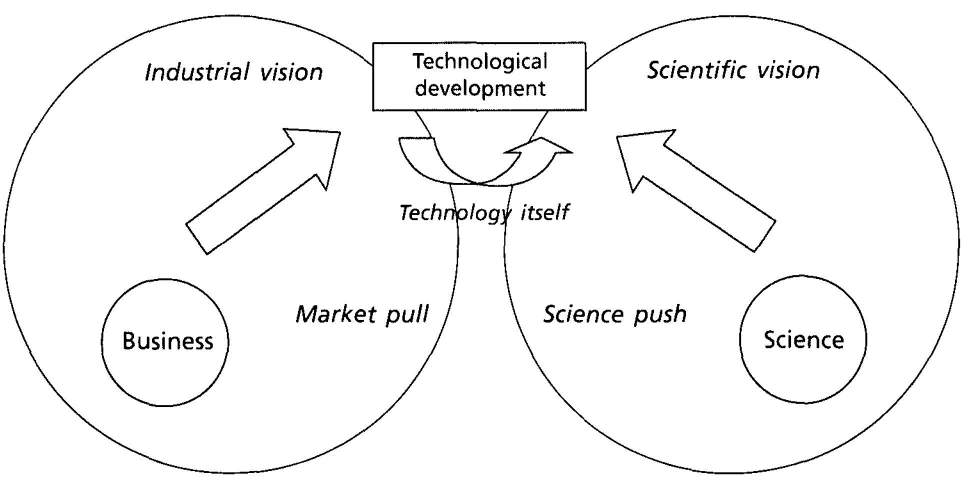
The market or business is the third engine of technological change. In fact, for the market, technology provides a solution to complex issues. The search for a technological solution prompts the demand for new technology and leads to improvements in existing technology.

Two visions of technology foresight

Both a scientific vision and an industrial vision are required to explain technological development (see figure II). The main difference between those two visions concerns the time factor.

In the scientific vision, science is the main element of analysis. That vision is characterized by a long time frame, because science is not constrained by time. The researcher must search, but not necessarily find what is being sought.

Figure II. Process of technological development



In the second vision, the market is the major element of analysis, and the main characteristic of the market is the short time frame within which it operates.

Technology foresight in France

French vision of technology foresight

The French technology foresight study was conducted in a specific context. The Minister of Economy, Finance and Industry requested the study with a view to the development of a new policy to support business efforts to adapt to major technological challenges, focusing on optimal allocation of the limited resources available for R&D programmes. The study was therefore based on an industrial perspective; its objective was to identify key technologies; it had a short-term horizon of 5 to 10 years; and it followed a market-driven approach. A science-driven perspective was incorporated by inviting scientific experts from leading public research centres, as well as industrial experts, to participate in the working groups.

French technology foresight study

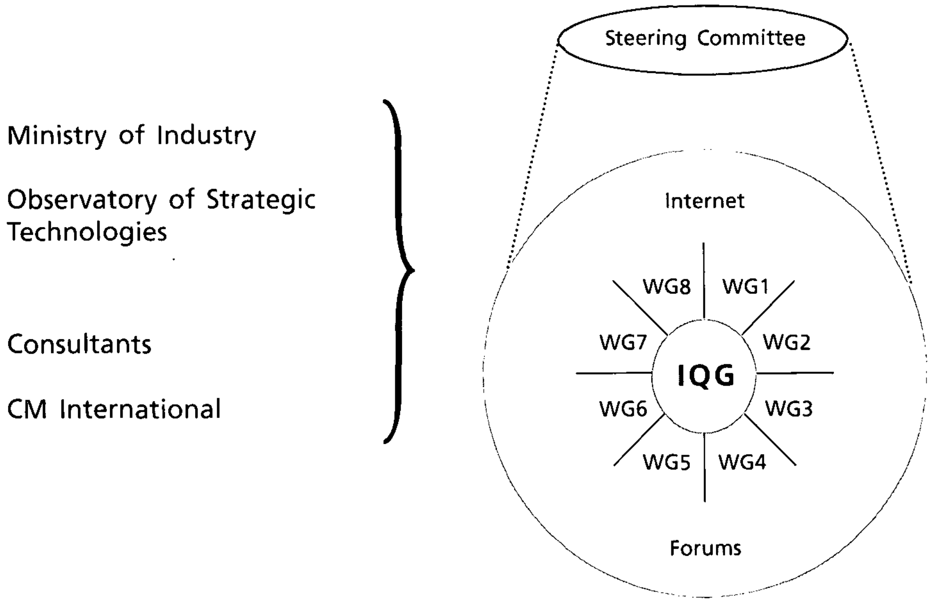
The objectives of the study were twofold. The first objective was to identify what the key technologies for French industry would be in 2005, so that the Government could define and implement appropriate policies to foster the development of cutting-edge technology. The second was to inform all companies, especially small and medium-scale enterprises, about the technological changes that would be required to remain competitive and at the forefront of innovation in 2005. A further aim was to evaluate the extent to which French industry, compared to that of other countries, was prepared to face the scientific and technological challenges of 2005.

The study was conducted between June 1999 and October 2000. Groups of experts were asked to identify key technologies that French industry would need to develop to be at the forefront of progress in 2005. A technology was defined as a key technology if it met the following conditions: first, it had to be attributed a high score by the working groups, according to the five criteria of "attractiveness"; secondly, it had to be a technology for which France had the required assets; and, thirdly, the key conditions for the successful development of the technology had to be present.

Organization of the study

The organizational framework of the study is reflected in figure III.

Figure III. Organization of the study



Note: Working group (WG); interactivity and quality group (IQP).

The following aspects of the conduct of the study should be noted:

(a) The Observatory of Strategic Technologies at the Ministry of Industry, in cooperation with the consulting group CM International, was responsible for establishing the conceptual and operational framework of the study;

(b) The Steering Committee supervised the whole study. The two essential missions of the Committee were the final selection of key technologies and deciding on the recommendations that would be forwarded to the Minister of Industry;

(c) Eight working groups, composed of representatives from the public and private sectors, had to identify the key technologies for the industrial sector assigned to each group;

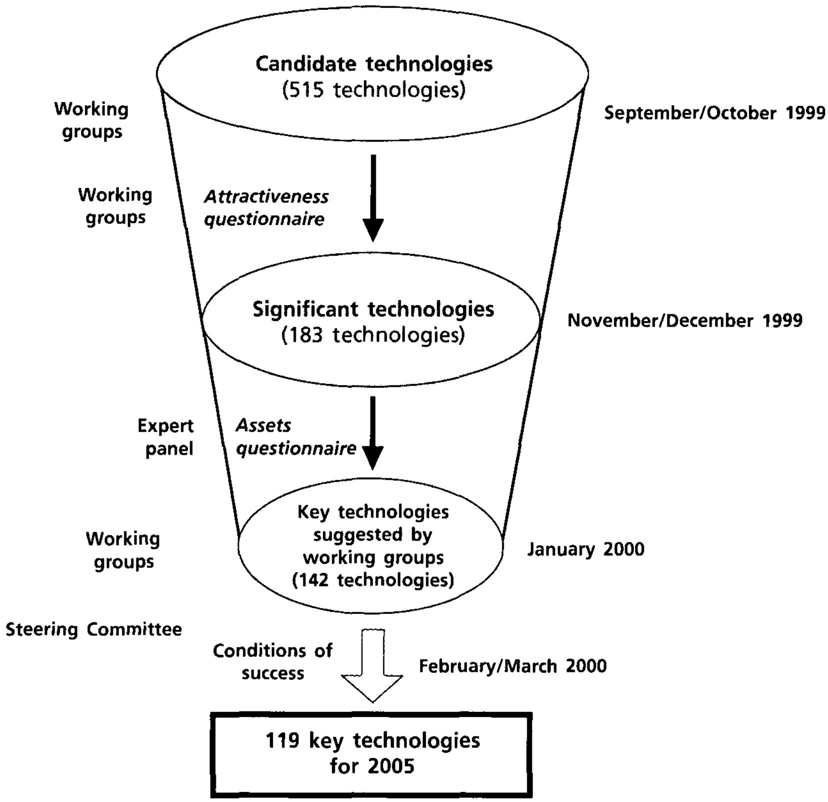
(d) The interactivity and quality group had the following two essential missions: first, to ensure the quality and coherence of the study; and, secondly, to advise and brief the project team.

To ensure the legitimacy of the results of the study, the participation of a large number of experts was needed. To widen the scope of the input, an

Internet forum was therefore set up to enable all those interested in the study to make known their views.

As reflected in figure IV, the process of selection of key technologies is in the shape of a funnel.

Figure IV. Selection of key technologies



At each stage of the selection process, the number of technologies retained for the following phase decreased. The first selection was made according to the criteria of attractiveness; the second was based on the availability of the required assets; and the final selection was made by the Steering Committee, which took into account the assets and the conditions for the successful development of the technology.

The progressive process of selection was designed so that the experts would not be required to evaluate the three types of criteria (attractiveness, assets and conditions of success) for all the candidate technologies. Only attractiveness was evaluated for all the candidate technologies, whereas the assets and conditions of success were used only for significant technologies, thus greatly reducing the evaluation workload of the experts.

The results of the study have been published. The following essential points should be noted:

(*a*) A total of 119 technologies with a definition and a grid for analysing each one were identified;

(*b*) Eight expert reports presenting the main trends in technological development for the eight themes covered by the working groups were submitted;

(c) The recommendations of the Steering Committee were delivered to the Minister of Industry.

The findings will serve as the knowledge base for political and economic decision makers to select and support the most appropriate technology for future development.

The Ministry of Industry will use the results of the study in a very different way from the results of a previous study carried out in 1995. In 1995, the results were used to reorganize public funding and support 50 key technologies. The results of the recently concluded study will be used to orient regional economic development in France. The scientific and technological potential of each region in France is currently being evaluated in terms of the key technologies identified in the study.

The change in focus clearly illustrates how technology foresight studies can be adapted to changing contexts. The current regional focus reflects the important role of regional development in overall economic growth in France.

Strengths and limitations of technology foresight studies in France

The four strong points of the methodology used in the French study are as follows:

(*a*) Having a clearly expressed objective is an essential element in implementing a technology foresight study. The objective indicates the destination of the study, and the methodology is the path followed to get there;

(*b*) Using the Internet to diversify the range of expertise is another strong point of the study. It seems important to include the largest possible number of experts because a diversity of points of view enhances the quality of the results;

(c) The interactivity and quality group played an important role by providing an outsider's view of the perspective taken by the working group. The questions posed and remarks made by the members of that group encouraged discussion and improved the organization of the study;

(*d*) A list of 119 technologies emerged from the study of key technologies for 2005. In addition to that list, the working groups produced reports presenting the main trends in technological development in each of the industrial sectors analysed. Those reports enhance the value of the study because they go beyond a simple list of technologies to provide a context for the technological challenges to be faced.

However, as there is no such thing as the perfect study, and given the benefit of hindsight in designing technology foresight studies, several areas in which improvements could be made have been identified and are described below.

Almost all of the experts were from French enterprises or research centres. Even though they are aware of what is happening abroad, they have a French view of technological development. Although every effort was made to introduce the viewpoint of foreign experts in the Internet forums by asking each French expert to register at least one foreign expert, the fact is that no foreign experts participated. That is regrettable, because input from other countries would have enriched the results of the study. A further aspect worth mentioning about that mode of communication is the need to have a well-managed site. Although more than 600 French people registered, very few participated in the forum. As most only came to "look and see", ways need to be found to encourage visitors to contribute to the forums. Improved site management may even be a solution to counteract the next point, which concerns what might be called the lobbying effect. During the earlier study, lobbying was minimal, since none of the experts tried to promote their own technologies. A few officials at the Ministry of Industry were upset because the technologies that they had supported did not appear in the final list. Through the intervention of the President of the Steering Committee, the situation was resolved. In the latest study, however, the experts clearly had in mind that the results of their work could be used to develop key technologies, as had been the case after the 1995 study. Even though the experts were selected for their expertise, and not because they came from a specific institution, it is an open question whether their viewpoint always remained neutral. As indicated above, the involvement of foreign experts would certainly enhance confidence in the results achieved.

Another difficulty was encountered in regrouping all industrial sectors around eight themes. For example, in the first study, environment and health experts had great difficulty understanding each other. For the second study, the environment and energy were put together, and the experts showed greater mutual understanding. It is therefore important to regroup industrial sectors around common problems.

The list of criteria used to select technologies was intended to achieve a little objectivity in the very subjective question "Is this technology important?" Other methods of selection are possible. But what seems significant is to be able to justify why one technology rather than another was selected. Examination of the selection criteria should provide an answer to that question. Such a process suggests that the criteria used in the latest study tried to cover far too much ground with too many stakes. The experts often had difficulty assessing the criteria. It would be more useful to limit the evaluations to only a small number of strategic stakes, which it would then be necessary to justify. The criteria adopted need to be re-examined, in particular those relating to assets. A conclusion of the study is precisely that the assets of a country do not play the same role today as they did five years ago.

Conclusion

In a continually changing world, it is important that public authorities and the business community have an insight into the technological future. Technology foresight studies are necessary and even essential tools for assisting decision makers in designing their strategies and implementing the most appropriate policy. In approaching such studies, the following points should be borne in mind:

(a) It is doubtful that any one methodology is better than another, or indeed that there is a "best" methodology. Each methodology has its inherent strengths and weaknesses. What is important is to recognize and acknowledge them, so that appropriate measures can be taken to reinforce the strong points, and instigate the weaknesses;

(b) Technological foresight is very complex because the field of investigation is very wide, the concept of technology is not always precise, the selection criteria are arbitrary, and there is an inherent risk of overlooking a significant technology. There are numerous traps along the way, but the benefits of technology foresight studies are worth the perilous journey.

4 Technology foresight and design support systems: the approach of the Central European Initiative

Gianfranco Cigognani*

Abstract

The structure and mandate of the Central European Initiative (CEI) promotes activities geared towards integrated sustainable development. At least 5 of the 18 working groups having the responsibility of identifying, promoting and implementing the CEI working plans (namely, agriculture, energy, environment, science and technology and small and medium-sized enterprises) are committed to this general objective, taking full advantage of the expertise and the priorities indicated by each of the 17 CEI member countries.

Although a coherent policy based on comprehensive technology foresight does not exist within the CEI, the majority of the activities addressed in CEI working groups are identified and implemented on the basis of proposals made by different member countries. These depend on the guidelines given by national policies and by the scientific and technological capacity available in each country. A few concrete examples of CEI activities demonstrate that the technological priorities at the national level are taken into account to identify subregional projects. Such projects represent a high degree of general consensus and can be proposed—following the "bankable" project approach—as "pilot" or "demonstration" projects to be implemented on a subregional basis.

A more systematic and comprehensive methodology should be considered by the CEI to properly focus science and technology (S&T) related activities. The CEI can count on two major advantages, which are a result of their activities, namely:

- The available network of institutions resulting from the activities promoted and implemented by CEI working groups;
- The results, in terms of priorities and opportunities, obtained by the multilateral, interdisciplinary S&T related events (seminars, workshops and expert group meetings) organized by the CEI in cooperation with different national and international institutions.

A general contribution of the CEI to a technology foresight programme for Central and Eastern Europe and Newly Independent States could be to show that the "subregional" approach (considering subregions with a high degree of homogeneity in terms of opportunities and expertise) should take precedence over

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other approaches. The CEI recognizes the subregion of south-central Europe as having the highest priority for a technology foresight programme. CEI strategy is focused towards the development of weaker CEI member countries, where a realistic policy of "integrated sustainable development" can be proposed and developed, counting on their most important resource, which is land.

An analysis of a number of case studies of regional projects shows both the pragmatic approach followed by the CEI and their willingness to offer a significant contribution to a technology foresight programme that has a rational and comprehensive approach.

Role and mandate of the Central European Initiative

Before addressing the specific objectives of this Conference, it is appropriate to remark on the role and mandate of the Central European Initiative (CEI) more than one decade since its conception. The CEI was officially established in 1989, when the Deputy Prime Ministers and the Ministers for Foreign Affairs of Austria, Hungary, Italy and Yugoslavia met in Budapest and founded the so-called "Quadragonale". In 1990 and 1991, respectively, Czechoslovakia and Poland joined the Initiative and it was renamed the "Hexagonale Group". With the addition of Bosnia and Herzegovina, Croatia and Slovenia in 1992, it assumed the name Central European Initiative. A number of other CEE countries (Albania, Belarus, Bulgaria, the former Yugoslav Republic of Macedonia, Republic of Moldova, Romania and Ukraine) entered the CEI, which at the end of 1996 counted 16 member countries. Finally, at the last CEI Summit (Budapest, 2000) Yugoslavia was admitted as the seventeenth CEI member.

The CEI membership is complete for the present. It covers all the countries of Central, South-Eastern and Eastern Europe, with the exception of the Baltic States, Greece and the Russian Federation. From a geo-political viewpoint, the CEI "region" represents the area between the European Union (EU) and the Russian Federation, a constellation that gives it great potential in many respects. This underlines CEI's importance in at least three different areas:[1] political, economic and cultural (S&T related aspects included). Its institutional mandate calls for bringing countries and institutions together in the spirit of flexible and pragmatic regional cooperation; creating an atmosphere of mutual understanding in which multilateral programmes and projects can be discussed, planned, financed and implemented.[2] Further comments about the CEI dimensions are useful for a better understanding of the general role of the Initiative, and more specifically on CEI programmatic lines that are related to the scope of this Conference.

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[1]Statement of Amb. Dr. Paul Hartig, CEI-ES Director General, at the CEI Parliamentary Committee (Rome, 9 March 2001).

[2]Additional information on CEI organization and activities is available on their website (www.ceinet.org).

At the Budapest CEI Summit of Heads of Governments and Foreign Ministers in November 2000, political dimensions of the CEI were emphasized. Together with the Zagreb Summit of the EU, the Organization for Security and Cooperation in Europe (OSCE) Summit in Vienna and the Nice European Council shortly afterwards, the CEI Summit in Budapest was one of the top events on the political agenda of Europe in 2000. In particular the CEI Summit welcomed the EU Enlargement Strategy Paper (published by the European Commission on 8 November 2000) proposing the "road-map" for finalizing the accession negotiations with each of the candidate countries. The same attitude was taken towards the Zagreb Summit which formally endorsed the Stabilization and Association Process for South-East European countries, clearing the way for their full integration into European structures. While the EU relations with these countries (accession candidates and non-candidates alike) are primarily bilateral in nature, based on the principle of differentiation and individual achievements, the CEI represents a forum for strengthening cooperation among and between these States. The CEI regional approach corresponds fully with the new concept of active cooperation required by the EU as a precondition for inclusion of the South-East European countries into the Stabilization and Association Process.

Within the general framework of regional cooperation, the CEI strategy focuses its efforts on assistance to the less advanced member States, to the countries in special need of accelerated development and/or recovery. It is for this reason that the CEI attaches technology adaptation to the productive sectors, well aware that market requirements have the highest priority in most cases. Two aspects of the CEI strategy should be emphasized:

- Economic development in this part of Europe relies on more than country-by-country plans, but on a regional/subregional approach based on similar opportunities and capabilities as well as on common "cultural" backgrounds. The well-known EU policy focusing on the development of the so-called "Euro-regions" clearly reinforces this aspect. This gives the multi-country, regional technology foresight process increasing importance;
- The first priority of the CEI is to help in the development of the weakest member countries where there is an urgent need to stabilize their economies. There are a limited number of high priority programmatic lines that meet the domestic opportunities and capabilities in these countries.

The last point is of major importance, and it is obvious when considering the economic performance of the Central and Eastern European countries in the last decade. With very few exceptions (Hungary, Poland, Slovakia and Slovenia) the economies of those countries show significant decreases in GNP. In some countries (Georgia, the Republic of Moldova, Ukraine and Yugoslavia) the GNP for 2000 is between one half and one third of GNP in 1990, indicating a dramatic collapse of the economy and requiring urgent measures to recover the productive systems. In two subregions—east-central and south-central Europe—procurement of technologies that are likely to give the greatest social and economic benefits will be required. This is necessary if countries are to master the difficult passage from the direct use of foreign technologies to either their proper integration into production systems or domestic development. Technology foresight exercises carried out within a sound regional framework will offer valuable support to policy makers.

The question to be asked now is, do we proceed with technology foresight exercises sooner or later? Within the CEI, we do believe that the reply has to be as realistic as possible and that only a pragmatic approach can produce concrete results in the short term, as required by the actual situation. In short, technology foresight techniques remain important tools, but their ability to offer solutions will be greater if they focus strictly on a limited number of high priority development strategies recognized to be of major importance by the countries in those subregions. There is no doubt that the "sustainable development" strategy deserves to be considered as a clear priority. However, an even more focused approach is possible, considering that land is the most important resource in these countries. Appropriate development of agriculture and related industrial activities (agro-industry, food processing, modern conservation techniques, quality control and food safety, agriculture machinery development) are clearly of high priority for the south-central European region as a whole. Thus, "sustainable agriculture development" is a fundamental component of the "sustainable development" strategy.

The sustainable development strategy

Most CEI countries recognize sustainable development as one of the basic strategies to be implemented during the coming years, favouring economic growth and helping the stabilization process. The related activities, even if carried out using modalities and time schedules which cannot be the same in all the different countries, represent common interests in the region. These strategies require the commitment of important resources and concerted efforts of the EU—and of the international community as a whole—within the framework of the Stability Pact for South-East Europe and the expansion of EU relations with the Balkans and the Western countries in the Commonwealth of Independent States. In this spirit the CEI strongly supports the full inclusion of the Republic of Moldova into the Stability Pact process as a beneficiary country and the admission of the Czech Republic, Poloand and Slovakia as donors and full participants of the Stability Pact itself.

The Italian Presidency of the CEI in 2001 is expected to give particular attention to the political dimension of the CEI. Political directors will meet twice, on 24 May in Vienna and on 24 October in Rome. The meeting of the Foreign Ministers is scheduled for 22 June in Milan, and the annual CEI Summit will take place in Trieste on 23 November. Other important events include the meetings of the CEI Ministers of Justice (Trieste, 26-27 March) and Ministers of Agriculture (Verona, 11-12 April). These events demonstrate the level of interest in issues of harmonizing legal/judiciary systems and developing a "sustainable" agriculture policy within the region.

The economic dimension of the CEI is of utmost importance for regional cooperation but, at the same time, it is considered to be underdeveloped and has little visibility. However, the most notable economy-related CEI activities are the Summit Economic Forums, organized in conjunction with the Summit Meetings of Prime Ministers (typically at the end of the year). Following Zagreb (1998), Prague (1999) and Budapest (2000), Trieste will host the 2001 Summit Economic Forum at the conclusion of the Italian Presidency of the CEI. The four-day forum provides an exceptional opportunity to present first-hand information on CEI countries' investment projects/prospects and to network with decision makers in the business community, banks, international organizations, S&T excellence centres, financial institutions and government. The Budapest forum focused on SME development, infrastructure and transportation, as well as on information technology development; specific attention was given to both Euro-regions and cross-border cooperation. Preparation for the Trieste forum is now in progress and, taking into account the involvement of the Italian Presidency, will be an important event, not only for the region, but also for all of Europe. The "sustainable development" strategy will be one of the key subjects discussed at the Trieste forum.

Regarding the economic dimension of the CEI, emphasis should be given to the special relationship between the CEI and the European Bank for Reconstruction and Development (EBRD), where a CEI trust fund (some €25 million) is available and a specific management structure in the EBRD Secretariat exists for CEI projects. A number of projects have been either approved or are under consideration for financial support and other projects are envisaged in the near future. While it is too early for concrete results, it is important to note that on 8 March 2001, the Italian Parliament approved legislation outlining Italian participation in the "stabilization, reconstruction and the development of the Balkans". The Parliament foresees a financial commitment for this purpose of €100 million for the years 2001-2002 and an additional amount of €60 million for the period 2001-2003, to be supervised by the Italian Ministry of Foreign Affairs.

The cultural dimension of the CEI refers to the activities carried out by the different working groups. Five of a total of 18 working groups are dealing with scientific and technological matters: agriculture, energy, environment, S&T and SME development. Regional projects are discussed and proposed to the national coordinators for consideration within the CEI work programme. Careful attention is given to the opportunities offered by the S&T programmes implemented by national and international research centres, with the aim of avoiding duplication and taking full advantage of synergy and complementary activities.

Of increasing importance in terms of the cultural dimension of the CEI are the relations with the academic environment, which is an extraordinarily valuable new element and instrument for promoting a better understanding of the values and traditions, as well as of the constraints and problems which characterize this part of Europe. A first step in this direction is the inter-university cooperation established within the Adriatic and Ionian Initiative (AII), which focuses on the construction of the Network of the Universities of the Adriatic and Ionian Basin (UniAdrion), a unique informatic tool for implementing both subregional projects and professional education courses. With the exception of Greece, all the member countries of the AII (Albania, Bosnia and Herzegovina, Croatia, Italy, Slovenia and Yugoslavia) are also CEI members. It is important to establish a close connection between the two Initiatives, counting on the commitment of the AII universities, which will play a central role in the cultural and scientific development of the region as a whole.

Technology foresight: the importance of a pragmatic regional approach

Technology foresight can be defined as a comprehensive and systematic overview of expected technological development, to be established by unique cooperation between S&T experts on one side and policy makers on the other. There is no doubt that in a few advanced economies—like the European Union, Japan and the United States—technology foresight has been widely recognized as one of the best policy-making instruments. In those countries, foresight studies have been implemented for several years with the aim of understanding to what extent the new and emerging technologies need to be developed and/or adapted to face global market challenges. The impressive performances of informatic tools, which offer increasing possibilities of data analysis, economic modelling and complex systems simulation, open new and even unexpected possibilities.

At least three basic questions about this scenario can be posed:

(a) Can the technology foresight techniques adopted by the most industrialized countries for optimizing their own economic strategies be applied in less advanced environments, more specifically in the transitional and developing countries?

(b) How far can the technology foresight analyses, once tailored to a single country, be utilized for evaluating strategies carried out at the multi-country, regional level?

(c) Should the answers to the first two questions be either negative or doubtful, how real is the risk that a theoretical approach to the problem—even if based on advanced and validated informatic techniques—cannot fully fit the reality, thus failing to offer sound information to the policy makers?

These questions are of major importance for assessing the CEI strategies in the field.

The majority of the CEI member countries suffered in the recent past huge political shocks resulting in serious technological and economical gaps.

To recover the pace of development they have to rely on imported technologies, which are not necessarily the most advanced. It is therefore very important to focus the cooperative S&T programmes—identified, promoted and implemented by the CEI—on well-identified sectors, taking into account the real priorities indicated by the beneficiary countries themselves. Having this basic approach in mind and with specific reference to the south-central European countries, a number of programmatic lines related to the sustainable development strategy have been identified through the work of the thematic working groups, namely:

(a) Information technology development, with emphasis on simulation techniques and modelling as well as on the advance of decision support systems (DSS), are considered one of the main instruments for identifying the best available technology for obtaining a well identified target;

(b) New technologies for "sustainable agriculture", including modern biotechnology, considering relevant issues such as bio-diversity protection and full appreciation of traditional products within the region;

(c) Environmental protection, including a number of activities related to pollution monitoring, prevention and—should it be necessary—remediation. Specific attention will be given to the agricultural and industrial development as it relates to environmental protection;

(d) Identification of energy sources showing low environmental impact, considering the technological and economical constraints recognized in the different countries.

The idea is to identify a number of regional project proposals to be presented at the CEI Summit Economic Forum (to be organized in Trieste on 21-24 November in parallel with the CEI Prime Ministers' Summit). This presentation will reflect the pragmatic CEI approach mentioned above.

This does not mean that the importance of the DSS and technology foresight activities will be left aside. To the contrary, their background and basic philosophy will be a reference point for properly identifying the development lines, selecting the most advantageous technologies and proposing the appropriate demonstration and pilot projects. Their importance is recognized in terms of: the basic bottom-up approach; the results obtained by the events (e.g., workshops, seminars and expert group meetings) organized in cooperation with other national and international organizations; and the new informatic methodologies of data collecting and processing. In short, we are fully convinced that technology foresight is just one component of a more comprehensive development strategy necessary for this part of Europe, in the interest of both these countries and Western ones. Mention should be made again of the sustainable agriculture strategy as an example of the approach the CEI is taking, in particular through the cooperation of the agriculture and S&T working groups.

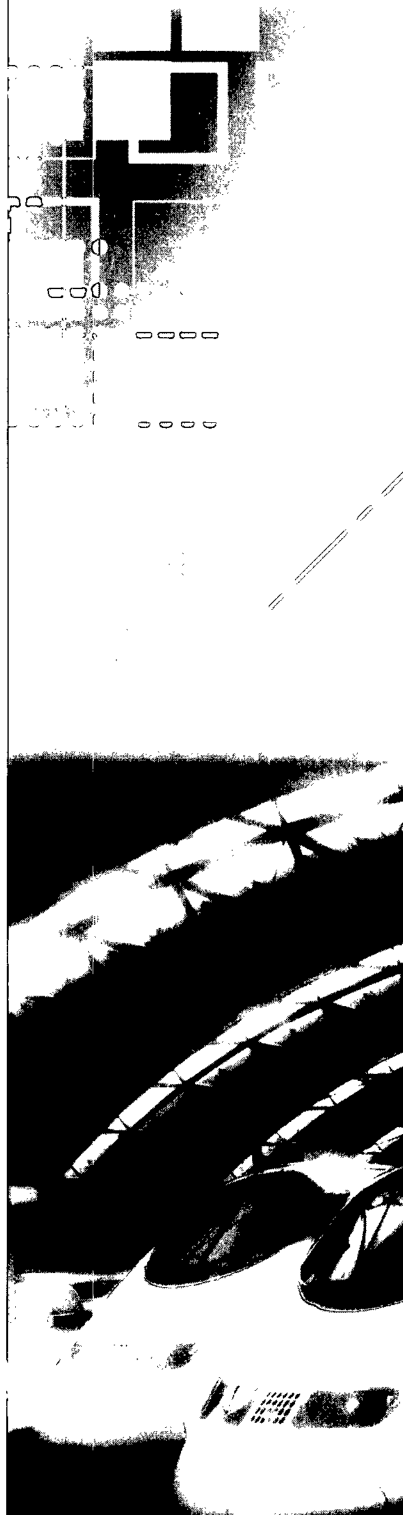
There is no doubt that a part of the economical difficulties faced by most of the Central and Eastern European countries in the last decade can be attributed to the poor performance of agricultural-related activities in terms of property issues, total production, quality control/certification, food safety and distribution systems. The consequences for the market, both internal and foreign, were significant. It is difficult to believe that a few of those countries, despite their beautiful and fertile landscapes, have imported basic agricultural products from Western countries, with catastrophic consequences for their domestic economies. On the other hand, the recovery of the productive systems does not necessarily require these countries to copy the approach used by Western Europe a few decades ago, that is, inappropriate land exploitation, intensive cultivation and breeding, uncontrolled used of chemicals and absence of balanced rural development. A number of Western countries, facing increasing problems (water pollution, soil acidification, eradication of the rural communities with consequent urban over-development and the unexpected—at least at that level—consequences of purely profit-driven policies) are reconsidering the development models. The new trend is also encouraged by the current market demand which is more and more oriented towards high quality, safe, certified and traditional products. This does not mean that we should go back to the point where we were 50 years ago: technology development and experience remain two important advantages on which we can rely. However, the need for a new approach is well evident now. We should avoid that countries repeat in the future the same errors we are now recognizing. We should help them in the area of sustainable agricultural and rural development, sharing our experiences and expertise, transferring the proper technologies and emphasizing the important added values that the new approach promises. Those innovative strategies, together with the use of the most useful technologies, demand the full validation of culture and traditional values.

Conclusion

A very general conclusion can be drawn from this short presentation. Techniques related to technology foresight and DSS are recognized as important tools for helping the sustainable economic development in this part of Europe. They will surely facilitate the assessment of the most advantageous strategies or, at least, verify if the adopted technologies have been properly chosen. The CEI recognizes that expertise about those techniques is available and is being promoted and further developed in a number of national and international research centres/organizations, the UNIDO centres among them. It is the intention of the CEI to establish cooperation in that direction at the level of both shared activities and programmatic agreements in order to contribute as much as possible to the economic stabilization and the sustainable development of the CEI member countries. We do believe, however, that only a fully comprehensive approach, pragmatically based on direct experiences and taking into account the "cultural" aspects of each country and subregion, is appropriate for identifying the paths towards development.

Session II.

Regional and national experiences in technology foresight



1 Technology foresight activities of Germany's Federal Ministry of Education and Research

Volkmar Dietz*

Abstract

In Germany, there are various established methods to identify future trends in science and technology.

Several Delphi surveys were carried out in the 1990s. More than 2,000 experts took part in the last Delphi study, published in 1998. The study presented experts' opinions on more than 1,000 visionary statements related to the question of how Germany's future is going to be influenced by future technologies. But the Delphi studies had little influence on concrete research strategies of the Federal Government, namely the Federal Ministry of Education and Research (BMBF).

In Germany, an "early warning system" for new technologies is included in the specific programmes of the BMBF. Methods used for this are: expert interviews, conference monitoring and patent and publication analysis. This early warning system has a great influence on the structure and implementation of new research programmes of the BMBF. Its disadvantage is that it is more or less technology-oriented.

A new initiative, called FUTUR, based on socio-economic demands is being launched. The objective is to present scenarios of the future in different interdisciplinary areas and to deduce larger research projects, called *Leitvisionen,* from these scenarios. An important issue of FUTUR will be the participation of the public in defining research fields.

The following general conclusions can be drawn from experience with technology foresight in Germany:

(a) Delphi is not suitable for finding priorities among a large variety of topics. Thus Delphi had little or no impact on the formulation of research programmes in Germany;

(b) Both technology-oriented and demand-oriented approaches should be used. Technology-oriented approaches ("early warning system") result in explorative research at an early stage of innovation. Pilot projects could be used to evaluate the possible applications of a future technology under investigation. On the other hand, demand-oriented approaches, as exemplified by the FUTUR initiative, can focus research on central problems of our society;

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(c) The early warning system shows one important deficit: it is unsuited for detecting interdisciplinary fields of activity. It reproduces the structures of the BMBF. Fields which do not fit into existing specific programmes are in danger of not being identified;

(d) New technologies in Germany, especially if they focus on social demands, cannot be implemented without public participation. The new FUTUR process includes consensus-building conferences, scenario workshops with interested citizens, Internet participation of the public, etc.

Research structure in Germany

The German science system is rather complex. Although the *Länder* (states) are in charge of science policy (for example, the basic financing of universities), most application-oriented research is funded by the BMBF. In Germany, research is carried out primarily by the following institutions:

- Max Planck Society: 72 institutes, €1.0 billion per year, mostly fundamental research;
- Fraunhofer Society: 49 institutes, €0.7 billion per year, mostly application-oriented research, cooperation projects with industry;
- Leibnitz Science Association: 84 institutes, €0.9 billion per year, fundamental science and application-oriented science;
- Helmholtz Association of National Research Centres: 16 national research centres, €2.3 billion per year;
- Higher education: 161 universities, 183 *Fachhochschulen* institutions (universities of applied science).

The first four institutions are partly funded by the BMBF (68 per cent on an average) and by the *Länder* (32 per cent). Besides basic support for the institutions the following organizations provide funding of R&D projects: the German Research Association (DFG); the Confederation of Industrial Research Associations (AiF); various private foundations like Volkswagen Stiftung, etc.; and the BMBF and the Federal Ministry of Economics and Technology (BMWi), together with their project-management agencies *(Projektträger)*. The largest part of R&D expenditure in Germany comes from industry.

In the following, the focus is on project funding by the BMBF amounting to a total of €2.3 billion in 2001, of which €1.5 billion are spent on technology-oriented R&D projects. The funding by the BMBF is organized in specific programmes. Most of them concentrate on a special technology, for example, research programmes on laser technologies, microelectronics or superconductivity. Some programmes are focused on a special application such as health or mobility and transport.

A comprehensive discussion between the various programmes (to identify synergies for example) is not systematically implemented in the BMBF. This will be the aim of the FUTUR initiative which will begin in April 2001 and is addressed in this paper.

Research policy of BMBF

In order to explain the principles of the intended foresight-process in Germany, it is necessary to outline the main issues of German research policy. The focus of our research policy is the human being and not technology as such. Research should contribute, for example, to health, responsible treatment of the environment and the quality of life or employment. A second aim is to strengthen the basis of German industry. Economic potential is always an important criterion for the evaluation of a new technology and is usually correlated with employment.

One of the central objectives of German research policy is to contribute to world-wide sustainable growth. Thus, before starting a funding programme we evaluate the contribution of the respective technology to sustainability (for example, reduction of emissions, substitution of an environmentally hazardous production process etc.).

Ethical questions need to be assessed before making a decision on funding a new programme (for example, the recently intensively discussed research on human embryos). Not every field of research which is feasible is desirable. The discussion shows that research must be done within established ethical boundaries.

Before starting to fund research in a future technology, risks must be evaluated. A new funding focus has begun on technology assessment. Technology assessment has to be closely correlated with foresight. To give you an example, the American computer expert, Bill Joy, started a discussion on the combination of genetics, nanotechnology and robotics. His scenario envisions intelligent machines which are superior to humans and make humans superfluous in 20 or 30 years. Although most experts do not believe in the future he describes, possible risks must be analysed, and scenarios such as the one described should be discussed and evaluated simultaneously with the intensification of our activities in nanotechnology. Innovation is always accompanied by risks. Foresight together with technology assessment should result in a decision concerning which risks we want to take and which risks we are not willing to accept.

Government funding does not intervene in existing markets. Product-oriented R&D is the responsibility of enterprises. The BMBF funds projects involving larger technological and economic risks, especially in areas where a concrete market potential is not yet known. By providing such financial support, the BMBF encourages industry to invest in high-risk fields offering potential medium- and long-term applications.

Developments in recent years show that the most interesting research fields are found at the boundaries between the classical disciplines of physics, chemistry, biology or engineering science. One of the principles of the BMBF is to identify and promote interdisciplinary fields of research. To give you some examples:

- The advances in the technology of medical operations are based on a combination of laser technologies, microsystem technologies and new measuring techniques from physics, computer science and medicine;

- Research on artificial intelligence brings together computer scientists, neuroscientists, microsystem technicians, biochemists and others;
- In nanotechnology, molecules are investigated as construction elements in molecular machines, drug-delivery systems or techniques to manipulate individual atoms, among other technologies. The boundaries between physics, chemistry and biology vanish in nanotechnology.

Identification of future technologies in the BMBF

Various methods of technology foresight are used in the BMBF, including Delphi studies, early warning system for new technologies, and the FUTUR process.

German Delphi reports

In the 1990s, four Delphi studies were carried out in Germany. The first German Delphi study was published in 1993, followed in 1995 by a Mini-Delphi, which concentrated on selected topics and was carried out simultaneously in Japan. In 1998, the second German Delphi survey took place. These three Delphi studies were managed by the Fraunhofer Institute for Systems and Innovation Research (ISI). The paper by Knut Blind, included in this volume, gives a more detailed analysis of the methodology and the results of the Delphi surveys. During all phases of Delphi in Germany there was close cooperation between German and Japanese experts so that comparable results could be achieved.

In addition to the technology-oriented surveys, a Delphi study focusing on education issues was launched.

More than 2,000 experts took part in the 1998 Delphi survey in Germany[1] concentrating on the following 12 fields:

- Information and communication;
- Services and consumer goods;
- Management and production;
- Chemistry and materials;
- Health and life sciences;
- Agriculture and nourishment;
- Environment and nature;

[1]The Delphi survey can be downloaded from the ISI website: www.isi.fhg.de.

- Energy and resources;
- Construction and housing;
- Mobility and transport;
- Space technology; and
- Large-scale experiments.

The experts were provided with dozens or even hundreds of visionary statements in their respective fields of knowledge and asked for their opinions. The study contains a total of 1,070 visionary statements in the abovementioned 12 fields. Some examples of those visionary statements are:

- New materials can be produced by self-organization;
- The pathogenesis of cancer is understood by identification of most of the genes participating in the formation of cancer and by understanding the environmental influences promoting cancer;
- Memories based on biomaterials with a storage density 1,000 times larger than the actual semiconductor memories will be realized; and.
- Vehicles and machines using alcohol or hydrogen instead of fuel are commonly used.

The experts examined such questions as:

- Time-frame until realization of technology;
- Importance for economic, social and ecological development, for increase of knowledge and for employment;
- Status of research, especially comparing the United States, Japan, EU and Germany;
- Important measures to realize the visionary statements; and
- Possible problems arising for environment, security, society, etc.

In a second round, the experts had the chance to change their opinions in light of the evaluation of all the statements of their colleagues, providing a consolidated opinion of experts.

The strength of the Delphi survey's coverage of all the fields of technology is also its weakness. In the wide field of 1,070 visionary statements, no priorities among a set of recommended measures can be seen. This may be the reason why Delphi had nearly no influence on strategic decisions in research policy or on the shaping of research programmes of the BMBF. Delphi did not produce an interdisciplinary discussion about priorities. On the other hand, the majority of the visionary statements were already taken into account in the various research programmes existing in the BMBF.

Early warning system of the BMBF

The BMBF covers a vast spectrum of application-oriented research fields and research funding is subdivided into a number of specific programmes

(*Fachprogramme*). They are not static: as so-called "learning programmes", their development is permanent and there is continuous search for new aspects and fields within the respective programme. Out of this process, new programmes may develop or those dealing with technologies that have reached a certain level of maturity will be stopped.

In 1993, the BMBF (formerly known as BMFT) published a study on "Technologies of the 21st Century", managed by ISI. In this study the knowledge of the *Projektträger*, the project management agencies of the BMBF, was used to identify new trends in critical technologies. Eighty-six emerging technologies with a time-frame for application of about 10 years were identified in the fields of new materials, nanotechnology, microelectronics, photonics, microsystems technologies, software and simulation, molecular electronics and biotechnology. One important finding of the study was that new technologies will be more and more interdisciplinary, which should have consequences for structuring funding programmes. The study indicated that research efforts should be bundled in larger so-called *Leitprojekte* (lead projects), which follow a longer-term vision and should not concentrate on a distinct technology, but on social and economic problems to be solved. Some years following the ISI study *Leitprojekte* were implemented in the BMBF.

Nanotechnology provides an example of how the early warning system for new technologies in the BMBF generally works. Nanotechnology is considered to be a key technology of the twenty-first century. It is a field of research that is in an early stage and basic research is still necessary. New fields—like nanotechnology—are implemented as a funding priority in a three-phase process—the identification, evaluation and implementation phases—described below.

Identification phase

The first permanent active phase of the early warning system is a broad "technology screening", conducted in the framework of the different specific programmes of the BMBF. New technology-oriented subjects are identified by interviews with experts and workshops, by evaluation of scientific conferences, patent or publication analysis, or by observation of international activities.

Since the late 1980s we have known that single atoms or molecules cannot only be made visible but can be manipulated in a specific way. In principle it became possible to construct atom by atom, or molecule by molecule. Eric Drexler visualized that medical "nano-submarines" could be incorporated in the body and repair defects in the blood-stream. The potential of nanomachines constructing, atom by atom, new products out of waste was recognized by the public, but criticized by experts. It became evident that nanotechnology is a field of increasing importance in research, but a clear definition and realistic opportunities for its application are still missing.

The BMBF organized several expert workshops and developed the definition of nanotechnogy as "production, analysis and application of systems with critical dimensions below 100 nanometres showing new applicable effects due to the small structures". Having this definition of the field of interest we could proceed to the next phase.

Evaluation phase (pilot projects and pilot studies)

The fields identified in the first phase have been evaluated, mostly in the form of a "technology study". This technology study aims to answer the following questions:

- What is the quantified economic potential of this technology? Which concrete products and which fields of application are realistic? In the case of nanotechnology a world market of about €55 billion could be predicted. Considerable applications have already been realized especially in the area of high precision engineering (e.g., high precision optics for semiconductor equipment);
- Is the identified future technology of interest from a scientific point of view? What is the level of innovation associated with the underlying scientific field? In the case of nanotechnology there are several completely new basic effects found by scientists which may lead to new products. Further basic research is needed, for example, in the field of nanobiotechnology or nanoelectronics. Nanotechnology is an interdisciplinary field covering physics, chemistry, biology and engineering science. Interdisciplinarity is a challenge to research policy, for example, in regard to questions of adequate training and education;
- What is the influence of the new technology on society? What contribution does it make to sustainability or to ethical questions? Several questions are raised in the case of nanotechnology. Nanotechnology will contribute to the reduction of resource consumption. It promises new drug-delivery systems or medical methods like hyperthermia by using ultra-fine magnetic particles. On the other hand, there are risks associated with nanotechnology. As mentioned previously, one risk was formulated by Bill Joy, co-founder and chief scientist of Sun Microsystems last spring: "Our most powerful 21st-century technologies—robotics, genetic engineering, and nanotechnology—are threatening to make humans an endangered species." He envisioned machines being more intelligent than humans and thus making man superfluous. Identifying a new technology for funding should be accompanied by technology assessment from the very outset;
- What is the state of the art of the respective technology compared to the international situation? Which funding activities exist in other countries? To return to the nanotechnology example, it is being paid great attention world-wide. For example, about one year ago, the United States administration started an initiative on nanotechnology amounting to US$ 500 million per year;

- What is the research capacity in Germany for working on a specific technology?

The results of the technology study lead to recommendations on funding activities. In the case of nanotechnology, we implemented an interdisciplinary programme at the beginning of 1999, including aspects of physics, chemistry, materials science, biotechnology, health research and microelectronics. At the moment the BMBF funds nanotechnology with about €41 million per year.

Typically, it takes months or up to one year to elaborate a technology study. To avoid losing time, pilot projects are usually started at the same time as the technology study. The objective of pilot projects is to learn about the potential for application and to give scientists and technologists a chance to define relevant questions. In the case of nanotechnology we started with pilot projects in the most promising fields (nanoanalytics, nanoparticles, nanoelectronics and lateral structuring, and ultra-precision engineering).

Implementation phase: funding: funding new programmes

Sometimes the funding of pilot projects is called the "greenhouse" of the BMBF. We grow new technologies like small plants and after a while, only the most interesting and mature plants survive. Not all examples of pilot funding were as successful as nanotechnology. Some technologies had very promising beginnings but had to be stopped after a year or two. But others will continue to grow and will finally be implemented as a new funding programme.

These activities are closely coordinated between science and industry. The BMBF expects companies to participate and to finance projects at a certain percentage, at least after the pilot project phase. The ultimate objective is innovation, and this can only be achieved if enterprises are involved. At the same time, the financial engagement of companies is a good test of the economic significance of a technology.

Nanotechnology was implemented as a strategic interdisciplinary initiative of the BMBF. Besides research projects, the BMBF supports six centres of competence. Their aim is to make Germany an excellent location for nanotechnology. These centres should become starting points for the application of nanotechnology in industry. Although nanotechnology is rather young and the centres of competence have existed for only two years, more than a dozen new enterprises were established demonstrating that this technology offers promising market opportunities.

FUTUR initiative

At the beginning of April 2001, a new German foresight initiative called FUTUR was launched. With the sponsorship and close cooperation of the BMBF, FUTUR is organized by a consortium of institutes led by the Institut für Organizationskommunikation in cooperation with ISI and others.

An earlier process called FUTUR was initiated in 1999 at the "Forward Thinking" conference in Hamburg. It was mainly focused on the use of the Internet as the medium of work. This concept, of course, did not work. The BMBF is applying new concepts, more manpower, various methodologies and concrete objectives to the new FUTUR process, as described in the following sections.

Objectives of FUTUR

FUTUR should provide a systematic look into our future. Fields should be identified which show the correlation between new technologies and social demands. In this way FUTUR supplements the technology-driven early warning system of the BMBF. Contrary to the early warning system, FUTUR starts with social demand and socio-economic questions. The objectives of FUTUR are to establish the following:

- *Scenarios*—FUTUR will establish visions of the future using scenario techniques. Future scenarios will be those that are possible, probable or desirable. They will be publicly presented and discussed in order to make research priorities more transparent and understandable;
- *Leitvisionen* (lead visions)—From the scenarios we would like to deduce *Leitvisionen*, which will be larger research projects oriented towards the demands of the people (not technology "push" but societal "pull") and which offer great market potential. FUTUR will be the permanent process to identify these *Leitvisionen;*
- *Participation*—Germany has learned that it is counter-productive to develop a new technology and present it to the public without involving the affected persons. One example of this has been the use of nuclear energy, which will be phased out in the next few years. The human being is the centre of our research policy. This means that people should be involved in the process of identification of research activities. Not only experts, but also a broader part of the public should participate in FUTUR, leading to more transparency in research policy. Acceptance of a new technology can be tested at a very early stage of investment. The BMBF wants to achieve more open-mindedness towards future technologies in the public;
- *Interdisciplinary cooperation*—Most of the interesting fields of science and technology are increasingly interdisciplinary. FUTUR is a systematic approach to implement interdisciplinary cooperation in the work of the BMBF.

Methodology and structure of FUTUR

The FUTUR process will be organized to involve the following groups:

- Experts from science and industry, who will identify future trends;

- Trendsetters, who will propose activities of interest, allowing unconventional ideas to be taken into account. By trendsetters we mean young scientists, founders of start-ups, winners of the "Young Researchers Competition", etc.;
- Interested citizens who will discuss and comment on identified trends and scenarios;
- Experts from the BMBF, who will make final decisions and implement concrete projects.

The complete process is rather complicated, consisting of expert workshops, scenario workshops and consensus-building conferences. The Internet, as a medium to involve the public and as a platform for input of new ideas, will be used, but in contrast to the past activities in Germany will not be the main focus of FUTUR.

The first step, identification of trends in technology and society, has to be done by experts or trendsetters. Integration of the public in this phase of FUTUR will not be very fruitful. From 10 to 20 focus groups, concentrating on special subjects, will elaborate the input for an open-space conference in the second phase of FUTUR, which will involve not only experts, but also interested persons from the public. The objective of the open-space conference is to find priorities among the 10 to 20 subjects so that in the next step scenario workshops *(Zukunftswerkstätten)* can be organized. A first set of scenarios should be published at the end of the year 2001. By summer 2002, these scenarios will be developed into *Leitvisionen*. These leading visions will include concrete R&D requirements in the field under investigation and will be implemented as funding projects in the BMBF.

Conclusion

In Germany, there are various established methods used to identify future trends in science and technology: Delphi surveys, a technology-oriented "early warning system", and the FUTUR initiative of the BMBF.

The following conclusions can be drawn from experience with technology foresight in Germany:

- Delphi is unsuited for finding priorities among a large variety of topics. Thus Delphi had little or no impact on the formulation of research programmes in Germany;
- Both technology-oriented and demand-oriented approaches should be used. Technology-oriented approaches ("early warning system") result in explorative research at an early stage of innovation. Pilot projects could be used to evaluate the possible applications of a future technology under investigation. On the other hand, demand-oriented approaches, as specified by the FUTUR initiative, can focus research on central problems of our society;

- The early warning system has one important shortcoming: it is unsuited for detecting interdisciplinary fields of activity. It reproduces the structures of the BMBF. Fields which do not fit into existing specific programmes are in danger of not being identified;
- New technologies in Germany, especially if they focus on social demands, cannot be implemented without public participation. The new FUTUR initiative includes consensus-building conferences, scenario workshops with interested citizens, Internet participation of the public, etc.

2 Technology foresight in the Russian Federation: background and agenda for the future

Mikhail Ksenofontov*

Abstract

The Russian Federation has its own experience of realizing technology foresight projects. Almost 30 years ago, in 1972, a large-scale project—the "multi-aspect programme of technology progress"—was started. There were four cycles of this project, each of which consisted of about three years of active research and a two-year interval. The initial concept of this project corresponded almost precisely to the modern definition of technology foresight. Of course, its results were biased due to strong ideological pressure, but in its essence (aims, methodology, organizational structure, cooperation links, orientation towards technological impacts on social and economic development, and vice versa) it was really a technology foresight project.

In the last decade there were several successful attempts to realize projects aimed at the identification of research and development (R&D) priorities, or to assess the role of technological changes as factors in the Russian Federation's national economic development. Nevertheless, one can see trends of degradation in practically every aspect of technology foresight activities in the Russian Federation: their scales have been considerably reduced, their content narrowed, and former cooperation links have been lost. The major factors determining degradation trends are:

- Limited interest of governmental authorities in development problems of a long-term perspective. This is due, first, to urgent current problems; second, to a general misunderstanding of interrelations among various social, institutional and technological aspects of the market-oriented transformation of the Russian Federation economy; and, third; to the fact that long-term economic forecasts have turned out to be politically sensitive spheres;
- The prolonged investment and innovation crisis, due to deep declines in output and existence of spare capacity in the real sector of the national economy of the Russian Federation.

To work out an adequate and effective policy of structural and technological modernization of the Russian Federation national economy—that is, to identify a role technological factors could play in solving urgent socio-economic problems, as well as a system of social and economic prerequisites for future

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positive technological development—we need to revive multi-aspect long-term forecasts based on technology foresight methodologies.

UNIDO could play a positive role in supporting the Russian Federation's projects in the field of technology foresight, because it could provide the support to encourage a transition to a more constructive paradigm of elaboration and realization of the economic reform policy. This is a paradigm of active construction of the future, and active preventive policy for future problems and challenges.

Regional technology foresight programmes for Central and Eastern Europe could promote and stimulate the elaboration of more adequate and active national policies on social, economic and technological developments, thus ensuring the region's innovational and ecologically sustainable character. The regional technology foresight programme will promote long-term visions of Central and Eastern Europe development perspectives, help identify a role for technological factors and, in particular, national innovation systems, while working to achieve the strategic aims of social and economic development.

Technology foresight in the Russian Federation: background and present situation

Technology foresight in the Russian Federation in the 1970s and 1980s

Almost 30 years ago, in 1972, a large-scale project aimed at the elaboration of the long-term national economic development forecast—the Comprehensive (Multi-aspect) Programme of Scientific and Technological Progress and its Social and Economic Consequences for the Period of Twenty Years—was started.

The initial concept of this Programme almost precisely corresponded to the modern definition of technology foresight:

(a) It was a multi-aspect research study, aimed at identifying priorities for technological change, the role of new technologies as factors in the positive development of the national society and economy, and the introduction of long-term visions of future social, economic and technological changes into the process of policy-making;

(b) It was a long-term, 20-year forecast, based on various scenarios describing available policy alternatives and the corresponding future states of the national economy and society;

(c) It was a systematic and periodic forecast. Beginning in 1972 there were four cycles of this project, each consisting of about three years of intensive research activity followed by two-year intervals, which were used to analyse results of the previous cycle and to prepare for the next one;

(d) It was a project based on the cooperation of those government bodies in charge of economic and technological development, academic institutes and representatives of real sectors of the national economy;

(e) It was based on various research methodologies including the Delphi technique, scenario analysis, cross-impact analysis, expert panels and mathematical modelling.

Thus in its essence (aims, methodology, organizational structure, cooperation links, orientation towards identifying technological factors, impacts on social and economic development and, vice versa, the social and economic impacts on technological changes), it was really a technology foresight project.

The structure of the Programme is described below.

There were many research teams that provided reports with detailed analysis of particular issues and evaluations of development trends, which then were summarized and generalized in the following five major sections (volumes) of the Programme:

- Science development prospects;
- Technological progress in the national economy;
- Technological progress and major economic and social development problems;
- Regional aspects of technological progress;
- World economy and technological progress.

For example, the first section of the Programme for the period 1991-2010, "Science development prospects", summarized materials of reports concerning:

- Basic science;
- Applied R&D;
- Instrument making for science;
- Management of scientific research;
- Discoveries, inventions, patents and licensing;
- Higher education.

The second section, "Technological progress in the national economy", consisted of 17 reports concerning the assessment of the potential role of technological factors in solving development problems of particular sectors of the national economy, as well as environmental problems. These reports addressed the following areas:

- Machine-building;
- Fuel and energy sector;
- Ferrous metallurgy;
- Non-ferrous metallurgy;
- Chemical industry;
- Wood, pulp, and paper;
- Construction;
- Agriculture, food-processing industry and light industry;
- Services;
- Transport;
- Trade;
- Telecommunications;
- Information technologies;
- Standardization;

- Natural resources;
- Recycling resources;
- Environmental protection.

The total output of the Programme in terms of documentation (including various analytical and forecasting materials and preliminary reports), was more than 100 volumes. These concerned development problems and opportunities for particular sectors of the national economy, special issues (ecology and world economy) and regional issues.

Some major results of the Programme are as follows:

- The introduction of new ideas and new development concepts into the policy-making process. The most important of these are: the concept of demilitarization of the national economy and conversion of the military industrial complex; scientific, technological and material potential for technological modernization of the civilian sector of the national economy; and the concept of activating social factors of economic development;
- The introduction of future development problems into discussions concerning current (short-term) economic policy (e.g., quality of life, demographic and environmental issues and lags in technological development);
- The introduction and intensive development of interdisciplinary research activity.

To realize a technology foresight project it is necessary to develop a specific research culture based on an integrated, multi-aspect vision of social, economic and technological evolution, and to form a team of researchers with similar views on these processes. The formation of such a team could be considered as one of the most important tasks (and results) of the technology foresight project. The development of a research culture, and the accumulation of research experience of several interdisciplinary teams which were in charge of the retrospective analysis and forecasting of various aspects of interrelations and interactions of social, economic and technological changes, were important results of the Programme. Networking activities produced a variety of links among representatives of various branches of the social and natural sciences, and provided the basis for intellectual exchange. Potential for research cooperation increased, along with the development of informal contacts between various researchers and research groups, and the accumulation of mutual understanding and experience of joint research. Experience was also gained in addressing the advocates of easy, straightforward (but inadequate) technological solutions to problems which really have a social and economic nature.

Of course, some results of the Programme were biased due to ideological pressure, organizational inefficiency and various lobbying activities. Very often it failed to produce sound and consistent policy recommendations, and to overcome an excessive a priori focus on technological factors as a driving force of economic development. Nevertheless the Programme itself created a very favourable research environment, which stimulated interest in long-term forecasting, predetermined a wide variety of forecasting methodologies within the academic community, and strengthened the positions of academic researchers in their relations with State authorities and business circles.

Technology foresight in the 1990s

In the last decade, in spite of many institutional reforms and reorganizations of the government structure, there were still special State bodies which were in charge of the Russian Federation's economic, scientific and technological development. At least formally there was an opportunity to present problems and priorities of the S&T sphere of development at the highest policy-making level. One could easily find certain formal and sometimes more fundamental similarities with leading countries in global technological development in the structure of the innovation sector in the Russian Federation. This was the case in the structure of those economic sectors functioning in the sphere of scientific and technological development and systems assigning priority for technological development. The Russian Federation State authorities discussed and approved a number of documents declaring the State scientific and technological (and/or innovation) policy. One example is the involvement of the Russian Federation State legislative bodies such as the State Duma, in elaborating the Law on Economic Forecasting and its subsequent modifications which helped stimulate long-term social, economic and technological forecasting. There were several successful attempts to realize projects aimed at the identification of R&D priorities, and/or to assess the role of technological changes as factors of national economic development (for example, the Russian Federation Ministry of the Economy project on problems of competitiveness and the Russian Federation Technological Security Concept).

In spite of these positive circumstances, one could see obvious trends of degradation in practically every aspect of technology foresight activities in the Russian Federation. Their scales were considerably reduced, their content narrowed (especially as far as social and economic aspects were concerned) and former cooperation links among those who deal with economic, technological and social aspects of the future were lost to a great extent.

The major factors determining degradation trends in the sphere of technology foresight activities in the Russian Federation are:

- Limited interest of governmental authorities in the long-term perspective of development problems. This is due, first, to the necessity of dealing with urgent current problems. Second, it is a result of a general misunderstanding of interrelations among various social, institutional and technological aspects of the market-oriented transformation of the Russian Federation's economy. Third, it is due to the fact that long-term economic forecasts are politically sensitive spheres of research activity.

- The general passive character of the Russian Federation Government's R&D and technological development policies; passive government attitude towards the phenomena of technological degradation; and negative shifts in the technological structure of the national economy due to the deficit of available financial, material and organizational (institutional) resources;
- The absence of demand for innovations from a major part of the market subjects of the Russian Federation's national economy (and as a consequence, the lack of interest in technology foresight perspectives, future trends and requirements of technological development);
- The prolonged investment and innovation crisis due to the deep decline in internal demand. This predetermined declines in output and existence of spare capacity in the real sector of the Russian Federation's national economy.

There is no actual demand for long-term, social and economic forecasts from the government bodies (executive authorities). The activity of governmental structures in the sphere of long-term forecasts and technology foresight usually has a ritualized character, because the Government is actually occupied with current, pressing problems—it works like a "fire brigade". Low-level activity in addressing long-term strategies of social and economic development predetermines low interest in innovations. Interest in innovation should be based on an understanding of the role that technological innovations could play as factors ensuring the realization of strategic development goals, particularly the realization of the Russian Federation's market-oriented reforms. As a direct consequence, there is no "demand" for the technological forecasts. The socio-economic context necessary for elaboration of the technology development forecasts is also lacking. The science and technology development policy has a passive and defensive character; it is a policy of "survival" because any positive purposes should be based on knowledge about the possible role of innovations in realization of the socio-economic strategy (and until now there has not been any officially approved strategy). Academic institutions with the potential to realize long-term economic and technological forecasts have fairly limited opportunities to influence either the decision-making process in the sphere of socio-economic, scientific and technological policy or the actual practice of innovation and investment activity.

In addressing long-term economic forecasts, many basic questions about the economic reform policy that are perceived by many politicians and the general public as having an ideological nature (and thus having only political solutions) can be formulated in terms of applied economic analysis, which requires appropriate professional arguments. It was usual for high-ranking officials and experts of the Russian Federation's Ministry of the Economy to actively defend the government variant of economic reform policy. But in 1999, when they attempted to work out a long-term forecast concerning the Russian Federation's social and economic development, they were forced to recognize that this policy had no long-term prospects, because they failed to find reasonable opportunities for high rates of economic growth. It was the first time that government experts assessed the results of reforms not in terms of the degree of financial stabilization, budget deficit trends, or scales of privatization and liberalization, but in terms of essential results of economic development (e.g., standards of living, competitiveness, production efficiency, rate of technological modernization and so on). There is active political opposition towards the government variant of the economic reform policy, and thus government authorities perceive long-term economic forecasts as politically sensitive (or even politically "dangerous"). Under these conditions, the formal or ritual character of the technology foresight activity helps to avoid critics.

The Russian Federation's technological development (as well as their technological policy) is passive. Any economic reform policy in spheres where the Russian Federation Government had actual opportunities to intervene had consequences in terms of corresponding changes in the material structure of the economy (particularly in an output structure by branches and a technological structure for production). From this point of view technological policy is an integral element (consequence) of realized economic transformations. However, a basic feature of such a technological policy is its secondary character, a character of the implicit failure to take into account the consequences of decisions undertaken to reform (or regulate) other aspects of the economic system. Such a passive technological policy, which has no specific positive purposes, is a constraint on the freedom of choice of reform policy in financial and institutional spheres and was characteristic of the earlier period of market-oriented reforms in the Russian Federation.

The major features of the current economic conjuncture are high uncertainty about prospects for social and economic development (caused, among other reasons, by uncertainty about long-term purposes of the Government's economic policy), and the rigid constraints of final and intermediate effective demand, which determine a low level of internal market capacity and, as a result, a low level of productive capacity in the real sector of the economy. We have a situation of investment crisis, steep recession of investment activity, and therefore, minimal urgent demand for innovations at an individual firm level. It is necessary to note that this demand is not only low but it is "biased," due to scarcity of financial and material resources for investment.

There is a widening gap between the innovation sphere and the national economy in the Russian Federation. This is a result of growing divergence between the innovation supply structure (both actual, and especially, potential scientific and technological resources), and the structure of internal demand, which is limited and biased due to the current economic conjuncture. In this situation, how should we assess the fact that the Russian Federation's system of priorities for technological development is to a great extent similar to that of the United States, Japan, and the most developed countries of the European Economic Community? The similarity to technological priorities of developed countries is determined by certain similarities in their initial economic and technological positions. These include common characteristics such as their aspirations concerning their future role in the global economy, political will, availability of economic resources, and the mobilization necessary for effective fulfilment of the stated development tasks. In this respect, however, the Russian Federation, due to its state of crisis, has essential differences from the advanced economies. Should the similarities continue to serve as one of the working criteria for procedures in selecting the Russian Federation's national system of technology development priorities, or should a national system of priorities be based on more adequate grounds? Moreover, should it take into account initial negative economic and social circumstances?

The inclusion of domestic scientific and technological potential into the system of global economic cooperation also creates a conflict. On the one hand, some segments of the available innovation potential appear to be completely geared towards external demand, which corresponds with a qualitative level of the R&D already achieved in the Russian Federation. It appears that these elements of the national R&D sector are able not only to survive, but also to grow. On the other hand, these elements of the Russian Federation's innovation sphere have become almost completely inelastic in their response to internal demand. This is characterized by insignificant scales, and non-progressive, retrograde features in comparison with external demand, and thus will not help in solving the national economy's modernization problems. As a result, the Russian Federation's national science and technological potential is losing its former internal integrity.

Agenda for the future

Actions to be taken in transforming current approaches to positive social economic and technological development in the Russian Federation include:

- To return to multi-aspect long-term forecasts, technology foresight methodology, and to the set of tools used to elaborate social, economic, scientific and technological policy, thus reviving regular activity in long-term forecasting;
- To work out an adequate and effective policy of structural and technological modernization of the Russian Federation's national economy, to identify a role technological factors could play in solving urgent socio-economic problems, as well as a policy establishing the social and economic prerequisites for positive technological development.

The Russian Federation's position as an economy in transition provides specific motives for reintroducing technology foresight methodology, as well as long-term social-economic forecasting into practice for policy-making. It is necessary to transform the current reform process, which is to a great extent spontaneous, with a consistent strategy of positive social, economic and technological development. Technology foresight and long-term forecasting are important prerequisites for such a transformation.

Despite the pressure of accumulated social and economic problems (which objectively reduce the Russian Federation State authorities' interest in analysis of long-term perspectives of development of economy and society), the technology foresight projects and long-term forecasts were, and continue to be, important types of research activity. Forming the scientific bases of socio-economic policy, they have a great practical significance. To develop and realize market-oriented economic reforms, they must be viewed as an integrated programme of measures that take into account objective differences in the possible rate of transformations of various elements of the previous socio-economic system, which account for the inertia in the transformation process in various spheres and sectors of the national economy.

Many urgent economic reform policy issues can be adequately analysed only within the framework of the long-term forecast. Long-term forecasts should be used to determine the need to realize in advance those structural, technological, institutional and financial changes that will provide effective adaptation to challenges of the future social and economic situation. As a result, increased priority is given to problems that the economy will meet in the future, allowing them to compete for economic resources with the current problems, providing a more effective system of compromises in current economic policy. When elaborating and realizing economic policy, one should take into account remote consequences of these decisions. The realizations that progressive changes require significant time, and that inadequate economic policy can immediately cause a chain of irreversible destructive changes are important in the analysis of long-term consequences of current tactical economic decisions.

To work out effective reform policies, it is necessary to take into account internal conflict among various development objectives and trends which are characteristic of different spheres of the economy and various aspects of the transformation process. As a result of the extension of temporary frameworks of the forecasts in particular, it appears possible to formulate and consider conflict between the short-term objectives of certain policy measures on financial stabilization and social and economic development objectives in a more remote future. It also however, raises the problem of elaboration of acceptable variants of reform policy as a compromise policy, bringing tactical and strategic development priorities into agreement.

The practice of elaboration and realization of economic policy confirms the fact that there are no mechanisms to support necessary priorities of future development problems. Thus, we should not lose the time that is necessary for the preparation of scientific backgrounds of economic policy, combining priorities of systemic market-oriented transformation of the Russian Federation's national economy and positive economic development.

The agenda for the future should include the construction of an integrated national innovation system. This should be new and adequate to solve the problems associated with realizing large-scale technological modernization of the Russian Federation's national economy. Institutional requirements must be met in order for technology foresight to become a useful instrument for the highest level of State authorities in elaborating economic and technological strategy, and a natural element of the national innovation system.

There is also a series of issues to be addressed concerning the interactions among new results of the technology foresight project and already existing attitudes, including relationships and visions of the future, the right way to communicate between researchers and policy makers, and the right way to present and disseminate the results of the technology foresight projects. Likewise, it must be decided in advance how to introduce important elements of the political conjuncture and to address the existing stereotypes of the political decision-making process in order to prevent the misinterpretation or/and misunderstanding of the technology foresight project results by policy makers, and by those who will be in charge of implementation of the project recommendations. Thus, future technology foresight activity should be aimed not only at identifying technology development priorities, but also at the creation of new productive networks. We especially need to broaden the base of participation beyond that of regular advisers to the Government. This entails introducing new experts and, accordingly, new policy alternatives and new assessments and points of view to create a forum for elaboration of broad and efficient consensus concerning economic and technological strategy.

In principle, UNIDO could play a positive role by providing methodological support (disregarding financial support) to the Russian Federation's projects in the field of technology foresight. Such support would be perceived by government and academic circles as well as by the general public as necessary for building a more constructive paradigm of elaboration and realization of the economic reforms policy—a paradigm of active construction of the future, and active preventive policy for future problems and challenges.

Regional technology foresight programmes for Central and Eastern Europe could promote and stimulate the elaboration of more adequate and active national variants regarding policy on social, economic and technological development, thus ensuring the innovative and ecologically stable character of those countries. The regional technology foresight programme will promote long-term visions of Central and Eastern Europe development, help to identify the role of technological factors, and in particular, national innovation systems, in achieving the strategic aims of social and economic development.

Conclusion

Concerning the Russian Federation's experience in realizing technology foresight projects, it is necessary to stress that there are several external factors and circumstances that can predetermine to a great degree the practical results of technology foresight, and thus its applied significance and effectiveness:

(a) Even large-scale projects could produce biased, inadequate results. In introducing technology forecast results in the policy-making process, the role of State authorities in the project team (the problem of ideological or conceptual pressure), is crucial. Organizational issues (e.g., balanced leadership, balance between intellectual freedom of the academic circles and a priori preoccupation of the government and industry representatives with specific pragmatic issues) and procedures for reaching compromises are also factors of paramount importance;

(b) The technology foresight project could be designed and realized as just a formal ritual activity, providing some a priori predetermined results. Opportunities ultimately exist to form expert teams (panels) for the technology foresight project providing just formal representation of the alternative points of view, but implicit domination of one a priori selected concept. In other words, there is an opportunity to produce alleged scientific basis for an a priori selected variant of economic or technological policy, and thus to prove its correctness and adequacy. In such cases where the economic and political situation is not stable (e.g., in economies in transition such as the Russian Federation and many other CEE countries and newly independent States) there are a variety of views concerning the right choice of policy for economic reforms and economic development in general. There are several groups of influence (government, opposing parties, industrial and financial groups) which are profoundly interested in introducing some specific bias in the technology foresight activity in order to use its results as arguments in political discussions, or to gain some economic advantage. Technology foresight as well as long-term social and economic forecasts are politically sensitive areas for applied economic analysis;

(c) There is an opportunity for the domination of technocratic approaches to the solution of problems of social and economic development in the technology foresight projects. Technological development is not a panacea; only a limited number of economic and social problems could be solved by means of technological changes;

(d) The availability of government bodies formally responsible for elaboration and implementation of policy on technological developments and market-oriented institutional reforms in the sphere of innovation are necessary, but these are insufficient prerequisites for the effectiveness and adequacy of technology foresight activity. Within the technology foresight methodology there are no guarantees against implementation of the a priori biased approaches to working out economic and technological forecasts, initial scenarios and selection of alternatives. Technology foresight and long-term forecasts could just as easily be the tools of ideological pressure or ideological influence on public opinion;

(e) Long-term forecast or technology foresight are types of research activities that could provide the scientific base for achieving national consensus on current economic and technological policy, corresponding to the long-term development context;

(*f*) The lack of financial and material resources necessary for elaboration and implementation of active preventive policy concerning future problems is not sufficient cause to exclude these problems from the context of a current economic policy.

3 Enlargement seen from the other side (foresight in a pre-accession country)

Ferenc Kováts*

Abstract

The future of Europe, especially its global competitiveness, is strongly dependent upon the success of the enlargement process. Thus, it is necessary and inevitable, both for EU members and countries of Central and Eastern Europe and Newly Independent States, to be not only aware of positive prospects, but also to be prepared to overcome the difficulties. There is no "free lunch" for either side.

It is essential for pre-accession countries to face globalization and integration. It is equally imperative to outline in detail the opportunities and dangers presented by globalization and integration, especially from the point of view of a small country.

Regional aspects of EU enlargement and the feasibility of a regional foresight exercise must be discussed.

Among the many forms of assistance of the various international organizations, the practical benefits of the regional initiatives of UNIDO should be analysed. Best foresight practice can be executed more easily using the Manual and the so-called Easy Software; and through the utilization of three types of software, (Surveylet, Strategylet and Tracklet) and processing on-line Delphi exercises, allowing results to be obtained faster and in a more cost-effective manner.

The comparison between the Latin American and Central and Eastern European foresight exercises has resulted in several unexpected findings, uncovered similar problems and underlined the need for interregional cooperation.

Background and major characteristics

The future of all European countries—members of the EU, or not—is dependent upon the future of Europe's competitiveness in the global environment. Following enlargement, Europe will, in purchasing power terms, be by far the largest common market in the world, with a population of over 550 million.[1]

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[1]*Futures Report* (EC JRC-ITPS).

However, the continuity of the EU's cohesion and the competitiveness of our continent depend upon the stability of the new members. Central and Eastern Europe must, therefore, become a safe, stable and prosperous region. The process of enlargement of the EU will need basic socio-economic changes in Central and Eastern Europe, partly in addition to the ongoing fundamental economic and social changes incidental to the transition of centrally planned to free-market economies.

The Government of Hungary realized both the necessity and the difficulties of this transition period. In order to create public awareness and consensus, a foresight programme was launched in 1997. At that time the so-called transition decline started to turn into economic growth, so it was time to think about medium- and long-term tasks. The aim of the Hungarian Technology Foresight Programme (TEP) has been to prepare recommendations for improving the long-term international competitiveness of the country and the quality of life of its inhabitants.

The TEP utilized the experiences of other foresight exercises—the British and German foresight exercises in particular. The assistance of the British Council and personal help from the staff of Policy Research in Engineering, Science and Technology (PREST) and the ISI proved to be very useful.

The programme was financed by the Government, but was realized by individual experts in their own capacity who worked without any governmental influence in forming opinions or recommendations. The experts are leading industrialists, academics and government officials. It was ensured that the majority of industrialists and academics had close contact to business. The majority of work was done in seven panels, each consisting of 20-25 members. The TEP Office (six staff) managed the programme and progress was supervised by the Steering Committee (19 members).

The panel activities (regular meetings, special workshops, studies, scenarios, recommendations, final report) were complemented by Delphi surveys. A detailed description of the structure and methodology used by the TEP is discussed in Mr. Havas' presentation, "Technology Foresight in Hungary", which is included in this volume.

Particular stress should be given to one aspect of the TEP: the so-called "macro scenarios" which were elaborated separately from the individual scenarios developed by the panels.

The future of the Hungarian economy is strongly dependent upon its competitiveness, in the same manner in which the future success of the enlarged EU is dependent upon its own competitiveness in the global market.

The future of our continent is a great concern for all of us and the scenarios for Europe published recently[2] do not provide only optimistic options. Among the drivers of the five scenarios in *Scenarios Europe 2010*, several may be useful for small countries. For example in the "triumphant market"

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[2]European Commission, Forward Studies Unit, *Scenarios Europe 2010: Five Possible Scenarios for Europe*, (Brussels, 1999).

scenario, the unchallenged leadership of the United States model in technological innovation and enterprise organization may show our way for innovation policy for the future. In the "shared responsibilities" scenario, gradual enlargement accompanied by robust neighbourhood policies, development of a pan-European security umbrella addressing soft-security concerns, and positive socio-economic development in the CEE region can be cause for optimism. In contrast, the rather pessimistic descriptions of the "turbulent neighbourhood" scenario ("persisting instability beyond EU borders, chaos engulfing part of Eastern Europe, major problems with organized crime, terrorism and immigration") should compel us to be prepared for and to avoid—if possible—the less favourable options.

A detailed comparison of the macro-scenarios of the TEP and the *Scenarios Europe 2010* is beyond the scope of this presentation. It will be on the agenda (together with other available scenarios) of a workshop planned in the near future.

Preparing scenarios proved to be one of the most useful means to arouse participants' interest, and to raise ideas and proposals. It is strongly recommended for new foresight exercises.

The challenges of globalization

Globalization and integration

First, the difference between globalization and integration must be established, followed by the various forms of integration.

The expressions globalization and integration are frequently confused—probably because they are closely related, overlapping in many respects. Both are practically unavoidable and may have rather similar advantages and drawbacks.

However, there is a basic difference between them. Globalization is independent of our will. You may like it or not, but it is spreading at increasing speed. Integration, on the other hand, is a voluntary option, dependent upon (our) will. We may refuse it, or choose from its various forms.

Integration can be political or economic. Political integration (between countries) may have various strengths, it may appear in closer or looser relations. For pre-accession countries enlargement of the EU represents the most important form of integration.

The same can be said of economic integration. The mergers of big companies are resulting in international and multinational networks and represent the best examples of the overlap between globalization and integration. Their financial strength is sometimes greater than that of national Governments.

The importance of the globalization/integration issue is paramount in small developing countries, because it is often regarded as the source of all political disputes.

Impacts of globalization on society

The following section draws heavily from the *Human Development Report 1999* published by the United Nations Development Programme (UNDP).[3]

Globalization is more than the flow of money and commodities—it is the growing interdependence of the world's people. It is a process integrating not just the economy, but culture, technology and governance.

Globalization is opening many opportunities for millions of people around the world. Increased trade, new technologies, foreign investments and expanding media and Internet connections are fuelling economic growth and human advancement. Global markets, global technology, global ideas and solidarity can enrich the lives of people everywhere, greatly expanding their choices.

However, competitive markets may be the best guarantee of efficiency, but not necessarily of equity. Liberalization and privatization can be a step towards competitive markets, but not a guarantee of them.

The challenge of globalization is not to stop the expansion of global markets. The challenge is to find the rules and institutions for stronger governance—local, national, regional, and global—to preserve the advantages of global markets and also to provide for human, community and environmental resources to ensure that globalization works for people, not just for profits.

When the market goes too far in dominating social and political outcomes, the opportunities and rewards of globalization are spread unequally, concentrating power and wealth in a select group of people, nations, and corporations while marginalizing the others. Inequality has risen in many countries since the 1980s. The countries of Eastern Europe and the NIS have registered some of the largest increases in income inequality.

As globalization expands a variety of threats to human security are created:

- Financial volatility and economic insecurity such as that experienced during the financial turmoil in East Asia in 1997-1998;
- Job and income insecurity resulting from massive layoffs due to mergers and acquisitions;
- Health insecurity as a result of increased travel and migration;
- Political, personal and community insecurity results from illicit trade and global crime that corrupts business, politics and even police;
- Environmental insecurity results from poverty, over-consumption, traffic and military activities.

Globalization requires strong governance

Globalization offers great opportunities for human advancement, but only with stronger governance. Governance does not mean mere government. It means the framework of rules, institutions and established practices that set limits and give incentives for the behaviour of individuals, organizations and firms.

[3]United Nations Development Programme (UNDP), *Human Development Report 1999* (New York, UNDP, 1999).

National and global governance must be reinvented with human development and equity at their core. With stronger governance—local, national, regional and global—the benefits of competitive markets can be preserved with clear rules and boundaries, and stronger action can be taken to meet the needs of human development.

Economic policy-making should be guided by pragmatism rather than ideology and a recognition that what works in a particular country does not necessarily work everywhere.

The role of new technologies in globalization

Information and communications technology (ICT) and biotechnology are among the main drivers of globalization because of the following characteristics:

- The lead companies are multinationals: they are transforming the rules of competitiveness, new markets are opening up, strategic acquisitions are being made and alliances formed. The pace of change brings increasing uncertainty;
- People and firms will need new skills and knowledge to use and work with these new technologies effectively;
- These technologies raise global governance issues (for example, privacy and security in e-commerce and on food policy regarding genetically modified organisms).

The Janus head of globalization

Globalization has two faces, and decision makers should be cognizant of the benefits and drawbacks presented by each, as outlined here:

- Communications and networking seem to be the key drivers of future development (economic, scientific, cultural and social) and have the potential for yielding unprecedented benefit especially for small countries;
- Small and medium-size companies will have access to global information on markets, technologies and innovations. They can participate in global competition, because they will have access to markets all over the world;
- Research and development institutions can be present in the global R&D arena and colleagues can exchange information within minutes. Small scientific workshops, laboratories and individual scientists can participate in global cooperation without leaving their country or institution. They will have access to new methods and up-to-date instruments;
- The potentials in cultural life (entertainment, music, literature, films, games, etc.) are being realized already in our everyday lives. The Internet is one of the best means of exchange in this arena;

- Concerning communications, mobile phones yield a never anticipated means for developing countries to catch up with the rest of the world, or even to overtake industrialized countries.

The above benefits do not come without costs, however. The following features of the "other face" of globalization should be considered:

- In order to be able utilize the above advantages, one has to be a member of the "network". The country must have proper infrastructure and up-to-date communication facilities. The users of the network must be educated;
- The same pertains to the small enterprises; they can have access to world-wide markets for their products if the quality and prices are competitive;
- Research teams may have fruitful cooperation with their partners only if they have competitive knowledge;
- The cultural influence through the mass media has its unwanted side effects. Traditional cultural values may be jeopardized.

Role of non-governmental organizations

The discussion of globalization would not be complete without mentioning the increasing global influence of various citizens' groups, including non-governmental organizations (NGOs).

Their most successful action was undertaken in Seattle. The difference between the working methods of official politicians and the NGOs was striking. The "... NGOs that descended on Seattle were a model of everything the trade negotiators were not. They were well organized. They built unusual coalitions (environmentalists and labour groups ...). They had a clear agenda—to derail the talks. And they were masterly users of the media."[4]

The influence of NGOs contributes to deepening divisions between the United States and Europe (agriculture, farm-export subsidies, genetically modified products) and between rich and poor countries regarding future liberalization. This influence also raises doubts about whether the World Trade Organization can cope with its 135 member-countries all demanding their say.

Citizens' groups are increasingly powerful at the corporate, national and international levels. The question of whether or not their activity is the first step towards an "international civil society" (whatever that might be) is increasingly relevant. Or, do they represent a dangerous shift of power to unelected and unaccountable special-interest group?[4]

How to handle globalization

The basic rule for handling globalization is to find the ways to utilize its advantages and reduce its damages. This may sound like a platitude, but one

[4]*The Economist*, 11 December 1999.

must bear in mind that all slogans and appeals to go to war against globalization are more than useless—they are perilous, because during the hopeless fight, time is wasted and opportunities lost.

Potentials of EU enlargement for small countries

The opportunities (and dangers) that the enlargement of the EU may create for small CEE countries and newly independent States are related to basic changes in their competitiveness. This pertains to the national, enterprise, or even to the individual level.

Survival of enterprises—especially of the smaller ones—is dependent upon their buoyancy. Heightened world-wide competition requires a high level of adaptability from the participants. The main components of successful adaptation are: quality, information and marketing, flexibility and innovation, properly educated staff and good luck.

Concerning quality, it is important to be conscious that its various forms are equally important. Not only the product, but also the whole manufacturing process must meet the relevant requirements. It is not sufficient to make products of good quality; they must be identical, not just similar. The concept of "content uniformity" is spreading from the pharmaceutical industry to the chemical and the agro-food businesses. The philosophy of quality management (or total quality management) is going to be generally accepted and required.

The quality issue has some unwanted side effects as well, which are important, especially for small companies. First, formal compliance with internationally accepted requirements or standards is not a guarantee of appropriate quality. Second, the exaggerated requirements can be unnecessary and misleading. Examples from the fruit and vegetable markets are well known: apples that are uniform in size and colour but tasteless are imported for high prices, while apples that are delicious but not uniform are unexportable. The unnecessarily high quality parameters of certain cosmetics can also be mentioned.

Deliberately exaggerated quality requirements for certain drugs and foods belong to the sophisticated weapons of rich companies, because the necessary instruments, manufacturing and/or testing procedures are usually out of reach of their competitors.

The role of information cannot be overemphasized. A pragmatic response to the market demands and opportunities is essential in a competitive environment, and can be done using the Internet and other networks as practical tools. Data processing (analysing the data-dumping) needs skill and experience. Computerization and networking are indispensable if small companies are to keep up with bigger competitors and reach distant markets.

The most significant potential for pre-accession countries provided by enlargement is the direct access to the market of the 15 EU member States. The challenges of this market will revitalize the economies of CEE countries. It is difficult to exaggerate the importance of this issue. Meanwhile, dangers of both naive optimism and demagogic pessimism must be overcome. The enlarged common market yields new, hitherto never seen possibilities—but only for competitive products and producers. This applies to the whole enlarged territory, i.e., also at home, since competition will not be limited to the Western part of Europe and cannot be stopped at State borders. Preliminary phenomena have already appeared: Western products, networks and franchises are spreading in the Eastern European market even before formal political unification has taken place. The broad variety of goods is a pleasant experience—especially for those who can afford to buy them—and an unexpected surprise for those whose products become obsolete.

Awareness and preparedness for the basic changes in market situation are essential. One of the main tasks of the national foresight exercises is to build and disseminate these capabilities.

Flexibility and innovation are interdependent issues. All participants of the competition—be it regional or global—must be flexible: they have to react quickly and properly. The smaller the enterprise the more flexibility is needed. Flexible and quick reactions can be realized only in a suitable milieu, i.e., in an innovative society.

The protagonists of a national innovation system are the enterprises; the main actors are the research and development institutions, technology transfer ("bridge") companies, banks, investors and governmental and non-governmental organizations. The excellence of the actors is important, but success is dependent upon their cooperation. The detailed discussion of how to create and maintain an innovative society is beyond the scope of this paper, but it has to be emphasized that one of the most difficult tasks of pre-accession countries is to improve coherent interinstitutional linkages between the main actors of the national innovation system (the universities, academies and enterprises), namely, to build an innovative economy/society.

The importance of properly educated manpower has already been mentioned in relation to the new skills needed for computerization and networking. Education is a major investment, financed mostly by the public in Europe, with the exception of Germany where the share of private financing is 22 per cent. Public resources, however, are often transferred to private educational services. Given the emphasis on the knowledge economy and the role of technologies, educational expenditure is likely to enter a new growth phase, in spite of the shrinking size of the youth cohort. This statement relates to the EU countries. For pre-accession countries even more is needed.

One of the most important statements of the TEP is that in order to be able to become a reliable partner and to catch up to EU countries, Hungary has to increase its GDP, expenditures in education and in the quality of life at a higher pace than its Western counterparts. This aim seems to be rather ambitious, but is necessary. One of the problems is that apart from financial constraints, traditional education systems are slow to change and have limited scope for productivity improvements.

One source of skilled manpower for professional education of the new generation in various industries is—or in Hungary was—realized by industrial enterprises. Unfortunately, due to the collapse of many major companies this sort of education has practically disappeared. Although occasional or regular training courses still exist in certain companies, the resuscitation of this form of vocational education seems to be hopeless.

Another difficulty is that education is currently targeted at initial stages of life. The changes in the technologies (but also in our everyday life) make our knowledge quickly obsolete. So it is not by chance that recommendations for "life-long learning" can be found in several—if not in all—foresight reports.

This field provides an excellent opportunity for (small) private enterprises to join or rather, to start the private education business, thus participating in the development and broadening of national educational systems.

Subsidies are often mentioned as concomitants of EU enlargement. In order to avoid misunderstandings, it is important to stress that assistance for pre-accession countries is necessary, but coming from EU taxpayers is not free of charge—it must provide benefit for the donors. The benefit will be an enlarged, prosperous and globally competitive common market.

Stability and safe conditions together with a healthy environment must be brought into being not only because of humanitarian considerations, but because they are sine qua non conditions of the compatibility of the enlarged EU. This transition needs efforts and sacrifices on the part of the affected countries as well. There is no free lunch, and there is no free accession either.

Research and development

R&D has traditionally been an essential part of Hungary's innovation system and an engine of technical development. Recently it has been observed that the country's ability to enter into the international scientific arena and economy is strongly dependent on its state of scientific infrastructure. Namely, in the process of technology transfer a certain technical level (including the necessary scientific background) is needed from the receiving partner. Therefore it is essential for CEE and NIS countries to preserve their R&D capabilities, maintain their functioning and retain personnel to the extent possible.

R&D potential has encountered severe cutbacks in the region. Scientific life and research have traditionally been strong in Hungary. However, the economic transition in the last decade has not been favourable to R&D. Industrial research has virtually collapsed. Conditions in industry are not conducive to undertaking R&D activity. Many companies are struggling for survival and follow rather short-sighted attitudes: lacking R&D strategies, they are pursuing drastic cutbacks in such expenditures.

Fortunately there are positive examples as well: vitality will return gradually to more and more companies. Several multinational companies have set up their own research organizations in Hungary (for example, General Electric, Ericsson and Nokia), which is a positive development.

The Government has recognized the essential role of R&D in economic development and started ambitious initiatives (outlined in the: Széchenyi Plan) to stimulate demand-side oriented R&D projects.[5]

Recognizing the impact of science and research on competitiveness, growth and jobs and on the quality of life in Europe, the Heads of State and Government of the Member States of the European Union endorsed the creation of the European Research Area (ERA) project, and put it on the EU agenda in the form of a central plank of Europe's knowledge-based economy and society. The project will be executed by IPTS.[6]

The prospective cooperation and network of the European (not limited to EU) research institutions and facilities will give incentives to scientific life and contribute to enhancing the competitiveness of Hungary.

Regional aspects

To benefit the most from the globalization process and integration of the economy in the global market, a long-term development vision of a region is badly needed. (This relates to states and regions of a particular country as well, but in this section the focus of our attention will be directed to the CEE and NIS region.) That was the philosophy of UNIDO when the "Regional Initiative on Technology Foresight for the CEE and NIS countries" was launched.[7]

This approach, as such, is not new. In the last decade (in addition to the traditional geographic groupings such as the Balkan States, Central European States, Eastern European States, or Newly Independent States) several regional movements have emerged. For example:

- Vizegrád Countries;
- Pre-accession countries;
- Central European Initiative;
- East European "Benelux" Countries;
- Danube Countries;
- Carpathian Countries.

The list is far from complete, however it is a significant sign of demand for regional integration and underlines the importance and timeliness of UNIDO's initiative.

On the other hand, is it necessary to start another project in addition to the EU's European Research Area project? The question can also be formulated: What is special in the initiative of UNIDO? The answer is the method, i.e., the use of foresight exercises.

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[5]Gy. Matolcsy. Hungary in transition to EU (Széchenyi Plan).

[6]JRC Institute for Prospective Technological Studies, Seville, Spain.

[7]Regional Forum on Industrial Cooperation and Partnership in Central and Eastern Europe and the New Independent States, Budapest, Hungary, 12-13 October 2000.

The usefulness and advantages of a foresight exercise in general have been widely discussed over the last few years, so they should be known. Results of national foresight programmes and methodological aspects are given in other presentations at this conference. The following statements and recommendations concentrate on the most important issues proposed for envisaged foresight exercises.

First, the question, "Are these national or regional foresight programmes?" must be answered. The answer is, "Both". The future of a particular country is dependent upon that of its neighbours. This interdependence makes it necessary to prepare a regional foresight programme in addition to the individual country programmes.

The second question is, "Which comes first?" The answer is, "The national programme comes first." The regional foresight programme must be a synthesis of those of the involved countries, similar to the IPTS Futures project which was based on the statements of the national foresight reports. However, in order to ensure the conditions of a synthesis, some common points and parameters—called "cornerstones"—for the national foresight projects must be determined. In all other aspects the national foresight programmes must remain independent from each other; this is the real basis for the success of the regional foresight exercise.

The next question is, "How are the foresight exercises executed?" The answer is not as simple as those to the above two questions. A short survey of the various foresight exercises makes us certain that at present there are no similar foresight projects. In some cases they are not a "regular" foresight exercise but just a Delphi survey; in some others just a study or report. The majority use panels, with or without dedicated workshops and with or without scenarios. The scenarios may be their own or borrowed. In some cases the project is concluded with a report, some others are kept in motion and they utilize the process itself for the dissemination of statements and recommendations. The differences in methods make their comparison or benchmarking difficult; preparing a synthesis is practically impossible.

The following proposal may not be the sole answer but is a practicable one. The implementation of the programme must be executed in four steps:

- Preparatory stage. Before starting the project, the region and the participants are to be determined. The participation of all involved countries is essential;
- Thorough consideration of the aims, subjects, methods and time horizon (preferably 10-20 years) of the regional study and time schedule for the programme. To ensure the feasibility of a regional synthesis, the above-mentioned cornerstones should be selected. The elaboration of these cornerstones will be obligatory for all participating countries;
- Implementation of the national foresight programmes in the agreed time schedule. The output will be a report and dissemination of results;

- Implementation of the regional foresight programme. Input consists of national foresight reports. The output will be a report and dissemination of results.

Some issues for the regional foresight programme are recommended as follows (the list is not complete and does not represent a sequence of priorities):

- Knowledge of society;
- Health of society;
- Civil order;
- Environmental (natural and built) protection and sustainable development;
- Transport and traffic (personal, goods);
- Energy (production and utilization);
- Research and development (information and communications technology, life sciences);
- Where, what, how and why to produce (agriculture, agribusiness, industry);
- Financing, banking and insurance;
- Tax and customs policy;
- Prudent governance, new role of the State, globalization, integration and competition.

It is not difficult to forecast that the hardest task of the regional foresight initiative will be the creation of harmonized scenarios for the development of the particular countries.

Role of international institutions in technology foresight

Recently foresight has become a widely spread means of systemizing participative public policy debates at a national level on the future impacts on science, technology and on their interrelationship with social and economic drivers of development. The following summary tries to give concise information on those institutions that may be able to provide help or assistance to foresight exercises.

Institutions of the European Commission

In view of the rising importance of foresight, a recent restructuring of the European Commission's Research Directorate General has resulted in the creation of a Foresight Unit (K1) within the newly established Directorate K: Technology foresight and socio-economic research.

Directorate K is responsible for economic analysis of research, science and technology indicators and the management of socio-economic research and cooperation activities. Foresight Unit K1 is tasked to stimulate a European Area for science and technology foresight and to collect and synthesize results of foresight for informing EU research policy. It is also in charge of science and technology foresight and links with the Institute for Prospective Technological Studies (IPTS).

The Joint Research Centre (JRC) has the mission of providing scientific and technical support for EU policies. One of its specialized research units is the IPTS in Seville, which is the centre of competence in the field of foresight and prospective studies and supports the design and development of EU policies.

The IPTS has stimulated the creation of a European community of foresight specialists and developed its own EU-level foresight work. The IPTS Futures Project (already referred to in this paper), which concluded its first cycle in February 2000, constituted an EU-level foresight study. It drew on national-level expertise, and made extensive use of the written outputs of national foresight exercises. The reports of the IPTS Futures Project may be regarded as a model for "foresighters".

A special volume of the "The Wider Picture: Enlargement and Cohesion in Europe" addresses the issue of enlargement from the point of view of the EU countries.

As a continuation of the Futures Project, IPTS has organized a Thematic Network on Foresight in Enlargement Countries and recently launched the Futures Project on Enlargement intended to be a major foresight initiative for pre-accession countries.

Institutions of the United Nations

The United Nations Development Programme (UNDP) initiated the *Human Development Report* series in 1990. The annually published reports are oriented towards stopping the mismeasure of human progress by economic growth alone, and consider the sustainable human development (quality of life) as well. They can be useful for the evaluation of socio-economic impacts of technological development.

The Institute for New Technologies of the United Nations University (UNU/INTECH) conducts research and policy-oriented analyses and undertakes capacity building in the arena of new technologies: the opportunities they present, the vectors for their generation and diffusion, and the nature of their economic and social impact, especially in relation to developing countries.

Last but not least, support services of UNIDO and the International Centre for Science and High Technology (ICS) for the CEE and NIS countries that intend to conduct foresight exercises can be summarized as follows:

(*a*) Organizing seminars and forums to build awareness and commitment in the particular regions and countries. The objective is to create international platform(s) of discussion to ensure that the interest in technology foresight in the region is real and backed by practical intentions and commitment;

(b) Exchange of experience, supplying methodology to conduct best practice foresight;

(c) Reciprocal exchange of experiences between regions.

A UNIDO-ICS Initiative for Latin America and the Caribbean started in December 1999 and after one year notable progress had been reported.[8] The comparison between the case studies of Latin American and some CEE countries produced striking similarities and proved to be very informative to both regions. One of the common problems seems to be the change in social inequality and development of GDP in the Latin American and CEE regions. The study conducted by the World Bank in Latin America comparing the changes of income distribution between rich and poor cohorts, and the development of GDP of countries in the last decade are very informative for our region as well. The Steering Committee of the Hungarian Technology Foresight Programme envisages investigating the socio-economic impacts of the transition process and analysing the comparison between so-called "transition countries" of different regions (for example, Latin America and South Africa).

The most valuable support of UNIDO to new foresight exercises is their "foresight tool kit" which provides software and manuals that should reduce the costs of implementing foresight programmes. They provide information on methodology, information on current ongoing foresight projects, benchmarking and execution of on-line Delphi questionnaires.

A manual on foresight will be translated from Spanish into English soon. It will help to select the most appropriate methods to conduct the "best foresight practice". "FirstClass" software will be available for members of the network through the Internet and will contain information on ongoing foresight projects all over the world.

Surveylet, Strategylet and Tracklet are members of a software family developed by the Central University of Venezuela and Calibrium Ltd. (United States) for conducting and processing Delphi exercises on-line. The software will be available, under special conditions, to the countries participating in the UNIDO foresight programmes.

UNIDO, in keeping with its mandate, can provide assistance in—among other areas—industrial policy formulation, metrology, standardization, quality management, environmental policy framework, rural energy development, cleaner production, pollution control, policy framework for small- and medium-scale enterprises, entrepreneurship developments, upgrading agro-industries and related technical skills, etc.

Central and Eastern European countries and the Newly Independent States have every reason to rely upon the assistance of the above-mentioned organizations. But it should be emphasized that commitment to the implementation of technology foresight cannot be borrowed.

[8]Technology Foresight: A UNIDO-ICS Initiative for Latin America and the Caribbean, (Trieste, Italy, 7-9 December 1999); and Technology Foresight Regional Seminar for Latin America and the Caribbean, (Montevideo, Uruguay, 10-13 December 2000). More details on the progress of foresight exercises in Latin America are presented in G. Aishemberg, *The UNIDO TF initiative and methodologies in Latin America*, ...

4 Technology foresight in Hungary: objectives, methods, results and lessons

Attila Havas*

Abstract

Experts and laymen in different historical periods and in different socio-economic systems have shared at least one desire: to know their future in advance or even influence it for their advantage. They used very different approaches and methods, from spiritual-religious ones to scientific investigations and various modes of planning. One might bluntly claim that the history of mankind could be written by analysing these different attitudes, methods and approaches towards the future. Recently, yet another future-oriented method is being used in an ever increasing number of countries, namely technology foresight. It has almost reached a point where it has become too fashionable, and too many expectations surround it.

Hungary launched its first Hungarian Technology Foresight Programme (TEP) in 1997. The country is undergoing fundamental economic and social changes—that is, the transition towards a market economy—and major institutions are currently being shaped. The first phase of the transition process is now over. Most firms and banks have been privatized and the most important political and economic institutions have been re-established, for example, a parliamentary democracy based on the multi-party system and the stock exchange. The so-called transition decline has turned into economic growth in the last few years. Therefore, it is high time to think about medium- and long-term issues. It is now possible to devise strategies aimed at improving the quality of life and long-term international competitiveness.

Foresight appears to be an adequate tool to bring together business, the science base and government in order to identify and respond to emerging opportunities in markets and technologies. In short, TEP should contribute to a national strategy based on a comprehensive analysis of:

- World market opportunities (new markets and markets niches);
- Trends in technological development;
- Strengths and weaknesses of the Hungarian economy and its R&D system.

TEP is a holistic foresight programme, based on both panel activities (formulating scenarios, conducting SWOT analysis, devising recommendations and

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policy proposals, etc.) and a large-scale Delphi survey. The Programme is being conducted in three stages, namely, the pre-foresight stage (October 1997 to March 1998), the main foresight stage (April 1998 to May 2000) and the dissemination and implementation stage (June 2000 onwards).

The presentation is aimed at analysing the reasons to launch TEP and its results achieved so far and it raises some methodological issues. It highlights the role of specific actors, namely foresight participants, the wider professional communities, policy makers, politicians and journalists in the various phases of the programme. It also reflects on the relevance of various foresight methods/ approaches in the transition context, and concludes with policy and methodological considerations.

It is important to note that it is not only the "products"—i.e., the different documents, final reports, policy recommendations—that are important results of a foresight programme, but also the "process" side, namely disseminating a new, consultative, future-oriented decision-making method and intensified networking, cooperation and institution-building activities. In other words, a foresight programme can strengthen the national system of innovation in two ways: through reports and recommendations, as well as by facilitating communication and cooperation among various professional communities.

There is an obvious scope for regional cooperation. It might be extremely useful to exchange experiences on methods applied in various countries, as well as identifying success and failure factors. Moreover, some analytical activities (issues that extend beyond national borders) might also be harmonized if there is a mutual interest in doing so. In other words, it can not, and should not be imposed by any national or international player. However, various international organizations, notably the European Union (EU) and the United Nations Industrial Development Organization (UNIDO), as well as national governments and professional associations might play a crucial role in facilitating this cooperation.

Introduction

Experts and laymen in different historical periods and in different socio-economic systems have shared at least one desire: to know their future in advance or even influence it for their advantage. They used very different approaches and methods, from spiritual-religious ones to scientific investigations and various modes of planning. One might bluntly claim that the history of mankind can be written by analysing these different attitudes, methods and approaches towards the future. Recently yet another future-oriented method is being used in an ever increasing number of countries, namely technology foresight. It has almost reached a point where it has become too fashionable, and too many expectations surround it.

This paper has rather modest aims: it does not intend to classify, characterize and analyse all the possible methods used to predict, influence or shape our future in different periods of time in different countries; nor does it attempt to provide a comprehensive methodological introduction to the foresight school. Its approach is a fairly practical, down to earth and descriptive one, sharing some preliminary results and tentative lessons/characteristics of TEP, the Hungarian Technology Foresight Programme.

As TEP is still in progress, it is too early to formulate firm conclusions. The paper introduces very briefly the concept of foresight; outlines the specific aims and methods of TEP; summarizes the main results and the constraints that had to be overcome during the process; highlights the role of specific actors, namely foresight participants, the wider professional communities, policy makers, politicians and journalists in the various phases of the programme; reflects on the relevance of various foresight methods/approaches in the transition context; and concludes with policy and methodological considerations.

Foresight: definition and rationale

Our world is characterized by increasingly rapid changes in which global trends cannot be stopped at national borders, and new technology is playing a growing role. The world is also becoming more competitive, with national competitiveness depending on technological, organizational and social innovation. As is widely recognized, firms cannot survive the ever more fierce global competition without investing in emerging technologies and strategic research. These activities, however, are often too risky or too expensive for industry to take sole responsibility for them. Therefore Governments must assume at least part of the financial responsibility. This, in turn, requires devising policy tools to promote innovation, based on thorough, comprehensive, strategic analysis.

Technology foresight—a systematic means of assessing scientific and technological developments which could have a strong impact on industrial competitiveness, wealth creation and quality of life—provides an essential tool to this end. Another reason why Governments have to take part in foresight is that exploitation of science and technology largely depends on effective networking between business, academia and government. Many Governments have realized the importance of foresight activities, and thus this relatively new, and innovative, technology policy tool is spreading across continents.[1]

Aims, methods and the first phase of TEP

Background: systemic changes

Hungary launched TEP, its first foresight programme in 1997. As the country is undergoing fundamental economic and social changes—that is, the transition towards a market economy—major institutions are currently being shaped. The first phase of the transition process is now over. Most firms and banks have been privatized, the most important new political and economic institutions have been re-established, e.g., a parliamentary democracy based

[1]For a detailed and systematic analysis of the rationale for foresight and description of national exercises, see the articles, papers and books listed in the References.

on a multi-party system and the stock exchange. The so-called transition decline has turned into economic growth in the last few years; therefore, it is high time to think about medium- and long-term issues. It is now possible to devise strategies aimed at improving the quality of life and long-term international competitiveness—the major goals of TEP.

Objectives

Foresight appears to be an adequate tool to bring together business, the science base and government in order to identify and respond to emerging opportunities in markets and technologies. In short, TEP should contribute to a national innovation strategy based on a comprehensive analysis of:

- World market opportunities (new markets and market niches);
- Trends in technological development; and
- Strengths and weaknesses of the Hungarian economy and R&D system.

These demanding objectives of TEP can only be achieved if researchers, business people and government officials join intellectual forces to assess Hungary's current competitive position and the impacts of likely global market and technological trends. Hence their realigned and reinvigorated relationships can be regarded as a means of the principal goal. However, the process in which these experts with different backgrounds communicate and share ideas about longer term issues, generate consensus, and cooperate with increased commitment in devising and realizing a national strategy, seems to be so crucial that it becomes an end in itself. The Programme is also aimed at strengthening the formal and informal relationships among scientists and engineers, managers and civil servants alike, spreading cooperative and strategic thinking.

Hungary will join the European Union in the near future. Accession to the EU is a major challenge, since it is likely to shape Hungary's future to a significant extent. It requires a clear and sound vision about Hungary's role and opportunities in the enlarged European socio-economic system. TEP activities and results can contribute to the success of the integration process.

Written TEP results are comprehensive analyses of strengths and weaknesses, visions based on these inquiries and likely global trends, as well as recommendations for public policies regarding how to realize the most desirable vision (future). These analyses and information should also assist Hungarian firms in devising and implementing their strategies to improve their competitiveness.

Methods and the first phase

TEP is a holistic foresight programme, based on both panel activities (formulating visions, conducting SWOT analysis, devising recommendations, policy proposals, etc.) and a large-scale Delphi survey. It is being conducted in three stages, namely, pre-foresight (October 1997 to March 1998), main foresight (April 1998 to May 2000) and dissemination and implementation (June 200 onwards).

Awareness seminars were held across the country in the pre-foresight stage to promote this new concept among experts and professionals. Participants and organizers of these seminars (that is, chambers of commerce and scientific associations) were also invited to nominate panel members.

A Steering Group of 20 leading industrialists, academics and government officials—deliberately comprising a majority of industrialists and academics with close contacts with businesses—was set up in October 1997 to oversee the Programme. Following a thorough discussion the Steering Group has defined the following topics for panel discussions:

- Human resources (education and employment);
- Health;
- Information technologies, telecommunications, media;
- Natural and built environment;
- Manufacturing and business processes (new materials and production techniques, supplier networks, globalization, etc.);
- Agribusiness and food; and
- Transport.

The above panels were formed and trained in April 1998; they began by identifying major developments in their respective fields and devising alternative visions (possible futures) for the long run. They have relied on the expertise of their members—who represent different schools of thought in a given field—as well as commissioned reports by other experts not belonging to foresight panels. They have also formulated statements for the two-round Delphi survey. Their tentative results have been continuously discussed with the wider expert community in their fields at workshops held across the country and organized jointly with the regional chambers of commerce and professional societies. All the background reports, the alternative visions and the Delphi statements have been made available on the Internet.

Characteristics of TEP: methodological issues

Having summarized the reasons to launch TEP and the methods applied, some methodological issues are highlighted in the remainder of this section.

Strong emphasis on scenarios, institutions and regulation

Given the transition process major institutions are still being shaped in Hungary, as opposed to, for instance, the United Kingdom, where "the lawn has been mown and watered for centuries". The fundamental institutions have crystallized in the advanced countries for quite some time, whereas Hungary is still at a crossroads. Moreover, coming back from the Soviet political, military and economic bloc and attempting to join the EU, which is also in the middle of a major transition process, the wider, international institutional context (economic environment) where Hungary is attempting to find its place, is changing. It is of the utmost importance to analyse this turbulent environment, hence the emphasis on formulating alternative visions, both at the macro-level (socio-economic framework conditions) and at the micro-level of panels. Macro-scenarios had not been developed in any other country engaged in foresight activities when TEP was designed.[2]

Regional scenarios have also been devised, as background documents, aiming at identifying the possible futures of that part of the Central and Eastern European region which might have significant influence on the Hungarian developments.

For the above reasons, TEP panels have also devoted a significant part of their interest to institutional development and regulatory issues. This is also reflected in the Hungarian Delphi statements: quite a few of them deal with these issues, rather than technological ones.[3] Moreover, respondents who returned the questionnaire put a significant emphasis on these non-technological issues as shown by the number of these types of statements among the so-called top 10 issues.[4]

Education and learning as input of competitiveness

There was a "Leisure and Learning" panel in the first British foresight exercise, where learning was mainly understood as a market opportunity, not as a major factor of competitiveness. TEP has opted for the latter approach, for obvious reasons.[5] Furthermore, human resources have also been given a significant emphasis in the work, and, concomitantly, in the recommendations of the Steering Group. More recently other programmes have followed a similar approach, e.g., the Swedish programme.

Employment as a unique issue

TEP has put education, learning and employment together in one panel under the heading of human resources. To my knowledge, employment has not been an issue anywhere else. Our decision, however, is self-explanatory in a country in transition, where unemployment was an unknown phenomenon

[2]Scenario-building has been an important innovation in the British foresight exercise, but only applied at panel level. More recently, macro-scenarios have been developed in the South African foresight programme.

[3]In comparison, the first British foresight exercise contained a Delphi questionnaire in which there were four categories: elucidation, prototype development, first practical use and widespread use. All clearly characterize different phases of technological development.

[4]An index was designed to reflect the combined social and economic effects of a given event/development (contained in a Delphi statement) based on the assessment of the respondents. The issues (statements) were ranked, and the first 10—with the highest score of the combined index—are called the "top 10".

[5]In the process of the second British foresight exercise, launched in April 1999, more emphasis would be given to learning as input to competitiveness.

for decades, before suddenly jumping to 12 per cent in the early 1990s (now it is down to around 7 per cent).

Broad issues as panel topics

In general, TEP has brought together various issues that were treated separately in most other foresight exercises. For example, the health panel covers life sciences, related fields of biotechnology, health care, pharmaceuticals and medical instruments. Some of these issues are not analysed at all in other foresight exercises (e.g., the health-care system) and others are treated in separate panels (e.g., life sciences has a separate panel and pharmaceuticals are included with chemicals in other exercises). Also, agriculture and food processing belong to a single panel in the Hungarian case (as opposed to the first British exercise).

Although TEP has tried to set up panels around broad issues, some real-life cases are even more complex and require expertise from many disciplines and economic sectors. For example, our health is influenced by a number of factors, among others by one's lifestyle, social status and diet, as well as the medical care system and the environment. All these issues belong to different panels, and. a close and well-reasoned collaboration is required to carry out a reliable, thorough analysis and formulate sensible policy proposals. Having recognized that need, some panels have joined forces (i.e., their budgets) in the early phase of the Programme, and together have commissioned a group of experts to analyse issues from different points of view. For example, the healthy diet issue is considered by both the health and agribusiness and food industry panels; issues relating to causes of allergy are analysed by the same two panels.

Given the legacy of the planned economy—that is, strong "departmentalism"—and the inherent isolation of various disciplines, this can be regarded as an achievement in itself.

Cross-cutting issues

In spite of defining broad fields as panel topics to be analysed, strong emphasis is also given to the so-called cross-cutting (cross-panel) issues. The panels are encouraged to identify and adequately deal with these issues while analysing major trends and developing alternative visions (futures) for their fields, and a list of them was developed at the very beginning of the TEP process. This list includes, among others:

- Education, training and re-training;
- Information technology;
- Environment;
- Accession to the EU (threats and opportunities, impacts);
- Competitiveness;
- Social cohesion;

- The role of large (multinational) and small and medium-sized (indigenous) firms;
- Control and self-control of different systems and subsystems;
- Research and development, manufacturing (services), marketing;
- New materials.

Special workshops were organized to analyse these issues, and two of them were incorporated into the Delphi questionnaire as variables, namely impacts of a given event/development on the environment and lack of skills as a potential constraint. The latter variable (availability of skills) has been used in a number of Delphi questionnaires (in the United Kingdom, Germany, Japan, etc.), but the former one is only applied in the Hungarian survey.

There are a number of "cross-cutting" Delphi statements, too, for example, those concerning environmental issues but formulated by other panels (health, information technology, manufacturing and business processes, etc.). We have collected these statements, and the respective panels—i.e., both those panels which formulated these "cross-cutting" Delphi statements and those which are affected by these statements—have been urged to analyse them.

The discussions of the panel and Steering Group reports so far clearly show that even more systematic efforts—and more sophisticated methods—are required to deal with these cross-cutting issues. There is also an obvious need to find appropriate, efficient and convincing ways and means to convey these complex "messages" to decision makers and opinion leaders.

Organization

The former socio-economic system has been influential concerning the organization and management of TEP. It has been a well-considered, conscious decision from the very beginning not to involve anybody from the former OMFB[6] in the running of the programme from a professional point of view (i.e., decision on panel topics, issues to be analysed, priority-setting, etc.). The role of OMFB has been restricted to providing financial and methodological support. No OMFB official sits either on the Steering Group or is a member of any panel.[7] Moreover, members of the Steering Group and panels have been appointed as a result of a wide consultation process. All the major decisions are taken by the Steering Group—more recently at joint meetings of the Steering Group and panel chairs and secretaries—or the panels themselves.

Ambiguous ("double") legacy of planning

Centrally set, mandatory plan targets were abolished in 1968 in Hungary, the first time among the centrally planned economies.[8] Yet, its legacy is still

[6]OFMB was a government agency responsible for S&T policy, supervised by the Ministry for Economic Affairs (previously the Ministry of Industry and Trade). As of January 2000 it is the R&D Division of the Ministry of Education.

[7]In comparison, the Chairman of the Steering Group was the Head of the Office of Science and Technology during the first British foresight programme.

[8]Central planning was not abolished until 1989.

rather strong among some experts, and it has had some important impacts on the foresight process, especially in its beginning. Two rather different consequences have become visible:

(a) Some engineers and scientists have understood foresight as just another form or tool of central planning, and hence wanted to devise just one future (vision, scenario), i.e., not alternative, qualitatively different ones, and seek funding for that target (as a sort of "central development programme or plan");

(b) Some other professionals have also understood foresight—at least at the first glance—as just another form or tool of central planning, and hence rejected it immediately.

The perception of foresight has considerably changed as TEP has progressed. Yet not everyone shares the same understanding of the role and aims of foresight.

Results and constraints

This section briefly reviews first the products, that is, the written results of TEP, namely the Delphi survey and the various reports, and then highlights some of the process results as well as some of the major difficulties and constraints experienced so far.

Delphi survey

The first round of the Delphi survey was completed in May 1999. Some 1,400 questionnaires have been returned, an average of 200 per panel. Each questionnaire consisted of 60-80 statements describing an event, development or phenomenon occurring in one of the fields analysed by the given panel and the following set of questions:

(a) Respondent's degree of expertise;

(b) Respondent's assessment of economic and social impact, and impact on natural environment;

(c) Period within which the event/development will have first occurred (including "never");

(d) Hungary's current position vs. advanced European countries in the following four respects: S&T capabilities, exploitation of R&D results, quality of production or service and efficacy of regulation;

(e) Constraints (social/ethical, technical, commercial, economic, lack of funding, regulatory standards and education/skill base);

(f) Promotion of development and application (domestic R&D, purchase of licence, know-how or ready-made products).

The second round was completed at the end of 1999, after which the data were processed and analysed.[9]

[9]For a more detailed account of the Delphi survey see Havas (2000).

Panel and Steering Group reports

Panels formulated the first versions of their alternative futures by September-October 1998, and have discussed, revised and extended them in several rounds, relying on the expertise of the wider professional community. (see examples of these alternative futures in table 1 below). They have also analysed the underlying structures, human resources, economic factors and results, as well as institutions and regulations in their respective fields. Their final reports have been based on background reports (some 15 to 25 background reports have been commissioned by each panel), panel discussions, Delphi results and conclusions of the series of regional workshops. The main chapters of these reports are as follows: a critical description and assessment of the current situation (a sort of SWOT analysis), alternative futures (visions) and recommendations (policy proposals) to "prescribe" the way leading to the most desirable—and feasible—future.

The panel reports were launched and discussed at a conference in June 2000, and then finalized by taking into account the feedback and conclusions of the conference.

Table I. Examples for alternative futures/visions developed by TEP panels

		Health	
	Health-oriented, multisectoral	*Restrictive, efficiency-oriented*	*Profit-oriented, driven by suppliers' interest*
Conditions	Conscious governmental policy, long-term professional programme	State supply: uniform, cheap, equally available	Minimal role of the State (regulation and public health)
	Public expenses: 5.5-6.0 per cent of GDP; private spending 3.0-3.2 per cent	Reduced public expenditures resulting in limited health care	Health expenditures: ~ 10 per cent of GDP; deepening gap between the poor and rich
Results	Public finance dominates	Rate of public finance: 60-65 per cent	Increasing role of private finance
	Priority: prevention	Meet non-financial requirements: ambulance, epidemic control, international regulation	Preservation of health is not a priority
	Basic health services for all	Limited services by the State, need for private finance	Fixed-price services predominate

	Information Technology, Telecommunications, Media		
	"Tiger"	*"Sparrow-hawk"*	*"Dinosaur"*
Technological trends in Hungary	Continuous, well-balanced development	Continuous, well-balanced development	Slow technological development, lack of convergence
Global environment	Favourable conditions	Strong influence of global players in Hungary	Favourable, but hardly any impact in Hungary
Role of the State	Active, promotes development	Passive, weak	Passive, weak
Impacts	EU-conforming regulation	National cultural heritage threatened	Economic and technological isolation
	Integrated ICT networks	Growing economic differences between regions	Size advantages are not ceased
	Agribusiness and food		
	"Garden" Hungary	*Drifting*	*"Green" alternative*
Overall features	Shift to vegetables, fruit, bio-cultivation	Grain-meat chain predominates	Socially and ecologically sustainable system
Integration	Local and global actors, mutually beneficial cooperation	By the pressure of the world market	High-level international collaboration
Knowledge intensity	High and wide-ranging	High, but only in a small circle	High and wide-ranging
Activity	State and farmers' coordinated responsibility	Low, foreign actors dominate	High: State and civilian self-organization
Results	Increasing employment	Fewer market players	Priority: employment and environmental farming
	Most dynamic development	Increasing efficiency in a shrinking agribusiness	Efficiency is subordinate to environmental and social aspects

Macro visions

The first draft of the so-called macro visions—analysing the broad social and economic trends at a macro level—has been developed and discussed by the Steering Group and other experts on several occasions.[10] Scenarios describing the potential developments of the neighbouring countries, broadly defined, were also developed and discussed in several rounds by the autumn of 1999.

[10]A group of experts coordinated by Anna Vári and László Radácsi drafted these scenarios in September-October 1998; they were discussed in November 1998 through February 1999, and revised extensively.

Having discussed a number of possibilities, three macro visions—alternative futures at the macro level—were elaborated. With hindsight, they can be depicted as cells of a 2 x 2 matrix, where the columns represent whether Hungary actively pursues a firm, well-designed strategy, and the rows describe if there are fundamental structural changes in the global settings (table 2).

Table 2. Three macro visions

	Drifting (no strategy)	*Active strategy*
Fundamental, structural changes occur in the global settings		*Macro Vision III:* Hungary is integrated into a new, "green" world by active strategy along a knowledge-intensive path.
No major changes in the global settings	*Macro Vision II:* Hungary is forced into the current system of the international division of labour by multinationals along a low-skills, low-wages path.	*Macro Vision I:* Hungary implements an active strategy characterized by strong integration and high level of knowledge-intensity.

These three macro visions share one common feature, namely in all cases Hungary is integrated into the international division of labour in the future, as it is already part of the global and European economic and political systems. In other words, we have excluded the case of isolation.

"Activity" or "strategy" is understood as an interplay of yet another "magic trio", namely the civil society, businesses and the Government. The actual value of this variable is determined by the intensity and quality of the activities of these players.

One major characteristic, that is, knowledge-intensity, is not represented by a separate axis in table 2 as it can be regarded as a dependent variable of "strategy". In other words, active strategies pursuing a path of low knowledge-intensity—and thus low value-added, low wages and weak local markets—as well as drifting along a highly knowledge-intensive path can be excluded from scenario-building.

All these macro visions take into account demographic, societal, environmental, economic and political factors as well as the physical infrastructure when describing potential futures. Policy recommendations of the Steering Group aim at facilitating Macro Vision I, emphasizing the importance of an educated, flexible and healthy population and an appropriate, strong national system of innovation. Of course, panel and Steering Group recommendations should be understood as equally important elements of an integrated policy "package".

"Process" results: workshops, networks, new ways of thinking

Taking into account the membership of the Steering Group and panels (some 200 leading experts), the respondents of the Delphi survey and the participants of the various workshops organized across the country, a few thousand industrialists, academics and government officials have contributed to the above written results. In other words, the products (that is, the reports) and the process are hardly separable. On the one hand, without a lively and constructive, creative process a high-quality final product cannot be produced. On the other hand, without inspiring "semi-finished" products (background papers, draft visions and reports) the process cannot be triggered at all. Experts would not attend meetings and workshops, or at least not at a satisfactory level, and people would not feel that they were being intellectually rewarded for their time and efforts.

However, the process in itself is a very important result, and it is worth mentioning that more than 100 regional workshops have been organized to discuss the Delphi results, background papers, draft visions and policy proposals. These workshops and meetings are likely to have contributed to the strengthening and redirection or refocus of existing cooperation and communication among different communities, as well as having facilitated new contacts and initiated new channels and actions. The extent to which these new forums have been useful, however, is very difficult to measure in an exact way.

There have been clear signs of emerging, strengthening and diffusing new ways of thinking. One important example is the fact that policy recommendations have taken into account the complex, multisectoral nature of crucial issues, e.g., health, environment and the information society. Moreover, non-panel-member experts have also understood the significance of these new types of policies, and have been willing to subscribe to them. In most cases consensus has been reached among the experts, although obviously not all them would share these policy conclusions. Moreover, the real challenge, and in a way the ultimate test, is to convince policy makers who are constrained, inter alia, by various political and/or ideological factors to implement these policies based on a new type of analysis. Obviously it is going to be an even more difficult task than to reach consensus in a professional community.

Another promising sign has been that a better understanding has evolved from the close relationship between technological and non-technological factors influencing the quality of life and competitiveness. It is reflected in the various reports and has been sensed at some workshops, too.

In sum, however, a systematic evaluation conducted by independent experts seems to be an inevitable step in establishing which process-type results and benefits have been achieved, and what needs to be done to improve the efficiency of the foresight process in the next phase of TEP.

Constraints

Two kinds of constraints are worth mentioning here: a psychological and an institutional one. The first one is mainly visible during the so-called main foresight phase, while the second one becomes apparent in the implementation phase. In spite of this somewhat abstract distinction, both constraints might be present in both phases. In practice usually there is no clear-cut separation between these factors; moreover, they might even reinforce each other.

The first constraint is the mind-set of a number of experts: in their view there is only one "scientific" way of analysing a field, and as a result it is possible to define an "ideal" development path. More precisely, there is only one scientifically acceptable, sound and feasible strategy, which is this "ideal" trajectory. They do not understand the importance of developing and analysing qualitatively different futures or visions. Some would even deny the very existence of these different possibilities. Only a few can be convinced or converted in the course of the foresight process, as this way of thinking has been deeply ingrained during their studies and subsequent decades of work. This points to the need for some foresight methods to be developed at universities.

The second type of constraints are the institutional (organizational) hurdles. Clearly there is tension between compartmentalized government bodies on the one hand, and the complex, multisectoral issues (e.g., health, quality of life, innovation systems, environment and information society) on the other. While the Governments are organized vertically, making communication and cooperation among various agencies very difficult, if not impossible, the fundamental issues are horizontal in nature. In the same way that generals fight the previous war when preparing for the next, Governments are preoccupied with the nineteenth century's problems, and hence their approach, attitude, decision-making methods and organizational structures are geared towards the past, not the present. In the meantime, the future is already here. It is obvious that we are living in a rapidly and fundamentally changing period, when we have to be prepared for future challenges.

Implementation

TEP results (panel reports, including policy recommendations) are currently being discussed by parliamentary committees and with government officials responsible for devising strategic plans of various ministries and other government bodies. Panel reports and proposals have been received favourably; some parliamentary committees have specifically asked the responsible ministers to form task forces to analyse how to implement policy recommendations put forward by TEP panels.

It is too early, however, to draw any conclusions on the speed and efficiency of implementation. Only three parliamentary committees had actually discussed panel reports by the end of March 2001; a number of others have only expressed their interest in doing so. A similar summary can be given about specific meetings held with government officials. For these reasons one simply has to wait before assessing the implementation stage.

So far there is no overall, mandatory plan to implement TEP policy recommendations. It might not even be a good idea, as that kind of approach or method might be in conflict with the underlying principles of foresight. A more cautious yet harmonized and coordinated method might be relevant and efficient. It could evolve somewhat naturally as the Prime Minister's Office, for example, is to be involved in most issues. Other ideas might emerge in the course of further discussions and meetings. In sum, this method has yet to be elaborated and agreed upon.

The role of specific actors in the foresight process

A number of groups can, and should, play crucial yet different roles in the national technology foresight exercise. Their connection to the policy- and decision-making process and practices are briefly highlighted below.

Foresight participants already constitute a somewhat diverse group. Some of them are directly and intensively involved in drafting, discussing and revising various documents, visions, policy recommendations and the final reports. They are members of, and experts working for, the Steering Group and the panels. Because of their close involvement they are the most committed to advancing the implementation of their proposals. They are respected members of their professional communities (which is why they have been appointed as Steering Group and panel members) and have both formal and informal channels to facilitate the dissemination and implementation process. They make or strongly influence decisions in their respective organizations, provide opinions on important issues and proposals formulated outside of the foresight machinery for various bodies, are asked to deliver lectures at workshops and conferences, publish articles in professional journals and/or in the more popular press (weeklies and dailies), and are interviewed more frequently than others.

Other participants, namely experts responding to the Delphi survey and/or attending seminars and workshops organized by the foresight panels, also contribute to the final products by giving their opinion. They are also committed to implementing policy recommendations, although to a somewhat lesser degree (in principle, at least) than those who are more directly involved in producing the reports. They have more or less the same ways and means for influencing the dissemination and implementation process as outlined above.

The wider professional communities, business people, university lecturers and other researchers should be informed as extensively as possible because eventually implementation depends on their day-to-day activities. The more they know about the foresight process and products, the more they are in the position to align their actions with the foresight proposals.

Government officials, policy makers and politicians clearly play a very direct role in formulating and implementing policies. A carefully balanced approach seems to be appropriate as far as their role in the various stages of the foresight process is concerned. In the so-called pre-foresight stage their participation at the foresight workshops is very likely to attract more attention since more people can be informed about the objectives, methods and expected results of the programme. This can be very useful. However, even then it should be emphasized that foresight is fundamentally not a political but a professional programme.

The next stage of the foresight process is more delicate in that aspect: the experience and insights of policy makers are obviously crucial in shaping discussions, identifying issues and formulating the various documents and conclusions. However, they should not represent any organization at this stage and their role must not advance the agenda of any ministry or government agency. Other views, obviously, should also be given the appropriate weight during these analytical activities. Because of these considerations government officials have been asked to join TEP panels as well as the Steering Group, but they have not been in dominant positions.

To regularly inform interested ministries and government agencies, an Interministerial Committee was formed at the very beginning of the process, and its members had the opportunity to represent the official view of the organizations delegated to them. (Ministries have also been asked to nominate panel and Steering Group members, but not necessarily their employees.)

Politicians and policy makers are crucial to implement any proposal: without them no decision can be made on budget lines, organizations, concerted actions, etc. Therefore, as already mentioned, a series of discussions and meetings are being organized with politicians (parliamentary committees) and policy makers for the implementation phase of TEP.

Journalists can also play both a direct and indirect role in the foresight process. Some of them can be panel members (as in the case of some TEP panels), or might be commissioned to write background reports (some TEP panels also did this). They need to be kept continuously informed through special briefing meetings, press releases and press conferences, allowing them to play their indirect role, that is, to inform the public. It is especially important that people be made aware of the impact of new medicines and other medical R&D results, food safety, biotechnology, information technology, new materials and energy technologies, etc., on their health, work and leisure time. In short, an efficient media strategy is crucial to a successful foresight programme.

It is practically impossible to involve lay people directly in the foresight programme. Although making all documents available through the Internet is a must, experience so far has shown that the public is not very active in reacting to foresight results even in those countries (e.g., the United Kingdom and Germany) where the use of the Internet is relatively high and foresight has a longer tradition than in Hungary. Citizens are represented to some extent by NGOs and they have been asked to nominate panel members and/or attend workshops organized by TEP (especially those active in the fields of environment, alternative agribusiness methods and energy technologies).

It is worth remembering a simple, but often forgotten fact in this respect: experts of a given profession are non-experts in many other fields. Hence when they are involved in various foresight activities as experts, they are also involved as non-experts and they can provide their views on a variety of issues (e.g., when education, health or the environment is discussed at Steering Group meetings). On the other hand, "non-experts" are also exposed to experts' views, and they can share those observations with their respective expert and non-expert communities.

The use of international foresight experiences in Hungary

Having discussed the various foresight techniques it was decided in 1997 that TEP should be a holistic programme relying both on a large-scale Delphi survey and panel methods (SWOT analysis, vision-building, explicit policy recommendations). Broadly speaking, this was the structure of the first British technology foresight programme. In the course of our work, it has turned out that some modifications are necessary; most importantly another level of vision-building has been introduced, namely the macro level. Other techniques have also been adapted to the Hungarian settings, discussed in more detail in the following sections.

In the course of TEP foreign foresight experts were invited several times to give presentations. Some of these occasions have been devoted to discussing the overall picture or nature of foresight, others discussed very specific techniques (e.g., in training seminars). Two international workshops were organized to discuss the preliminary results of TEP and lessons of other national foresight programmes (British, German, South African and Swedish). Hungarian experts have attended some specific meetings on foresight where they have benefited from both the formal presentations and informal discussions or had in-depth, face-to-face meetings with foreign foresight experts.

In sum, the international foresight community has been very helpful from the very beginning of TEP, providing the experiences of other foresight exercises. Hungary has tried to avoid the mistakes made in other countries (with some success), and adapted their methods and techniques to Hungary's circumstances.

The following sections offer a more detailed account as to the relevance of various foresight techniques in the Hungarian context.

Raising awareness

A narrow definition of foresight techniques would not include seminars on raising awareness. However, if we think of foresight methods, not only techniques in the strict sense, we should consider the role of awareness seminars. Foresight should be as participative as possible and it is crucial to inform the various actors (e.g., academic and business people and policy makers) about the objectives and methods of a foresight programme from the very beginning, and even more importantly, to involve as many of them as possible in different roles (panel or Steering Group members, respondents of Delphi surveys, participants of foresight workshops, etc.).

For these reasons TEP, following the British example, has put a strong emphasis on organizing awareness seminars across Hungary in the first stage of the programme (September 1997 through May 1998). Building on the contacts developed during this phase, dozens of further workshops were organized for the next stages of the programme: first to discuss the preliminary results and recommendations, and then to disseminate the final reports.

Delphi survey

In preparation for the Delphi survey a one-day training seminar was organized for panel chairs and secretaries, who also studied the Japanese, German, French and British questionnaires. It has been the panels' responsibility to formulate statements for the Hungarian questionnaire. The overall structure (i.e., the variables, questions or column headings of the questionnaire) was discussed and adopted by a joint meeting of the Steering Group and panel chairs and secretaries. Another training seminar was organized with an invited foreign expert on processing and interpreting the Delphi results.

The most important difference between the foreign and the Hungarian questionnaires has been that TEP panels formulated quite a few non-technological statements (issues related to human resources, regulation, policy, etc.) as opposed to the rather strict technological character of the Japanese, British and German questionnaires.[11] As already mentioned (see the section on scenarios, institutions and regulation), putting more emphasis on non-technological issues has been validated by the respondents (who were not involved in the formulation of the statements and have not "defended" their own work or ideas).

Another difference has been that we have asked for our experts' opinions not only on social and economic impacts, but also on environmental impacts.

Panel methods

TEP has relied to a large extent on the British methods, as mentioned above. Our panels have also organized consultative workshops, commissioned background papers, and on the basis of information obtained from these and other sources, have developed alternative visions (futures). These have not been fully fledged scenarios (i.e., an explicit chain of actions and events leading to an end result), yet they have been significantly more detailed than the ones developed by the panels of the first British foresight exercise. Again,

[11]The first German and French Delphi questionnaires were directly translated from Japanese, using the fifth Japanese Delphi questionnaire, which is why they are not mentioned in this comparison.

this is due to the very nature of the transition process: since major institutions have just been formed or are still evolving, TEP panels have put more emphasis on developing these alternative visions. It is worth recalling that the TEP panels were not organized along disciplines or economic sectors (as in the case of the first British exercise), rather they have analysed complex issues (see the sections on education, employment and broad issues as panel topics in this paper).

Steering Group discussions and report

The Hungarian Steering Group report is not just a summary of the panel reports (as opposed to the British or Swedish synthesis reports), but does, of course, draw upon the panel results. In short, we have "repeated" all the panel activities at a macro level: analysed the current situation, developed visions and formulated policy recommendations.

When developing the Steering Group report and discussing preliminary versions, experts were invited to give their opinion at Steering Group meetings. We have also searched for global and European scenarios and prospective studies as background information for our own analysis. Some were found, of course, but most were published too late for our own purposes.[12]

Conclusion and recommendations

The Hungarian foresight programme clearly shows that various foresight methods developed and applied in advanced countries can be relevant and useful in the context of transition. Obviously, some modifications and adaptation to the local needs and circumstances are inevitable. Some more detailed, but still somewhat general and tentative conclusions are offered below. (More precise recommendations can only be made in the actual context of a given country.)

Most of the tentative conclusions are formulated in the conceptual framework of the so-called innovation system approach. This understanding of the innovation process emphasizes the importance of communication, mutual learning and cooperation among various actors (e.g., scientists and engineers, business people and policy makers); strengthening existing institutions and building new ones; and developing formal and informal networks conducive to innovation. It is systemic as well in the sense that a successful innovation process encompasses not only technological elements (inputs, actors) but economic, organizational and social ones as well.

Consideration of the following aspects of the organization and the management of the programme is crucial:

[12]For instance, both "Europe 2010: Five scenarios for ..." and the reports of the "Futures" project (EU, JRC IPTS) were published after our macro visions had been developed.

(a) The design of the programme should take into account the level of socio-economic development; the size of the country in question; the socio-psychological legacy of central planning; the overall communication, co-operation and decision-making culture (norms, patterns, written and tacit rules); the legal institutional framework; etc.;

(b) Objectives should be formulated clearly at the very beginning. It must be determined whether the programme is limited to assisting in the decision-making process of setting narrowly defined R&D objectives, or it is geared towards broader socio-economic needs and problems of the country in question. That is,. what is the role of S&T developments, various policies and regulation in solving these broader problems, and what are the responsibilities of the various actors (government, scientists and researchers, businesses, NGOs, families, individuals)?;

(c) Thorough consideration also should be given to the following questions in the framework of the overall objectives: What issues have to be analysed by which methods (Delphi survey, wide consultations and discussions, developing visions, etc.) and by whom?

Given the challenges and the very nature of the systemic changes, it seems appropriate to stress the importance of visions (i.e., futures, or fully fledged scenarios) for a transition country both at panel (micro, mezzo) and macro levels. In other words, there is obviously room and a need for methodological innovations. The decision on appropriate issues for panel discussion is also crucial in terms of the expected output. One possibility is to set up panels to analyse various disciplines and/or economic sectors (as in the case of the first British foresight programme). A different approach would be to analyse broader socio-economic issues, like human resources, health, environment and business processes, with, of course, a strong emphasis on technological issues in that context. For transition countries the latter approach seems to be more appropriate; this approach has been followed by the Swedish and the second British foresight programme, too.

There are a number of important cross-cutting issues in all countries (for the Hungarian case see the section on cross-cutting issues in this paper). Because of their very nature—being at the crossroads of various fields—it is simply not possible to find a single structure that would allow the necessary complex analysis of these issues. Therefore specific attention needs to be paid to develop, and apply, a mechanism that would facilitate adequate co-operation among the various foresight panels and experts who approach these issues from different angles.

The transition process also calls for specific policy recommendations (as opposed to, for example, the Austrian, German and Japanese foresight exercises). Again, the decisions on the objective, methods and scope of the programme (e.g., whether it has a technological or a broader socio-economic focus) would influence the issues for policy proposals (e.g., human resources; regulation, competition and innovation in various fields; foreign direct investment and regional development policies; and institution- and network-building).

The other major foresight method, namely the Delphi survey, can be useful in transition countries not only to collect information (experts' opinions) but also to disseminate that information (during the second round), and involve more participants in the process as opposed to the case when only the panel method is applied. However, the Delphi survey should be carefully designed and certain aspects need to be considered thoroughly. Examples of questions to be asked are listed below:

- Is there a sufficient number of technical/ technological experts to run the survey, or is it better to target a wider, different audience?
- What structure is more appropriate: the traditional one aimed at collecting opinions or the more decision-oriented Austrian version?
- What is the appropriate balance between the strictly technological and non-technological issues in the statements?
- What are the appropriate questions (taking into account the nature of statements/issues and the country characteristics)?
- What is the appropriate size of the questionnaire (the number of statements and questions)?

For a successful, effective foresight programme strong emphasis should be put on organizing awareness-raising seminars in the first stage, and then on continuous, wide-ranging dissemination and discussions in parallel with the analytical activities. Without a carefully designed dissemination and implementation stage most of the efforts and resources committed to the programme in the first two stages (time of experts, tax-payers' money to cover the organizational and publication costs) would be wasted.

In sum, it is not only the "products"—i.e., the different documents, final reports, policy recommendations—that are important results of a foresight programme, but also the "process" side, namely disseminating a new, consultative, future-oriented decision-making method and intensified networking, cooperation and institution-building activities. In other words, a foresight programme can strengthen the national system of innovation in two ways: through reports and recommendations as well as by facilitating communication and cooperation among various professional communities.

Finally, there is obvious scope for regional cooperation. It might be extremely useful to exchange experiences on methods applied in various countries, as well as identifying success and failure factors. Moreover, some analytical activities (issues that extend beyond national borders) might also be harmonized if there is a mutual interest in doing so. In other words, it cannot, and should not, be imposed by any national or international player. However, various international organizations, notably the EU and UNIDO, as well as national Governments and professional associations might play a crucial role in facilitating this cooperation.

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5 Delphi Austria: an example of tailoring foresight to the needs of a small country

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Abstract

The world-wide diffusion and recognition of technology foresight suggests that it is of value for quite diverse types of economies and societies. Its merit as an important tool of strategic intelligence for policy-making in small countries and transition economies depends on a careful tailoring to specific needs. Practice of foresight is rather diverse among small countries, but approaches tend to be more selective in scope, have more specific goals, and put greater emphasis on demand aspects than in bigger countries. Austria's first systematic foresight programme (completed in 1998) is an example of an innovative approach tailored to the needs of a small country. This paper describes how Delphi Austria was tailored to a small economy which had undergone a successful catch-up process and how the foresight process and its results have been utilized.

The specific goals of Delphi Austria and its approach are explained as a selective, demand-, problem-, and application-oriented foresight exercise with a number of innovative elements. It has been built on a series of preparatory studies, expert panels, and two parallel large-scale Delphi exercises: a Technology Delphi exercise in conjunction with a Society and Culture Delphi exercise. Experiences with some other innovative elements are outlined: the modification of the classical Delphi exercise towards a decision Delphi; a broader definition of the expert base; the focus on technological as well as organizational innovations; a higher degree of "finalization" of measures; and the application of a so-called "megatrends section" serving multiple functions.

The focus of the Austrian Technology Delphi exercise has been on the following subject areas: tailor-made new materials (focus on metals); production and processing of organic food; environmentally sound construction and new forms of housing; lifelong learning; medical technologies and supportive technologies for the elderly; cleaner production and sustainable development; and mobility and transport.

The results of the foresight programme are built on a sufficiently broad basis of expertise to be used as an important information source for technology policy makers as well as other actors of the innovation system, in companies and research institutions. The process of involving a great number of these actors, either as members of one of the panels developing the contents of the Delphi

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questionnaires or as participants in the Delphi surveys, has already been a deliberately promoted and valuable result of the whole foresight programme. It has stimulated cooperation and networking, which is seen as a strengthening of the national innovation system. Delphi Austria has also raised foresight awareness and triggered other sectoral foresight projects. In addition, it is shown that the results of Delphi Austria have had considerable impact in research and technology policy. They have directly influenced the start of new support programmes (in the field of sustainable production) and measures to support cluster building (food production). And they have been utilized for a newly created technology policy instrument, a programme named "K-plus", designed for promoting "competence centres" (centres of excellence); most of the proposals selected are in fields which have been identified as promising in the Delphi study.

Introduction

It is widely accepted that science, technology and innovation have become more important for today's economies and societies than ever. This clearly implies a key role for technology and innovation policy. But the question of how these policies should look for an individual country to achieve economic and social progress is not at all an easy one. Several factors make the design of appropriate policies a highly demanding task which requires strategic intelligence. They include the following:

(a) Increasingly liberalized global markets and global enterprises intensify the competitive pressure for all economies and call for strategies tuned to the situation of the specific country and region;

(b) The traditional rationale for technology policy has been changing. Advances in economic theory have extended the view from mere "market failure" to "systemic failure", i.e., the lack of coherence among institutions and incentives in complex innovation systems;

(c) Improved understanding of innovation and technology diffusion processes calls for policies which are capable of responding to a variety of challenges (Kuhlmann et al., 1999). These include: the changed nature of technological innovation processes necessitating inter- and trans-disciplinary research; the growing importance of the non-technical, "soft side of innovation" (design, human resource management, consumer behaviour); the transition from "mode-1 science" to "mode-2 science", a far more demand-driven mode of knowledge production (Gibbons et al., 1994). Hence there is increasing pressure to produce results in terms of concrete contributions to the solution of societal problems and to increased competitiveness of national economies.

More recent efforts to improve inputs into the design of effective technology policies have concentrated on instruments such as policy evaluation. Technology foresight is increasingly recognized as a useful policy instrument and source of strategic intelligence. It has been defined as "... 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, p. 140).

Some overriding trends have become visible along with the remarkable upswing of technology foresight during the last decade when it was establishing itself as a key policy instrument (Gavigan and Cahill, 1997; Grupp and Linstone, 1999). These include:

(a) In contrast to earlier periods one can observe a proliferation of foresight activities among practically all sorts of economies, not just among the leading industrial countries. Foresight activities take place in smaller countries as well as developing countries and transition economies;

(b) Foresight is no longer undertaken with the claim of forecasting or predicting a certain future situation but recognizes the possibility of alternative futures and also tries to shape or create certain paths of development;

(c) The foresight process, with its stimulation of communication and future orientation among the actors of the innovation system, is regarded at least as important as the outcomes in terms of identified areas of strategic research and emerging generic technologies;

(d) The function of mobilizing and "wiring up" national innovation systems adds to the function of informing science and technology policy-making, for purposes of priority setting, for example (Martin and Johnston, 1999);

(e) Increasing attention is being paid to socio-economic embedding and demand aspects of emerging technologies;

(f) Finally, with the growing diffusion of national technology foresight studies in Europe and indeed on a world-wide scale, a differentiation and blending of approaches, tailored to different sets of objectives, is occurring.

This paper starts with a look at the relevance of technology foresight for countries and economies of different sizes and development stages before giving a brief overview of practice, particularly in small countries. It then concentrates on specific characteristics of the Austrian foresight programme as a recent example in Europe. The examination of the Austrian case emphasizes the necessity—as well as possibility—of tailoring the design of a technology foresight programme according to the specific situation and needs of a country. Austria's approach is that of a small country which has undergone a very successful economic catch-up process since the Second World War. The country's foresight exercise was oriented towards responding to societal needs, the search for niches within world-wide technology trends where Austria could expect special opportunities to gain a leading position in the mid- and long-term, and corresponding prospects for product demand.

The relevance of technology foresight for different economies

The question to what extent technology foresight and in particular the goals and approaches established by large and highly industrialized countries are relevant for other economies is certainly important. In the past, foresight studies had been the domain of a few big players among industrialized countries, notably Japan with great regularity, with the United States as the pioneer. In the 1990s small countries began to move to the front stage of technology foresight and indeed make up a substantial part of the recent proliferation. But newly industrialized and developing countries as well as transition economies also have become increasingly interested in technology foresight.

The specific situation of small countries has a long research tradition (Soete, 1988). According to Katzenstein (1985) one has to acknowledge small States as a category of their own ("small" is defined here by a population size below 20 million). From an economic point of view, openness of the national economy, production for small segments of the world market, adaptation pressure exercised by economic "giants" and selective government interventionism are characteristic elements. Further characteristics such as stronger dependence on foreign trade, more limited resources for R&D and a disproportionate spending on basic science rather than on applied R&D may be added. A second part of Katzenstein's argument is that the economic openness and vulnerability of the small European States has favoured neo-corporatist political systems (which are less common in larger countries) and that both sets of characteristics together shape the politics and policy of industrial adjustment. While further research has led to some refinements and concentration on socio-institutional differences among small countries, the fact that they are under stronger pressure to specialize and that their adjustment policies will have to include an explicit "technology" dimension is most relevant here.

This situation suggests that for small countries technology foresight can indeed be an instrument to cope with these demands but that the approach would seem to require an appropriate tailoring to more specific goals. Rather than identifying emerging technologies of strategic relevance across a broad spectrum (as appropriate for big countries), developing or redirecting technological specialization strategies and matching national potentials with economic opportunities and societal demand are crucial for small countries.

For developing countries the situation and problems are of a different nature, although some of the distinctive features of small countries may be given in more extreme forms. Even if they might see themselves less in a position to compete in technology development, there are reasons for them to be interested in using advanced technologies, in identifying and realizing their national potentials to apply these within the economy in a future-oriented perspective, in stimulating key actors and institutions to contribute to this, and in informing their future policies in this connection on the national level. Indeed, a growing interest in technology foresight is evident among developing countries: Brazil, Indonesia, Malaysia, Mexico, the Republic of Korea, South Africa and Thailand are examples with activities in this field. The ways foresight is being applied by small countries and their experiences should in some respects also be a useful source for developing countries.

Transition economies in Central and Eastern Europe (CEE) are another type of economic system with different sorts of issues and problems. One common set of aspects is the shrinking of R&D systems and the organizational, functional and funding restructuring these systems undergo. The rationale for foresight as an instrument for science, technology and innovation policy in CEE countries could be to provide a mechanism to address structural problems and opportunities, helping policy to identify and respond to crucial linkages within the national innovation system. It also offers a mechanism to address trade-offs between different objectives (growth, competitiveness, sustainable development and equality) and a mechanism to depoliticize the process of S&T policy-making. A specific feature suggested by economists emphasizes absorption and transfer rather than generation of technology at the present stage (see Radosevic, 1999; 1997).

Many of the CEE countries are small and the approaches of countries with similar size are of interest. Out of the group of small countries in Europe, the Netherlands was one of the first to carry out a major technology foresight experiment with a study commissioned to the Science Policy Research Unit (SPRU) at the University of Sussex (United Kingdom) in 1988. It served as preparation for area-specific foresight exercises which were started by the Ministry of Economic Affairs of the Netherlands with mechatronics in 1989 and followed by six similar studies on adhesion, chipcards, matrix composites, signal processing, separation technology and production technology (OECD, 1996). An evaluation of impacts led to the design of a knowledge transfer programme oriented at SMEs and to another major technology foresight exercise titled "Technology Radar" in 1997/98. It identified technologies of strategic importance for the Netherlands and focused on the needs of business and industry (Netherlands Ministry of Economic Affairs, 1998).

Ireland has published the results of its first technology foresight exercise after a process of 12 months (Irish Council for Science, Technology and Innovation, 1999) and in Austria the first national foresight programme was completed in 1998 (it will be further examined in paper). In the early 1980s, Norway, Portugal and Sweden made their first steps in the area of foresight (Gavigan and Cahill, 1997). Towards the end of 1998, Sweden launched a new technology foresight project on eight quite broadly defined areas. Finland, which started the foresight process with the Technology Vision project in 1996, is preparing a further sector study in the chemical industry, following a foresight exercise in the food and drink industry. As the first out of CEE transition economies, Hungary has undertaken a major technology foresight project which started in 1997. Combining a panel and Delphi approach the Hungarian Technology Foresight Programme "aims at creating sustainable competitive advantage and enhance the quality of life by bringing together business, the science base and government to identify and respond to emerging opportunities in markets and technologies" and "should result in a national innovation strategy" (Havas, 1998). Other small countries have also carried out foresight exercises or are planning to do so, such as the Czech Republic, Denmark and Estonia.

Further examples could be added from other continents, e.g., Singapore in Asia. In the late 1980s, Australia had embarked on prospective studies and applied priority setting mechanisms. A first comprehensive foresight exercise at the national level "examined possible national and global changes to 2010 and Australia's key future needs and opportunities that rely on, or could be significantly affected by, scientific developments and the application of technology with an emphasis on demand-pull" (ASTEC, 1994; OST, 1998, p. 87). New Zealand has some experience in applying foresight for identifying international leadership opportunities in areas of national strength and priority setting after two exercises carried out in 1992 and 1995. New Zealand is planning for a further foresight project started in 1997, this time with greater emphasis on consultation of end-users of science and technology (Martin and Johnston, 1999).

Identifying common trends in the foresight exercises conducted in all these small countries can best be attempted using a set of criteria developed by Martin and Irvine (Martin, 1995). It means to look at characteristics such as those of the performing organization, specificity, functions, orientation of research, "intrinsic tensions", time horizon and methodological approach. In short, evidence from a number of well documented foresight exercises indicates that even among small countries the approaches are quite varied. However, some common traits may be pointed out:

The goals and scopes of foresight exercises are more frequently oriented at specific national conditions and the identification of niche potentials. Time horizons are less long term but more often around 15 years. More and more emphasis is laid on the value of the foresight process itself as a means to stimulate communication, mutual learning, innovation-oriented consensus and coordination among the actors within national innovation systems. Mobilizing innovation awareness rather than limiting the function of foresight to priority setting is prevailing. Decentralized and bottom-up approaches tend to be favoured and combined with central steering agencies, usually at national S&T policy level. To some extent a broadening of the expert base along with an integration of socio-economic demand and impact factors into foresight designs is observable. A stronger orientation towards the implementation, the applicability of results and transfer to SMEs is also more typical for small countries. Finally, a variety of methods is applied including the use of expert panels, widespread consultation, lists of strategic technologies, scenarios and also quantitative models, but some preference for the Delphi method is also visible. Many of these characteristics that are more typical for small than for big countries are most pronounced in the Austrian foresight exercise.

Goals and approach of the Austrian Foresight Programme

Austria's decision to undertake a foresight exercise came out of the following situation (Tichy, forthcoming). The country had undergone a successful catch-up process from a largely destroyed economy by the end of the Second World War to a position among the leading industrial countries. The closure of the income and technology gap had relied on importing foreign technology. With the position achieved in the 1980s, a policy change to master the difficult transition from a technology importer to a technology developer in promising future markets was perceived as highly necessary. As Austria is still specialized in a broad range of traditional medium-technology goods—though of the highest quality—a focus on three aspects seemed reasonable: to create and support conditions for successful independent fundamental innovations, to upgrade existing technology in general by marginal innovations, and to concentrate on a limited number of innovative high-tech-market segments (niches), in which fundamental Austrian innovations and consequently Austrian market leadership appear likely.

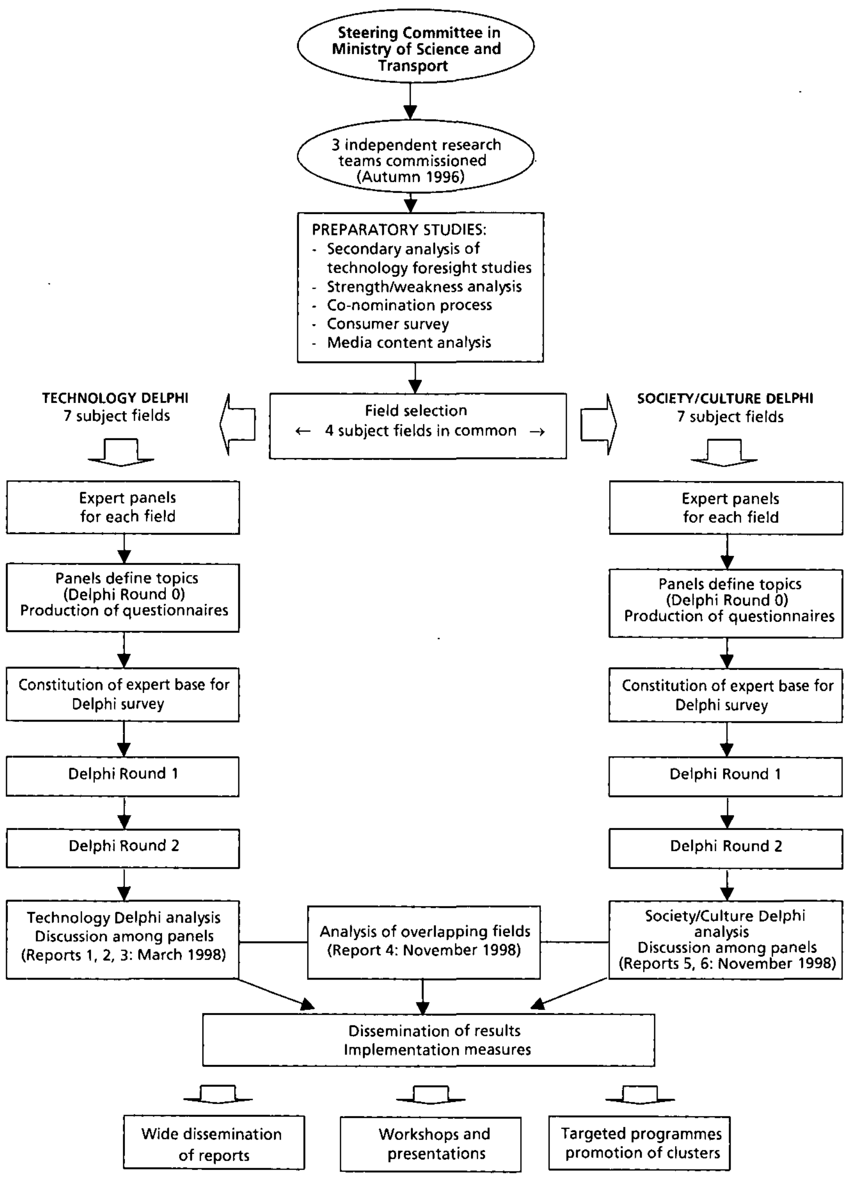
After several steps in this direction (e.g., the design of a comprehensive strategy for technology policy and a number of priority programmes in several high-technology fields) national technology policy was looking for new ways to stimulate the national innovation system effectively. The selection of priority areas was also seen as a problem and a concentration on a top-down approach proved less and less promising. Interested by foreign examples, the Ministry of Science and Transport decided to plan and commission a foresight exercise which would be tailored to the specific needs of Austria.

The task of the Austrian foresight exercise differed markedly from that of most of its foreign predecessors. Technologically leading countries such as Germany, Japan or the United States used foresight to search for emerging technologies, to concentrate their innovative efforts on emerging markets and to profit from first mover advantages. For Austria, however, a search for these emerging technological trends did not seem advisable—Austria can utilize the results of foreign technology Delphi studies. What has to be sought for are the market segments and niches within these world-wide emerging markets in which specific Austrian advantages in R&D, skills and production facilities provide good starting positions for successful innovations, i.e., innovations promising a good chance for future Austrian leadership in these very niches.

This situation shaped the overall goals and the approach of the Austrian foresight exercise. It had to be above all problem- and demand-oriented, responding to actual societal needs, and at the same time heading for the identification of the most promising areas of innovation in which Austria could hope to achieve a leading position both in R&D and in terms of economic success. Further objectives established from the outset were to build on a bottom-up flow of expertise. It was also clear that the foresight exercise should not deal with technology only; the technology foresight exercise should also include organizational innovations and was to be combined with a society and culture foresight exercise as a consequence of the declared demand- and problem-orientation. Finally, the Austrian approach aimed at producing information to be implemented through technology policy-making and at concentrating the foresight efforts on a selection of areas with particularly high priority.

It was in autumn 1996 when the first initiative for a systematic foresight process on a national level in Austria was launched. The approach which was developed for this foresight task entailed a number of innovative elements whereby two Delphi processes represented a core instrument. They will be outlined in the following text together with a brief overview on execution, major outcomes and impacts to date. To give an impression of the main building blocks of the Austrian foresight programme, its organization as a whole is summarized in figure I.

Figure I. Organization of the "Delphi Austria" foresight programme



Execution of the Technology Foresight programme

The Ministry of Science and Transport (now Ministry of Transport, Innovation and Technology)[1] commissioned different parts of the foresight programme Delphi Austria to three external research teams and established a small Steering Committee at the ministerial level (comprising some chief executives from different departments of the science ministry, a representative of the Austrian Academy of Sciences and a science journalist with experience as a former minister).

Essentially, the foresight programme Delphi Austria consisted of a series of preparatory studies,, a number of expert panels, a Technology Delphi and—as a quite unique feature—a combination with a Society and Culture Delphi.[2] The selection of areas on which the foresight exercise should concentrate and the topics within the field are of utmost importance. To solve this task, the main stage of the Austrian foresight exercise was preceded by several other foresight-oriented preparatory studies. The work of defining suitable subject fields was, however, less focused on technological development to avoid the frequent trap of new technologies urgently searching for application; rather it was problem-oriented, assuming that innovations with a potential to solve existing problems will also more easily find a market in the future, as is described by Tichy (1999):

> "The set of Austrian foresight studies started with *an analysis of the already existing foreign (Classical) Delphis,* to evaluate the predicted world-wide technology trends. Only those trends were considered as relevant for Austria which showed up in already existing Austrian strengths. To find these already existing strengths of the Austrian technology sector, the economic *literature was surveyed* and 350 *experts* (response rate 39 per cent)[3] *were interviewed*. Sectors leading in R&D were found to be medical science, environmental techniques and materials, sectors leading economically proved to be environmental techniques, physical mobility and materials. In all these fields the experts indicated good cooperation between academia and firms in addition to high competitive performance. The same survey and the same sample of experts was used for a *co-nomination study,* searching for the networks of appropriate experts, as a basis for selecting the experts for the working panels responsible for elaborating the questionnaires as well as for the respondents of the later Delphi survey. All these preliminary studies did, however, not suffice as they concentrated on supply while the Austrian Delphi study ought to give an at least equal weight to demand. Methods to forecast long-term demand for high-tech goods,

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[1]See annex IV, showing the present institutional set-up of the Austrian technology policy.

[2]The Technology Delphi exercise was designed and carried out by the Institute of Technology Assessment (ITA) of the Austrian Academy of Sciences, while the Institute of Trend Analysis (ITK) in Vienna was responsible for the Society and Culture Delphi exercise.

[3]Of whom 17 per cent were entrepreneurs, 23 per cent were physical scientists, 16 per cent were technicians, 13 per cent were social scientists and 19 per cent were administrators.

however, are still lacking. Two proxies, therefore, were utilized: A consumer survey and a media analysis. The *consumer survey* indicated a high acceptance of research in the fields of medicine, environment, energy and materials on the one side, and a heavy resistance against research in gene- and communications-technology. More than half of the respondents would not consume genetically modified food, even if it is better, and almost two fifths favour the production of bio-food, even if it is more expensive. The *analysis of opinion-forming media* yielded medicine, computer and telecommunication as the subjects most frequently dealt with, followed by bio-/gentechology and space-research. As an important non-technical cross-sectional area pragmatics of everyday life *(Alltagspragmatik)* showed up."

On the basis of these six studies the Austrian foresight exercise arrived at the selection of subject fields for the Technology Delphi. The following criteria were applied in the selection process in cooperation between the research teams and the Steering Committee: positive world-wide trend, capacity to solve problems, presumed high future demand, early stage of the product cycle, already existing strengths of Austria, complexity of the product or the process, acceptance by the population, sufficient differentiation of fields (portfolio aspect) and sufficient size of the field. A broad definition of technology was applied, including organizational innovations.

The resulting fields which were given highest priority and hence deemed subject areas of the Technology Delphi foresight exercise are the following:

(a) New forms of housing and environment-oriented construction;
(b) Lifelong learning;
(c) Medical technology and support for elderly people;
(d) Clean and sustainable production;
(e) Organic food;
(f) Physical mobility;
(g) Tailor-made materials.

The combination with the subject fields of the Society and Culture Delphi will be described in the next section. In total, the Austrian foresight exercise comprises seven fields studied in each of the two combined Delphi processes, i.e., the Technology Delphi and the Society and Culture Delphi.

For each of these fields, expert panels were established with up to two dozen members consisting of professionally experienced persons with high levels of competence, largely belonging to the decision-making hierarchy in science and research, business, public administration as well as intermediate interest organizations (including NGOs, consumer organizations and user representatives). These panels were key to the intended bottom-up creation of the contents of foresight, i.e., visions of innovations promising Austrian lead positions and of corresponding support measures. The next steps were the nomination of a large number of experts in each field (and the generation of an associated address database) who should later assess the hypothesized innovations as respondents in the large Delphi surveys. The results of these two Delphi rounds were statistically analysed by the research teams responsible and the outcome was summarized in a series of reports as the main products of the foresight exercise.[4]

The combination of Technology Delphi with Society and Culture Delphi

A consideration of the broader societal context of technical change has turned out to be a gap in earlier technology foresight studies. For instance, the first German Delphi study had concluded that "technological developments should not be investigated and assessed in isolation from social and cultural circumstances" and that "the question of social desirability has to match the question of technical feasibility" (Germany, BMFT, 1993). Among others, a social technology foresight exercise had also been explicitly suggested in relation with decreasing acceptance of products and technology development programmes in society (Todt and Luján, 1998).

In the Austrian foresight exercise, the inclusion of societal aspects was one of the principles guiding the whole approach (ITA, 1998a). This is reflected by the design and questionnaire contents of the technology Delphi itself as well as the idea of matching the Technology Delphi with a Society and Culture Delphi. This combination was motivated by the objective to shed light on the social embedding of the various technical and organizational innovations and to examine different scenarios of social and cultural developments expected by experts in the short, middle and long term.

The two strands of Delphi studies in the foresight programme overlap in terms of subject areas: out of the seven fields of the Technology Delphi and the seven areas of the Society and Culture Delphi, four focus on the same subject area. This combination was regarded as a reasonable mix of technology-specific and general scope of societal developments. These overlapping fields include: new forms of housing and living; lifelong learning; medical technology and health and clean and sustainable production (figure II).

The particular objectives pursued by the Society and Culture Delphi were the following (ITK, 1998): to map social, cultural, economic and political trends within the Austrian society; to assess the societal and political significance of each of the trends; to assess impacts of societal trends on research and development as well as in terms of priorities for politics; to identify conflict potentials of societal trends; and finally, to assess the desirability of trends as perceived by Delphi experts.

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[4]The results of the technology foresight comprise volumes 1, 2 and 3 of the series *Delphi Report Austria*. Volumes 4, 5 and 6 of this series contain the results of the Society and Culture Foresight exercise and the cross-cutting analysis. All volumes are in German and available from the Austrian Ministry of Science and Transport (contact: Mag. Erfried Erker, Tel. ++43 1 53120-7171; e-mail: Erfried.Erker@bmwf.gv.at). They can also be downloaded from the following Internet address: http://www.bmwf.gv.at/4fte/materialien/delphi.index.htm#Downl. A summary report in English will be available in spring 2001 and will be announced at: http://www.oeaw.ac.at/ita/.

Figure II. The subject fields of the Austrian foresight programme

Technology Delphi	*4 fields in common:*	*Society and Culture Delphi*
• New forms of housing and environment-oriented construction	⟷	• New forms of housing and living
• Lifelong learning	⟷	• Lifelong learning
• Medical technology and support for elderly people	⟷	• Health and illness in social transformation
• Clean and sustainable production	⟷	• Clean and sustainable production
• Organic food		• Ageing and life cycle
• Physical mobility		• Structural change of work
• Tailor-made materials		• Social segmentation

It is useful to consider a few examples of the results obtained in the subject field "health and illness in social transformation". Most important trends are: an increasing awareness of and interest in prevention; the growing importance of research on diagnostic and therapeutic strategies in the area of chronic disease; a split into high-tech medicine in central hospitals and treatment of patients with chronic disease in hospitals with less sophisticated equipment or in day-care centres and at home; and a wide diffusion of voluntary service throughout the health-care system. Highest priority for research and development was attributed to: electronically networked health centres which coordinate research via data networks, enable tele-consultations and exchange results, patient-related data and expertise of consultants on-line; diagnostic and therapeutic strategies in the area of chronic disease with a corresponding upgrading of the image of chronic patients; and intensified health education in families, schools and companies, leading to increased interest in prevention. The following trends deserving highest political priority were identified: a potential breakdown of the solidarity principle in health insurance (which is also seen as one of the highest conflict potentials); the increasing interest in prevention; psycho-social support services for long-term unemployed people; a predominance of cost-benefit analyses in the medical system; and the split between central high-tech hospitals and marginalized chronic patients. Finally, further trends which are attributed major conflict potentials are: growing difficulties for planning in the health-care system; increasing codification in law of the doctor-patient relationship as a source of increases in price; the dominance of cost-benefit analyses in the medical system; and discussions on the issue of euthanasia.

The emerging split between an area of acute treatment with high-tech equipment in a few centres on the one hand and external treatment of chronic patients on the other hand is one of the central themes in this subject field. Increasing polarization turned out to be a trend also in other subject fields of the Society and Culture Delphi (work, housing, information and new media, gender). Further trends which are suggested by the experts' assessments as dominant across several fields are: a change of the demographic structure towards the elderly with impacts on the generation contract, health care, housing and living; increased outsourcing in all service sectors and a role for decentralized networks; a preservation of the State's governance function, e. g., in environment policy and education policy; at the same time increased importance of the civil society through new forms of community action; and a continued role for national-level policies complemented by European Union and regional policies.

Regarding time horizons, the assessments of trends for the next 5 to 15 years are characterized by a surprising continuity of the societal status quo. However, within a horizon of 15 to 30 years quite a profound structural change of the Austrian society is expected to occur. The authors of the report (ITK, 1998) interpret this contrast as an alarming time lag between unsolved social problems and successfully coping with them.

The matching of the questionnaire contents of the two Austrian Delphi exercises executed in parallel also allowed for a synthesis of the results of the four overlapping subject areas. This analysis concentrated on a number of cross-cutting themes which were seen as major elements generating change: service economy; science industry; information and communication technologies (ICT); and market opportunities (Rust, 1998). The overall picture emerging from this synthesizing view is a somewhat muted modernization profile for the next 15 years: A number of technical and organizational innovations will impact on everyday lives and business but the basic institutions of the existing social market economy and public services will remain unchanged. Traditional values like regional identity and public financing of health, education and other public services will be preserved. In none of the areas under investigation does technical change take on revolutionary forms. The health and medical system is one of the areas with particular innovation potentials with impulses both for aspects of service economy, science industry, ICT and market opportunities.

The design of the Decision Delphi

According to Rauch (1979) it is useful to distinguish three types of use of the Delphi method: Classical, Policy and Decision Delphi. He called the traditional Delphi approach a Classical Delphi: It seeks to obtain a group opinion through an anonymous, multi-level group interaction in the form of a conditional scientific prognosis. A precondition for the reasonable application of a Classical Delphi are developments following explicit laws or at least certain regularities. Such an environment is often lacking in social systems, as well as in technological development.

By contrast, a Decision Delphi is an instrument to prepare decisions and to influence social developments: "reality is not predicted or described; it is made" (Rauch, 1979, p. 163). A Decision Delphi is also described as more appropriate in fields which are shaped by a mix of individual decisions rather than by general rules or regularities. If developments are dominated by a multitude of independent and uncoordinated decision makers, a Decision Delphi is recommended to structure and coordinate them on a path leading to a desired future situation. The participants of a Decision Delphi are recruited primarily with regard to their actual position in the decision-making hierarchy and in the second instance to their expertise.

It has been pointed out that the goal of the Austrian foresight exercise was not to detect the general outlines of emerging technologies but to map out those fields and niches in which Austria could reach a leading position within the next 15 years, either in R&D, in economic exploitation or in social and organizational implementation. For this task of field identification a Decision Delphi was regarded the appropriate tool.

As Tichy (1999) argues, these fields:

> "... are not so much determined by technological development and economic laws, but by the decisions and the efforts of numerous scientists, entrepreneurs and managers, by their expectations, uncertainties and actions or non-actions. The participation of these persons in a Decision Delphi is part of a foresight exercise as well as part of 'making of the future': Answering the questionnaire in the first round forces the decision makers to deal explicitly with probable future developments, a subject normally deferred to the Greek Calends, to the never-never time of less urgent business. Answering the questionnaire in the second round confronts the decision-makers with the evaluations of their colleagues and competitors, and allows them to adapt their own assessment anonymously, thereby probably creating some form of consensus and implicitly formulating a national path of development and specialization. The results may or may not be acceptable for the Governments' technology concept; they can, however, provide a basis for policy action in any case".

According to the bottom-up approach inherent in a Decision Delphi and the necessity to involve decision-makers as much as possible, heavy weight was given to the expert panels in this design. They prepared the topics and questions used in searching for promising innovations. This input formed the basis for questionnaires which were then responded to by a much wider group of experts in a two-stage Delphi survey. In particular, the task of the expert panels was to formulate around 40 hypotheses on promising innovations in a 15-year time horizon in each field (e.g., "Simulation-software for virtual optimization of vehicles and their components with respect to weight, safety, and emissions will be developed").

Special emphasis was given to orienting the visions of innovations towards a successful realization in Austria and on specific support measures to achieve this goal. This latter aspect has to be seen as a deliberate attempt to arrive at a "higher degree of finalization" of policy measures than other foresight exercises had done so far. For this purpose, the expert panels had to compile lists of concrete policy instruments for appropriate groups of innovations likely to improve the chances of Austrian leadership.

The questionnaires for the Delphi surveys were designed in detail by the Institute of Technology Assessment (ITA): For any one of the around 40 hypothesized innovations within each of the seven fields, the respondents indicated *(a)* their specific knowledge, and *(b)* gave assessments on the following dimensions:

(a) The degree of innovation implied in the respective vision;

(b) Its importance (for society, economy and environment);

(c) The chances of realization in Austria in general;

(d) The chances of Austrian leadership with respect to R&D, organizational and social implementation, as well as economic exploitation; and

(e) The desirability of the development in question.

In addition, the respondents indicated which policy measures out of a given list they considered as appropriate to enforce the envisaged development. Moreover, space for open comments was provided (see annexes I and II for examples). Seventeen so-called mega-trend questions tapping on more general societal and global developments as a background to the innovation processes in question were posed to all respondents.

The respondents to the Technology Delphi were selected according to their expertise and an intended equal composition of the sample constituted by three broad categories: academia, business and a category comprising equal numbers of administrators and groups of lobbyists. The co-nomination study served as the main pool of experts and was complemented by persons nominated by the basic expert panels. In addition, a number of other sources were used to fill the remaining gaps to reach a sample with nearly equal proportions of the three categories outlined (see tables in annex III).

The Austrian Technology Delphi consisted of two rounds, like most other foresight exercises of this kind: 3,748 questionnaires were mailed in the first and 1,597 in the second round; 46 per cent and 71 per cent, respectively, were returned. Out of the respondents of the second round about one third were employed in firms and one quarter in academia; in terms of function, one third worked in R&D and management, respectively; one eighth indicated a combination of several functions. Women were heavily underrepresented while the age structure was rather balanced.

The Decision Delphi approach and the combination with a Society and Culture Delphi were not the only innovations of the design of Delphi Austria. The broader conception of the expert base deserves to be pointed out as an integral component: The composition of the expert base for the Delphi surveys aimed at including not only research and technology experts but also an adequate share of what can be described as practical user, public management and market-related expertise. However, an absolute requirement for an assessment to be taken as valid has been at least a medium level of expertise in the innovation in question.

Assessment of mega-trends and profile of the expert base

In the latest German Delphi study (Cuhls et al., 1998) an assessment of some general societal trends on the national as well as global level—a so-called mega-trends section—was added to each field-specific questionnaire of a technology foresight exercise for the first time. This novel element served to control for more general visions of the future and world views among the respondents. Participants of the Delphi exercise in each field were invited to respond to the same set of 19 statements on general (economic, social, political, cultural and environmental) trends world-wide and in relation to the national context.

In the Austrian study, this tool was used in a slightly modified way. It should serve three functions: first, the world views of the respondents to the Technology Delphi as well as the Society and Culture Delphi should be examined and compared. Second, the general attitudinal profile of the Austrian experts should be assessed by way of comparison with that of the experts of the German Delphi. Third, it should enable a control for two potential subjective biases of the experts' assessments: *(a)* a bias due to particular world views, and *(b)* a bias due to vested interests in a particular area. For these purposes the list of items used in the German study was partially adapted. The same items as in Germany were presented to the participants in the Austrian Society and Culture Delphi, whereas for the respondents to the Technology Delphi seven more global statements from the German list were replaced by newly created items; each of these described a key trend in one of the seven subject areas. The idea was to have the possibility to compare, with respect to key trends, the views of field experts with assessments by experts from all other fields as a—admittedly rough—check for a potential interest-based bias.

In brief, six different types of world views were identified among the respondents of the Technology Delphi. They largely reflected optimism or pessimism vis-à-vis economic and ecological trends, national sovereignty and societal progress. A comparison with results from the German study showed considerable similarity in assessments of general trends and confirmed the balanced mix of Delphi experts. Some field-specific subjective bias could not be excluded in all subject areas but was not found to have a significant impact on the assessments of particular innovations (see Aichholzer, 2001).

Main results and impacts

The analytical findings and implications derived from the results of the Austrian technology foresight exercise for technology policy are summarized below.

In certain areas Austrian research institutions or firms already have achieved leadership or have the potential to do so in a middle range perspective, especially through the application of high—if not highest—technology in otherwise medium technology fields and, on the other hand, in markets in which Austria has lead market character (e.g., in clean technologies and organic food) because of a special demand situation (shaped, for instance, by legal regulation, characteristics of the social system, consumers' preferences, etc.). In general, however, Austria has not yet accomplished the leap from a technology adopter to a technology developer.

Special opportunities to achieve leadership exist in the following areas:

- Simulation models in construction processes;
- High-tech steel and low-weight materials;
- Recycling of composite materials and mixed materials;
- Low noise equipment for railways;
- Cleaner production technologies (especially in metal and paper production);
- Wood as material in constructive applications;
- Ecologically sound construction;
- Organic food (seeds and breeding, conservation and analysis techniques);
- Technologies supporting lifelong learning (tailor-made packages for further training, intelligent information agents, electronic learning media);
- Technologies supporting independent living of the elderly without losing personal contacts;
- Substitutes for organs and functions (in conjunction with biocompatible materials, hybrid technologies); and
- Information and communication technologies which are part and parcel in almost all cases of successful or potential leadership while as independent technologies they only play a role in certain niches.

The foresight studies also identified major problem areas. A specific problem is that the time horizon anticipated and taken into account in innovation activities by firms and applied research is too short. It also became clear that isolated technological efforts are not very likely to pay off: Success in achieving leadership requires a wider approach, networking, cooperation between firms and research institutions, a linking of technical and organizational innovations and a critical mass of firms and research institutions. Attitudes towards organizational innovations turned out to be more ambivalent, indicating a higher level of mistrust in their realization.

As concerns policy options, the most important measure suggested by the technology foresight exercise is the strengthening of cooperation between research institutions and firms as well as among firms and research institutions themselves. Recommended measures include: actions promoting the development of clusters in future-oriented core areas; the creation of new institutions for the coordination of interdisciplinary research focuses; a differentiation in research promotion between more routine and high-risk, long-term projects; the prescription of targets and continuous evaluation in project promotion; and the setting up of pilot projects, especially regarding organizational innovations. For each of the seven sectors more specific policy recommendations can be found in the volume devoted to sector-specific results of this technology foresight exercise (ITA, 1998b).

Three years after completion Delphi Austria achieved some real and measurable impacts. Direct impacts (i.e., policy measures) can be observed in the form of implementation of policy measures, initiated by the Science Ministry. Figure III shows that several of Delphi Austria's subject fields are matched by such implementation measures:

Figure III. The subject fields of the Austrian foresight programme

Technology Delphi - Thematic field		***Impact 1: Targeted Impulse Programmes***
Environmentally Sound Construction and New Forms of Housing	→	"Building of the Future" Programme
Cleaner Production and Sustainable Development	→	"Factory of the Future" and "Renewable Raw Materials" Programmes
Production and Processing of Organic Food	→	"Food Initiative Austria", cluster initiative for organic food
Mobility and Transport	→	"M.O.V.E" Programme
Tailor-Made New Materials (focus on metals)	→	"K-plus Programme" (competence centres; 12 centres established)

In total, 1,530 million Austrian schillings (€110 million) have been invested by public funds into R&D initiatives which were directly recommended or confirmed by the results of the foresight programme Delphi Austria since its completion in 1998.

Impact 2: Input to "Green Paper on Austrian Research Policy 1999"

Use of Delphi Austria to enforce interdisciplinary, problem-oriented research as well as for the elaboration of an appendix catalogue of concrete measures

Impact 3: Orientation support for Research Strategy 2000

Function as guiding document for the creation of a framework for research promotion aimed at the solution of societal problems (Research Report of the Minister of Science and Transport, 1999)

Impact 4: Stimulation of cluster building

Cluster development project "Organic Food Cluster Austria" started. Several clusters at regional level established (automotive, wood, plastics, eco-energy)

Impact 5: Stimulation of sectoral foresight projects

Examples: Stationary treatment of elderly in selected medical fields and effects on hospital costs; biomedical technology; vocational training.

Three targeted programmes are subprogrammes of "Sustainable Development": "Building of the Future" and "Factory of the Future" are already in operation and "Renewable Raw Materials" is about to be launched. The "K-plus" programme has established 12 competence centres (centres of excellence) since 1999 which promote cooperation between firms and research institutions on major innovative projects in a pre-competitive stage. They also support the development of clusters in promising areas. The majority of centres within this programme work in areas suggested by technology foresight results (e.g., new materials, wood technologies, information technologies). Also at least one new research facility of the Christian Doppler Laboratories was established in a field suggested by Delphi Austria (wood research).

It has to be said that a causal relationship cannot be postulated in all cases, but at least such measures are confirmed by results of Delphi Austria. On the other hand, some initiatives have been stimulated by way of self-organization. A case in point is the creation of the programmes "Building of the Future" and "Factory of the Future" which a participant in the Technology Delphi survey organized.

Another important impact concerns the new research strategy programme (Österreichische Forschungsstrategie 1999) adopted after the discussion of a "green" paper based on Delphi Austria. It has strongly influenced strategic programmes at the regional level, such as in the Province of Upper Austria where several clusters have been set up.

Finally, more or less directly related with panel activities, independent foresight projects have been triggered in the fields of vocational training and retraining, mobile communications, medical technologies, and transport. For instance, a study on the future of vocational training and retraining has been undertaken by the Institut für Berufs- und Erwachsenenbildung at the University of Linz (IBE) within the framework of an international study commissioned by the European Foundation for the Promotion of Vocational Training (CEDEFOP), Berlin.

Although a systematic evaluation in a formal sense has not been undertaken, an internal assessment of impacts of Delphi Austria by the Ministry of Science is provided. It lists the measures stimulated by Delphi Austria and uses of results by different agencies. It includes a quantification of the leverage effect in terms of the volume of promotion measures which amounted to 1,530 million Austrian schillings (€ 110 million) by late 1999 (approximately one year after the completion of the last of a series of Delphi reports).

On the other hand, one can see the following indirect impacts two years after the completion of Delphi Austria. The results of the Austrian foresight programme are built on a sufficiently broad basis of expertise to be used as an important information source for technology policy-making as well as actors of the innovation system, especially in companies and research institutions. The process of involving a great number of these actors, either as members of one of the panels developing the contents of the Delphi questionnaires or as participants in the Delphi rounds themselves, has been a deliberately promoted and valuable result of the whole foresight programme.

Further steps in that direction have been undertaken with the wide diffusion of the results of Delphi Austria on the national level. Several thousands of copies of the reports were distributed among business, academia, public administration and other organizations in spring and towards the end of 1998. All reports are accessible via the homepage of the Austrian Ministry of Science and Transport on the Internet and can be downloaded, including the tables containing the quantitative results. A number of major presentations and workshops have complemented this diffusion process as well as wide circulation of a number of contributions both in print media (several newspapers and magazines) and on radio and TV.

This means that with the foresight process itself and the dissemination of its results the stimulation of cooperation and networking has started. It can be expected to continue with ongoing and future sectoral activities and to contribute to "wiring up" the national innovation system.

Summary and conclusion

It has been shown that technology foresight programmes have flourished, especially among small countries in the 1990s. Such exercises have been taken up also by transition countries and seem to be a useful instrument for them when tailored to the specific needs of the country. Goals and approaches are generally different and need to be adapted to the particular position of a country in the global economy as well as respond to national problems. Experience to date indicates that even among small countries the approaches are quite varied. However, the scopes of foresight exercises are most frequently oriented at specific national conditions and the identification of niche potentials, time horizons are less long-term, more emphasis is laid on the foresight process itself and bottom-up approaches tend to be favoured.

The Austrian foresight programme Delphi Austria is a typical example of a small country approach. It was tailored to the present stage of economic and societal development and should serve as a strategic intelligence input to a mid- to long-term oriented technology policy. Therefore the approach put emphasis on a problem- and demand-driven orientation, applicability of results and on strengthening the links among the national innovation system.

The technology foresight process used a bottom-up approach including expert panels and Delphi exercises as key elements which had mainly two tasks:

(a) To identify and assess those areas of innovation with high importance in the next 15 years in which Austria could achieve a leading role, and

(b) To consider and assess a variety of measures for each group of innovations to support this goal.

The technology foresight exercise led to the identification of a number of promising innovation areas and policy measures. Around a dozen such areas have been pointed out as most likely to allow Austria to achieve a lead position in R&D and market segments. Matching the Technology Delphi with a Society and Culture Delphi shed some light on the social embedding of the various technical and organizational innovations. A perspective emerging from this synthesizing view is a somewhat muted modernization profile in Austria. The assessment of some general societal trends which were first introduced in a German Delphi study was used as a novel element and allowed the examination of the homogeneity of the expert base.

The Austrian foresight results are built on a broad basis of expertise and accessibility for technology policy-making as well as for actors of the innovation system, especially in companies and research institutions. A great number of these actors have been involved in the foresight process, either as panel members or as respondents to the Delphi questionnaires in two survey rounds. This has been deliberately promoted and proved to be a valuable result of the entire foresight programme.

The results of Delphi Austria have had considerable direct impact in shaping central technology policy measures so far. They have stimulated the start of new targeted programmes in the field of sustainable production, influenced the selection of subject areas of "centres of excellence" for promotion as well as of cluster building at national and regional levels.

ANNEX I

Innovation statement
(questionnaire sample page)

1. Biological digestion processes are used for pulp production instead of sulphite or sulphate processes in order to reduce the specific energy demand

*(in the cases of a-d: **insert** applicable number)* *Assessment scale:* *1=very high* *2=rather high* *3=medium* *4=rather low* *5=very low*

a. My general expertise concerning this thesis is ________ ○

b. The degree of innovation of the development mentioned in the thesis is ________ ○

c. The importance of this development is ________ ○

d. The chance of realization in Austria within the next 15 years is ________ ○

(in the case of e and f: please mark with ⊗ a cross) *(in the case of e: multiple answers possible!)*

	research & development	organizational-societal implementation	commercial exploitation
e. Austria has good chances especially regarding	○	○	○

	desirable	not desirable
f. I consider the development described as	○	○

Comments:

ANNEX II

Policy measures
(questionnaire sample page)

How high or low do you assess the suitability of the following measures to increase Austria's chance of succeeding in the cases of the most promising innovations in the area of cleaner processes?

Assessment scale: 1=very high 2=rather high 3=medium 4=rather low 5=very low
(please mark with a cross in every case ⊗)

Strengthen basic research	①②③④⑤
Increase the use of simulation methods (EDP) for the development of processes and materials	①②③④⑤
Strengthen application-oriented process and material development	①②③④⑤
Establish and support pilot plants	①②③④⑤
Reduce capital raising costs	①②③④⑤
Increase financial support for developers and users	①②③④⑤
Support opening up new markets	①②③④⑤
Simplify existing support procedures	①②③④⑤
Achieve steady and long-term oriented environmental policy	①②③④⑤
Realize ecological tax reform	①②③④⑤
Increase transparency of environmental regulation	①②③④⑤
Strengthen cooperation between basic research and application-oriented research	①②③④⑤
Strengthen cooperation between process or material producers and users	①②③④⑤
Support cooperation between different areas of processes and materials	①②③④⑤
Strengthen cooperation between application-oriented research and process and material producers	①②③④⑤
Strengthen the training of process and material users	①②③④⑤
Increase the sensitivity of the public with respect to cleaner processes	①②③④⑤

Other important measures:

Space for comments regarding Cleaner Processes:

ANNEX III

Table 1. Composition of expert panels and participants in Technology Delphi

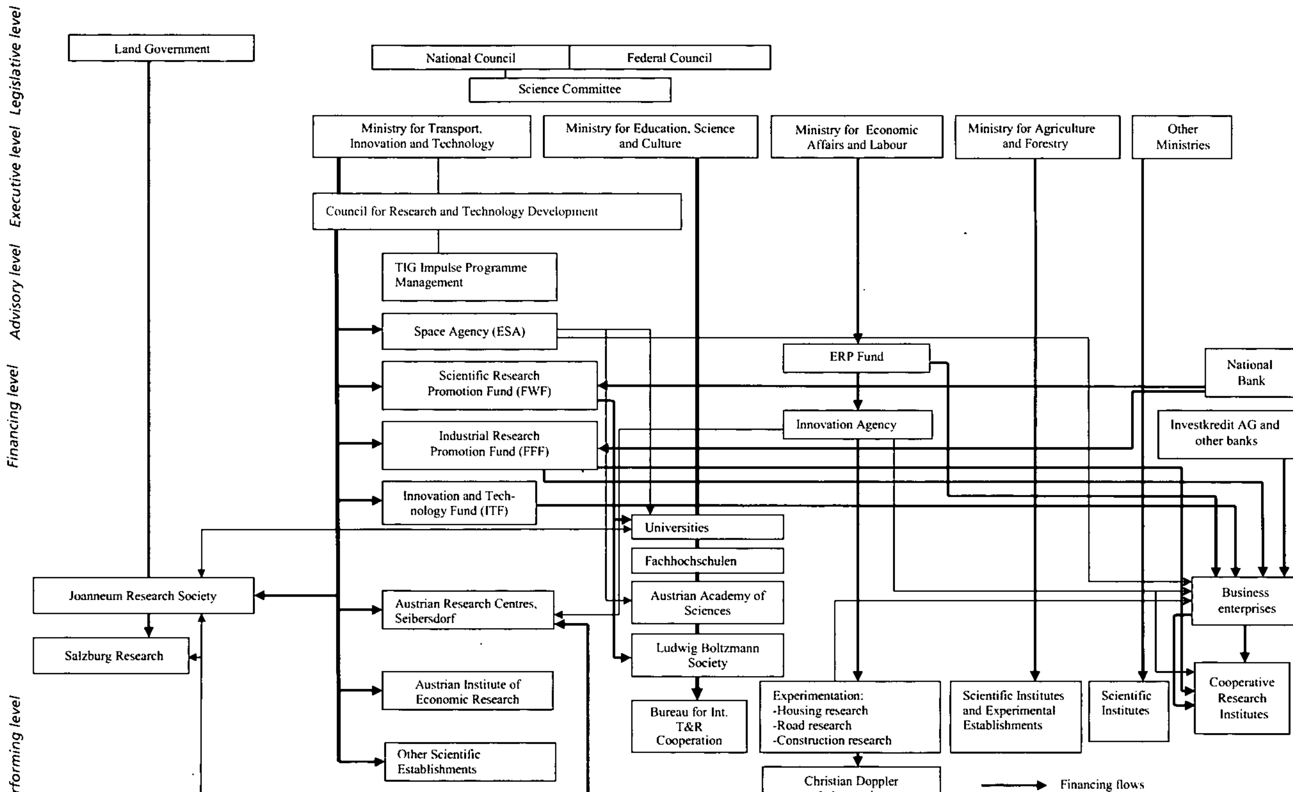
	Panel members		Delphi respondents	
	No.	%	No.	%
Science	42	34	321	25
Business	53	41	451	35
Administration	21	16	214	17
Interest organizations	12	9	90	7
Other	-	-	209	16
Total	**128**	**100**	**1,285**	**100**

Table 2. Numbers of participating experts in Technology Delphi (round 2)

	Questionnaires delivered (No.)	*Questionnaires for analysis (No.)*	*Response rate (%)*
Lifelong learning	301	219	73
Environmentally sound construction and new forms of housing	216	142	67
Medical technologies and supportive technologies for the elderly	191	139	74
Cleaner production and sustainable development	302	211	71
Tailor-made new materials	121	90	75
Mobility and transport	290	200	70
Production and processing of organic food	176	126	72
Total	**1,597**	**1,127**	**71**

ANNEX IV

Science and technology policy institutions in Austria



Source: G. Aichholzer based on OECD, 1988.

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6 The Swedish Technology Foresight project

Lennart Lübeck*

Abstract

The Swedish Technology Foresight project is a national project aimed at creating insights and visions about technological development over the next 10 or 20 years. It is also aimed at identifying worthwhile strategies in education, research and development that may help to promote the advancement of Swedish society.

During 1999, more than a hundred experts—women and men of all different ages from the private business sector, research community, and public sector—worked in eight panels, studying and discussing their respective foresight sectors. The eight foresights sectors are as follows:

- Health, medicine and care;
- Biological natural resources;
- Society's infrastructure;
- Production systems;
- Information and communications systems;
- Materials and material flows in the community;
- Service industries; and
- Education and learning.

The project has three objectives:

(a) To strengthen a futures-oriented approach in companies and organizations;

(b) To identify areas of expertise with potential for growth and renewal in Sweden; and

(c) To compile information and design processes identifying high-priority areas in which Sweden should build expertise.

Similar foresight studies are under way around the world. People have begun to realize the need for common visions in a country and its regions. How can we—and how do we wish to—promote growth in Sweden? And how can people living in different regions help to shape positive development in their part of the country?

To start this process, regional conferences were organized around the country during 2000. They give all parts of Sweden an opportunity to learn some of

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the findings of the Swedish Technology Foresight project. These findings will help give the discussion at the regional level a long-term perspective, about 10-20 years. We are providing background information in the form of reports, websites and resource persons for continued discussions about the future.

The intent is to carry out a comprehensive Swedish technology foresight exercise fairly regularly, as a number of other countries do. In general, such a process should have the same purpose as the current one, but we should naturally be open to changes in our working methods. Among other things, all the lessons—positive and negative—from our first technology foresight exercise should obviously be taken into account, along with the lessons continuously being learned from similar processes in other countries.

The lessons from the implementation of the Swedish Technology Foresight project have been followed up on a continuous basis by an Evaluation Committee, which reported its observations and conclusions to the four organizations that ran the project. This evaluation focused on the actual process, not the findings of the project's work.

Introduction

The American futurologist Peter Schwarz is among the world's leading designers of future scenarios about how we live, communicate, work, consume or amuse ourselves. A very optimistic image is apparent in his most recent scenarios. Among other things, they assert that large portions of the world will experience 25 very good years, characterized by greater freedom, better environment and increased material welfare.

New technological advances are the most important driving force behind growth and renewal in such fields as information technology, energy supply and genetic engineering, which are predicted to provide increasing quality of life. According to these scenarios, in 2020 we will experience "quantum computing", buy the first commercial nanoproducts and be able to treat one third of humanity's 4,000 genetic diseases. The point of these technological predictions is that they draw attention to the potential for improving the quality of life that new technology can deliver.

A number of elements of development work reinforce the need for long-term technology assessments. To an increasing extent, new technology is selectable and adaptable—in other words, there is no optimal solution. This applies, for example, to information technology (IT), which has the paradoxical characteristic of simultaneously becoming more complex, robust and generally adaptable—something that, for traditional technology, sounds like an impossible combination. One consequence is that technology implies substantial freedom of choice. That freedom of choice provides major opportunities for companies and organizations capable of spotting new opportunities, embracing new technology and integrating technology into the other competencies of their operations.

Technological advances are behind much of the world's growth and renewal, but globalization is perhaps the most important driving force. During the foreseeable future it will dominate the changes in our living conditions. Meanwhile, changes in attitudes and values are essential for social and technological development. It is also becoming increasingly important for all technological development to take ethical issues into account.

In a way, Sweden faces greater challenges than many of our large trading partners. Countries and regions with small populations and an open economy are always heavily dependent on foreign trade. This gives them strength, flexibility and major opportunities to identify new markets and achieve good economic growth, but it also creates vulnerability.

One way to increase the chances of maximizing one's advantages and minimizing one's vulnerability is to predict the future as accurately as possible. This has always been the case. Princes have surrounded themselves with fortune-tellers and astrologers. Modern companies and Governments engage the services of global analysts, think tanks and forecasting institutes.

Ordinary people, too, have always speculated about the future. A large proportion of science fiction deals with how technological and scientific development may conceivably affect our future. Science fiction has often also been used to elucidate the consequences of contemporary trends. Examples of this are H.G. Wells' *The Time Machine*, George Orwell's 1984 and Harry Martinsson's *Aniara*.

More systematic future studies have existed since the 1950s. Various institutes have been founded in order to study future scenarios. Governments, organizations and companies are continuously conducting a large number of studies of the future in order to elucidate developments in various sectors.

In recent years, a number of countries have carried out national studies of the future. Japan publishes a study with a 30-year horizon that it updates every five years. The United Kingdom published its technology foresight study in 1995. Australia, Germany, Hungary, Ireland, the Netherlands and New Zealand are among the other countries that have carried out this type of study.

A Swedish preliminary study completed in 1997 stated that a Swedish technology foresight exercise could be expected to provide valuable contributions to long-term planning for companies and organizations.

During the spring of 1998, a decision was thus made to carry out Teknisk Framsyn (Swedish technology foresight) as a national project. Its purpose would be to engage many of the players in Sweden's "knowledge society" in a discussion of the best ways to promote a long-term interplay between technological, economic, institutional and social processes.

The project has been run by the Royal Swedish Academy of Engineering Sciences (IVA), the Swedish National Board for Industrial and Technical Development (NUTEK), the Swedish Foundation for Strategic Research and the Federation of Swedish Industries. It has been implemented with support from the Swedish Government and in close collaboration with companies, public agencies and other interested parties.

The objective of the Swedish Technology Foresight project has been to strengthen a futures-oriented approach in companies and organizations and to identify and prioritize areas of expertise with potential for growth and renewal in Sweden.

Technology foresight has therefore attempted to convey insights and credible images of the future that may form the basis for a discussion of trends in Swedish society and in the business sector, and on how Sweden can use technology in the service of humanity.

Hindsight

"The telephone is a fantastic invention—I am sure that every city will get one."

This quotation illustrates the difficulty of foreseeing the full use and consequences of new technology and new ideas.

The Swedish Technology Foresight project carried out a separate study of earlier attempts at predicting the future, "*Teknisk Baksyn*" (technology hindsight).

This study discusses various difficulties and sources of errors that should be borne in mind. Among the factors contributing to the failure of previous predictions, it found:

(a) The belief that new technology will replace existing technology, and that this will happen relatively fast. In reality, competing technologies often coexist over a rather long period;

(b) The belief that new technology will only solve old problems and supplement existing technological systems. Instead, new technology often lays the groundwork for entirely new systems;

(c) The belief that new technology will function as a panacea for various social problems;

(d) The difficulty of seeing important links between different fields of technology in cases where this combination of fields is precisely what will offer major developmental opportunities;

(e) That those who have tried to predict the future have become bogged down in the actual technology and thus neglected the economic aspects;

(f) That people have been prisoners of the spirit of their times (or Zeitgeist), believing that the big issues of today will also be the big issues of tomorrow;

(g) That rational economic considerations are not the only factors behind the choice of a new technology. Seemingly irrational considerations often determine such choices;

(h) That the information on which future studies is based has often been insufficient. A great deal of technological development takes place secretly, mainly in the military sector.

No method in the world can provide a sure image of how Sweden will look in 15-20 years. The only thing that can be predicted with certainty is that unexpected things will happen. Technological development is not linear and predictable, any more than political and social development.

But the difficulties of foreseeing the basic outlines of the future should not be exaggerated either. Every generation perceives itself as living in an age of major changes. Perhaps the generation of August Strindberg (1849-1912) experienced larger actual changes than today's Swedes. It is quite certain that the Sweden of 2020 will not have changed to the point of being unrecognizable. A large proportion of the infrastructure—such as buildings and roads—are renewed over longer periods than 20 years. The same is true of many technological systems. Most of the Swedes who will be alive in 2020 are already adults, and many developments over the next 20 years will be based on technological advances that are already known.

Swedish technology foresight has deliberately chosen to ignore pure disaster scenarios. We cannot rule out that over the next 20 years our society may be subjected to wars and blockades. Nor can we predict terrorist actions, devastating epidemics, the collapse of the food or energy supply system or large-scale disruptions in the world economy. The mere act of worrying about the possibility of such events may be of great significance to national development, for example in the form of military build-ups or trade barriers of various kinds. In this respect, Swedish technology foresight is optimistic—perhaps excessively coloured by its own Zeitgeist.

In this context, it is important to be aware that the Swedish Technology Foresight project has been based on different assumptions and has had a different objective from other comparable studies. The project is uniquely Swedish. Instead of saying, "This is how it will be!", the project has assumed that there is no need to be familiar with the minutiae of the future in order to prepare for it. We can go a long way by analysing the main features of likely developments. The important thing is to have enough knowledge to dare realize that we cannot know how it will turn out, to dare to act without being completely sure of the direction of the journey and, based on the right knowledge, to constantly be prepared to reassess our decisions.

Implementation of technology foresight

The idea of carrying out a technology foresight project in Sweden emerged in the mid-1990s under the pressure of rapid technological and political change around us. Technologically oriented future studies had been conducted in Sweden during the 1970s and even earlier, but during the 1980s such studies, if at all, were only pursued inside private organizations. Perhaps the difficulties that had recently affected the Swedish national economy contributed to the increased interest during the 1990s.

There were several conceivable foreign models for Sweden's technology foresight project. The British version of technology foresight, which was presented at IVA in April 1996, was an important source of inspiration. The Federation of Swedish Industries analysed the effect of relevant European studies and decided to initiate a Swedish study. IVA and NUTEK carried out a joint preliminary study about international experiences and on the preconditions and interest in Sweden for carrying out a corresponding project. This initiative evoked interest in many quarters.

After further preparation in 1997, the four organizations behind the study—IVA, NUTEK, the Federation of Industries and the Foundation for Strategic Research —formed a committee to evaluate the possibility of carrying out a technology foresight project. Unlike most studies in other countries, the Swedish Technology Foresight project was not carried out on behalf of the Government, although it has enjoyed strong government interest and support.

To direct the Swedish Technology Foresight project, in 1998 the four organizations behind the study formed a Steering Committee with the following members: Arne Wittlöv, Executive Vice President, AB Volvo (Chairman); Gunnel Färm, Director-General, Swedish Council for Work Life Research; Christer Heinegård, Director, Technical R&D, NUTEK; Professor Ingvar Lindgren, Swedish Foundation for Strategic Research; Camilla Modéer, Research, Education and Development Programme, Federation of Swedish Industries; Professor Kurt Östlund, President, IVA; and Enrico Deiaco, Secretary to the Academy, IVA, who was appointed Secretary of the Steering Committee.

A project office was attached to the Steering Committee to administer the project. Lennart Lübeck, Chairman of the Swedish Space Corporation, was appointed Program Manager. Others working in the project office were Enrico Deiaco (IVA), Lennart Elg (NUTEK), Bengt Mölleryd (IVA) and Lennart Björn, Project Controller.

The four organizations behind the study also established an Advisory Committee in order to broaden the range of organizations involved in the technology foresight process. Some 30 interest organizations have been represented in this Committee. The task of the Advisory Committee has been to ensure that important interested parties in Sweden have been integrated into the process, as well as to suggest names of possible panel participants. Another task of the Committee has been to create involvement and generate support for the project in their respective organizations, disseminate its findings and advise the expert panels on their work. In addition, an Evaluation Committee was established and entrusted with continuously following up and evaluating the implementation of the project.

The work of the project was mainly carried out within the eight expert panels. In each panel, a chairperson and about 15 other participants were appointed. Each panel engaged its own project manager, who worked in this capacity at least halftime. The panels were created and staffed by the Steering Committee after thorough deliberations on the delimitation of their subject areas and their composition. Among other things, the Steering Committee examined how comparable foreign studies had been implemented and what lessons had been learned.

The Steering Committee chose to create a limited number of panels, each with a broad-based composition and a broadly defined field, well aware that because of this, complete coverage of the technology would not be possible.

The division into panel subject areas was made on the basis of need and user perspectives, not fields of technology.

No.	*Panel*	*Chairperson*	*Project Manager*
1	Health, medicine and care	Leni Björklund	Cecilia Warrol
2	Biological natural resources	Per Ove Werling	Monika Carlsson Ulin
3	Society's infrastructure	Ulrika Francke	Jan Parmeby
4	Production systems	Bengt Palmér	Arne Otteblad
5	Information and communications systems	Ulf J. Johansson	Cecilia Sjöberg
6	Materials and material flows in the community	Gunilla Jönson	Kerstin Lekander
7	Service industries	Rolf Skoglund	Charlotta Eiborn
8	Education and learning	Clas Wahlbin	Börje Svensson

A total of 130 people sat on the eight panels. By means of seminars, conferences etc., a few hundred additional people participated. The work of the panels began with a kick-off conference in January 1999 and ended one year later. A joint conference for coordination of their work took place in August 1999.

It was recommended to the panels that, within a firmly fixed timetable, they should follow a given methodology whose point of departure was a project plan based on the lessons of technology foresight exercises in other countries. The Steering Committee also asked the panels to take into account certain lateral, multidisciplinary themes, for example, environmental and energy aspects, economy and market, and attitudes and values. Within their project plans, the panels were then given great freedom to define and prioritize their tasks.

By and large, the panels followed the project plan. First they carried out an inventory of a large number of subject areas which they believed would prove to be of decisive importance to society in their respective sphere of responsibility. After thorough discussions, they grouped these under various themes. They selected a limited number of key areas for more detailed analysis. The structure of the final phase of their work varied between panels.

The panels had the option of forming subgroups and, as needed, outsourcing assignments in order to compile documentation for their work.

As a form of back-up for their work, during the spring of 1999 the project, together with consultants from Sweden's Defence Research Establishment (FOA), worked out four future scenarios. These were based on different assumptions about the role of geographic proximity in development, and about whether development would be characterized by relatively few or relatively many players. The panels used these scenarios to varying degrees in their work.

The eight panel reports were completed in draft form late in November 1999, and in final form in January 2000. A number of highly qualified referees—Bo Berggren, Lars Bergman, Kerstin Fredga, Kristoffer Hallén, Lars Ilshammar, Arne Kaijser, Anders Lindström, Peter Nygårds, Maria Stenström, Björn Sällström and Karl Johan Åström—were asked to read the panel reports and provide overall opinions as background material for the synthesis report.

The Swedish Technology Foresight project was implemented in a very open way. Among other things, the drafts of the panel reports were successively posted on a technology foresight website (www.tekniskframsyn.nu) and all interested individuals were invited to comment on the drafts.

The results of the Swedish Technology Foresight project were presented at a final conference in March 2000. During the spring and autumn of 2000, the project was also presented at a number of meetings, including a series of regional conferences around Sweden.

The synthesis report was written on behalf of the Steering Committee, and under its supervision, by Leif Magnusson (EnerGia), Stefan Zenker (Swedish Space Corporation), Olle Rossander (independent consultant) and Benny Kullinger (Ord & Vetande).

The project was run within a cost ceiling of 34 million Kronor. The financiers were the Swedish Foundation for Strategic Research (SKr 17 million), NUTEK (SKr 10 million) and the Swedish Government (SKr 7 million).

The process moves ahead

The Swedish Technology Foresight project is an ongoing process, in which the presentation of the reports on 28 March 2000 only marks the end point of an introductory phase. The objective of technology foresight has thus been to use technological development as a point of departure for stimulating a discussion of the future development of Swedish society and business. Among other things, the project has identified fields of expertise with potential for growth and renewal in Sweden, for the purpose of strengthening the futures-oriented work of companies and organizations. This is not something that can be done on a single occasion and then be regarded as finished. The Swedish Technology Foresight project must be carried forward in various ways, and in various forms.

Dissemination of findings

During the spring and autumn of 2000, the Technology Foresight project has organized regional conferences at many locations in Sweden. Participants in the various panels have presented the results of their work. In the best case, this may lead to the beginning of local "foresight activities," perhaps with the Technology Foresight project as a model. A number of organizations and companies have also invited project participants to present the project's findings at various events and gatherings during the year.

The findings of the project are also being disseminated via the four organizations behind the project, through their human networks. All the project reports are available from the Internet on the Technology Foresight project's website, www.tekniskframsyn.nu—mainly in Swedish—and are also available in printed form.

The most important method of all for disseminating the thoughts and findings of the Swedish Technology Foresight project, however, is the informal conversations and discussions conducted by the people who participated in its work, or by others who have come into contact with technology foresight in some other way.

Broadening and intensifying the process

The Swedish Technology Foresight project chose to work with relatively few panels and thus with broad subject areas. All panels were also given the specific assignment of weighing in and taking into special account a number of interdisciplinary themes, among them environmental and energy issues. Within these limits, the panels made their own prioritizations. A prioritization means that certain subjects were highlighted while others, which are not thereby considered unimportant, were treated in a more summary way. Nor has the project conducted in-depth studies in its various fields. After all, its purpose was not to carry out research planning. The panel reports will provide a starting point for a continued process, which will include more in-depth analyses of Sweden's areas of expertise, improvement needs, consequences for various fields of technology and science, strengths and weaknesses, threats and opportunities, both nationally and regionally.

The shape of these in-depth and follow-up studies will be up to the players in the Swedish business sector and public sector to decide.

Recurring technology foresight projects

In Sweden we should carry out a comprehensive national technology foresight exercise fairly regularly, as a number of other countries do. In general, such a process should have the same purpose as the current one, but we should naturally be open to changes in our working methods. Among other things, all the lessons—positive and negative—from the current Technology Foresight project should obviously be taken into account, along with the lessons continuously being learned from similar processes in other countries. This may apply, for example, to such fundamental issues as how much time to allocate to the project and how best to utilize this time, especially considering that the most insightful people tend to have little time.

The interval between recurring technology foresight exercises at the national level should probably not be much shorter than five years, but perhaps not so much longer either.

Evaluation

The lessons from the implementation of the Swedish Technology Foresight project have been followed up on a continuous basis by an Evaluation Committee, which will report its observations and conclusions to the four organizations that ran the project. This evaluation will focus on the actual process, not the findings of the project's work.

7 Adaptation of foresight exercises in Central and Eastern European countries

Jan Kozlowski*

Abstract

One basic question is whether it is possible to transfer technology foresight from highly developed Western countries to less developed Central and Eastern European countries without losing its particular advantages. The main thesis is that success of the foresight exercise depends on many cultural conditions, often tacit and hidden. These conditions were existent in the most advanced countries where foresight was born. They are not necessarily apparent in less developed countries. The best way to make them visible is to ask what the reasons for success of foresight are in the most advanced countries.

Foresight appears to be of great interest as a subject of study. We have not only more and more foresight exercises but also foresight studies and foresight training and foresight education, which are probably growing at the same speed. One can see a diffusion curve of foresight exercises carried out in the world beginning in the early 1970s. In the mid-1990s technology foresight suddenly gained very wide acceptance, and shortly after that foresight made a shift from the most industrialized to less developed countries.

What are the problems connected with this transfer of foresight from the most advanced to less developed countries? The main issue is that the success of the foresight exercise depends on several premises. These premises exist in the most advanced countries where foresight was developed and applied in the early 1990s, but they are not necessarily apparent in less developed countries. The best way to understand these premises is to ask what are the reasons for the success of foresight in the most advanced countries? The most important question for us in Poland is how to use foresight as a means to modernize public opinion on the most vital economic and social issues.

The emergence and diffusion of foresight in the most advanced countries should be viewed as a sign of the shift towards a world that is perceived as complex, multidimensional and difficult to categorize. Foresight was invented as a tool for coping with this new situation. However, definitions of situations and priorities of Central and Eastern European countries are not necessarily the same.

Today, Western experts scarcely find in foresight even one element or aspect that is unknown to them; it is, rather, the way in which these elements or aspects

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are connected one with the other that might be seen as new. They are much better acquainted with policy analysis instruments (e.g., evaluation), informed policy-making, organizational auto-diagnosis, team work techniques, discussion methods, strategic planning, comparing different points of view, negotiating and seeking consensus. Also, the social reality they live in is much more favourable for conducting foresight exercises (e.g., stronger science-industry networks and more efficient public administration).

One of the most difficult problems that the CEE countries will face when implementing foresight methodology is how to adapt it and/or to develop all the necessary and lacking assets to make it a tool that will help to capitalize on their own most important issues and aspirations.

Introduction

The aim of this paper is to discuss whether it is possible to transfer technology foresight from highly developed Western countries to less developed Central and Eastern European (CEE) countries without losing its particular advantages. The main thesis is that success of the foresight exercise depends on many cultural conditions, often tacit and hidden. These conditions were existent in the most advanced countries where foresight was born. They are not necessarily apparent in less developed countries. The best way to make them visible is to ask what the reasons for success of foresight are in the most advanced countries.

What is foresight?

Some decades ago, low labour and resource intensive technologies could be easily transferred from advanced to developing countries. But today, as technologies become much more knowledge intensive, technology transfer between countries also becomes much more difficult. It includes not only machinery, but also assets that are harder to transfer, like tacit and explicit knowledge, organization and management.[1] Foresight belongs to very "knowledge-intensive" social technologies. Its success depends on translation of the best practices to the language of cultural and social habits of the recipient country. Adoption/adaptation requires some dose of creativity and inventiveness.

Foresight seems to be one of the thousands of inventions aimed at improvement of human activity. As such, it might be placed in the same category as, for example, double accounting, the extended military line, printing, Cartesian idea of thought processes or Taylor's idea of scientific management. As with all other technical or intellectual inventions it has been devoted to the same goal—to facilitate tasks, to use more effective tools and

[1]Slavo Radosevic, *International Technology Transfer and Catch-up in Economic Development* (Cheltenham, Edward Elgar, 1999).

methods to satisfy needs and to apply more economical methods to do what has been done before.

More specifically, foresight belongs to that group of tools supporting production and transfer of ideas that Paul Romer calls "meta-ideas" and acknowledges as the most important type of invention. Foresight belongs to that category together with the seventeenth-century British inventions of patent and copyright and the twentieth-century American inventions of peer review.

But contrary to the older policy and management tools, foresight—in the form of technology foresight, research foresight or science and technology foresight—is much harder to grasp, define and classify. It is one of the policy instruments, but it is more than that; it is one of the policy analysis tools. But it could also be described as a knowledge management instrument for branches, regions and enterprises. It could also be considered a public debate forum; an act for establishing the collective definition of the situation;[2] a social experiment aimed at raising the awareness of a common long-term future; "... a combined analysis and communications process in which informed parties and stakeholders participate in a forward-looking exercise to identify the most important issues in the emerging S&T portfolio ...";[3] one of the participatory democracy mechanisms; a "...process by which one comes to fuller understanding of the forces shaping the long term future which should be taken into account in policy formulation, planning and decision making ...";[4] one of the "... means of communication for the negotiating system of society, [a] code to communicate between social actors in science, technology and society...";[5] "... systematic attempts to look into the longer-term future of science, technology, economy and society with a view to identifying emerging generic technologies likely to yield the greatest economic and/or social benefits ...".[6] Foresight is also defined in opposition to other policy analysis tools; for example, Kerstin Cuhls states that "...[t]he major difference between foresight and forecasting is that in forecasting the conclusions for today are missing. The difference between foresight and planning is that planning has to be more concrete, that things might be flexible but written down in a binding plan. [F]oresight is without obligation... it is more open to include and integrate new ideas."[7] All definitions are not necessarily exclusive; they approach the subject from different points of view.

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[2]See W.J. Thomas, *The Unadjusted Girl* (Boston, Little, Brown, and Co., 1923). It should be interesting to analyse foresight in the context of (political) "problem definition": see, e.g., Peter S.G. Bots, http://www.tbm.tudelft.nl/webstaf/tinekep/TB4110/problem_structuring/sld001.htm.

[3]Organisation for Economic Cooperation and Development, Science Technology Industry Outlook 1998 (Paris, OECD, 1998).

[4]Knut Blind, Kerstin Cuhls and Hariolf Grupp, "Current foresight activities in Central Europe". *Technological Forecasting and Social Change*, vol. 60 (1999), p. 17.

[5]Hariolf Grupp and Harold A. Linstone, "National technology foresight activities around the globe: resurrection and new paradigms", *Technological Forecasting and Social Change*, vol. 60 (1999), pp. 86, 89.

[6]Organisation for Economic Cooperation and Development, *Technology Foresight: A Review of Recent Government Practices* (Paris, OECD, 1995), p. 2.

[7]Kerstin Cuhls, *From Forecasting to Foresight Process* (in print).

It is always better when the subject of our study is open, puzzling and disputable; not many subjects fulfil these criteria as well as foresight. Sometimes foresight looks like time for Saint Augustine: "I understand it as long as I am not thinking about it", he said. Foresight both expresses and reflects specific features of our times. But it also makes foresight difficult to describe in its full complexity and hard to transfer from one country to another.

Foresight exercises seem to consist of a "hard core" of concrete techniques (e.g., Delphi or scenarios) and "soft surroundings", with general goals, aims, expectations, motives, attitudes, managerial skills and capabilities that are difficult to define. It is said that in foresight, the process itself is more important that its outcome; but the process is more difficult to measure. That is why contrary to other policy tools, foresight does not have any clear performance indicators. Techniques are relatively easy to transfer from one country to another; but success of foresight depends mostly on the presence of these factors which are more difficult to measure (and more difficult to transfer).

Like almost all technical and intellectual inventions, foresight has its own life history: the period when it is conceived; the period when it is refined and developed; the period when it becomes topical, widely diffused and effective; and the last period, when it declines, first in the world centre, and next, at the world periphery.[8] Seen from this point of view foresight enters the second stage; we all are witnesses of its enormous success, diffusion and acceptance. Why has it been born? Why is it so widely accepted and disseminated? Could its success really be explained by optimization of policy and management?

The best way to discuss foresight issues is first to approach them from a very broad perspective and then to pose more specific questions.

Many theoreticians of social systems describe basic, opposite driving forces of every society: stabilization and flexibility; continuity and change; the fixing of norms of behaviour and relaxing of them; habitualization and openness for innovations, coming either from external influences or (more rarely) from our own inventiveness. Both driving forces are (to some degree) necessary; balance between them is needed and extremes are harmful. Stabilization at its best preserves social cohesion but excessive rigidity leads to petrifaction; flexibility is necessary for development but permanent experimenting is as harmful as excessive rigidity. "Open societies"—from Athens through Renaissance Italy to contemporary Western societies—are usually placed at cultural crossroads; they consist of different competing political and cultural institutions and have in-built, self-imposing institutions which promote inventions and innovations such as—first of all—the market.[9]

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[8]Lancelot Law Whyte, *The Unconscious before Freud*, 1962, p. 15.

[9]Wladyslaw Bienkowski, *Theory and Reality: The Development of Social Systems* (Allison & Busby, 1981); Wladyslaw Bienkowski, Problemy teorii rozwoju spolecznego (PWN, 1966). Peter L. Berger and Thomas Luckmann, *The Social Construction of Reality: A Treatise in the Sociology of Knowledge* (New York, Anchor Books, 1966), pp. 51-55, 59-61.

Flexibility is possible due to the constant feedback between changing environments and existing organizational structures and practices. Feedback enables self-correction of the chosen course of action and is a kind of antidote for petrifaction of social norms. In recent times, a lot of different political and managerial tools serve as an instrument for conscious feedback (i.e., benchmarking, monitoring, watching, assessment, audit, evaluation and trend analysis). Among all of these tools foresight has its own distinctive features. As a tool for comparing the environment and social structures it does not prepare (homeostatic) reaction, but creative and anticipatory pro-action.

How should foresight be adapted?

How should foresight be adapted to suit the needs of less developed countries? It is known that almost all technologies lose their productivity and efficiency while being implemented in less developed countries. Does foresight contradict this general rule?

What are the basic conditions for successful adoption/adaptation of foresight? Leaving the long discussion among sociologists and anthropologists on diffusion of innovations aside, let us review some of their basic observations:

(a) Usually inventions appear at the crossroads of other inventions: e.g., the first aeroplanes used the (already-known) propeller and internal-combustion engine. They then appear more frequently in time and place when all the necessary circumstances exist. Invention is usually a result of solving problems with one unknown factor. For example, the man who invented the steamship knew the effects of both the steam engine and the sail. More complicated inventions involving solving complex sets of equations with a number of unknown factors are possible. They have become frequent in recent times due to computers and large R&D centres and design teams. But even they cannot surpass certain limitations. A similar principle governs adoption and adaptation of inventions made in other societies: the larger the number of (technical, managerial, social and cultural) premises, the easier the assimilation; the more the unknown factors, the smaller the chances for successful adaptation. When necessary premises are not met the adoption/adaptation either is retarded or the invention plays a different role than in the society where it was born;

(b) The diffusion process can occur between related social structures; whenever the discrepancy is too wide diffusion is not possible, retarded or deviates from the previous application (for example, the clock was used as a status symbol among Polish gentry in the eighteenth and the nineteenth centuries);

(c) Assimilation of innovations is conditioned by the absorptive capacity of social groups and organizations; assimilation of the higher culture can

occur when it meets the internal process of change of the absorbing culture (for example, the adaptation of Roman law in Renaissance Europe was successful because ancient law expressed and was relevant to the contemporary aspirations of growing and prosperous towns);

(d) Assimilation of the more effective innovations occurs only when they are not perceived as being a major threat to social cohesion, the status quo (securing moral and material privileges) or fixed patterns of behaviour. Numerous examples taken from cultural history show that potentially progressive innovations (e.g., the plough, loom or—currently in India—sterile seed) were temporarily rejected.[10]

History matters

A brief excursion into the history of foresight could bring us closer to our aim.

The word "foresight" was used for the first time in the English language in 1591.[11] Up to the beginnings of the nineteenth century foresight was often used in the titles of sermons and comedies. Samuel Coleridge (1772-1834) used it in the sense of political skills in the title of his book in 1816 (which had many reprints in the course of the nineteenth century), since by that time foresight was included in the emerging vocabulary of political sciences. In the twentieth century its meaning has grown. In the years listed below the term was used for the first time in book titles in the following subject areas:[12]

- 1917 - Administration ("civic foresight, municipal interest, administrative efficiency");
- 1918 - Industrial engineering;
- 1931 - Biology and psychology;
- 1936 - Life assurance;
- 1938 - Foreign affairs;
- 1939 - Economics (in the context of econometrics, economic development, investment models and economic policy);
- 1949 - Management (factory, city, state or risk management);
- 1957 - Health;
- 1961 - Famous book written by Stephen Toulmin, Foresight and Understanding; an Enquiry into the Aims of Science;
- 1968 - Word "foresight used in the sense of forecasting;
- 1972 - Educational sciences;
- 1973 - Law sciences;

[10]Based on Stefan Czarnowski, *Kultura* (Ksiazka, 1946).
[11]Denis Loveridge, *Foresight and its emergence* (Manchester, PREST, 1998), p. 2.
[12]Based on a search of the Outline Computer Library Center (OCLC) WorldCat database.

1974 - Civil defence;
1975 - *Foresight*, a monthly publications on insurance and risk management;
1976 - Cognitive sciences (perception, reasoning and applied mathematics);
1977 - Marketing research;
1979 - "Foresight Hearings" before the United States House of Representatives.

In the second half of the 1970s, the meaning of "foresight" as a political skill of the great statesmen disappeared; instead, the word was used more and more frequently in the context of econometrics, strategic planning and management.

1983 - Business forecasting;
1984 - Motivational literature;
1984 - John Irvine and Ben Martin publish *Foresight in Science: Picking the Winners*. The term foresight is used for the first time in the book title in the context of S&T policy and management;
1984 - *Foresight*, a monthly publication on emerging trends and issues;
1986 - Air Force intelligence service;
1989 - Another John Irvine and Ben Martin book, *Research Foresight*, is published.

Since 1994 there has been a growing number of books with "technology foresight" in their titles; they concern foresight either at a national, branch, regional, disciplinary or company level. However, books on foresight in administration, economic or political sciences prevail:

1995 - Richard Slaughter's *Foresight Principle: Cultural Recovery in the 21st Century* is a bestseller in the United States;
1996 - Philosophy;
1999 - *Foresight: the Journal of Futures Studies, Strategic Thinking and Policy* begins publication.

Modern technology forecasting is generally said to have its roots in military planning during and after the Second World War. In the 1950s a new forecasting community appeared outside that of the science and technology community in most advanced Western countries.[13] As Irvine and Martin said, "... the failure to predict the 1973 'oil shock' led to considerable skepticism concerning the validity and utility of forecasting and the boom in futurology which began in the mid-1960s ended equally rapidly during the latter part of the 1970s when many firms disbanded longer-term corporate planning".[14]

[13]Denis Loveridge, *Foresight and its Emergence* (Manchester, PREST, 1998), p. 7.

[14]Ben R. Martin and John Irvine, Research *Foresight: Priority-Setting in Science* (London, Pinter Publishers, 1989), p. 73.

Today foresight seems to be "ready made" to be transferred "off the shelf" everywhere in the world. In the 1970s and 1980s it underwent a long process of crystallization, when progress came step-by-step, by trial and error, by learning and by doing. Foresight has emerged as an answer to real questions and as a tool for resolving real problems. All of the problems have to do with the growing disparity between the complexity and the speed of change of S&T and innovation systems and our ability to apply relevant political and managerial measures. This problem is not necessarily considered vital in less developed countries.

What is more, foresight emerged in the 1970s and 1980s on very fertile ground. Already at that time in all sectors—the science sector, governmental sector or industrial sector—many similar tools were used and upgraded, like technology assessment, trend analyses, strategic planning, priority setting, policy evaluation, goal-oriented functional S&T budgeting, field surveys, S&T statistics, science and technology monitoring, patent indicators and many others. All these tools nourished one another; there was strong synergy between them. They teach actors to think systematically in a long-term horizon, to overcome limitations in their own fields, to see their own fields in a wider context and to work together. Without this fertile environment foresight could not have emerged. Once again, such conducive conditions do not necessarily occur in less developed countries.

Table 1 lists countries that have introduced foresight at a national level, starting with Japan in 1970 and with some Latin American and European countries more recently. It shows that foresight starts to be diffused in the mid-1990s according to the general pattern of innovation diffusion (a flattened S-curve). This can be seen as an important threshold. Since that time foresight has been dispersing quickly all over the world.[15]

Foresight, forecasting and technology assessment movements are attracting a growing number of experts and interested people. There are already numerous journals, manuals and "futures societies", based mostly in the United States. There is a full-time Master's course in the area of foresight studies run by Leeds Metropolitan University in the United Kingdom. A number of centres in the United States offer similar courses. Throughout the 1990s, foresight was included in the activities of international organizations and networks, like UNIDO, the European Union, OECD, the European Science and Technology Observatory network (ESTO) and the European Science Foundation. Consulting and research in foresight is undertaken, for example, by the Science and Technology Policy Research Unit (SPRU) and the Policy Research in Engineering, Science and Technology (PREST) in the United Kingdom or Germany's Fraunhofer Institute for Systems and Innovation

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[15]Based on: Loveridge, op. cit., United Kingdom, Office of Science and Technology (OST), *The Future in Focus: A Summary of National Foresight Programmes* (London, OST, 1998); J.P. Gavigan and E. Cahill, *Overview of Recent European and Non-European National Technology Foresight Studies* (Seville, JRC-IPTS, 1997); ITPS, Recent National Foresight Studies. A Review (Seville, JRC-IPTS, 1998); UNIDO, *Technology Foresight: A UNIDO-ICS Initiative for Latin America and the Caribbean* (Vienna, UNIDO, 1999).

Table 1. Introduction of national technology foresight programmes, 1970-2001

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99	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
98	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
97	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X										
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Country																													
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	+	*	#

a – Japan	k – United Kingdom	u – Ireland
b – United States	l – India	v – Spain
c – Germany	m – Indonesia	w – Sweden
d – Australia	n – Canada	x – Argentina
e – Republic of Korea	o – Thailand	y – Bolivia
f – Philippines	p – Finland	z – Brazil
g – Netherlands	q – Hungary	+ – Mexico
h – New Zealand	r – South Africa	* – Venezuela
i – Italy	s – Nigeria	# – Czech Republic
j – France	t – Austria	

Research (ISI) in Karlsruhe. Despite the boom of research and training, little is still known of many crucial topics, including the following:

- Evolution of foresight;
- Internal structure of contemporary foresight exercises (except for the important IPTS report);
- Connections between national foresight exercises and wider political and social processes;
- Foresight's linkage with other "strategic intelligence" policy tools (e.g., evaluation, technology assessment, etc.). An exception to this is the EC network that completed the project known as Advanced Science and Technology Policy Planning (ASTPP) two to three years ago. It sought to investigate the possibilities for linkage between foresight, evaluation and technology assessment.[16]

To explain in one sentence why Poland needs foresight, one might say that it might help the country to shift from the burden of history to the opportunities created by geography. Before 1989 both our history (an agricultural tradition with slow-paced urbanization) and geography (located between two superpowers, Germany and the former Union of Soviet Socialist Republics) posed more threats than opportunities. Now our geographical location—between highly industrialized Germany and the rest of the European Union and the promising future markets of the Russian Federation and Ukraine, between Scandinavian countries and the Czech Republic and Slovakia—has become one of Poland's main assets.

Geography matters because the main challenge of post-communist countries is the disparity between living standards in those countries and living standards in Western countries. The "civilization challenge" is the strongest in the Western parts of CEE and at the same time these countries have relatively better chances of being the first to enter the path of continuous economic growth. The importation of cultural norms seems to be the single most important variable explaining changes in Poland. But the scale of the benefits coming from its geographical location depends on upgrading our own Polish human capital.

Foresight is one of the innumerable goods, standards, norms and values, habits and blueprints that Poland is importing. As with many other goods, it needs to be adapted. This is because foresight was invented as a tool for resolving problems of highly industrialized (rather than developing) countries.

It is extremely interesting to trace the birth and the world career of foresight. Foresight has made a long walk from:

- Slightly modified traditional forecasting method, to a clearly new idea;

[16]Based on personal communication from Michael Keenan.

- Rarely applied, to very frequently applied;
- A variety of forms, to stabilization, standards and codified knowledge;
- Dispersed initiatives, to focal points;
- Focal points, to an informal network of organizers;
- Informal network of organizers, to organized networks (e.g., UNIDO or IPTS);
- Use by highly industrialized countries to use by less developed countries.

Many other ideas have followed the same road, but only a few gained such wide acceptance.

One of the secrets behind the great success of foresight lies in its flexibility, i.e., its ability to be developed and adapted to very different needs, tasks and situations.

Why has foresight emerged and gained such wide acceptance?

Historians usually divide causes of new social phenomena into three broad groups: general conditions, longer-term reasons and immediate causes. The 1973 oil-shock, cited as the reason for the emergence of foresight, belongs to this third category. Several more general reasons are described below. As one of only very few tools, foresight expresses and reflects the more general cultural, social and economic trends of the most advanced countries, be they long-term, mid-term, recent or only just emerging, and that are historic on a global scale or only locally (e.g., birth of a new research and consulting area). These trends are often related one with another. There is a question of whether these trends are equally present in less developed CEE countries, and if not how this might influence the adoption of foresight.

Foresight reflects and expresses a shift from the industrial to the information society. It is not a coincidence that the oil shock of 1973 in the Western world caused both the development of foresight and—as a more general trend—the transformation of the economy and society. While the excessively high increase in energy costs in 1973-1974 in Western countries accelerated the shift of the techno-economic paradigm from energy, labour and natural resource-intensive industries towards a knowledge economy based on telecommunications and electronics, the abundance of cheap oil and the absence of a market with performance signals prolonged the existence of the old paradigm in the Soviet bloc countries.[17] Political reasons for the delay were strengthened by the historical backwardness of the Soviet bloc countries (the Czech Republic and, to a certain degree, Hungary being exceptions).

[17]Claes Brundenius, "Lang Waves and the Demise of the 'Socialist Camp'", in Research Policy Institute, *Annual Report* (Lund University), p. 6; Eric Hobsbawn, Age of Extremes, 1994.

In the mid-1980s, foresight simultaneously crystallized in countries where GDP per capita surpassed US$ 14,000. Gross expenditure on R&D (GERD) as a percentage of GDP surpassed 1.3 per cent and business expenditure on R&D was comparable or even two or three times higher than governmental expenditure on R&D. None of these criteria has recently been met in CEE countries. The current GDP per capita in Poland and the structure of the Polish economy resembles that of the Federal Republic of Germany or France in the early 1960s. Although "history never repeats itself", the fact that many structural indicators of CEE economies resemble that of the more advanced Western countries some decades ago does matter. We need not share the Marxist point of view to state that despite the information technology invasion in the mid-1990s, economic backwardness has a strong impact on the social consciousness as well as on the political and managerial capabilities of economic and social organizations in countries of CEE.

Looking from a longer historical perspective, the emergence of foresight could be viewed as a sign of the shift from a traditional to a post-modern society. Traditional societies were based on routine and repetition, legitimized by divine order. With the exception of merchants, travellers and the social elite, the majority of people in pre-industrial Europe perceived the world as unified, undisputable and without any alternative.[18] These days it is more and more often perceived as complex, dynamic, multi-dimensional, ambiguous, blurred, unpredictable and hard to categorize.[19] Rather than routine, risk-taking, entrepreneurship and creativity are considered to be vital individual and social assets. Foresight is said to be the best tool to cope with this new situation. It is not by accident that it was born in Japan.

> "Some nations and some people have been shown to have a low tolerance to uncertainty and ambiguity. Sociological research reveals that this is an important characteristic of the Japanese culture. However, this is also combined with another feature, the desire to innovate and the acceptance that change, not stability, is the natural state of human society. These two factors would appear to impose conflicting claims difficult to resolve, but they also lead to a strengthened realization that the two strive to reduce the uncertainty from innovation by an investment in forecasting ...".[20]

In some CEE countries, traditional societies survived intact in rural areas up to the second half of the nineteenth century and remains of traditional approaches endure to the present day. Generally, the senses of uncertainty and ambiguity (as well as the innovation approach) are not as strong as in Japanese culture.

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[18]Jerzy Szacki, *Tradycja: Przeglad problematyki* (PWN, 1971). See also John Naisbitt, *Megatrends. Ten Directions Transforming Our Lives?* (New York, Warner Books, 1982), pp. 11-38; Alvin Toffler, The Third Wave (1980).

[19]Stefan Kwiatkowski, *Przedsiebiorczosc intelektualna, Wydawnictwo Naukowe* (PWN, 2000).

[20]Brian C. Twiss, *Forecasting for Technologies and Engineers: A Practical Guide for Better Decisions* (London, Peter Peregrinus Ltd., 1992), p. 9.

Referring to the well-known Ferdinand Tönnies dichotomy, i.e., community *(Gemeinschaft)* versus society *(Gesellschaft)*, which reflects the transition from a feudal, rural community to a modern society, one can state that in CEE countries the transition from community to society occurred much later than in Western countries. For instance, in the part of Poland incorporated into the Russian empire, socage was not abolished until 1864 and large-scale industrialization was not undertaken until communist rule. Community remnants are still much more apparent even in the big urban settlements. Respect for the law and observance of rules and regulations (as opposed to the informal connections and individual exchange of services) is weaker than in Western countries.

Foresight could also be treated as a significant sign of the long-term historical process that has transformed the world from past-oriented to future-oriented.[21] The world of repetition, tradition and faith in the wisdom of ancestry has declined and a new world of the cult of novelty, invention, innovation, discovery and originality has emerged. Even in the old world, the future was present and in the new one, the past is often remembered and cultivated. Nevertheless, in the most advanced countries the "turning-point" —i.e., the change of the individual and group attitudes regarding time— occurred between the end of the nineteenth century and the end of the First World War. In Stefan Zweig's fascinating *Die Welt von Gestern: Erinnerungen eines Europaers* (1941) he described this turning-point in Vienna after the Great War. Communism froze a lot of past-oriented attitudes; with the exception of the younger generations the Polish continue to be past-oriented.

Foresight is also evidence of a historical shift from short-term to long-term thinking.[22] Thinking in the long term started at least with Kondratieff's long waves theory. For many years computer games like "SIMCITY 2000" have taught us how our daily decisions could have long-term consequences. In CEE countries short-term thinking still prevails. It seems to be a reaction to socialist planning and an expression of the consciousness of being a subject (and not a player) of historical processes.

We could also look at foresight as an illustration of the change from routine to innovation. Once again, it is not a coincidence that foresight was developed alongside innovation policies, management practices and economic theories. Until the industrial revolution most societies were conservative; they observed traditional procedures and resisted any change. Even potentially useful innovations were often treated with suspicion. Technical progress was slow.[23] Since the industrial revolution innovations have become one of the basic elements of the new capitalist economy. However, it was only the rise of the new techno-economic paradigm that made innovation one of the

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[21]Krysztof Pomian, "Kryzys pryszlosci", in: Rozmowy w. Castel Gandolfo, O Kryzysie (Res Publica, 1990). (Polish translation of: *Über die Krise* (Institut für die Wissenschaften vom Menschen, 1996).

[22]Naisbitt, op. cit., pp. 106-206.

[23]Fernand Braudel, Civilisation matérielle, économie et capitalisme, Xve-XVIIIe siècle. Les structures du quoritien: le possible et l'impossible (Paris, Librairie Armand Colin, 1979).

central topics for economists, entrepreneurs and politicians. Until the end of the 1970s, innovation theory had only marginal status;[24] innovation statistics were not developed until 1992 ("Oslo Manual"). Because of the anti-innovative nature of the communist economy, there is still a delay in understanding the importance of innovation by entrepreneurs, economists, policy makers and the public in post-communist countries.

Foresight with its wide civic participation is also evidence of the historical process whereby "civilization competences" are constantly upgraded in the most advanced countries. In their historical experience, which had and still has an adverse effect on economic growth, Central and Eastern European countries followed a different path of economic and social development starting from the sixteenth century. The so-called second serfdom, represented by stagnation, the downfall of towns and weak bourgeoisie were the reasons why nations of Central and Eastern Europe (the Czech Republic being an exception) became either peasant-and noblemen-nations or purely peasant-nations. The two social layers, peasants and noblemen, while separated by impassable barriers, had a lot in common, i.e., low geographical and social mobility, narrow cognitive capacity and strong traditionalism. The historical experience of peasants (who much more numerous) was lack of subjectivity (i.e., serfdom) and forced labour for the benefit of others. Some important elements in the mentality of noblemen survived even after noblemen as a social class disappeared. They included contempt for town-related occupations (handicrafts and trade), condemnation of success and entrepreneurship, and ostentatious consumption. In the years of the Second World War and, notably, under the communist regime many social regulatory mechanisms were destroyed. There were no favourable circumstances allowing new positive social mechanisms to develop.

As a consequence of the above, CEE countries still lack the attitudes, skills and institutions necessary for an efficient modern society, or, in the term coined by Polish sociologist Piotr Sztompka, "civilization competence", that is, skilful and semi-automatic mastery which are prerequisites for participation in modern civilization. According to Sztompka, four substantive sub-categories of civilization competence coincide with four main areas of modern developed society for which they are immediately relevant: economy, polity, social consciousness and everyday life. First, there is enterprise culture, which is indispensable for participation in a market economy; the second is civic culture, which is indispensable for participation in a democratic polity (rule of law, discipline, respect for opponents, compliance with the majority and the like); the third is discursive culture, indispensable for participation in a free intellectual community (tolerance, open-mindedness, acceptance of diversity and pluralism, scepticism and criticism); and finally, everyday culture, indispensable for daily existence in an advanced, urbanized,

[24]Jon Sundbo, *The Theory of Innovation: Entrepreneurs, Technology and Strategy* (Cheltenham, Edward Elgar, 1998).

technologically saturated and consumer-oriented society (orderliness, punctuality, facility to handle mechanical devices and the like).[25]

Foresight is also an expression of a long-term process by which boundaries between previously separated professions and activities are becoming blurred.[26] Today, not only is almost every research field seeking its own area of application, but almost every profession and activity is also developing its own extension in R&D. Entrepreneurship enters into almost all professions and activities, including research, universities, health care, the priesthood or charitable foundations. This process is not so advanced in CEE countries and, the majority of researchers are trying to maintain their independence. Multidisciplinary research or multi-professional problem-solving communities[27] (as opposed to disciplinary communities) are less common in CEE countries.

"The whole process management [of the foresight exercise] is supposed to be as self-learning as the process itself".[28] Organization of foresight exercise expresses another historical process-the shift from petrifying to self-learning systems. This shift is retarded in post-communist countries. Discussion on the reasons for the demise of the communist system will survive as long as historiography. Six reasons put forward by John Naisbitt and Patricia Aburdene are: globalization of the world economy (marking the end of self-sufficient economies); telecommunication technologies; the failure of centralization; the high cost of the welfare state; the shift in the workforce (decline of the blue-collar working class, being an ideological basis of the communist doctrine); and the new importance of the individual (towards the State).[29] But an even more general and important reason was discussed by Kyoung Won Lee:

> "... the state socialist system lacks the ability to 'reform itself' in order to improve its adaptable capacity in rapidly changing external and internal environments. ... the system lacks the capacity for self-transformation that

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[25]Factors described by Sztompka could be partly measured or explained by empirical surveys. Important explanatory variables concern human capital: "Between 1970 and 1997 the share of inhabitants with high ... education increased in Poland from 2% to 10%, whereas the percentage of those with utmost basic education fell from 50% to 33% respectively. This trend accelerated after 1989, e.g., the number of students ... doubled between 1990 and 1997 ... However, indices based on formal educational statistics do not suffice to appraise the capabilities of the people to cope with various every-day situations in the contemporary world with its modern techniques of communication, of banking services and of using information helpful in health care, in a search for employment, in self-education etc. According to the tests, conducted within an OECD comparative research project, the grown-up part of the Polish population has relatively insufficient qualifications to use written information in coping with ... every-day problems." (Cited from Krzysztof Porwit, "The Role of Institutions and Human Values on the Road to 'A Knowledge-based Economy' in Poland", in Antoni Kulínski [ed.], *The Knowledge-based Economy: the European Challenges of the 21st Century* [Warsaw, Komitet Badan Nankowych, 2000], pp. 153-154.

[26]See, e.g., Harvey Brooks, "The Relationship Between Science and Technology", *Research Policy*, 23 (1994), pp. 477-486.

[27]Werner Christie Mathisen "The Problem-Solving Community. A Valuable Alternative to Disciplinary Communities?" *Knowledge: Creation, Diffusion, Utilization*, vol. 11, No. 4 (June 1990), pp. 410-427.

[28]Kerstin Cuhls, op. cit.

[29]John Naisbitt and Patricia Aburdene, *Megatrends 2000: Ten New Directions for the 1990s* (New York, William Morrow, 1990), pp. 93-95.

is needed to sustain the system in the changing environment. The process of information gathering and allocation of resources based on the bureaucratic mechanism of state socialism curtails the system's ability to enforce its preferences. ... the origin of the breakdown of state socialism should be sought in its institutional design".[30]

The same idea is developed by Manuel Castels in the context of the new information technology paradigm:

> "Soviet statism faced a particularly difficult task in managing its relations with the economy and society in the historical context of the transition to informationalism. In addition to the inherent wasteful tendencies of the command economy, and the limits imposed on society by the structural priority given to military power, were the pressures of adapting to the specific demands of informationalism. Paradoxically, a system built under the banner of the development of productive forces could not master the most important technological revolution in human history. This is because the characteristics of informationalism, the symbiotic interaction between socially determined processing of information and material production, became incompatible with the monopoly of information by the State, and with the closing of technology within the boundaries of warfare. At the level of organizations, the structural logic of vertical bureaucracies was made obsolete by the informational trend toward flexible networks, similar as to what happened in the West. But, unlike in the West, the vertical command chain was at the core of the system, making the transformation of large corporations into the new forms of networked business organizations much more difficult."[31]

This lack of the ability to "reform itself", i.e., learning from experience, learning by learning, learning by monitoring and innovating, survived in CEE countries in almost all spheres subordinate to the State.

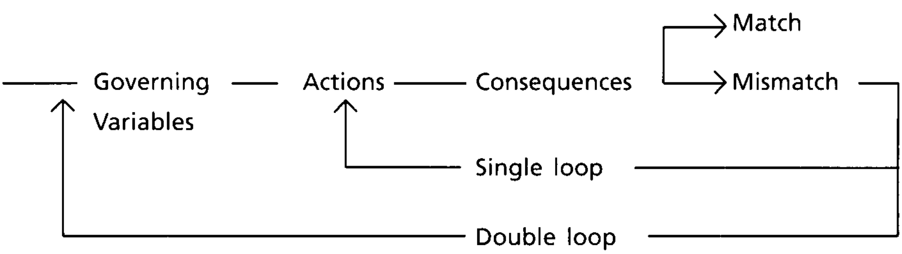
Foresight is also a channel for the development of "double-loop learning" (a term used by Chris Argyris). According to Robin Hill, the double-loop learning concept "refers primarily to problem solving and decision-making processes, particularly by managers. Managers become rewarded (with promotions and success, etc.) for making relatively quick, and off-the-cuff solutions and decisions. They may not address the alternatives. They're thinking only 'inside the box'. Hence they have only processed the problem they face through a single loop. A second loop occurs if they consider the problem

[30]Kyuong Won Lee, "A Study of the Breakdown of the State Socialist System: A System Approach", *System Research and Behavioral Science*, vol. 16 (1997), pp. 393-398.

[31]Manuel Castels, *The Information Age: Economy, Society and Culture*, vol. III of *End of the Millennium* (Oxford, Blackwell, 2000), p. 65. Castels also states: "By statism, I understand a social system organized around the appropriation of the economic surplus produced in society by the holders of power in the state apparatus, in contrast to capitalism, in which surplus is appropriated by the holders of control in economic organizations ... By informationalism, I mean a mode of development in which the main source of productivity is the qualitative capacity to optimise the combination and use of factors of production on the basis of knowledge and information." Op. cit., p. 8.

from an alternative point of view. Perhaps even role play from another point of view."[32] Double-loop learning is considered an antidote to over-protective and defensive organizational routines, as figure I below.

Figure I. Double-loop learning



The concept and the practice of double-loop learning are still much less known and used in CEE countries.

Foresight also could be interpreted as an illustration of the advancement of meta-thinking (techniques of thinking) and thinking about doing (management and self-management techniques). Currently there are thousands of courses and training sessions to teach how to think, decide, manage and behave in thousands of situations of public and private life. Lateral, creative, critical or system thinking; decision-making techniques like SWOT and PEST (i.e., politics, economics, social factors and technological change) analysis; brainstorming; nominal group techniques; the Delphi technique; and the Consensus Card Method as well as team management tools are now taught in Western countries at all levels of education. Almost all of them were used in foresight (or could be adopted to its needs). Up to the end of communism the "know what", "know that" and "know what for" training and literature prevailed over the "know how" approach. This trend has changed but the delay has been significant. Team working and the art of discussion belong to one of the most important civilization "Achilles' heels" of the CEE countries; every foreigner will immediately recognize this when participating in (usually) never-ending, chaotic and rarely conclusive public meetings.

One could not imagine foresight without the historical shift from static to the process concepts. "In Europe from 1750 onward", writes Lancelot L. Whyte, "a shift of emphasis is evident in philosophical and scientific thought from static toward process concepts which is still in progress today. ... The transformation from 1750 [being preceded by philosophical writings of Giambattista Vico, 668-1744] found its best known expression in the development of the evolutionary ideas ...."[33] Although the process of change has been taking place for more than two centuries, in CEE countries there are

[32]Robin Hill, http://www.well.com/user/philips/d-l.html.

[33]Whyte, op. cit., pp. 47-57.

many areas where static concepts prevail. Even the forced transfer of Marxism did not inculcate fruitful ideas of dialectics. For example, many public organizations are still built according to the timeless pattern without the in-built capacity for self-learning.

Foresight is also a striking example of the shift from linear and deterministic to non-linear system thinking. It is not a coincidence that foresight was born in the 1970s when the development of the system approach was accelerated. Jay W. Forrester, George J. Klir and Mario Bunge published classical books in the 1970s on the system approach. Tony Buzan built the mind-map concept (marking the break with linear thinking) and the first non-linear models of innovation were proposed. Today, the system approach has a decisive impact on the way S&T issues are treated by policy analysis. In recent years the disparity between the complexity and the speed of change of S&T and innovation systems and our ability to grasp it and apply relevant political or managerial measures has attracted growing attention and has became one of the key topics of S&T and innovation policy studies.

How are we to cope with complex, unpredictable social systems by using decision-making procedures that are also complex and unpredictable? Several very different solutions have been proposed and many of them have been implemented. One solution relies on strengthening policy evaluation (as a tool for self-correction in policy programmes, strategic planning, or foresight as a means of involving researchers, policy makers, the business world and citizens in shaping the future, and, generally, in the development of so-called "strategic intelligence" (S&T and innovation statistics, science and technology monitoring, etc.). Another consists in more open decision-making procedures using "system- and problem-oriented" approaches in which science, politics and economics are linked by strategic networks. These open procedures often include public participants (e.g., representatives of non-governmental organizations, local communities, interest groups and individual citizens) along with researchers, technical experts and decision makers. Public participants act not only as information sources, but also as citizens with the right to co-determine public policy. It appears that this mismatch between complexity of S&T and innovation systems and policy measures has not been realized in CEE countries.[34]

Foresight with its "futures" and not "one future" approach[35] could also be cited as an example of the historical change from a "no alternative", through

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[34]Simon Joss, "Public Participation in Science and Technology Policy- and Decision-Making—Ephemeral Phenomenon or Lasting Change?", *Science and Public Policy*, vol. 26, No. 5 (1999), p. 292; Ortwin Renn, "Style of Using Expertise: A Comparative Framework", *Science and Public Policy*, vol. 22, No. 3 (1995), p. 147; Chris Caswill, "Social Science Policy: Challenges, Interactions, Principals and Agents", *Science and Public Policy*, vol. 25, No. 5 (1998), p. 295; Barend van der Meulen, "Science Policies as Principal-Agent Games: Institutionalization and Path Dependency in the Relation between Government and Science", *Research Policy* 27 (1998), pp. 397-414; Barend van der Meulen, "Mediation in the Dutch Science System", *Research Policy* 27 (1998), pp. 757-769; Robert Hoppe, "Policy Analysis, Science and Politics: from 'speaking truth to power' to 'making sense together'", *Science and Public Policy*, vol. 26, No. 3 (1999).

[35]Gunther Tichy, "Technology Assessment and Technology Forecasting in Austria", *Futures Research Quarterly*, Fall 1999, p. 28.

an "either/or" to the "multiple option" culture.[36] Until the nineteenth century (and even in the beginnings of the twentieth century) European authors and their audiences shared common concepts, experiences and taste. But this unified cultural order was broken and was never restored. The nineteenth century gave us non-Euclidean geometry and the twentieth century gave us multivalent logic, philosophical theories of the multitude of realities, as well as the choice of hundreds of kinds of tea in shops and the choice of hundreds of TV channels and millions of web pages. Once again, transformation from "no alternative" to "multiple option" occurred suddenly in post-communist countries, but numerous remains of "no choice" thinking are still to be found.

Foresight could be also cited as an idea expressing the shift from hierarchies to networking.[37] Denis Loveridge writes: "In virtually all countries ... the main thrust of innovation policy has switched from provision of grants towards support and infrastructure. ... Foresight is a manifestation of this policy style"[38]. Communism was based on centralization, hierarchies and a linear model of innovation. The lack of civil society and domination of the Communist party hindered the creation of the horizontal connections.[39]

Manuel Castels, in describing the Soviet model, states:

> "The entire economy is ... moved by vertical administration decisions, between planning institutions and the ministries of execution, and between the ministries and the production units. ... Furthermore, scientific research and industrial production were institutionally separated. The powerful and well-provided Academy of Sciences was a strictly research-oriented institution with its own programs and criteria, disconnected from the needs and problems of industrial enterprises. Unable to rely on the contributions of the Academy, enterprises used the research centres of their own ministries. Because any exchange between these centres would have required formal contacts between ministries in the context of the plan, applied research centres also lacked communication

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[36]Naisbitt, op. cit., pp. 231-248.

[37]Gunther Tichy, op. cit., p. 29; Naisbitt, op. cit., pp. 232-249.

[38]Loveridge, op. cit., p. 10.

[39]"In socialism, most of technical change was pushed from one institutional [R&D] sector. ... This sector was considered as a separate branch which was through vertical links connected with industrial enterprises. This sector was involved in activities far beyond R&D including design, engineering and often trouble-shooting activities. Since innovation and production were two quite separate activities the whole process was managed by government ministries and central institutes. ... Innovation process was organised on the basis of the linear innovation model with the main push coming from externalised R&D and engineering towards production which was seen as a mere implementation of designs developed elsewhere. Production and users were not considered as sources of improvements and innovations. ... [E]nterprises in the Western sense did not exist in socialism. These were basically production and not business units. Business functions like marketing, finance and R&D were rudimentarily developed 'in house' or were entirely 'outsourced', either to ministries or to other organizations. ... S&T system was very much branch oriented as confirmed by the extent of intersectoral flows of innovation that were very modest." (Slavo Radosevic, "The Transformation of Science and Technology Systems into Systems of Innovation in Central and Eastern Europe", *Structural Change and Economic Dynamics*, vol. 10, Nos. 3-4 [December 1999], pp. 277-320.)

between each other. This strictly vertical separation, imposed by the institutional logic of the command economy, forbade the process of 'learning by doing' that was critical in fostering technological innovation in the West. The lack of interaction between basic science, applied research, and industrial production led to extreme rigidity in the production system, to the absence of experimentation in scientific discoveries, and to narrow application of specific technologies for limited uses, precisely at the moment when advancement in information technologies was predicated on constant interaction between different technological fields on the basis of their communication via computer networks".[40]

Today, networking and clustering are still considered as one of the most important problems of industrial enterprises and the society as a whole in CEE countries.

Foresight cannot be understood beyond the whole science-technology-economy-society complex in which relationships between each sector are becoming closer and boundaries between each of them are becoming blurred. Democratic capitalism in Western countries (where democracy and capitalism enhanced each other) led to great dynamism in areas such as economy, technology and science. Technological, managerial and social innovations allowed developmental barriers to be overcome. Innovations that became commonly applied in business, administration and research activities include: technical standards, quality assurance, scientific management, agents' reporting to patrons, surveys, marketing efforts, statistical forecasting, and comparative standards derived from scientific observations and statistical research. Scientific and technological research (despite all the declarations about the need for science to remain autonomous) was an important component of those transformations. For instance, as early as the middle of nineteenth century, public authorities in the United States used statistical research as the basis for government policies, and industrial enterprises commissioned research in order to identify possible market applications or enhance the properties of certain materials. Science and technology were in much more harmony with everyday culture and specific social needs in Western countries than in less advanced societies.[41] Formation of the science-technology/economy-society complex gained momentum around the 1870s in Germany (between the chemical and electric industry, electrotechnics, chemical engineering, and chemistry and physics) and after that time expanded into other countries, branches of industry and spheres of life. Integration gained momentum in the mid-1970s; now it is said that in Western countries the shift from the "science and technology system" to the

[40]Manuel Castels, op. cit., pp. 20, 32. See also Slavo Radosevic, *International Technology Transfer and Catch-up in Economic Development* (Cheltenham, Elgar, 1999); David Dyker, "Technology Policy and the Productivity Crisis in Eastern Europe and the Former Soviet Union", *Economic Systems*, vol. 18, No. 2, June 1994.

[41]For instance, Western cattle breeders have meticulously followed researchers' recommendations and monitored development of each animal for many years; they are also familiar with new technologies and business techniques, etc.

"innovation system" has occurred. In CEE countries the science-technology/economy-society complex is much less integrated. For example, the share of industry in R&D expenditure is much smaller, mutual flow of funds for R&D between the business sector and the government sector is weaker and social sciences are underused in the policy-making process. The shift from the "science system" to the "science and technology system" and from the latter to the "innovation system" is delayed. CEE countries "face the question of how to create a new capitalist innovation system, which helps to improve the competitiveness of domestic enterprises under predominantly post-socialist conditions. Western models cannot be applied under these post-socialist circumstances because the required financial and institutional conditions do not exist".[42]

The diffusion of foresight exercises in the 1990s coincides with the expansion of the national innovation system (NIS) research idea and political practice. Foresight is already used as a vehicle for formulating policy towards NIS and—at the regional level-could also be applied as a NIS management mechanism.[43] At the regional level, CEE systems of innovations, as compared with that of developed countries, are immature. For example, as concerns Poland, "... [f]irstly, there are no—so-called—regional organizations. Many autonomous activities are observed both at administrative level, in business practice, education and R&D institutions. Secondly, there are practically no regional policies. Thirdly, innovative practices of the investigated firms are not region-oriented".[44] Referring to the interesting taxonomy of national systems of innovation proposed by Yong-tae, one could ascribe CEE to the "cluster VI" type: i.e., government-education. "Specifically, the distinctive property of this cluster is the dominating role of the government and education sectors in terms of both R&D funding and performance. Government supplies the majority of R&D funds and the education sector, together with public institutes, spends the most. The share of the private sector in insignificant. ...[T]he industrial base is as yet insufficiently developed ... to form a critical mass of private R&D."[45]

Foresight could also be also described as an example of the shift from research autonomy to science policy and research management that has occurred gradually in advanced countries but with important acceleration since the first half of the 1960s. This systemic change as described by John Ziman in *Prometheus Bound: Science in a Dynamic Steady State* (Cambridge, 1994) could be characterized as a simultaneous invasion into the republic of science

[42]Jürgen Bitzer, "An Evolutionary View of Post-socialist Restructuring: From Science and Technology Systems to Innovation Systems", in C. von Hirschhausen and J. Bitzer (eds), *The Globalization of Industry and Innovation in Eastern Europe: From Post-Socialist Restructuring to International Competitiveness* (Cheltenham, Edward Elgar, 2000), pp. 13-35.

[43]See, e.g., Gunther Tichy, op. cit.

[44]Bogdan Wawrzyniak, "Innovative Practices of Polish Firm. Regional Perspective, Globalisation and Change: Ways to the Future" (Warsaw, 2000), p. 248.

[45]Yong-tae Park, "A Taxonomy of National Systems of Innovation: R&D Structure of OECD Economies", *Science and Public Policy*, vol. 26, No. 4 (1999), p. 245.

governmental S&T policy, managerial techniques, reflexivity (science and technology policy studies and analyses), new professions (e.g., research evaluator, S&T programmes evaluator, S&T policy analyst) and educational programmes aimed at teaching how to carry out S&T policy, manage research laboratories or run innovation projects. Norms and values learned by researchers in their academic environment are typically contradictory to policy and management; even in the most advanced countries the change from research autonomy to science policy and research management was never fully accepted by the scientific community.[46] However, this systemic change is only beginning in CEE countries and Western countries are now several decades ahead. It is important to take this into consideration because foresight exists not only for its own sake, but for something else—for priority setting, budget allocation, planning, development of networks and communication. It might be used as a tool for upgrading other social tasks and functions, but in CEE countries its final success depends not only on how its actors and stakeholders understand its aims and tasks but also whether they are acquainted with modern decision-making procedures in public administration or innovation management techniques in industry. The creation of currently lacking complementary assets such as improvement of decision-making procedures in public administration seems to be unavoidable.

Foresight could also be cited as an illustration of the shift from administration to management, which began to occur in American business in the second half of the nineteenth century and since that time has spread out to other countries and sectors. In the United States this shift began to affect public administration in the 1950s and research laboratories and universities in the 1960s.[47] The introduction of management techniques in public administration improved its efficiency and effectiveness.

The secret of efficient public administration in Western countries lies, inter alia, in the fact that both officials and politicians know and automatically apply certain basic reasoning and action procedures (just like researchers know essential elements of their research arguments and scientific methods). Therefore, in order to be solved, a problem must first be identified, options described and the best one selected, performed and evaluated. Action plans include preparation, implementation, monitoring and final assessment. Financial decisions must be justified and their effects checked. When taking an important decision all the complex circumstances must be taken into account, long-term consequences foreseen, etc. The ABCs of effective behaviour are learned in secondary schools (decision-making procedures, the art of giving speeches, discussion and rules for debate), during administrative and political studies, from managerial computer games (available in many offices) as well as from practical experience.

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[46]Erik-Ernø-Kjølhede et al., "Managing University Research in the Triple Helix", *Science and Public Policy*, vol. 28, No. 1, February 2001.

[47]See JoAnne Yates, *Control Through Communication: The Rise of System in American Management* (Baltimore, Johns Hopkins Univ. Press, 1989).

This historical shift has scarcely begun in CEE countries in either the public R&D sector or in public administration. Governmental departments responsible for S&T and innovation are still very far from standards observed in advanced Organisation for Economic Cooperation and Development countries. The patron-agent relationships are not clearly defined. The political cycle lacks the necessary expertise. Research institutions rarely have missions or plans. Political institutions undertake tasks that should be performed separately, such as financing, funding, evaluation, research policy advising and strategy formulation. In the absence of a well-defined economic and social development strategy, science, technology and innovation policies are relatively vague. Political instruments are mostly general, passive (i.e., initiatives for application come from the enterprises and research organizations that are to be affected by them), incomplete, redundant (many policy instruments are supposed to act in the same way) and have conflicting purposes.[48] The absorptive capacity for introduction of new political tools (e.g., those proposed by the new public management or OECD Directorate for Science, Technology and Industry) is still relatively weak. Similarly, in research laboratories and universities modern management techniques are being introduced very slowly.

Foresight, with its emphasis on wide participation[49] and negotiation between stakeholders, could also be cited as an example of historical transformation: a shift from a representative to a participatory democracy and from a linear to an interactive model of the policy-making process.[50] Public participants act not only as information sources, but also as citizens with the right to co-determine public policy. The role of researchers in the decision-making process has been changed. For a long time, they "offered their capabilities as 'speaking truth to power'. Since the early 1990s, this input has been transformed in an argumentative policy analysis ... 'making sense together'".[51] CEE countries are much less advanced in that process, e.g., they have not introduced consensus conferences, another new tool for participatory policy-making.

Foresight could also be treated as a policy analysis instrument and from this point of view its emergence is one of the signs of the development of a broad policy analysis arsenal (including, e.g., policy evaluation, S&T monitoring, technology forecasting, technology assessment and trends analysis). Daniël Tijink outlines the evolution of policy analysis in the following:

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[48]See F, R. Sagasti, "The Science and Technology Policy Instruments Project", *Science and Public Policy* (1979), pp. 281-285.

[49]Loveridge, op. cit., p. 12.

[50]Naisbitt, op. cit., pp. 159-188; S. Joss and J. Durant (eds), *Public Participation in Science: The Role of Consensus Conferences in Europe* (Science Museum, 1995); A .J. Hingel, "European Consensus Conferernces—A New Tool for Policy Making", Futures, 25(4):472-475, 1993; Simon Joss, "Public Participation in Science and Technology Policy- and Decision-Making—Ephemeral Phenonomenon or Lasting Change?", *Science and Public Policy*, vol. 26, No. 5 (1999), p. 292; Daniël Tijink, "Foresight in Science and Technology Policies as Participatory Policy Analysis", http://www.deruijter.net/ocv.htm.

[51]Robert Hoppe, "Policy Analysis, Science and Politics: From 'speaking truth to power' to 'making sense together'", *Science and Public Policy*, vol. 26, No. 3 (1999).

"The term policy analysis emerges in the fifties in the United States. Its concern is the support of decision-making and the prioritization of government projects. The first analyses were primarily economically orientated. The basic idea was that a thorough analysis of economic advantages and disadvantages would give an objective base for priority setting and policy decisions. Later this approach was broadened and other values such as social and environmental ones were also taken into account. New methods like multi-criteria analysis were developed to enable decision-making on alternatives with values that are difficult to compare. In the seventies, policy analysis was used to support policy-making more broadly. Apart from priority setting, policy analysis also tried to clarify the problem definition, to identify stakeholders and their interests, to come up with policy strategies, etc. Dunn (1981, p. 35) defines policy analysis as 'an applied social science discipline which uses multiple methods of inquiry and argument to produce and transform policy relevant information that may be utilized in political settings to resolve problems'. The basic assumption still is to gain objective information to support the decision-maker to make the best decisions."[52]

Except for some departments like the Ministry of Finance or Ministry of Foreign Affairs, policy analysis in CEE countries is still relatively poorly developed.

Finally, new phases of foresight exercises are used more and more as a tool of knowledge management. In the mid-1990s—exactly at the same time as the foresight boom—a new area in management sciences emerged based on the concepts of "intellectual capital" and "knowledge management". Both terms are different expressions of the same deep changes occurring in contemporary societies and economies-discovering intangible resources as an important kind of capital, and the drift towards the "knowledge society" and the "knowledge economy". New definitions, taxonomies, measurement techniques, empirical observations and recommendations for intellectual capital and knowledge management were built. This new knowledge was immediately used for managerial methods, as well as in forecasting and economics. New professions have risen around these concepts. At the same time intellectual capital and knowledge management redefined the whole group of cognate terms (of different meanings and functions): human resources, intangible resources, intellectual assets, intellectual capital, intellectual capitalism, knowledge, knowledge assets, knowledge capital, knowledge capitalism, learning organization, organizational capital, relational capital, social capital, structural capital, tacit knowledge, and many others. A new language, new research and managerial practices, and new ways of thinking were born.[53] Knowledge management is a sharing and cooperative culture (instead

[52]Daniël Tijink, op. cit.

[53]Jan Kozlowski, "Intellectual Capital, Knowledge Management and Intelligent Products in the Light of Catalogue and Abstract Data Basis" (forthcoming).

of the individualistic, competitive business culture)[54] and is therefore easy to link with the foresight exercise. This new idea was transferred relatively quickly to some CEE countries; for example, in Poland a new Knowledge Management Institute and a new journal were created recently.

Conclusion

Summing up, the emergence and diffusion of foresight in the most advanced countries should be viewed as a sign of the shift towards a world that is perceived as complex, multi-dimensional, blurred and difficult to categorize. Foresight was invented as a tool for coping with this new situation. However, definitions of situations and priorities of the CEE countries are not necessarily the same.

Western experts today scarcely find in foresight even one element or aspect that is unknown to them; it is rather, the way in which these elements or aspects are connected one with another that might be seen as new. They are much better acquainted with policy analysis instruments (e.g., evaluation), informed policy-making, organizational auto-diagnosis, teamwork techniques, discussion methods, strategic planning, comparing different point of views, negotiating and seeking consensus. Also, the social reality they live in is much more favourable for running foresight exercises (e.g., there are stronger science-industry networks and more efficient public administration).

One of the most difficult problems CEE countries could face when implementing foresight is how to adapt it and/or to develop all the necessary assets that are lacking to make it a tool that will help them to conceptualize their own most important issues and aspirations.

[54]Daniel L. Knight, "Performance Measures for Increasing Intellectual Capital", *Strategy and Leadership*, vol. 27, No. 2 (1999), pp. 22-27; Bernadette E. Lynn, "Intellectual Capital: Unearthing Hidden Value by Managing Intellectual Assets", *Ivey Business Journal*, vol. 64, No. 3 (2000), pp. 48-52.

Annex

How the State Committee for Scientific Research plans to implement foresight in Poland

In 1999-2000, on the initiative of Poland's State Committee for Scientific Research, the Science and Technology Foresight: Preparatory Phase project was executed by experts from PREST, the Victoria University of Manchester (United Kingdom) and ISI. Funding was provided by the EU's Phare Programme. Authors present an interesting analytical framework for discussing foresight. The project consists of three axes: the "elements of foresight axis", the "diachronic axis" and the "structural axis".

How will the project results be used by the beneficiary organization, the Polish State Committee for Scientific Research? As the programme is at a very early stage, it is sufficient to confirm strong determination to conduct foresight and briefly describe some proposals that will be put forward to a future Steering Committee.

Like in other countries, foresight in Poland should be based on the following main organizational elements:

(a) The Steering Committee will be established by the Minister of Science. One third of its experts will be appointed by the respective ministers (e.g., Ministers of Labour and Social Policy, National Education, Health and Social Care and Internal Affairs); one third will represent the world of science; and one third will represent users (e.g., businesses, non-governmental organizations and the media). The Steering Committee will take major decisions concerning objectives, problems, methods, the organization and timetable of the exercise on the basis of proposals received from the Department of Studies and Scientific Policy. Its other tasks would include: supervising the Management Unit; contracting and approving a final report; monitoring and evaluation; financial reporting on foresight; and ensuring political support for the project. The Steering Committee would be chaired by the Minister of Science;

(b) The Management Unit, established by an institution to be selected in a bidding process, will manage and coordinate the foresight exercise and supply information about the project's progress to the Steering Committee;

(c) Area panels will conduct scenario writing and a unit will be responsible for conducting the Delphi questionnaire survey and processing its results (to be managed by the Management Unit).

The contract tendered for the foresight exercise should be based on a detailed foresight scenario, including its tasks, procedures, timetable, evaluation rules, dissemination methods and preliminary budget (to be approved by the Steering Committee).

Terms of reference in the contract would cover the following tasks: developing reference materials, including scoping studies (analysis of foresight findings in various countries), position papers and a description of problems to be studied by panels; conducting pilot research (scenarios, Delphi survey); selecting experts for the panels and the Delphi questionnaire (through the co-nomination technique); and carrying out the foresight exercise.

As regards scenario writing, it is suggested that scenarios include three elements, i.e., an analysis of the last decade and an analysis of developments in periods of 10 and 20 years. They should be concerned with three types of future, including: the preferable future (visions, values and objectives), the expected future (trends) and the possible future (unexpected events and trend breakers).

It is also suggested that scenarios cover areas that attract considerable public interest and are of major importance in terms of developmental opportunities available in the country.

According to preliminary estimates, duration of the foresight exercise would be 1.5 to 2 years and cost approximately 2 million zlotny. This would cover the period from the contractor selection in a tender procedure to submission of required documents to the Steering Committee.

It is expected that foresight conducted by the State Committee for Scientific Research will become an important policy tool for designing and coordinating future actions concerning science and technology. The PREST/ISI report financed by the Phare Programme and supervised by the Bureau of European Cooperation of the Foundation for the Polish Science seems to be an important step towards this goal.

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8 Technology foresight in the Czech Republic

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Abstract

By adopting Resolution No. 16 of 5 January 2000, the Government of the Czech Republic approved the National Research and Development Policy of the Czech Republic as a key strategic document defining the relationship of the State towards research and development. A significant part of the document deals with oriented research—that is, research which has been oriented to achieving results needed to solve specific technical problems or improve the quality of life.

The Government entrusted the Technology Centre of the Academy of Sciences of the Czech Republic in collaboration with the Engineering Academy of the Czech Republic to manage the process of identification of detailed priorities of the oriented research using the technique of technology foresight. The national foresight programme is currently in progress; the results of the exercise should be delivered in November 2001. The programme addresses two basic questions:

(*a*) What are the most urgent economic, social, environmental and market needs of the Czech Republic in the time horizon of 2010?

(*b*) Which technologies and areas of research and development best address the future needs?

It is anticipated that the results of the foresight exercise will guide the distribution of about 70 per cent (about 8 billion Koruny annually) of public funding for research and development.

Regarding national and regional technology foresight activities, the following can be recommended:

(a) In the dynamic political and economical environment of countries in economic transition, the technology foresight activities are clearly a useful tool for decision-makers and strategic planners;

(b) It is not possible to define a single, best foresight technique for any situation or set of objectives. Each national foresight exercise has to be specifically tailored to the particular situation of the respective country, that country's targets and time available for the study;

(c) Industry must have the innovative capacity to fully utilize the foresight results and recommendations;

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(d) National teams should complete the national foresight projects since they have knowledge of tacit information that is hardly accessible to foreigners. Direct participation of a small advisory group (5-10 people) consisting of experienced foreign technology foresight experts may significantly enhance the project outputs and help to avoid operational mistakes;

(e) Growing interest in foresight exercises world-wide has influenced the continuous development and enrichment of foresight methodology; it has also produced some duplicity, particularly in introductory project phases but also in later analytical stages and interpretation of results. For that reason it seems useful to consider the development of cooperating structures that would share methodological principles and data. In this context the coaching role of well-established international organizations like UNIDO should be considered.

Introduction

The paper provides an overview of current technology foresight activities in the Czech Republic. Background conditions and strategic issues for future technological development and oriented research in the country are discussed in detail, particularly in the context of recently approved political documents.

The role of specific institutions in the national technology foresight exercise is reviewed and their relation to the policy/decision-making process is outlined. Generally, the foresight exercise is very close to decision-making-structures, as it is conducted upon a direct order of the Czech Government.

Short- and long-term plans for the development of technology foresight in the country are discussed, particularly in view of the anticipated enlargement of the European Union. In this context, international links in technology foresight are discussed with an emphasis on the need for broad international cooperation including an exchange of best practices. The possible role of UNIDO, as an experienced international organization, in promoting international cooperation in technology foresight activities, is suggested in the final part of the paper.

Background

Historically, the orientation and pattern of industry in the Czech lands was always strongly influenced by the demand of large economic blocks. It was the Austro-Hungarian Empire in the beginning of the twentieth century, followed by decades of incorporation in the so-called "eastern bloc" ruled by the former Soviet Union. The country developed strong manufacturing branches, for example, machinery, basic chemicals, arms production, material processing and food industry.

The transition from (a political) bloc dependence to independence has created a challenging environment for the national economy. The history of the former Czechoslovakia and its economy was shaped by the renewal of independent status in 1918, by political changes as a consequence of the Second World War in 1945 and, naturally, by the end of the cold war in 1989. The country was often called upon to utilize its strong manufacturing capacities, skilled labour force and the corresponding infrastructure in new conditions. In the first half of the twentieth century, Czechoslovakia ranked fifth among the most developed world economies in terms of GDP per capita. Naturally, there was a decline of the country's position as a consequence of divided Europe after the Second World War. Despite the political system, flexibility of the national economy and its core industry were always key conditions to succeeding in the changing environment. One of the prerequisites of success is knowledge of future market opportunities and technology possibilities. This is based on the critical evaluation of the country's resources and directing public spending to those research, engineering and technology development processes which are linked to favourable strategic possibilities. Such a task is usually accomplished through a systematic process of assessing market opportunities, strengths of national industry and research based on the expected needs of the country. That process, usually called technology foresight, is performed in all of the leading world economies and nowadays receives increasing attention in developing countries and in countries with economies in transition.

This paper provides an overview of the policy and strategy for future technology development in the Czech Republic with a particular emphasis on the present national technology foresight project.

Policy and strategies for future technological development in the Czech Republic

In the 1990s, there was a lack of strategically targeted initiatives regarding future technological development in the Czech Republic. Due to the basic restructuring of the whole system, including the industrial base, a turbulent environment throughout the first half of the 1990s brought about frequent changes in the positions of responsible persons, and strategic policy documents were practically non-existent. Most of the initiatives were short-term, targeted to cope with urgent problems and to prevent widespread social dissatisfaction. The situation began to change towards the end of the decade, when the Government decided to elaborate a basic document called the "National Research and Development Policy of the Czech Republic" (NRDP). At the beginning of 1999, nine Working Groups for the preparation of the NRDP were constituted. The project was managed jointly by the Ministry of Education, Youth and Sport and the Research and Development Council of the Government. The Working Groups consisted of representatives of ministries responsible for respective research areas in the country (Ministries of Education; Youth and Sport; Industry and Trade; Health; Environment; Defence; and Agriculture); experts nominated by the largest research bodies (universities, the Academy of Sciences and the Association of Applied Research);

deputies of important industrial associations and confederations; and other invited experts. Experts worked for six months in the following groups:

- Coordination;
- Research and development and transfer of results;
- Basic research;
- Applied research;
- Funding and indirect support;
- International cooperation;
- Infrastructure for research and development;
- Moral-ethical aspects; and
- Analysis.

In June 1999 a conference open for a broad, interested public was organized to discuss a draft version of the policy documents. Following the recommendation made by the conference participants and considering contributions from an Internet discussion forum, the final proposal of the NRDP was submitted to the Government for approval in December 1999.

By adopting Resolution No. 16 of 5 January 2000, the Government of the Czech Republic approved the "National Research and Development Policy of the Czech Republic" as a key strategic document defining the relationship of the State to research and development. A significant part of the document deals with oriented research-research, which is in its principle oriented to achieve concrete results, needed, for instance, to solve a technical problem or improve the quality of life. By its definition, oriented research partly involves also basic research. Oriented research is "demand-driven" whereas non-oriented research is "curiosity-driven". NRDP declares the need for early identification of priorities for oriented research using some of the proven methodologies (or a combination of methodologies) of technology foresight.

One of the basic objectives of prioritization is to create conditions for optimized spending of limited public funds to sustain an innovative science base, to support national wealth creation and to improve quality of life. It is generally acknowledged that the formulation of the priorities of the oriented research is a complex and time consuming as well as a financially demanding process. Such a process involves several stages:

- NRDP defines a limited number of thematic priorities—thematic programmes and a fundamental set of systemic priorities—cross-cutting (horizontal) programmes. Both groups reflect the assumed needs of the society in the time horizon of 10 years;
- Design of adequate concrete criteria for evaluation and decision-making during the selection of appropriate priorities of oriented research. The criteria should remain unchanged during the whole process until the priorities of oriented research have been implemented. The same criteria should also apply for the evaluation of research plans of research organizations;

- Selection of priorities of oriented research with a particular emphasis on matching the anticipated needs of citizens and the whole society.

The accomplishment of steps 2 and 3 is the principal task for a national foresight exercise.

Prerequisites and motivations for technology foresight at the national and regional levels

Generally, the NRDP defines the following fundamental priorities of the National Programme of Oriented Research (NPOR) grouped into five thematic and three cross-cutting programmes. The thematic programmes include:

(*a*) Quality of life;

(*b*) Information society;

(*c*) Competitiveness;

(*d*) Energy for economy and society; and

(*e*) Social transformation.

The cross-cutting programmes include:

(*a*) Human resources for research and development;

(*b*) Integrated research and development; and

(*c*) Regional and international cooperation in research and development.

Technology foresight exercises, which focus primarily on detailed identification of priorities of the oriented research, should start from and be particularly based on:

(*a*) Assumed needs of citizens and society to which oriented research (with possibilities of international cooperation) may contribute and for which public support may be obtained;

(*b*) The requirements on the development of human, knowledge and material potential of the Czech Republic;

(*c*) The needs of development of research and development capacities in the Czech Republic.

In addition to the selection of particular (research) priorities of the individual thematic programmes, the results of the national technology foresight exercise should also involve the recommendations for optimization of the structure and functions of cross-cutting programmes to create favourable conditions for systemic support of thematic programmes.

By the governmental resolution, the organization managing the technology foresight project had to be selected in a public tender. The Government commissioned the Ministry of Education, Youth and Sport to organize the tender and to represent the Government in the exercise. The Project funding, as a part of public R&D expenditures, should cover the costs related to the foresight exercise activity. The Project should deliver results in November

2001; NPOR should start in the year 2002 by supporting the first selected research projects.

Projects submitted to public tender were evaluated in October 2000. The committee of experts governed by the Ministry of Education, Youth and Sport selected the project submitted by a consortium of the Technology Centre of the Academy of Sciences (leading project partner) and the Engineering Academy (project partner).

Present national technology foresight programme

This section describes the current Czech technology foresight project, particularly its objectives and methodology. It should be emphasized that the project is "in progress", with results anticipated in November 2001.

Objectives

The Czech technology foresight project follows the tasks outlined in the NRDP for oriented research. The principal objectives of the project may be summarized as follows:

(*a*) A proposal of priorities (sub-programmes) of thematic programmes of oriented research defined by the NRDP;

(*b*) Recommendations for the optimization of the structure and functions of cross-cutting programmes to ensure favourable conditions for systemic support of thematic programmes and the NPOR as a whole;

(*c*) A design of basic principles of the management of the NPOR.

Due to the scope of this paper, only the methodology for the first task will be described in further detail.

Generally, the basic objective of the national foresight exercise is to identify the most important technologies likely to be required by Czech industry and the service sector over a 10-year period, and to create the conditions for development of the NPOR which are designed to achieve strategic goals in the preferred sectors important to national wealth creation and improving the quality of life of citizens.

Methodology

Methodology of the current national foresight programme corresponds to the objectives and conditions imposed by the formulation of the governmental request. The main objective is to identify priorities of oriented research within a relatively short time of one year. Selected research priorities should be able to address the most likely social, economic, environmental and market trends of the next 10 years (the time horizon of the study is the year 2010). Selection of priorities should be a combination of supply-driven and demand-driven attitudes with the emphasis on the latter.

Due to the above-mentioned conditions, the basic principles for the design of the foresight methodology are as follows:

(a) There is not sufficient time to perform a large-scale Delphi survey, which was the backbone of several recent foresight studies abroad (Germany, Hungary, Japan and the United Kingdom);

(b) The principal objective—identification of priorities of oriented research—may be accomplished using a modified method of "key technologies" (critical technologies, strategic technologies), which was successfully applied for instance in France, the Netherlands and the United States;

(c) An essential success factor is consensus building among various stakeholders—government, industry, commerce, academia and political circles;

(d) Input for the selection process should be collected from: potential "users" of results of oriented research (industry, entrepreneurs, commerce) to identify real needs of the Czech economy and society; "providers" of research results to evaluate the potential of the national research base to create required results; and government departments (ministries) to compare foresight findings with their strategic plans in the area of oriented research;

(e) To characterize the relative economic importance of individual business sectors, independent statistical data for each industry should be collected—e.g., its contribution to the GDP, its export potential, its potential to create a competitive advantage.

Methodologically, the foresight project consists of several consecutive stages depicted in figure I.

Figure I. Individual stages of the Czech technology foresight

Structure building

↓

Selection of business sectors

↓

Creation of a list of considered technologies

↓

Identification of important technologies to the Czech Republic

↓

Selection of strategic technologies to the Czech Republic

↓

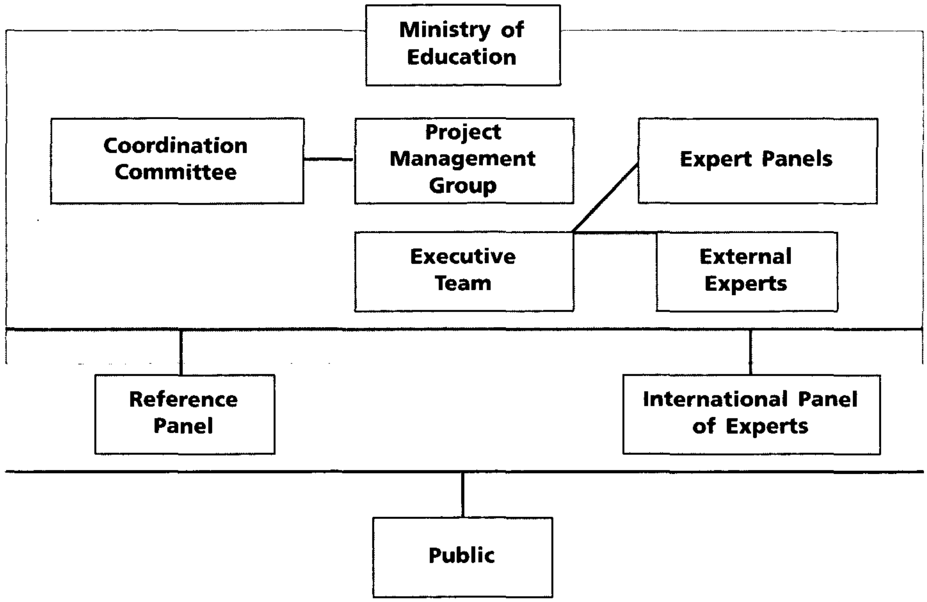
Final Report to the Government

The detailed methodology designed for the Czech exercise combines several patterns of foresight activities used in various countries, namely in Australia, France and the Netherlands. Corresponding sources are listed in the bibliography. Individual steps of the Czech exercise are described below.

Structure building

The main project objectives may be achieved only through cooperation of a relatively complex structure in which all the important stakeholders are represented. The basic structural elements of the Czech foresight project are illustrated in figure II.

Figure II. Structure of the Czech technology foresight project



The Ministry of Education, Youth and Sport is the principal project promoter and sponsor. The Ministry is not directly involved in project execution but it continuously monitors the progress of the project and approves nominations for the Coordination Committee and Expert Panels. The Ministry nominates permanent representatives to the Coordination Committee including the Committee Chairman and two Secretaries. Ministry representatives are authorized to participate in the meetings of Expert Panels and meetings of the Project Management Group.

The Coordination Committee consists of top representatives of key stakeholders—governmental departments, research organizations, industry, political circles, business managers, market and social forecasters, etc. The

Committee is chaired by the Deputy-Minister of the Ministry of Education, Youth and Sport, and the administrative functions are ensured by two secretaries in cooperation with the Executive Team. The main task of the Committee is to evaluate the project's progress, comment on its results, provide input on project modification and facilitate a broad consensus enabling the implementation of the project results.

The Project Management Group performs the executive management of the project. The Group is formed by representatives of the Technology Centre of the Academy of Sciences (leading project partner) and the Engineering Academy of the Czech Republic (project partner) and is headed by a Project Manager who reports directly to the Ministry. The Group manages the Executive Team and is represented in the Coordination Committee.

Expert Panels consist typically of 10-15 leading national experts for a particular field. Each Panel is chaired by a recognized expert ("a strategic thinker") preferably with mixed experience in research, industrial management and a knowledge of methods used in State administration. The Chairman is assisted by a Panel secretary who is also an expert in a particular field. In the Panel, experts from research (providers of a new technology) and industry (users of a new technology) should be evenly represented. The Panel outcomes are justified proposals of priority areas of oriented research including recommended measures for their implementation. A special Panel prepares a proposal of the management system for the NPOR and designs underlying principles for the transfer of ongoing programmes of oriented research into the new NPOR.

The Executive Team organizes and supports the activities of Expert Panels, performs in-depth interviews of industrial managers and completes the quantitative analysis of significance of individual business sectors to the Czech economy. The Team is led by the Project Manager and it cooperates with external experts.

External experts are leading national professionals from particular business sectors. They are invited to prepare a SWOT analysis of the sector and suggest the priority fields of oriented research to match the needs identified in the analysis.

The International Panel of Experts is a group of prominent international experts in the area of technology foresight. They provide their opinions on the project methodology and their views on the analysis and interpretation of results.

The Reference Panel is created from representatives of research institutions, industrial companies, associations of entrepreneurs and other organizations. The Panel includes several hundred people who are electronically contacted regarding their opinions on the intermediate project results. The judgement of the panel is considered in the formulation of final versions of project documents.

The public is continuously informed about the project course and results through a foresight website. A public seminar is planned for September 2001 to review the preliminary project results. The final results will be presented at a closing conference in December 2001. Suggestions and recommendations of the professional public will be used to modify the project conclusions.

Selection of business sectors

National economies comprise a large variety of economic activities based on different technologies and results of oriented research. Identification of business sectors accomplished by the projection of economic activities into groups with similar technological needs and requests for oriented research.

Identification of business sectors is based on the definition of the five thematic programmes (described earlier in this paper) by NRDP. As in the foresight study performed in the Netherlands, we tried to keep the number of business sectors to a minimum, as these sectors will correspond to Expert Panels in the later stages of the project.

The classification of national economy sectors of the Czech Statistical Office and strategic plans of individual governmental departments (ministries) were used as source material. After consultations with experts we selected the following 11 business sectors ("Social transformation" was added as a potential Expert Panel):

- Agriculture and food;
- Environment;
- Health and pharmaceuticals;
- Information society;
- Building and construction;
- Materials and their processing;
- Machinery, instruments and equipment;
- Chemical products and processes;
- Transport;
- Energy and raw materials;
- Social transformation.

Creation of a list of considered technologies

The list of technologies considered in the beginning of the project should meet two criteria:

(a) Include all the technologies needed by the business sectors listed in the previous section;

(b) Have a reasonable number of technologies deemed to be operable.

Similarly, as for the business sectors, a grouping of technologies is needed. Due to the time constraint for this project we have used the list of technologies used in the Dutch study. That list is a combination of results of previous technology foresight studies performed in France, Germany, Japan, the United Kingdom and the United States.

The initial list of considered technologies consists of nine technology clusters subdivided into 46 technology fields. Industrial strategists will review the list to insert some additional technologies if needed. The nine clusters of the considered technologies are:[1]

- Process technology;
- Biotechnology;
- Materials technology;
- Discrete production;
- Plastic moulding technology;
- Energy technology;
- Opto- and micro-electronics;
- Information and communication;
- Civil engineering.

Identification of important technologies to the Czech Republic

Identification of technologies that are important to the Czech economy and society is the next stage of the national foresight project, which is currently under way.

In order to arrive at the important technologies three steps will be combined in our exercise:

- *In-depth interviews* (the demand side) of a representative sample of key companies from each business sector. A structured questionnaire was designed for this purpose. In-depth interviews will be performed during face-to-face meetings with company managers responsible for the R&D strategy. To ensure fully professional communication external experts will be invited to perform this task;
- *Judgements of Expert Panels* (mixed demand and supply side) constituted for each business sector. Composition of the panels for the business sectors are described earlier in the paper. Panels will complete a similar questionnaire as company managers in the previous step. Results obtained for both types of questionnaires will be compared;
- *Judgements of independent experts* (preferably the demand side). Renowned national experts not included in the Panels will be asked for their opinions on important technologies for each business sector.

The respondents will be requested to assign weights to the technology fields that are, according to their opinion, important to a business sector (a

[1] Individual technology fields are not listed in this concise paper.

weight of 0 is considered not important, a weight of 3 is highly important). The results of the three steps above will be compared to find out if there are any principal discrepancies between technologies preferred by different types of respondents. In case of serious disagreement, the respondents will be contacted again to achieve consensual results. The results will be summarized in a "matrix of important technologies". Each column in this matrix corresponds to a particular business sector (12 columns in total); the rows correspond to a technology field (46 rows in total). The matrix is schematically illustrated in table 1.

Table 1. Matrix of important technologies

	Business sector 1	*Business sector 2*	*Business sector 3*
Technology field A	0	2	1
Technology field B	3	3	2
Technology field C	1	0	0

Naturally, some technologies are important to more business sectors than others. These technologies are likely to be selected as strategic technologies—priority areas of oriented research—described briefly in the following section.

Selection of strategic technologies to the Czech Republic

Strategic technologies correspond to the priorities of oriented research—the identification of which is one of the main objectives of the project. Two steps will be used to identify the strategic technologies:

- Quantitative analysis of the relative economic importance of individual business sectors and technology fields to the Czech economy using independent statistical data produced by the Czech Statistical Office (e.g., their contribution to the GDP, their export potential, their potential to create a competitive advantage). The result of this quantitative work will be a draft list of strategic technologies;
- Expert Panels will verify and refine the results of the quantitative analysis. The final list of recommended priorities of oriented research will combine the results of a Panel's opinion and that of the quantitative analysis.

Implementation

It was explained earlier in this paper that the results produced in this technology foresight exercise should be used by the Government for outlining the National Programme of Oriented Research (NPOR). Proposed priorities of oriented research will form the subprogrammes of thematic programmes. The identified systemic measures will outline the basic principles for the design of cross-cutting programmes to optimize the function of the NPOR as a whole. Suggested management and implementation principles will be used to create the NPOR management system and to transfer the ongoing, State-supported R&D programmes to the NPOR.

Constraints and results

The main constraint of the Czech national foresight project was the limited amount of time allotted for carrying out a detailed study. The project should be completed within 12 months. Due to the time constraint, only limited analysis could be performed. However, the output from this project, including the developed methodology, may be considered as input for future technology foresight activities in the country.

The role of specific institutions in the national technology foresight exercise

A number of institutions participate in the Czech technology foresight exercise. The project is very close to the policy- and decision-making process as the results were ordered directly by the Czech Government. The Government is also the only project sponsor and promoter.

The key governmental departments (ministries) are represented in the Coordination Committee of the project. Also Senate, Parliament and other important institutions have their representatives in the Committee.

The involvement of the decision makers in the foresight project may have a positive influence on the implementation of its results. Further, the participation of decision makers in the project from the very beginning may help them to gain a level of insight into the project achievements that would not be reflected in the final project reports.

Short- and long-term plans for the development of technology foresight in the country

Over the last two to three years, the Czech Government has become increasingly interested in using the results of foresight activities in policy-making in the areas of research, technology and innovation.

Short-term plans are focused on use of the one-year technology foresight exercise to formulate priorities and operational principles of the new National Programme of Oriented Research. However, it is widely anticipated that this first foresight activity will set out the conditions for establishing more sustainable foresight institutional structures and activities.

It is assumed that after the implementation of the results of this first exercise in the new NPOR, the methodology and general experience will be evaluated in detail to formulate underlying operational and strategic principles for the coming (cyclical) foresight activities in the Czech Republic.

Experience in international/regional links in technology foresight in the country

Activities in the area of technology foresight are quite recent in the Czech Republic. Therefore, international links are in an early stage of development: Contact has been established with the following organizations and institutions:

(a) PREST, University of Manchester, United Kingdom. Mutual cooperation started in 2000 when two Czech experts participated in the technology foresight course organized by PREST in Manchester. Two PREST experts are participating in the current Czech exercise with support from the British Council;

(b) The Institute for Prospective Technological Studies (IPTS) of the Joint Research Centre of the European Commission, Seville, Spain. Two Czech experts are members of the "Thematic Network on Foresight Activities on Science and Technology" managed by the IPTS. The Network was set up in June 1999 at a high-level meeting in Berlin. The initiative is part of a broader project—"Enlargement of the European Union". One IPTS expert participates in the current Czech exercise;

(c) The Fraunhofer Institute for Systems and Innovation Research (ISI), Karlsruhe, Germany. One expert from the ISI participates in the Czech foresight exercise with support from a bilateral Czech/German cooperation programme;

(d) UNIDO. Contacts with UNIDO have started just recently with prospects of further cooperation in technology foresight on the regional/international level.

In addition to the contacts mentioned above, there are also personal contacts, e.g., with the former manager of the Hungarian foresight project who is currently working at the United Nations University in Maastricht, Netherlands.

Needs for international/regional development of foresight activities

The region of Central and Eastern Europe is undergoing a transition of its economy and a restructuring of its industry. Some countries are preparing their economies for early accession to the European Union, while some countries are still at the beginning of a relatively long process of transition. In any case, a well-designed and carefully performed foresight project in these countries may positively influence policy-making in science, technology and innovation.

Proposals for regional collaboration on technology foresight

As a consequence of rising interest in foresight activities around the globe, there is an enormous amount of accumulated knowledge and experience. It is highly desirable to introduce some form of international exchange of experience and sharing of knowledge on the foresight methodology and accumulated basic information. Also, general awareness about foresight and its role in technological and economic development may be increased through international collaborative links. In this context, UNIDO should consider taking the role of an umbrella organization for such activities. Provided that suitable funding is available, UNIDO may promote cooperation by initiating the following activities:

(a) Establish a regional or global Working Group on Technology Foresight;

(b) Create a website dedicated to technology foresight;

(c) Organize awareness events on technology foresight in countries that lack knowledge on the subject;

(d) Organize workshops to exchange practical experience and good practice in technology foresight projects;

(e) Coordinate the actions in the technology foresight field with the European Commission to complement the activities and to multiply the results;

(f) Launch an international study (or several regional studies) aimed at the analysis of the need for the development of foresight activities.

Conclusion and recommendations

To conclude this paper, several general statements and recommendations may be formulated:

(a) In the dynamic political and economical environment of countries in economic transition, the technology foresight activities are clearly a useful tool for decision makers and strategic planners;

(b) It is not possible to define a single, best foresight technique for any situation or set of objectives. Each national foresight exercise has to be specifically tailored to the particular situation of the respective country, that country's targets and time available for the study;

(c) Industry must have the innovative capacity to fully utilize the foresight results and recommendations;

(d) National teams should complete the national foresight projects since they have knowledge of tacit information, hardly accessible to foreigners. Direct participation of a small advisory group (5-10 people) consisting of experienced foreign technology foresight experts may significantly enhance the project outputs and help to avoid some operational mistakes;

(e) Growing interest in foresight exercises worldwide has influenced the continuous development and enrichment of foresight methodology; it has also produced some duplicity, particularly in introductory project phases but also in later analytical stages and interpretation of results. For that reason it seems useful to consider the development of cooperating structures that would share methodological principles and data. In this context the coaching role of well-established international organizations like UNIDO should be considered.

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9 Technology foresight in Ukraine

Michael Zgurovsky*

Abstract

The main feature of the processes taking place in Europe today is global integration, both in the economic and political spheres and in the development of science and technology systems, environmental protection activities and social well-being. The Prime Minister of Ukraine, V. Yuschenko, states that "...the strategic objective of Ukrainian foreign policy is an active involvement of our country in the European integration processes".

At the beginning of its transition to a market economy, Ukraine had considerable opportunities for the development of its economy, particularly in the field of science and technology. Forecasts of some analysts, however, that Ukraine and other Eastern European countries would follow certain Asian countries in the development of high technology and economic growth have not proved to be true.

An increase of economic efficiency in industrial enterprises is ensured by scientific and technology development. Hence, this report is mainly devoted to the formation of State policies aimed at the development of progressive technologies in Ukraine, as well as the role played by specific institutions in the implementation of scientific and technology programmes.

The strategy of economic and social development of Ukraine for 2000-2004 envisages the main priority of State policy to be the structural reconstruction of industry, and the development of an innovation model of economic growth, demonstrating the capacity of Ukraine for producing high technology. The State must play a more active role in the development of science and technology leading to qualitatively new potential in branches such as machine-building and metal treatment, metallurgy, aviation and space technologies, etc.

In the modern world, the significance of international scientific and technological collaboration is increasing; export and import of technological services are widespread. In recent years, Ukrainian scientists have worked in collaboration with their foreign colleagues in the framework of the North Atlantic Treaty Organization (NATO), through the Ukrainian National Technology Centre and using grants provided by the United States Civilian Research and Development Fund (CRDF).

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Background

The main feature of the processes taking place in the world today is the global integration in economics and politics and in the development of science and technology, environmental protection and social well-being. Ukraine, as an independent State, lives in this interconnected and interrelated world.

Under the existing conditions of globalization of economic life, the industrialized countries in which science is the major factor in economic development ensure their progress by improving the existing technologies, techniques and methods, and by consistent implementation of new scientific knowledge and technologies. International technological and scientific exchange and transfer of intellectual potential are characteristic of the present.

Ukraine's participation in the European and global integration processes is impossible without taking into account the geopolitical realities that, to a considerable extent, determine current status of the Ukrainian economy and the forecast of its development. Ukraine is situated almost in the centre of Europe. In the west, it has a common border with Poland, Slovakia and Hungary; in the south-west the borders are with Romania and the Republic of Moldova; in the north and east it borders with Belarus and the Russian Federation. The territory of Ukraine, which occupies an area of approximately 604,000 square kilometres, has a population of about 50 million and is situated on the shores of the Black and Azov Seas. The heavily forested Carpathian and Crimean mountains encircle the vast steppes, which are known for their very fertile soil, and are among the richest of such land in the world. Ukraine has considerable deposits of iron ore, manganese, titanium, coal and phosphates. This fact has led to the growth of branches of industry such as the metallurgy, machine-building, power engineering, mining, oil processing, chemical industries; the aviation and spacecraft industry; as well as agricultural and food production.

One fifth of the entire working population is engaged in agriculture, in which a quarter of the funds are concentrated; almost 13 per cent of the gross added value of the country is produced in this sector.

Ukraine will only become a prosperous country under conditions that make optimal use and efficiency of its land and resources. It cannot be done, however, without close cooperation with the economically developed countries in the implementation of advanced technologies and managerial experience.

The strategic objective of Ukraine is to become a part of the international scientific and technological community, thereby modernizing production and ensuring the competitiveness of the major branches of industry.

Overview and evaluation of the policy and strategies for future technological development of Ukraine

The strategy of economic and social development of Ukraine in the period 2000-2004 foresees as the priority of State policy the structural reconstruction of industry, development of the innovation model of economic growth and strengthening Ukraine's position as a producer of high technology. This course, aimed at innovation development, is based on the structural reconstruction of the economy, technological updating of industry and wide application of achievements in science and engineering. The existing scientific and technological potential is able to ensure the economic progress of Ukraine.

At the beginning of the market transformations Ukraine had considerable possibilities for the development of its economy, particularly in the field of science and technology.[1] The available scientific and technological potential shared many characteristics with the most technologically advanced countries. In some fields, such as material science, theoretical physics, mathematics, welding technology and biotechnology, Ukraine is still among the leaders.

In Ukraine there are approximately 200,000 scientific personnel. Among them, there are 4,100 Doctors of Science and 18,900 Candidates of Science. In spite of reductions in scientific personnel, Ukraine remains among the more advanced countries of Europe if we take into account the number of scientific personnel engaged in the economy (table 1).

Table 1. Numbers of scientific personnel engaged in the economy of different countries

Country	*No. of scientific workers per 10,000 employees*	*No. of researchers per 10,000 employees*
Germany	120	58
United Kingdom	98	54
Denmark	95	47
Austria	66	34
Ukraine	55	41

The predictions of analysts, however, who stated that Ukraine and other countries of Eastern Europe would quickly follow the trend of some Asian countries in the development of high technologies and economic growth have not come true. The process of market transformation, which had not been studied adequately from the point of view of control theory and was not methodically grounded, has resulted in a sharp fall in gross production output during the first nine years, and a reduction of high technology production and scientific and research activities.

At the beginning of the market transformation, the following statements were extremely popular: "The market will sort out all the problems of the new country", and "The West will quickly accept us into their community as

[1]L. Hoffmann and F. Mullers, *Ukraine on its Road to Europe* (Kiev, Fenix, 2001).

an equal member". Any Western product and the Western way of life in general were taken as the paragon and were to be blindly followed. Anything produced in Ukraine was considered to be of second-rate quality, having no prospects and being non-competitive. Foreign trade grew quickly and without any control. Immense sums of money were spent for the purchase of various Western products, including industrial equipment, which were neither modern nor competitive. As a result, the innovations of Ukrainian scientists, designers and engineers were not in demand, and they themselves were not required. The chain that had united science and education with industry for many years was broken.

In the course of the last few years, some steps have been taken to improve State policy regarding science and technology at a governmental level. The Parliament has approved the new concept of scientific, technological and innovation development of Ukraine.

By signing the 1992 Rio Declaration on Environment and Development, Ukraine has assumed responsibility for promoting sustainable development in the twenty-first century. Because of its geopolitical and historical conditions, Ukraine faces the acute problem of working out an innovation development strategy and constructing appropriate economic mechanisms under market conditions.

In the formation and implementation of the innovation development model it is important to concentrate scientific potential on solving the most serious scientific and technical problems, and determining the most suitable technologies to introduce into production.

Priorities in establishing a strategy for developing high technologies in Ukraine are as follows:

(*a*) Concentration of resources for carrying out fundamental and applied research in the fields where Ukraine traditionally has considerable scientific, technological and industrial potential;

(*b*) Introduction of the target-oriented programme approach in the financing of all fields and sectors of science;

(*c*) Introduction of market economy mechanisms for support of new technologies and promotion of small and medium-sized businesses in scientific and technological fields;

(*d*) Inclusion of intellectual property protection in the recognized legal norms and introduction of intellectual property protection in production processes; and

(*e*) Development and implementation of up-to-date information technologies.

Prerequisites and motivation for technology foresight in the Ukraine at the national and regional levels

Ukraine has the unique conditions for the development of a modern civilized State. Its geographical position and climatic conditions are favourable.

Out of 60.4 million hectares of territory, 41.8 million hectares (69.3 per cent) are arable, making agricultural production one of the largest and most important sectors of the economy. The availability of considerable mineral resources makes the development of many branches of industry possible. The geopolitical situation of Ukraine, its natural resources and the available infrastructure dictate the necessity of planning and forecasting the development and implementation of new technologies at a national and regional level. The outlined programmes and the development of many scientific and technical projects, should reflect the strategic tasks of economic development of the country, meeting market demands for scientific and technological products and the needs of the regions.

The priorities of Ukraine in the development and implementation of new technologies are to be accomplished within the framework of State programmes and projects in traditional technological fields (such as metallurgy, power industry, chemical industry and agriculture) as well as in new, high technology fields (namely, space exploration, aviation, biotechnology, development of information and telecommunications systems, creation of new materials and health protection). It should be pointed out that the application of high-technology products in the national economy of Ukraine is almost twice as efficient as the traditional technological fields.[2]

At present the political elite of Ukraine understand that without the introduction of new technologies, economic expansion is impossible. There is a readiness to invest money in innovations as a means of economic development. It should be emphasized, however, that investment must be selective.

The current national technology foresight programme of Ukraine

The strategic objective of economic change in Ukraine envisages innovation development, which can be accomplished only with structural reconstruction of the economy, technological modernization of industry and agriculture, together with a wide use of advanced technologies.

Innovation development shifts the emphasis from the conventional scientific and technological solutions to the application of principally new, progressive technologies,[3] the production of high-technology products and the introduction of new organizational forms (such as technoparks, technopolicies, resource policies and power saving).

The methodology to be used for attaining these goals consists of identifying the priorities for scientific and technological development. These priorities (table 2) were approved by the Parliament of Ukraine in 1992.

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[2]V. Aleksandrova, "Development and Strategy of Implementation of the Target-oriented Scientific and Technical Programs", *The Strategy of Economic Development of Ukraine* (Kiev, 2000), pp. 7-13.

[3]"Scientific and technical potential of Ukraine and the prospects of its development", background report to the President's address to Verhovnaya Rada [Ukraine Parliament], Kiev, 2001.

Table 2. Priorities for scientific and technological development and corresponding State programmes

Priorities for scientific and technological development	*Number of programmes*	*Number of projects ordered for introduction (percentage of total number of projects)*
Environmental protection	7	6.7
Health protection	12	16.0
Production, processing and preservation of agricultural products	13	3.0
Ecologically clean power production and resource-saving technologies	10	4.3
New substances and materials	9	8.0
New information technologies and complex automation and communications systems	7	5.0
Scientific problems connected with national infrastructure	4	13.0

Implementation of scientific and technological development priorities is being accomplished, although, unfortunately, not within the framework of the unified national programme of advanced technology development. It is, however, connected to a number of separate State scientific and technical programmes (table 2). In addition to these programmes, development priorities are accomplished through State contracts for the development of scientific and technical products and branch scientific and technical programmes which have acquired national status (e.g., the National Space Exploration Programme and the National Programme of Informatization).

The dispersal of State funds and State clients and the absence of a unified coordinating centre have resulted in the following negative features:

(*a*) Insufficient financing of programmes;

(*b*) Incomplete implementation of programmes;

(*c*) Low rate of implementing priority developments into production.

As seen from table 2, the number of scientific and technological programmes approved for implementation does not exceed 16 per cent of the total number proposed.

The low salaries of scientific personnel results in an increase of emigration of young, gifted scientists. They emigrate to industrialized countries (Austria, Germany, the United Kingdom and the United States), where there are special employment programmes for promising scientists from the CEE countries, including the Ukraine.

The analysis of the present economic status shows that we can expect a gradual increase in machine-building, metallurgy and chemical industries,[4]

[4]V. Aleksandrova, "Development and Strategy of Implementation of the Target-oriented Scientific and Technical Programs", *The Strategy of Economic Development of Ukraine* (Kiev, 2000), pp. 7-13.

i.e., branches where the level of development is parallel to the level of profit. In these industries the majority of enterprises are introducing new technological processes and are starting to manufacture new products which are also connected with the improvement of technologies (see table 3). The profitability of industries such as chemicals, pharmaceuticals, woodworking and wood pulp and paper production, may also be considered stable.

Table 3. Profit resulting from application of scientific and technical developments in selected industries in Ukraine
(percentage of total profit)

	Year					
Industry	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Total	2.6	4.8	4	5.0	5.2	6.8
Electric power industry	0.2	0.1	0.3	1.2	2.0	4.7
Fuel production	1.3	0.8	—	0.16	1.97	—
Ferrous metallurgy	6.0	3.5	5	8	3	8.0
Machine-building and metal working	3.2	4.7	27	29	33	36
Chemical and petrochemical industry	5.6	13.8	4	2	5	10
Woodworking and wood pulp and paper industry	4.7	7.7	12.0	14.0	2.5	5
Light industry	4.3	5.9	14.0	16.0	4.0	10.0
Food industry	1.0	0.9	1.3	1.6	2.0	2.3

However, the problem of introducing scientific and technological developments into production still has to be sorted out. Today more than 90 per cent of Ukrainian products lack up-to-date scientific and technological applications,[5] which make most of these products uncompetitive and unprofitable. For example, products of the machine-building and metallurgical sectors do not meet the demands of the world market (for example, no more that 10 per cent of the Ukrainian machine-building products correspond to the highest technical level). The financial situation of many enterprises does not allow them to introduce new technologies or to employ highly qualified specialists. It is estimated that Ukraine loses US$ 10 billion annually as a result of insufficient application of modern scientific and technological achievements.

Technoparks, small scientific companies and other innovational enterprises show considerable possibilities for new innovation structures aimed at solving the problem of introducing new technologies.

In brief, there are clearly defined objectives and there is the experience of working under the present conditions. Some approaches have been elaborated

[5]T. I. Shchedrina, "The International Transfer of Technologies in Ukraine", *Problems of Science*, No. 11, 2000.

for implementation of the innovation model of economic development, but, as outlined in this section, there are numerous obstacles to overcome.

The role of specific institutions in the national technology foresight exercise

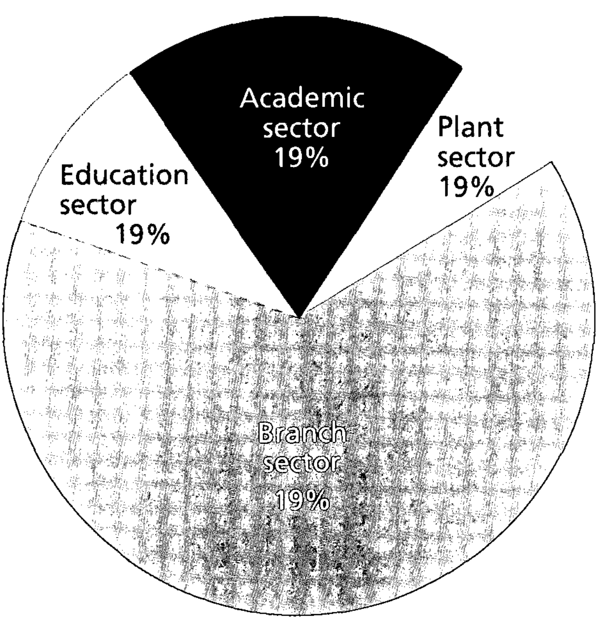
The development of science in Ukraine in the course of the twentieth century resulted in its structuring and division into separate sectors in order to solve fundamental problems. At present scientific research in Ukraine is being carried out by the following sectors (see figure I):

(a) The academic sector of science includes scientific and research institutions of the National Academy of Sciences of Ukraine and other branch academies;

(b) The education sector of science includes the scientific and pedagogical staff of educational institutions;

(c) The branch and plant sectors of science include research and scientific departments of enterprises and organizations belonging to various branches of the economy.

Figure I. Sectors of science in Ukraine



The distribution of the institutions in various sectors is given in table 4.

Table 4. The number of scientific institutions in Ukraine

	1991	1995	1997	1998	1999
Total	1 344	1 453	1 450	1 518	1 506
Academic	290	270	285	294	289
Branch	804	906	915	969	964
Educational	146	150	153	158	160
Plant	104	127	97	97	93

The tasks and objectives of these sectors vary. The academic sector deals with fundamental and investigative studies and, to a lesser extent, solving application problems, while the industrial sector only conducts applied studies (development and introduction of concrete technologies, systems, devices, etc.).

A special place is occupied by the educational sector of science that deals with both fundamental and applied problems. Thanks to a constant inflow of young scientists into this sector, research conducted at higher educational institutions is always supported and followed up by adequate personnel. At present the personnel of the academic institutions and higher educational establishments play the major role in implementing new technologies in Ukraine.

Decreases in industrial production have weakened the plant sector of science and resulted in a reduction in the number of corresponding scientific units (scientific and research organizations of industrial enterprises, design institutions, project organizations, etc.).

The network of scientific institutions in the Ukraine is a rather complicated system of various types of organizations, which ensures the development of technologies in all branches of the economy. In 1999, 1,506 institutions were engaged in scientific research; among them 52 per cent were scientific research institutions, 16 per cent were design institutions, 1 per cent were research plants, 4 per cent were project design institutions and 6 per cent were industrial research units.

In general, throughout various branches of the economy about 23,000 scientists (70 per cent) with advanced degrees (Doctors and Candidates of Science) are engaged in scientific and technological activities. Out of the total number holding Doctor and Candidate of Science degrees who carry out research, more than half (54 per cent) are working in higher education institutions; almost a third (28 per cent) are at academic institutions and the rest (18 per cent) work at research units attached to industry and economic sectors.

In spite of reductions, Ukraine still preserves a rather high concentration of scientific personnel in the economy, corresponding to that of industrialized countries (table 1). In some cases Ukraine provides these countries with professional personnel to assist in scientific research.

A considerable number of scientists working in academic and higher education institutions participate in scientific committees and boards, determining State policies and taking legislative decisions on State innovation policies in the field of science and technology. Among such bodies are the Council on

Science and Science and Technology Policy under the President of Ukraine, the Committee on Science and Education of the Ukraine Parliament and scientific and expert boards of the Ministry of Education and Science.

Short- and long-term plans for the development of technology foresight in Ukraine

The main objectives of the scientific and technological development of Ukraine, stated in the President's Address to the Ukraine Parliament in 2001, envisage short- and long-term plans for the country's development. Special focus is given to new progressive technologies, which are to become the basis for strengthening and reorganizing all branches of the country's economy.

The short-term plans for the period up to 2004[6] comprise three main tasks:

(a) Overcome the unprofitable (excess expenses), unacceptably high, specific power and materials consumption which is typical of all enterprises;

(b) Give priority to the support of innovation development in those branches of the economy which are able to enter the world market;

(c) Identify and ensure accelerated growth of new fields with high scientific and technological potential. The existing resources provide grounds for hope of strategic breakthroughs.

During the first stage (in 2001), it is necessary to strengthen the links between the scientific and research spheres, economic sectors and society, with the purpose of accelerating the process of structural reforms in science and the economy.

During the second stage (in 2002), the strategic objective is the integration of Ukraine into the international technological community which will allow for the wide introduction of competitive products and technologies, thereby modernizing local production.

At the third stage (up to 2004), the achievement of adequate levels of local scientific research and design works and innovations would make it possible for Ukraine to be competitive in the main branches of its economy.

The strategic objective of the long-term plan (up to 2010) is attainment of high levels of scientific and technological development, creating the conditions for efficient, steady economic growth in the country.

International and regional cooperation in technology foresight in Ukraine

During recent years in Ukraine, the legal basis for international cooperation in science has considerably improved. More than 30 international agreements on cooperation in the field of science and technology have been signed at

[6] "Scientific and technical potential of Ukraine and the prospects of its development", background report to the President's address to Verkhovnaya Rada [Ukraine Parliament], 2001.

the governmental level. Cooperation between Ukraine and the European Union is being developed mainly within the framework of the Fifth Framework Programme with the financial support of the EU Commission on Science and Technology. Specific EU initiatives in this region for scientific and technological development include the International Association for the Promotion of Cooperation with Scientists from the Independent States of the former Soviet Union (INTAS); the EU Tacis Programme; Cooperation in Science and Technology with Central and Eastern Europe (COPERNICUS); and others. However, the fact that there is no formal agreement on scientific and technical cooperation between Ukraine and the European Union hampers these developments.[7]

Cooperation with the United States and support of their international funding is important. The development of scientific contacts between Ukraine and the United States is supported by the United States Civilian Research and Development Fund (CRDF). Ukrainian scientists take part in their scientific programmes and joint projects (including those aimed at introducing research results into production), holding joint scientific conferences, exchanging working visits and other activities.

Within the framework of NATO's scientific programme, Ukrainian scientists have received more than 480 grants; among the countries of the Euro-Atlantic Partnership Council, Ukraine is second after the Russian Federation in numbers of participating scientists. During 1998-1999, NATO funded the participation of more than 300 Ukrainian scientists in scientific forums.

A notable aspect of international cooperation is connected with the Ukrainian Scientific and Technical Centre, which was founded by the United States and other leading industrialized countries. Over the last two years, about 180 contracts, worth over US $40 million, have been executed.

Ukraine has confirmed its membership in the Joint Institute for Nuclear Research, an intergovernmental organization. This cooperation, as well as participation in the programmes of the European Organization for Nuclear Research (CERN), makes it possible for Ukrainian scientists to take part in carrying out basic research in the field of advanced energy.

The Russian Federation and other newly independent States traditionally play an important role in the international scientific cooperation of Ukraine. Special mention should be given to the implementation of the joint Ukrainian-Russian scientific and technological projects in the field of new technologies, in particular, in the common priority of nanophysics and nanotechnologies.

Despite notable success in international scientific and technological cooperation, Ukraine still lacks systematic strategy in this area. The shortcomings in the status of international cooperation are as follows:

(*a*) Irregular participation of Ukrainian scientists in activities of international organizations due to the lack of financial support for the international scientific and technological community;

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[7]Ibid.

(*b*) Absence of a reliable information system regarding activities of the major international organizations, the dates of international scientific and technological events, etc.;

(*c*) Recurring failure by Ukraine to meet their obligations in international cooperation programmes because of discontinuation of financing.

Needs for international/regional development of foresight activities in Ukraine

The international exchange of scientific and technological developments is one of the most efficient ways to establish economic links. At the present stage of economic development in Ukraine, international scientific and technological exchange aims to fulfil the following tasks:

(*a*) To prevent bringing dated and inefficient technologies into Ukraine;

(*b*) To raise the level of sophistication of Ukrainian exports.

Factors that indicate improvements in the international transfer of technologies in Ukraine are a high level of scientific and technological development, an increase in the volume of products introduced into the country for the first time, and increased exports of new products.

A positive tendency observed in recent years is that in the volume of technological services rendered in 1998-1999, almost half are S&T and research design services.

Market studies, reaching potential clients, and exporting and importing technological services all require international and regional cooperation.

It should be pointed out that Ukraine is only at the beginning of the long road of integration into the European and global scientific and technological spheres. It has not yet achieved recognized status as an equal in the field of scientific and technological cooperation.[8] Ukraine remains a supplier of intellectual potential for other more highly developed countries. It is imperative to place emphasis on equal international cooperation and stopping the "brain drain" abroad, as well as to encourage Ukrainian scientists and specialists to return and to involve foreign experts in scientific and research work in Ukraine.

Thus, international links serve to promote Ukraine's integration into the international scientific community as an equal member, and also to speed up quality improvement of Ukrainian high-technology products. These links will assist in establishing regional cooperation with neighbouring countries and attaining the solution of mutual problems.

Proposals for regional collaboration on technological challenges

A number of problems faced by Ukraine today can only be solved with close international cooperation. In particular, natural global changes and the

[8]Ibid.

ruinous influence of humans on the environment demand that societies and their institutions unite in their efforts to eliminate the consequences and prevent further regional and global catastrophes. Ukraine is concerned primarily with the following problems:

- Liquidation of the consequences of the Chernobyl catastrophe. This requires a variety of scientific and technological measures, including the transformation of the Chernobyl sarcophagus to safe conditions, restoration of the ecology of territory in the Eastern European region (Ukraine, Belarus, the Russian Federation, Poland and other countries), closing the Chernobyl nuclear power plant and switching from nuclear fuel. This problem is one of global significance and its solution requires the efforts of the entire international community and the involvement of the most advanced technologies;
- Contamination of the Black Sea and the associated problems of the Dnieper basin. These matters are of concern not only for the countries of the Black Sea region, but also for other countries of Europe and Asia. It requires a sharp decrease in the volume of pollutants discharged into major rivers such as the Danube, Dnieper, Don, the Southern Bug, Dniester and others. It should be added that the production of oil and gas on the Black Sea shelf is another factor that influences Black Sea contamination. The chain of hydropower plants on the Dnieper has already caused changes in the climate of Ukraine, and poses a serious threat for the entire region. This global problem must be sorted out by the international community, with involvement of the most advanced modern technologies;
- The problem of flooding and soil displacements in Carpathian Ukraine, Slovakia, Hungary and Romania. Global warming, deforestation and deviations from the accepted technology in dam construction all result in tragic consequences for the entire region.

One country of this region cannot solve this problem on its own. The negative effects on the ecology of this region can only be reduced by the common efforts of the international community through the application of progressive technologies (including restoration of agricultural land, etc.).

Ukraine, in its turn, having considerable scientific and technological potential, can propose to the international community cooperation in a variety of fields. These include aviation and space technologies ("The Sea Start" Project and the joint manufacture of AN-140 and AN-70 planes and others); resources and power-saving (economical heat and power-generating technologies);[9] development of new materials (e.g., materials with shape memory, bio-compatible materials, materials with controllable functional properties); and protection of natural ecosystems and improvement of quality of life (e.g., technologies for drinking water purification and agricultural waste processing and utilization).

[9] Y. A. Bannikov et al., "On the Possibilities of Power Industry Development in Ukraine", *Power Industry: Economy, Technologies, Ecology*, No. 1 (2000), pp. 4-9.

Conclusion and recommendations

When discussing technology foresight in Ukraine, two aspects should be taken into consideration. First is the need to develop collaboration with European bodies and organizations, in implementing programmes of an inter-State and regional scale, taking into account the experience and international influence of UNIDO. The form of such collaboration may be the coordination principles suggested by UNIDO. Legislative and legal support on the part of Ukraine is also important for international scientific and technological co-operation.

The second aspect to be considered is the internal improvement of organization and financing of the scientific and technological sphere in Ukraine. The main tasks here are the following:

(*a*) Increase the role of the State in reforming the science and technology system during transition to the innovation model of economic development;

(*b*) Improve the financing mechanisms for scientific, technological and innovation activities through optimal use of State and non-State funds in creation of new technologies, providing material incentives for scientific work at the level of industrialized countries;

(*c*) Provide legal and legislative protection of intellectual property created by Ukrainian scientists;

(*d*) Promote progressive organizational scientific and technological structures such as technoparks and business incubators on a wide scale, with corresponding favourable terms for their establishment.

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Session III.

Regional foresight methodologies and applications

1 Society and technology foresight in the context of a multinational company

Dr. Frank Ruff*

Abstract

In the last two decades several large enterprises in such diverse sectors as energy, automotive, telecommunications and information technology have established foresight groups and strategic planning processes, which analyse the long-term prospects of new technologies and their impact on markets and corporate strategies. DaimlerChrysler's Society and Technology Research Group (STRG) is one of the first future research groups to be established within a company. Since 1979 it has investigated, in close cooperation with its customers, the factors shaping tomorrow's markets, technologies and products. Its focus is social science-based futures and business environment research to support strategy and product development processes.

The field of "technology foresight" has evolved from an earlier narrower focus on technology forecasts to a broader definition, which takes political, economic and societal factors and their interactions into consideration. The failures of technical forecasts and prognostics have also led to a rediscovery of complexity and uncertainty in futures studies and to a further extension of the set of methods deployed. With this modernized understanding of "foresight", a variety of research concepts come into play. It is argued that a broad set of foresight concepts is of relevance to corporate strategies, especially in large multinational companies.

A comparison of the major characteristics of foresight studies in the public and private sector reveals some shared objectives, features and methods but also some specific differences, which have to be taken into account when considering collaboration between public and private players.

The premise of the work at STRG is that it is not possible to predict the future, but it is possible to prepare for an uncertain future by thinking through a variety of possible developments and analysing the forces that influence them. Finally, preparation for the future involves an understanding of the way each of us shape it. In order to deal with the uncertainty inherent in technological and societal developments it is imperative to develop a set of methods grouped around the scenario technique. A scenario process is typically organized as a structured and focused communication process between experts from different disciplinary backgrounds and from different corporate functions about potential future

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developments, their driving forces and the interactions between them. The process follows seven steps:

(a) Definition of topic: what is the issue to be analysed?

(b) Influencing factors: what factors have an impact on the issue?

(c) Projections: how could the influencing factors develop?

(d) Networking of factors: what cross-impacts exist?

(e) Scenarios: what consistent images of the future can be inferred?

(f) Disruptive events: what events could lead towards radical trend deviations?

(g) Strategies: what strategies/actions/ideas fit with the scenarios?

In terms of technology foresight, a crucial step in the scenario process is to study the interactions between societal and technological developments. For this purpose STRG takes a close look at social trends and changes in consumer behaviour that are relevant to the diffusion of new technologies into the marketplace. Thus, STRG's foresight activities regarding future technologies are always embedded in a broader analysis of developments in the societal and economic business environments.

Introduction

With the spread and implementation of strategic planning processes since the 1960s large companies with special external risks in their business (e.g. the oil industry) or high investments in innovation and research (e.g. the automotive industry) have become interested in long-term planning and foresight. A few foresight groups within companies have existed now for more than two decades; a wave of new groups were founded in the 1990s. DaimlerChrysler is one of these early founders of a company-based futures research group, which was set up in 1979. Deviating from the then widespread mainstream path of most technology forecasting, the Society and Technology Group of DaimlerChrysler (STRG) started with two basic premises. Firstly, before focusing on technology, a broader view of the external business environment, including societal factors, has to be taken if a company is looking into the future. Secondly, to accept and learn about complex and dynamic environments, foresight within a company has to concentrate on an "outside-in" perspective. Thus the mission of STRG is social science-based futures and business environment research to support strategy and product development processes for DaimlerChrysler and its business divisions. The key question of this mission is: what business environment trends shape future markets and contexts for the automotive industry and the mobility business, and what key questions do these pose for DaimlerChrysler?

To accomplish this mission, STRG has five main fields of activities:

(a) Development of scenarios for future products, services and business processes;

(b) International and future-oriented analysis of the company's business environment;

(c) Identification of opportunities and risks for existing and new products, services and processes;

(d) Development and deployment of methods to generate and evaluate innovative ideas in the context of futures analysis and innovation management;

(e) Analysis of future customer needs and the derivation of requirements for future products and services.

The research group unites about 40 research scientists from a diversity of disciplinary and regional backgrounds. The headquarters are in Berlin, and there are branch offices in Palo Alto (United States of America) and Kyoto (Japan). For its international projects STRG maintains an international network of partners in Europe, the United States, Japan, Eastern Europe and parts of Asia.

Challenges of foresight

Looking at the historical record of forecasting technological developments and their impact on society and markets, one cannot evade the fact that many if not most forecasts have gone wrong. An analysis of the host of failed forecasts reveals a couple of frequent misguided approaches (see also box):

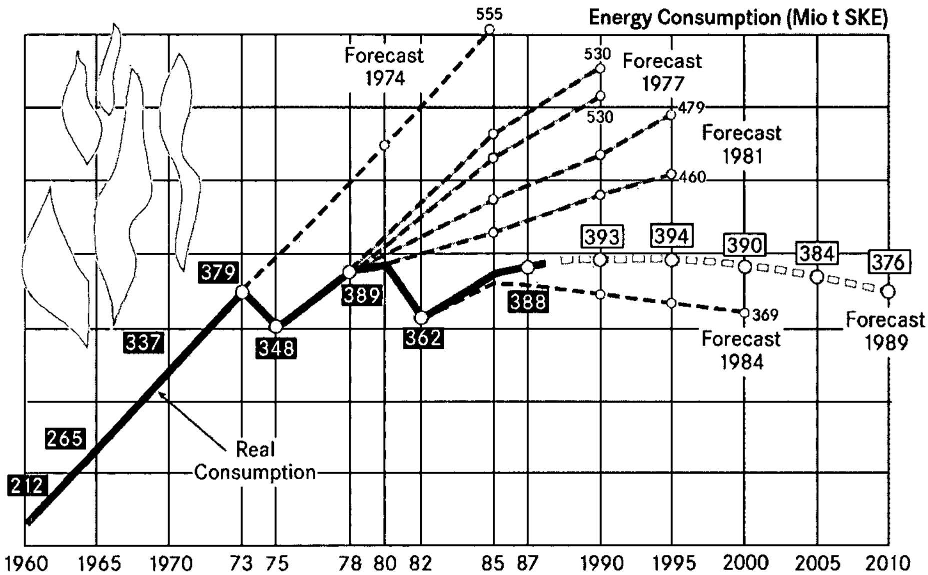
Frequent flaws in foresight activities

- Linear extrapolation of trends (life-cycle curves, quantitative forecast models).
- Underestimation of basic innovations in the early stages (e.g. new, broader applications are out of perspective).
- Incremental innovations: overestimation of speed of change (e.g. the speed of diffusion of new products is often overestimated).
- Technical feasibility is often equated with market demand (but: technology forecasts are not market forecasts).
- Abandonment of continuous monitoring (one-time assessment of developmental dynamics: "now we know where it is going").
- Inclination towards quantification where qualification is sufficient (exclusion of areas of influence/impacts that are not quantifiable).

Linear extrapolation of trends

A flaw that was particularly prevalent in the golden age of linear modelling in the 1970s but is still entrenched in a lot of forecasts is the use of linear extrapolation models, which have been applied to economic and energy forecasts and others (see figure I). Metaphorically speaking, linear extrapolation is like sitting in a car with a covered windshield and only the rear mirrors available for orientation. This means that one can only look back on the distance covered so far and try to make a good guess at what is going on along the road ahead. Evidently, in a dynamic and "curved" environment this no longer works.

Figure I. Example of linear extrapolation: energy demand forecasts



Source: ZfK 4 / 90

Underestimation of basic innovations in the early stages

Another major flaw is the underestimation of basic innovations in the early stages. There are some outstanding historical examples: Albert Einstein, for instance, said in the early 1930s: "There is not the least indication that we can ever develop nuclear energy". Or in the recent past (1977), people active in the computer business, such as Ken Olsen, Chief Executive Officer of Digital, said: "I don't see any reason why single individuals should have their own computer". There are many similar examples showing that outstanding experts in their respective fields were evidently unable to anticipate the disruptive and innovative consequences of their research and business activities, respectively.

There is also a related anecdote from the company history of Daimler-Benz: a market forecast of Mercedes-Benz in the year 1900 came to the conclusion that the worldwide demand for cars would not exceed 5,000 especially because of the lack of available chauffeurs. This example also illustrates how basic innovations are often underestimated. The dominant social model at that time was that people were driven around by chauffeurs and did not drive their cars themselves. This social model was so deeply implanted in the consciousness of people (including early market researchers) that they could not imagine a basic change.

Incremental innovations: overestimation of speed of change

Many contemporary forecasts of new technologies overrate the speed of diffusion of new products and services, underestimating the conservatism of customers and overestimating their willingness to accept changes. A topical example of this is provided by many prognoses of industrial analysts on the diffusion of third-generation mobile telephones (with Universal Mobile Telecommunications System (UMTS) standard). These prognoses often assumed that the introduction of technical equipment with the new, powerful standard would directly cause users to relinquish their old mobile telephones and replace them with new ones. The possibility that many mobile phone users would be satisfied with today's second generation (Global System for Mobile Communications (GSM)) and the coming intermediate generation of equipment (General Packet Radio Service (GPRS)) for some time to come was not taken into account.

Technical feasibility is often equated with market demand

A further flaw in prognoses may be that the technical viability of the new products and services is equated with the market's potential demands, without the latter actually being proved. For example, the proponents of automatic car driving simply assume that many drivers would allow themselves to be driven by such an autopilot system as soon as it became technically feasible. This disregards the fact that automatic driving comes up against substantial acceptance barriers with drivers as a result of fundamental safety concerns and the fact that most drivers will not change to an electronic system because they enjoy driving and the subjective feeling of control.

Abandonment of continuous monitoring

A flaw that is often encountered in companies is connected with the rise and fall of strategic planning efforts in the business cycle. During or after a crisis, companies often expand their field of strategic monitoring and planning. However, once a thorough strategic analysis and contingency plans have been made, the attention of the top management shifts to other topics and the strategic exercise remains a one-time assessment of development dynamics. It is evident that such an approach is risky and paves the way for the next crisis.

Inclination towards quantification where qualification is sufficient

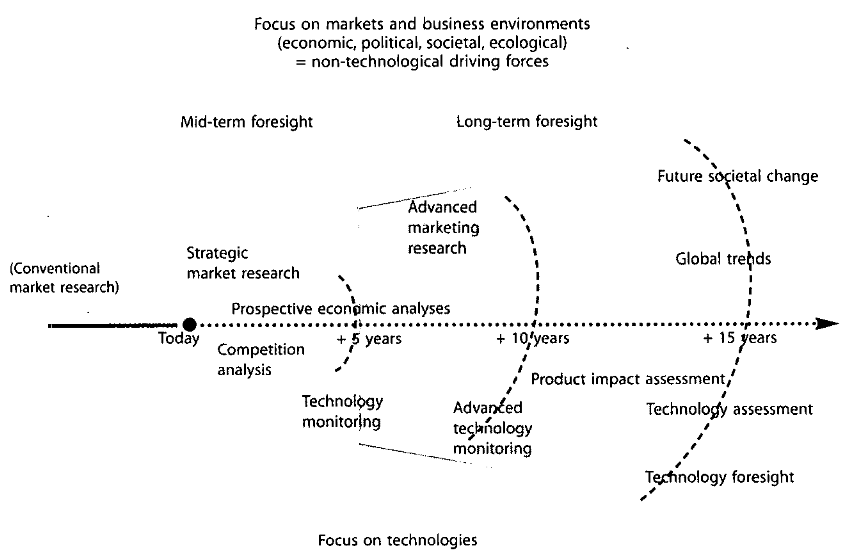
Another flaw in foresight results from the high regard for quantitative simulations in futures research and also the simple fact that numbers are more easy to deal with than phenomena that can only be described qualitatively. One consequence of this is that influencing factors are often excluded because they cannot be quantified. Thus the field of observation is often narrowed. Another consequence is that, even if qualitative factors can be quantified, the quantification is often used as the critical variable, and important additional information may be lost. An example of this is that when forecasting economic developments (e.g. stock markets) psychological factors, which are difficult to quantify, have long been neglected or even ignored. Only with the rise of the new discipline of behavioural finance in the last few years, have forecasters and analysts tried to rectify this imbalance.

Foresight in a business context

Fields of foresight activities of relevance to companies

Technology foresight is defined today as a "process involved in systematically attempting to look into the longer-term future of science, technology, the economy, the environment and society with the aim of identifying the emerging generic technologies and the underpinning areas of strategic research likely to yield the greatest economic and social benefits" (Martin, 2000, in this publication). This contemporary definition has largely extended the scope of earlier definitions, which in the literal sense of the concept restricted the meaning to a study of technological developments, as reflected in the initial national technology foresight exercises by Delphi surveys. It is a matter of opinion whether the "post-modern" extension of the definition is still properly reflected by the name "technology foresight" or if the concept should be renamed "society and technology foresight". At any rate, with such an extended definition, technology foresight encompasses a diverse range of approaches to research into the future (see figure II).

Figure II. Fields of foresight activities of relevance to companies



The various approaches can be broken down into four categories:

(a) Time frame of the foresight endeavour;

(b) Focus of the foresight (focus on technologies vs. focus on non-technical topics);

(c) Regional scope (local, national, regional, global);

(d) Focal perspectives and interests of the players engaging in foresight activities.

The various approaches to foresight and their major features are characterized in more detail in table 1 (see below). Despite the variety, the overview is still not complete, and the focus here is on approaches and concepts that are directly or potentially relevant for companies and long-term business strategy.

Historically, foresight activities were triggered by the prospect of the accelerated pace of science and technological innovations. Thus, most foresight projects in the public and private sector until the early 1990s focused on technological developments. In the public sector, offices for technology assessment have been extensively institutionalized as preparation and support for political decisions by national governments (Bröchler, Simonis and Sundermann, 1999). The technology assessment field that emerged from the early 1970s in the United States and from the 1980s in most Western European countries is a research concept dealing with the likely or already observable effects of new technologies, with special emphasis on secondary and tertiary effects (Büllingen, 1993). Technology assessment has typically focused on new "big" technologies such as nuclear technology, analysis of the human genome or space exploration, and on regional or local environmental issues.

A few companies have also adopted the technology assessment approach and adapted it to the needs of companies as "product impact assessment" (see Minx and Meyer, 1999). As companies mostly deal with products, i.e. integrated instead of "pure" technologies, the focus of "product impact assessment" is oriented more towards applications and the impact of product usage. It also varies in terms of scope and time frame compared with typical technology assessments in the public sector.

Very relevant for companies in the technology sector is the field of technology monitoring, which is usually pursued in a short- to medium-term time frame. Technology monitoring consists of the continuous monitoring and scanning of emerging technologies including an evaluation of which technologies could and should be integrated into the technology roadmaps of research and development units. Some companies, especially innovation leaders in technology, have extended the time frame of these monitoring activities to a long-term horizon (advanced technology monitoring).

Technology monitoring is often closely linked with competition analysis. However, beyond the technological scope, competition analysis also encompasses the monitoring of strategies and market positions of competitors, thus taking the non-technical business environment and markets factors into account.

Table 1. Selected fields of foresight and their relevance for companies

Field of foresight	*Major focus*	*Time frame and scope*	*Major players*	*Relevance for corporate foresight in multinational companies*
Competition analysis	Monitoring of technological and market positions (corporate strategies) of major competitors	Short- to medium-term (1-5 years). Specific technology fields and markets	Private business intelligence (e.g. business consultancies). Corporate units for competition analysis	Very high relevance: standard feature of most corporate strategy processes; very high relevance in highly competitive industries
Technology monitoring	Monitoring of short- to medium-term technological innovations in science, research and industry, analyses of patents/licences	Short- to medium-term (1-3 years). Specific technology fields and markets	Private business intelligence (e.g. business consultancies) Corporate units or projects	Very high relevance: standard feature of most corporate strategy processes in high-technology companies
Advanced technology monitoring	Monitoring of long-term technological innovations in science, research and industry, analyses of research topics and strategies in science and industry	Short- to medium-term (1-3 years). Specific technology fields and markets	Private business intelligence (e.g. business consultancies). Corporate units or projects	High to very high relevance: highly relevant for companies with long product development cycles and high investment risks
Product impact assessment	Analysis of likely or observable effects of new products, focus on secondary or tertiary effects	Medium- to long-term (5-15 years). Regional, national or market area- related scope	Public research institutes (e.g. environmental research institutes). Few projects within companies	Low to high relevance: highly relevant for companies with high risk potentials (e.g. chemical and pharmaceutical industries)
Technology assessment	Analysis of likely or observable effects of new (basic) technologies, focus on secondary or tertiary effects	Medium- to long-term (5-25 years). Regional, national or local scope	Offices for technology assessment (support for national governments). Public and private research institutes	Low to high relevance: relevant for companies with high or uncertain risk potentials and dependency on few basic technologies (e.g. mobile communications industry)
Technology foresight (narrow definition)	Projections of likely technological innovations in the long-term future (e.g. "classical" technological Delphi studies)	Medium- to long-term (5-30 years). National scope	Public and private research units	Low to high relevance: relevant for companies with high potentials for shaping markets by "technology push" strategies (e.g. life science and health industry)

Table 1. *(continued)*

Field of foresight	*Major focus*	*Time frame and scope*	*Major players*	*Relevance for corporate foresight in multinational companies*
Prospective economic analyses	Projections of economic growth/sector-specific forecasts (GDP, interest rates, sectors, etc.)	Short- to medium-term (1-3 years). Regional and global scope	Public and private economic research institutes. Corporate economic research units	Very high relevance: relevant for investment policies, projections of earnings/returns
Strategic market research	Anticipation/projection of customer needs in the short to medium term	Short- to medium-term (1-3 years). Regional or national market areas	Market research institutes. Corporate market research units	Very high relevance: relevant for product strategy, innovation process, fine tuning of products and services shortly before launch
Advanced marketing research	Anticipation/projection of customer needs in the long term	Medium- to long-term (3-10 years). Regional or national market areas	Strategic marketing research units. Corporate think tanks	High to very high relevance: relevant for product strategy, innovation process, early warning systems; highly relevant for industries with long product development cycles and high investment risks
Global trends	Broad-range analyses of future developments in economy, politics, societies, ecology on a global or macro-regional scale. Focus on global issues	Long-term (10-50 years). Global scope, sometimes with regional differentiation	Public and private future research units (e.g. political think tanks, World Bank, Worldwatch Institute, Millennium Project of the United Nations)	Medium to very high relevance: relevant for long-term strategic planning (e.g. change of core business); highly relevant for multinational companies with issue-sensitive business (e.g. energy industry, resource-dependent industries)
Future societal change	Driving forces of social change/scenarios of future societies, mostly national or regional focus (e.g. European Union)	Long-term (5-20 years). Sociocultural units (cultures, nations, subcultures)	Public and private social research units (e.g. political think tanks, Institute for Prospective Technology Studies of the European Union). Few corporate think tanks	Medium to high relevance: relevant for long-term strategic planning; highly relevant for companies with high sensitivity to societal changes, e.g. social issue management

As mentioned, most foresight activities focused initially for the most part on technological developments. Only a few studies have systematically incorporated economic, political or even societal perspectives. With the growing awareness of the relevance of political and societal factors, more and more foresight studies have integrated the impact of the economic, political and social environment in the analysis. This change is also reflected in the changing definition of technology foresight. Further evidence of this "societal evolution" of the understanding of technology foresight is the extension of the technology Delphi studies from a pure technological focus to include economic and social topics (Cuhls, Blind and Grupp, 1998) as well as the shift from Delphi studies (with more or less closed expert circles) to a broader public involvement of experts, stakeholders and citizens, for instance in the current FUTUR project initiated by the Federal Ministry for Research and Technology in Germany (Cuhls, 2000).

Foresight activities regarding the economic and market environments have been a standard functional element in most large multinational companies for quite a time (e.g. large companies in the energy, banking, chemical or automotive branch). Most of these companies have an economic research unit and also a market research unit, which deals with the customer needs of tomorrow in at least a short- to medium-term perspective.

A rarity is still the field of "advanced marketing", in which future customer needs or requirements regarding products and services are anticipated in a longer-term time frame of five to ten years. As conventional methods of market research have limited scope for anticipating future customer needs, the field of advanced marketing has developed its own set of methods, combining methods from market research with those from futures research. Examples of companies with specialized groups in this field are Philips with its Advanced Design unit or DaimlerChrysler with its Society and Technology Research Group.

Even longer-term foresight activities regarding economic, political and societal developments are usually conducted by specialized think tanks in the political or private sector or by non-governmental institutions. In the field of global trends, a broad diversity of institutions are involved including the World Bank, the Worldwatch Institute, national intelligence agencies (e.g. the Central Intelligence Agency) and the United Nations University with the Millennium Project, to mention just a few. Only a few companies deal systematically with this field of advanced global foresight: some think tanks in the energy industry (e.g. Shell), the financial and insurance industry (e.g. Swiss Re) or the automotive industry (e.g. DaimlerChrysler), for example.

Another relevant field of foresight is future societal change. The focus here is on long-term societal changes (e.g. in social structures and lifestyles) and on the generation of scenarios regarding future societies. This type of foresight is mostly conducted by supranational or national think tanks and research institutes (e.g. Organisation for Economic Cooperation and Development, the European Union's Institute for Prospective Technology Studies, foundations by political parties) or public and private social research institutes. Only a few companies take a look at this field, because social change is still very often regarded as a non-business topic. But multinational companies are becoming increasingly aware of the relevance of this research field as they experience the impact of social changes on their corporate strategy portfolio and corporate image.

Major characteristics of foresight in the public and private sector

In science and technology policies, the standard appeal for closer collaboration between the public and private sector in the fields of foresight is regularly encountered. Usually both sides affirm this general objective and some shared premises in the basic approach. However, for a realistic appraisal of opportunities for collaboration an awareness of the differences in interest, time frames and the process requirements regarding foresight in the public and private sectors is also required.

The major shared premises and differences in foresight activities are shown in table 2. Within the private sector, the focus is on large multinational companies, which basically have the resources to initiate corporate foresight activities on their own.

Table 2. Foresight in the public and private sector-major characteristics

	Foresight in the public sector	*Foresight in the private sector*
General objective:	Anticipation of future developments in science, technology, economy, politics and society	
Specific objectives:	Generating ideas and visions for technology and innovation Identifying/prioritizing related policy measures	Identifying opportunities and risks in markets, technologies and the business environment Identifying strategic options
Major players:	Governmental bodies Expert communities Non-governmental organizations	Strategic planning units Research and technology units Corporate think tanks
Time frame:	5-20 (50) years	2-15 years
Duration of typical projects:	1-3 years	3 months to 1 year
Major methods:	Technology monitoring/scanning Environmental monitoring/scanning Analysis of patents/licences Expert panels/interviews Delphi studies Participatory methods Technology sequence analysis Time series forecasts Trend impact analysis Systemic modelling Scenario construction (and others)	

The basic common feature of public and private sector activities is in the general objective, which is to anticipate future developments in science, technology, economy, politics and society.

In the more specific goals some differences in priorities emerge: whereas public sector activities by their very nature focus more on collective visions for technology, consensus-building and creating legitimacy for technology policies, companies focus primarily on market-related opportunities and risks. Of course, both the public and private sector can subscribe to these other objectives as well. When seeking to conquer new markets, companies rely on the "social capital" of the legitimacy and societal acceptance of technological innovation. Similarily, the public sector fosters societal discourse on technology for the sake of creating economic and social benefits. But beyond this reciprocal agreement, there remains a basic difference in terms of perspectives and the prioritization of specific goals.

Another difference lies in the organizational contexts and cultures of the major actors involved in foresight. In the public sector there is a more heterogeneous set of players, ranging from governmental or administrative bodies to (scientific) expert communities, non-governmental organizations and other collective or single stakeholders. Companies usually institutionalize foresight activities in strategic planning units, research and technology laboratories or corporate think tanks and thus have a more homogeneous set of actors and less organizational complexity to handle.

A major difference lies in the time frame. Public sector activities mostly consider a time frame of about 5 to 20 years ahead, in some cases even up to 50 (e.g. the project "Visions for a sustainable Europe", Rotmans, Van Asselt and Anastasi, 2000) or even 300 years (e.g. the Millennium Project of the United Nations University). In the private sector a 10- or 15-year perspective is already considered "very long term". Even among strongly capitalized large multinational companies, only a few take such a perspective.

Another difference, which is probably the greatest stumbling block to collaboration between public and private players in the field of foresight, is the duration of typical projects. Projects in the public sector often run for a couple of years until final results are presented, communicated and implemented. In the business context results including at least the first steps towards implementation are usually expected within less than a year. In some sectors, like the information and communications branch, typical time allocations for strategic projects are even shorter. This difference in the time logic of public and private activities is the main reason why only a few public-private collaborations in the field of foresight have come about to date and why companies even reject public funding programmes on a national or regional (e.g. European) level. Sometimes, the length of the application phase for public funding already exceeds the strategic planning cycle of the company for which the results are urgently needed. More fast-track funding for public-private collaborations would boost the involvement of companies.

In terms of methods deployed, there are only minor differences between the public and private sector. Delphi studies are more typical for publicly funded research, as they entail considerable costs and, because of their iterative character, are also time-consuming. Expert interviews, technology monitoring/scanning, scenarios and sensitivity analyses are major elements of the generic pool of methods. Because of their interest in exploiting economic opportunities, companies usually deploy a more differentiated set of methods regarding the evaluation and structuring of intellectual capital (e.g. patents/licences). Also the strategy and implications phase of foresight activities is methodologically more developed and differentiated in corporate foresight.

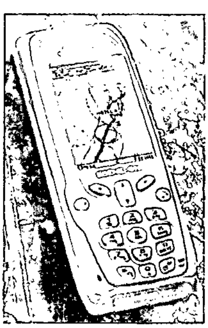
To sum up, public and private sector activities in foresight share some basic features but are also characterized by a number of crucial differences, which have to be taken into account and resolved if collaboration between public and private players is to be put into perspective.

An example of foresight in a business context: mobile communications in the vehicle of the future

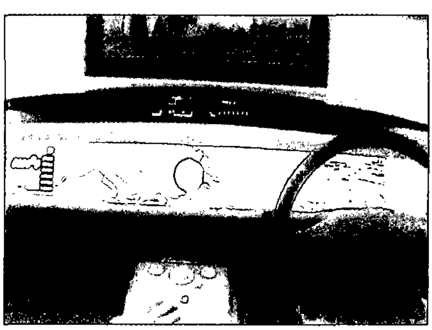
The continuous development of information and communication technologies (ICT) and the swift growth of mobile communications is a field that has been qualified as a current focal topic for foresight on account of its dynamism, complexity, uncertainty and the diverging assessments regarding the diffusion of new technologies and their impact on markets and societies.

Forecasts by future researchers and industrial analysts indicate continued, swift growth perspectives for mobile communications with mobile telephones, portable devices and for the use of telematics in vehicles in the coming five to ten years (see figure III for some examples of new products). Since the collapse of the "dot.com" boom in mid-2000, this optimism has been corrected to some degree but the basically optimistic tenets regarding mobile communications have survived.

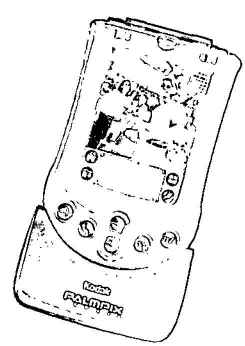
Figure III. A decade of revolutionary developments in mobile communications?



A mobile phone with navigation shown at the Cebit 2001



A futuristic multimedial car cockpit at the Tokyo Motor Show in October 1999



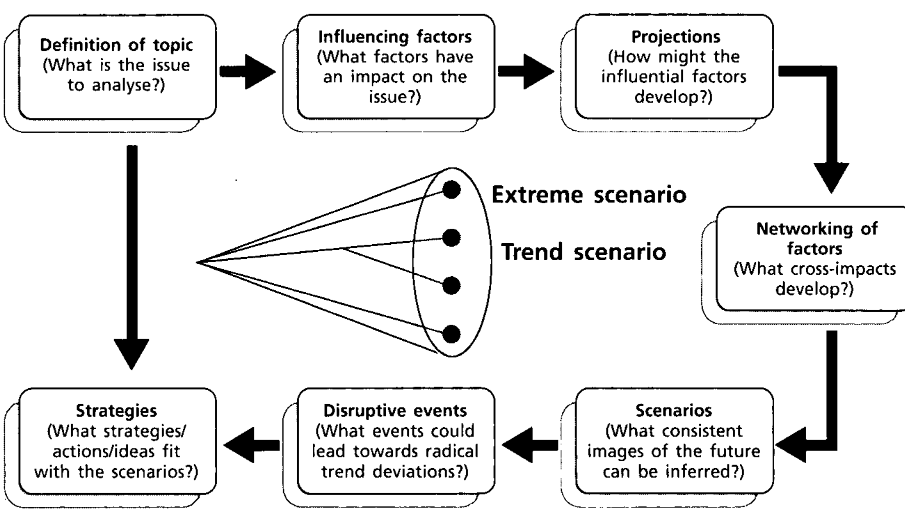
A personal assistant with digital camera at the Cebit 2001

For the automotive industry the focal question is whether these revolutionary developments will continue and how vehicle-bound mobile communications will look in the future.

To research this topic the Society and Technology Research Group of DaimlerChrysler conducted a series of foresight studies (for a broader coverage of this topic see Ruff and Järisch, 2000). A core component of these foresight studies is the scenario method, which compensates for some insufficiencies of traditional quantitative forecasts.

A scenario process is typically organized as a structured and focused communication process between experts from different disciplinary backgrounds and from different corporate functions about potential future developments, their driving forces and the interactions between them. The process involves seven steps (see figure IV), which are briefly described here:

Figure IV. Scenario process



Definition of topic: what is the issue to analyse?

This first step is a crucial one, because it creates a convergence between the various involved experts on the core question, the time frame and the regional scope of the foresight study. In the case study described here the core question was: How could vehicle-bound mobile communication look in Europe in 2010?

Influencing factors: what factors have an impact on the issue?

In this step a broad array of influencing factors from the economic, political and societal business environments is gathered. To reduce complexity, a structured evaluation of influencing factors on the basis of their impact on the issue and their uncertainty is a helpful tool.

Projections: how might the influencing factors develop?

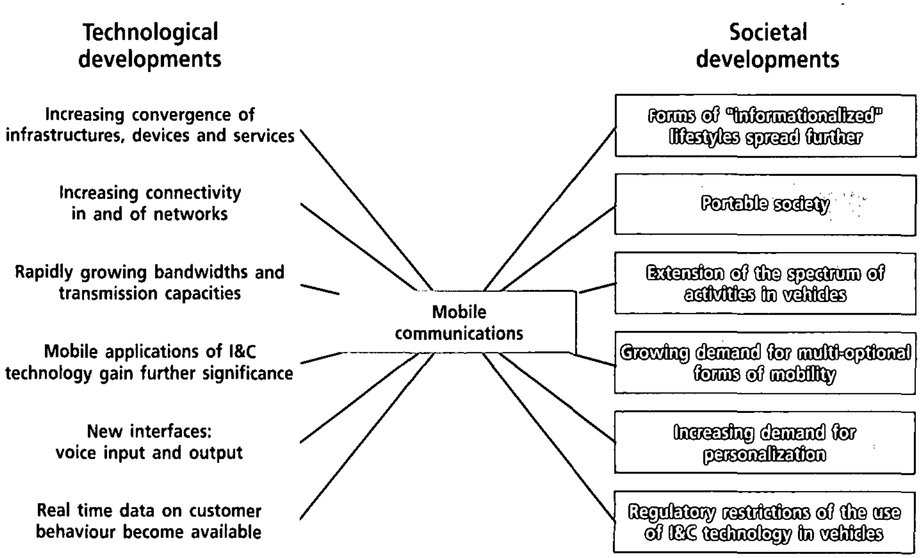
In this step the scenario team formulates alternative projections regarding the future developments of the identified influencing factors. For each factor likely and less likely developments should be considered.

An example in the area of societal developments is "the portable society": today we can observe the increasing use of portable information and communications technology equipment (mobile telephones, palmtops, etc.). "Portable intelligence" is especially popular in technophile metropolitan social milieus and with young people. The professional nomads of modern society, who move in individually configured, heavily communications-oriented life and working conditions tacitly introduce a new quality of interpersonal communication and social bonding through the use of portable and networked devices. Thus portable society is not just the use of new technologies but the subsequent change in social and communications behaviour.

Less likely but potential alternatives to the continuation and diffusion of this observable development are the stagnation of today's level of portable society (limited to only a small group of people), or even the rejection of portable intelligence and the retreat from portable lifestyles. Although considered less likely from today's common sense view, a rejection of portable devices could occur. What if epidemiological studies prove a significant negative health effect of high-frequency transmissions? Such unlikely but high-impact developments are systematically considered in a separate step of the scenario method, which is described below.

In our case study we identified a core set of 12 projections, including technological and societal developments, which were rated as very likely by the involved experts (see figure V).

Figure V. Mobile communications: projections of developments

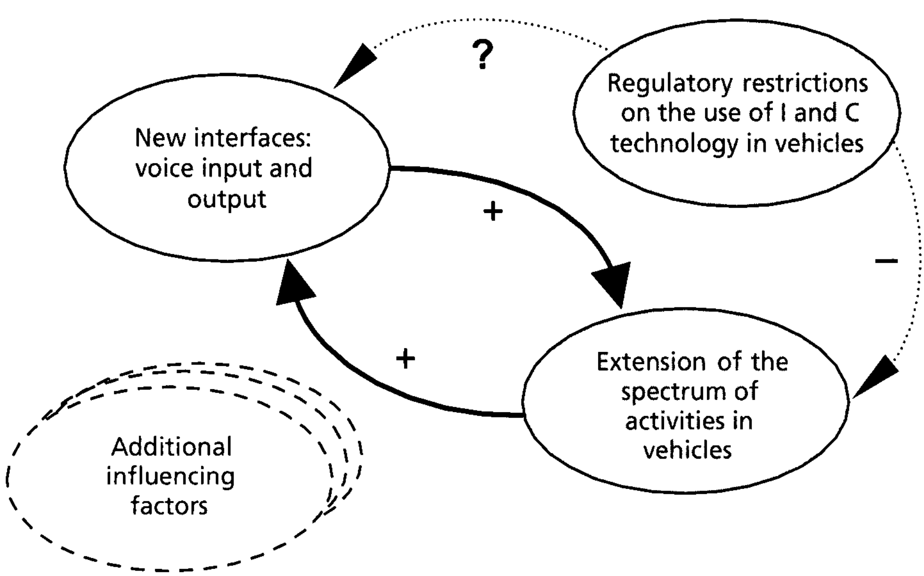


Networking of factors: what cross-impacts exist?

This step is at the systemic core of the scenario method and calls for a thorough and systematic look at the interactions between the influencing factors and their projections.

Figure VI shows part of the cross-impact analysis in our foresight study. In this example the technological availability of new interfaces with voice input and output has a positive effect on the extension of the spectrum of activities in vehicles. If information (e.g. e-mails) can be more easily accessed in the car by voice input and output, people would be inclined to extend their range of activities in vehicles. Conversely, this change of behaviour influences the supply side of developing new interfaces. A third factor, potential regulatory restrictions on the use of information and communications technology in vehicles, is related in a different way. If it turns out that the extension of the spectrum of activities in vehicles has a negative effect on driver concentration, safety regulators will be likely to restrict the legally approved activities in vehicles (e.g. information displayed on screens). On the other hand, legislation could also directly regulate technological standards.

Figure VI. Mobile communications—networking of influencing factors



This detailed look at interactions has to be conducted for all influencing factors and their projections so that counterintuitive or latent feedback loops can be distinguished.

Scenarios: what consistent images of the future can be inferred?

On the basis of the cross-impact analysis, a diverse range of scenarios is generated. From this basic pool of potential future situations two scenarios are selected as extreme scenarios at either end of the field of potential developments. Usually a trend scenario—as an evolutionary extrapolation of current developments—is also considered.

From our case study two scenarios are illustrated below.

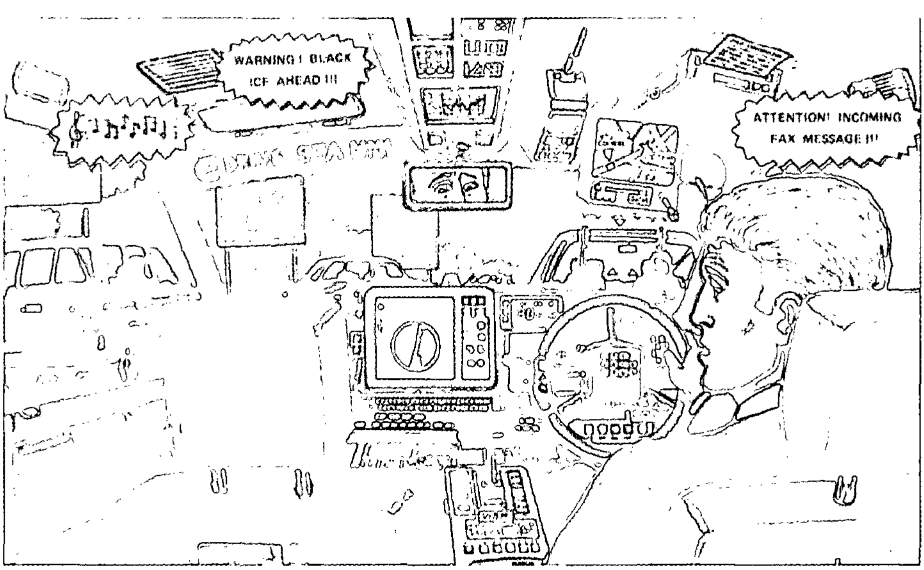
One extreme scenario envisages the vehicle as a permanently online multi-media environment. A cartoon was used to illustrate the consequences of a mainly technologically driven development path and to create sensitivity to the interactions between technology and human behaviour.

Extreme scenario 2010: the vehicle as a permanently online multi-media environment

Main features:

- Vehicles will have high-speed connections to the Internet and act as a permanent mobile network node;
- The willingness of customers to pay for new services is high;
- Customer acceptance will thus follow a revolutionary path (steep learning curve);
- Drivers and passengers will frequently use new services (e.g. navigation/traffic information, location-based services, customer assistance, mobile office services, personalized portals in the vehicle);

Figure VII. The vehicle as a permanently online multi-media environment



- A diversity of multi-media and information and communication devices will be plugged into the car.

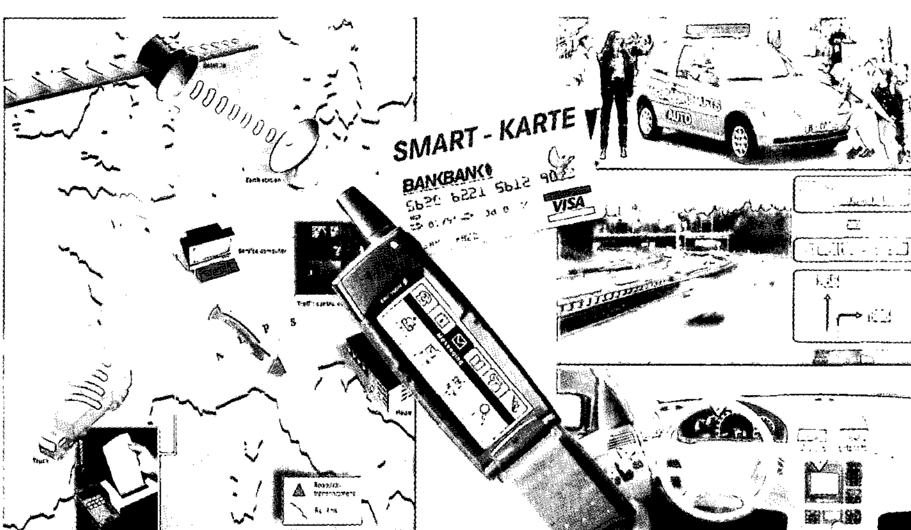
One trend scenario is illustrated by a more evolutionary development path, in which vehicles will be connected to the Internet but drivers and passengers will only very selectively use new devices and services in the car (e.g. navigation, location-based services or customer assistance).

Trend scenario 2010: the selectively connected vehicle

Main features:

- Vehicles will be connected to the Internet;
- Customer acceptance will follow an evolutionary path (flat learning curve);
- The willingness to pay for new services is limited;
- Drivers and passengers will use new services selectively (e.g. navigation, location-based services, customer assistance);
- Voice input/output and information filtering will slowly diffuse into the market.

Figure VIII. The selectively connected vehicle



Disruptive events: what events could lead to radical trend deviations?

This step is introduced to probe the sensitivity of the identified scenarios in the face of extreme external disruptive events or "wild cards". To analyse their impact, a diversity of potential disruptive events are gathered in a brainstorming session. They are sorted according to their uncertainty and their impact on the focal topic. Usually, wild cards with high uncertainty and high impact are selected for further analysis.

One example of a wild card in the case study is the accumulation of strong evidence for serious negative health impact by the electromagnetic fields used for wireless transmissions. Such an event would have dramatic consequences for the whole field of mobile communications. If consequences were serious enough (e.g. evidence of higher rates of cancer by the emissions of mobile communications devices), this could be the end for most applications of wireless communications. Alternative technologies (infrared or ultrasound transmission) are very limited in reach.

Another wild card in this area could be frequent and regular violations of privacy and data protection by the intrusion of hackers, spies and cyberterrorists into wireless communication networks.

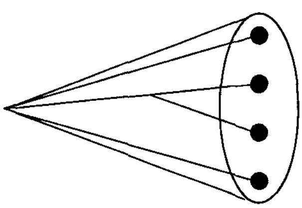
Strategies: what strategies/actions/ideas fit with the scenarios?

The last step of the scenario method, which is the bridge to the strategy process, deals with the identification and evaluation of options for action. In this step, a host of methodological procedures are again available, depending on the focus and target of the strategy process. A frequently used method is to focus on the opportunities and risks (or threats) that emerge in the scenarios (see figure IX).

After options for action for each scenario have been generated, the next step focuses on identifying common options for action. In our case study we

Figure IX. Analysis of scenarios

Generation of scenarios



Analysis of scenarios

Core statements	Opportunities	Risks	Options for action
Scenario A	• High adoption rate of new services by customers • ...	• Driver distraction becomes an issue • ...	• Design information filtering services • ...
Scenario B	• Slow adoption rate of new services by customers • ...	• Business model for new services becomes an issue • ...	• Probe into options for cooperation with service providers • ...

identified a couple of options that match a broad range of scenarios and can thus be seen as "robust" strategies. One evident result from the scenarios is that in the area of mobile communications the whole market is and will be dominated by the business logic of the telecommunications industry and service providers. Thus, automotive applications of mobile communications such as telematics and advanced communication services will be embedded in the broader and more rapidly evolving telecommunications markets and will not be a stand-alone or even trend-setting force in itself. Another "robust" conclusion is that voice input and output technologies with a high degree of individual adaptive capabilities are crucial to the success of extended in-car services.

Final remarks

As discussed in the previous chapters, a variety of foresight concepts and approaches are of relevance to long-term strategy processes within companies. Because of the focus in companies on risks and opportunities for business and on innovations, markets, branches and competitors, foresight studies in a business context have some specific features, which distinguish them from public foresight activities.

Beyond these specific characteristics and differences there is a lot of consensus in the basic principles and objectives. The major shared premises are that foresight (see also Martin, in this publication):

(a) Is a process and not a (forecasting) technique;

(b) Is an interdisciplinary endeavour;

(c) Takes a long-term perspective;

(d) Integrates various perspectives, including developments in technology, economy, politics and society;

(e) Is a supporting tool for decision-making, but does not deliver ready-made corporate or political strategies;

(f) Is an attempt to promote technological and social innovations in the public and private sector;

(g) Is best implemented as a participatory process with the promoters who have to implement the decisions later.

The frequently suggested and demanded collaboration of public and private entities in the field of foresight is still in its early stages and should be further encouraged. As the interaction of public and private sectors and players strongly depends on the specific political, economic and cultural context itself and is highly diversified internationally, no general recipes are available. It is important to be aware of the basic differences in the focal perspectives and interests of public and private players, respectively. It is evident that focus on the process design of public foresight projects and an acceleration of the funding allocation process would have a positive effect on future public-private collaborations.

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2 Planning and elaborating a technology foresight exercise

Michael Keenan*

Abstract

Policy Research in Engineering, Science and Technology (PREST), an institute of the University of Manchester, and German colleagues at the Fraunhofer Institute for Systems and Innovation Research (ISI) carried out an exercise for the Polish Government to provide a framework for strategic choice in technology foresight. By drawing upon a number of national foresight exercises conducted mostly in Europe over the last decade, we have managed to identify some of the most important elements that must be considered when planning a foresight exercise. These include consideration of an exercise's rationale and objectives, its framing scope, the sponsorship and resourcing of activities, the role and mandate of the main players involved, the research elements and methods that might be used, the nature of foresight outputs and interventions, and the outcomes that might be expected, including how these might be monitored and evaluated. In essence, these elements provide a sort of checklist that foresight planners will need to think about.

There are possibilities for applying foresight to regional level programmes by using ongoing efforts at bilateral and multilateral cooperation in the field, for example, through the European Commission (EC), United Nations Industrial Development Organization (UNIDO), Organisation for Economic Cooperation and Development (OECD), etc. Such organizations seem to be engaged in the following three broad types of activities:

- The support of national level exercises through active assistance and facilitation (e.g., UNIDO);
- The support of regional level strategic planning through the commissioning of regional foresight exercises, for example, the EC-wide Futures Programme (and its successor for pre-accession countries) managed by the EC's Institute for Prospective Technological Studies (IPTS);
- The production of futures reports that might have a regional, national or global focus and target national governments and/or international organizations (e.g., OECD).

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Introduction

Based on work already carried out for the Polish Government by PREST and German colleagues at ISI, this paper sets out to provide a framework for strategic choice in technology foresight.[1] By drawing upon a number of national foresight exercises conducted mostly in Europe over the last decade, we have managed to identify some of the most important elements that must be considered when planning a foresight exercise. These include consideration of an exercise's rationale and objectives, its framing scope, the sponsorship and resourcing of activities, the role and mandate of the main players involved, the research elements and methods that might be used, the nature of foresight outputs and interventions, and the outcomes that might be expected, including how these might be monitored and evaluated. In essence, these elements, which are individually discussed in the first part of the paper, provide a sort of checklist that foresight planners will need to think about.

The second part of the paper considers the possibilities for applying foresight to regional level programmes, and discusses existing efforts at bilateral and multilateral cooperation in the field, e.g., through the European Commission (EC), UNIDO, OECD, etc. The paper finishes with some pointers for those considering launching a foresight exercise.

Rationale and objectives

Looking at the various foresight exercises carried out over recent years, the drivers for conducting such activities would appear to be all too common. For instance, in Austria, a policy change to promote the difficult passage from importing technology to developing innovative technologies was seen as ever more necessary. The same driver was present in Japan more than 20 years earlier, where policy makers and industrial corporations began to move away from reliance upon imported technology and towards the development of indigenous technologies. In Germany, reunification led to severe budget constraints that required a more efficient way of financing research programmes. Budget constraints were also a driver for the first programme in the United Kingdom, with foresight viewed as one instrument for achieving better coordination of the country's already considerable R&D efforts. In Hungary, the transition to a market economy has seen experts and policy makers increasingly involved in studying and experimenting with various approaches to innovation policy, including foresight. In fact, it would seem that the main driver underlying national foresight exercises has been the desire to employ a "new" policy instrument for what have been perceived to be "new" policy challenges. Some of these new policy challenges can be summarized as follows:

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[1]The author would like to acknowledge the contributions of Dr. Maria Nedeva (PREST), Professor Denis Loveridge (PREST) and Dr. Kerstin Cuhls (ISI) in the preparation of this paper, although the views expressed remain the responsibility of the author.

(a) Policy makers are seeking to set science and technology (S&T) priorities in the face of restricted budgets and increased international competition. This development has coincided with the IT and biosciences revolutions, where future economic competitiveness in the industrialized countries is seen to be tied in with a healthy S&T base. Indeed, public support for S&T spending is now largely couched in terms of national economic competitiveness;

(b) We are perceived to live in a "network society". There is therefore an interest on the part of policy makers to create new networks and to strengthen existing ones, particularly between the S&T base and business. Companies are seen as trying to innovate in a "network economy", requiring them to manage interfaces with customers, suppliers, collaborators, regulators, etc. Under these conditions, there is a premium on reducing uncertainties, with foresight seen as a means of creating shared strategic visions;

(c) The so-called "Millennium Effect" should not be discounted—Governments the world over have sought at least to appear to be preparing for the new opportunities and challenges that lay ahead in the twenty-first century, and this has seen an explosion in futures-type studies;

(d) Finally, it could be argued that the 1990s have witnessed the emergence of a new, more inclusive style of policy-making, mostly in an effort to bridge the perceived "implementation gaps" associated with earlier policy interventions. Foresight exercises, with their inclusiveness and emphasis on processes, would seem to be part of this trend. Some commentators have interpreted this development as an abdication of responsibility on the part of the public sector, while others have welcomed the wider engagement of business and civil society in the public policy-making process.

These policy challenges tend to feed into the objectives set for foresight exercises. These tend to be pitched at various levels, from the near catch-all goals of improvements in wealth creation and quality of life, as used in the United Kingdom Programme, to more specific objectives set by programme managers for the day-to-day running of an exercise. The latter are rarely stated explicitly but are nevertheless considered essential for success by programme managers, who must ensure that an exercise has credibility, legitimacy and authority with the audience it seeks to address.

It should be noted that objectives have tended to be set with little thought on how they might be verifiable (see below). Thus, while stated foresight objectives are normally more specific than those mentioned above with respect to the United Kingdom Programme, they nevertheless remain quite general. The three key objectives that underpin virtually all national exercises are as follows:

(a) To inform national science, technology and innovation policy planning and formulation, through the provision of guidelines or recommendations that can be used for priority-setting. Such advice is based upon foresight's ability to provide an increased awareness of future trends or forces shaping the long-term future, whether these be market- or S&T-driven, coupled with an assessment of national S&T and business strengths and weaknesses. Recommendations may, for example, take the form of identifying areas where national expertise needs to be built. Emphasis is, more often than not, on improving national economic competitiveness, reflecting Governments' "new" rationale for the public support of S&T, i.e., industrial innovation;

(b) To encourage long-term strategic thinking amongst a wide range of actors, particularly firms. Again drawing upon an assessment of strengths and weaknesses, and opportunities and threats, the objective is to provide enterprises with guidelines for activities in S&T, as well as the strategic intelligence to flexibly respond to changes. The latter can go so far as to promote the use of foresight-type instruments, e.g., scenarios, by organizations such as firms;

(c) To encourage the development of better "wired" innovation systems, by improving cooperation and strengthening relationships and partnerships. The emphasis here is usually on the development of networks between business, the science base and government officials. These networks constitute part of the much-vaunted process benefits associated with foresight, as captured by Martin and Irvine's well-known "five Cs". Besides the development of networks, the creation of a commitment for action through participation in a foresight exercise is a notable phenomenon that programme managers also seek to exploit.

There may be other stated objectives that are specific to a given country. For example, the Hungarians view their programme as supporting their accession to the EU, while the Spanish hope that foresight will help them to improve their presence in European research programmes and institutions. Some exercises have also been overtly experimental in nature, and have sought to learn from experience so as to develop foresight "capabilities". The German and French uses of the Japanese Delphi survey are probably the best-known examples, although the Spanish "preliminary" exercise conducted in 1994/95 would also seem to fall into this category. Finally, in a move from learning to innovation, Germany's Delphi 1998 had as one of its stated objectives the development of foresight methodology.

Taken together, foresight objectives would therefore seem to be mostly concerned with S&T issues, no doubt reflecting the position of programme sponsors in Governments, since most exercises are sponsored by science and technology ministries. Any engagement with non-S&T actors tends to focus on commercial enterprises, reflecting, as we have already said, the "new" rationale for the public support of S&T. Yet, it is not uncommon for foresight exercises to arrive at non-S&T recommendations, which can pose a challenge to policy makers in S&T ministries.

Some countries, such as Austria, the Netherlands and Sweden, have sought to broaden the scope of their exercises from the outset by setting more socially oriented objectives, while even the second round of the United Kingdom Programme has opted for a more problem-oriented (as opposed to a technology- or market-driven) approach. It is likely that as foresight is more widely adopted and the co-evolution of the social and technological becomes more widely appreciated, exercises will become more sophisticated in what they set out to achieve.

Framing the scope of a foresight exercise

The rationales and objectives set for foresight exercises are obvious framing factors that influence the scope for action. But there are other significant framing factors, or dimensions, that we might consider, including an exercise's techno-orientation, the definition of themes, time horizons, the extent of participation and the degree of consultation.

Techno-orientation

Does the exercise have a mostly technological orientation, as in the "critical technology lists" that have proved popular in the United States and France? Or does it have a more techno-economic or socio-technical orientation, as in the majority of foresight exercises conducted in Europe? The extent of the latter orientation is a matter of degrees, with the most recent exercises assuming a more socio-economic focus. This shift in focus is embodied most obviously in the move towards problem-oriented panels and workshops in the latest German and British programmes, although a number of smaller countries, such as the Netherlands, had already been in this territory for some time. This development is no doubt symptomatic of a broader tendency to locate research in the context of socio-economic goals.

Definition of themes

Whether an exercise assumes a problem- or technological-orientation, it must usually be divided "vertically", i.e., into sectors or themes, if it is to be manageable. This decision can be highly political, since interested parties might lobby programme managers or a steering group to ensure inclusion of their particular area. Nevertheless, most of the expected areas, such as information and communications technologies, biotechnology, the environment, transport, and health care, tend to be represented, with most programmes organized around anything from 8 to 15 expert/stakeholder panels. Again, more recent exercises have evolved from this static position to a more dynamic one, where the number and identity of fields to be considered is not fixed from the outset, but rather emerges as the programme evolves. The German FUTUR Programme has explicitly taken this approach; the second round of the United Kingdom Programme also contains elements of an evolutionary approach, with panels able to create "extensions" of themselves through the establishment of sub-panels known as "task forces". The latter are viewed as being particularly important for capturing cross-panel issues.

Time horizons

The average time horizon for national foresight exercises seems to be around 10-15 years, although it may be as long as 30 or as short as 5 years. This is not to say that national exercises have few consequences for the present—on the contrary, many provide recommendations for immediate action, having taken account of existing national strengths and weaknesses.

Participation

Who participates in a foresight exercise is a central concern of programme managers, not least because of a perceived need to produce results that are widely considered to be legitimate, robust, and relevant, although the need to implement these results is also an important consideration, given the process benefits associated with foresight. Who participates obviously depends upon other elements of foresight's scope, including objectives, the degree of techno-orientation, the themes/sectors chosen and the intended audience.

A further debate centres on the relative role of experts and broader stakeholders, with many of the latter considered non-expert if only scientific or market criteria of expertise are included. This type of expertise also tends to predominantly reside with white, middle-class, middle-aged men, so that the potential exists for those of other age, gender, class and race to be disenfranchized. The widespread use of Delphi has probably reinforced this discrimination, although the recent Austrian programme, which itself relied heavily on this method, incorporated multidimensional concepts of expertise, relating not only to scientific and technological knowledge, but also to socio-cultural matters, economics, politics, administration, area-specific practical knowledge, user-perspectives, interest organizations, and NGOs. The German FUTUR Programme is similar in scope, and was in fact born as a result of criticisms that a range of stakeholders were excluded from the earlier German Delphi exercises.

But the debate is broader than consideration of just expertise: the fear is that stakeholders can harbour interests that could prejudice the results. Of course, experts are nearly always stakeholders themselves, so this argument should not perhaps be taken too seriously. Moreover, this argument seems to presuppose that foresight is some sort of objective and scientific activity. While few people would hold to this extreme position, it is considered important for exercises to be seen to be free from prejudicial influence, especially if they are to engender widespread credibility and authority. For this reason, programme managers are keen to balance interests on expert/stakeholder panels.

Degree of consultation

This can be thought about along two dimensions: "frequency" and "reach". Considering "frequency" first, it is often thought that the issue of consultation is associated with only the elicitation of expert/stakeholder views on the future, for example, through Delphi or scenario workshops. However, there are a number of points in a foresight exercise where views might be elicited—for example, programme managers may consult on the shape of an exercise (methods to be used, definition of themes, etc.), as well as on the implications of its results. These can often be the most significant (yet often forgotten) consultation points, since they allow participants to make strategic choices about an exercise, which, in theory, should engender greater ownership of the process and its outputs.

Who is to be consulted at each round of consultation is covered by our second dimension—"reach". This is obviously linked to our earlier discussion on participation, although it is unlikely that reach will be to the same extent for each and every consultation. In this respect, reach can be considered to be either "widespread" or "narrow". If, for a moment, we consider only the elicitation of expert views on the future, both approaches have advantages and disadvantages that need to be taken into account—some of their characteristics are illustrated in table 1 below. Although there are no rules for selecting one of the methods of consultation, it should be noted that this choice has implications for the credibility of the outcome of a foresight exercise, for the time needed for its completion and for its eventual cost.

Table 1. Characteristics of methods of consultation

Widespread consultation		*Narrow consultation*	
Advantage	*Disadvantage*	*Advantage*	*Disadvantage*
Reaches many more "experts"	**Survey costs and time needed for completion**	**Can be completed quickly**	**Opinions limited to small group that may have special interests**
Transparent procedure	Possibility of written instructions not being understood	Relatively inexpensive	May represent dominant person's views
Freedom to express opinions; non-threatening situation	Time-consuming for respondents		
Need to ensure confidentiality			

Sponsorship and resources

While we have chosen to discuss sponsorship and resourcing of foresight after having talked about rationales, objectives and framing scope, the latter group of issues are often constrained by the former. In other words, what can be done is limited by the resources available, as well as who is sponsoring the exercise.

Not surprisingly, formal sponsors tend to be those government departments in which the exercise has its origins. Sponsorship need not mean that exercises are actually "performed" by sponsoring organizations. Indeed, it is not uncommon for this work to be contracted out to national academies, industry groups, private consultants and academic groups, although sponsors are invariably represented on steering committees so as to keep a watchful eye on progress. The extent of contracting out and its associated costs mostly depend upon the methods to be employed. For example, mass consultation, through either large questionnaire surveys (such as Delphi) or workshops does not come cheap.

In a very limited number of cases, government departments or agencies are not the main sponsoring organizations of national foresight activities—examples include Portugal and Finland, where industrial federations and learned societies have played significant roles in this respect. In fact, spreading the costs and effort has become more popular, with both the new German FUTUR Programme and the second round of the United Kingdom Foresight Programme seeing other agencies assume the mantle of sponsorship. For instance, in the second round of the United Kingdom Programme, the Home Office, with its law and order brief, has assumed responsibility for resourcing the Crime Prevention Panel. In other countries, such as Finland, France and the Netherlands, more than one government agency has sponsored quite separate exercises, sometimes at the same time.

Yet, our account of sponsorship is limited if it concentrates only on formal, or official, sponsors. To gain a fuller picture of sponsorship of national foresight, it is necessary to bear in mind that exercises usually require underwriting by hundreds of organizations that provide human resources for panels, workshops, answering questionnaires, etc. A foresight exercise can also be a long-term undertaking, particularly if a proactive implementation strategy is to be pursued (see below). In other words, many organizations effectively sponsor national foresight exercises, and they are usually called upon to do this over an indefinite time period. Again taking the United Kingdom Programme as an example, this has cost the British Government around £1.5 million per annum since 1994, a not inconsiderable sum. Yet government officials estimate that the Programme leverages probably 5-10 times this amount of resource through the activities of other Programme participants, whose time and effort are paid for by their own organizations.

Foresight exercises can be expensive, particularly if a proactive implementation strategy is to be followed, as in the United Kingdom. We have already said that the United Kingdom Programme costs around £1.5 million annually, while each of the German Delphi exercises have cost DM 1 million to DM 1.8 million. We do not have data for other programmes, but note that resource constraints have been a limiting factor in some cases. In most exercises, the consultation periods are the most resource intensive, particularly in human terms. Not only are there workshops and questionnaires to organize, but the wider participant resource must also be managed. It remains unclear whether the use of the Internet in foresight will in fact have any impact on the cost base of foresight exercises.

Thus, discussion of nationally residing resources must take into account more than just the financing of a foresight exercise. As we have already indicated, human resources are an important consideration, but so are infrastructural and cultural resources. To elaborate:

(*a*) Human resources refer mostly to the expert/stakeholder pool available to participate in a national exercise. This can be a serious limitation, especially if a country is looking to reorient its S&T base or business community towards new areas through the use of foresight;

(*b*) Infrastructural resources refer to the extent and nature of the organization of human resources in firms, research organizations, trade associations, academies, universities, etc. Such "intermediary" institutions can constitute important conduits between foresight exercises and potential participants and end-users, and their absence from an exercise can be a serious barrier to progress. Of course, it is possible that the reverse will be true—the presence of powerful institutions that might feel threatened by a foresight exercise could undermine attempts to widely engage with the human resource base. This is why it is important to get such institutions on-board as early as possible in the foresight process. We should add that there are likely to be sectoral differences within a national territory in terms of infrastructural resources, with some areas better serviced than others. For this reason, it may be that the same foresight exercise will have to elaborate different strategies to engage the various areas it seeks to cover;

(*c*) Cultural resources are more difficult to specify, but here, we refer mostly to the disposition of actors (whether human or institutional) to think actively about the future. This is an area that is rarely discussed in academic or policy accounts of foresight, yet it is one of the barriers most frequently mentioned by those working most closely with foresight exercises. Again, the picture is likely to vary within a national level foresight exercise, requiring the advance elaboration of various bespoke strategies.

To sum up, a Government could throw millions of dollars at a foresight programme, but if it had failed to take account of these "softer", less tangible resources in the programme's design, then it runs the risk of failure.

Role and mandate of main players

There are a number of roles associated with the conduct of a successful foresight exercise, some of which are necessarily predetermined, while others are less organized and more ad hoc. We begin with a description of the role of foresight champions and experts who convince others of the merits of a foresight exercise (usually an ad hoc process), after which we will examine the formal structures commonly used, including steering committees, expert/stakeholder panels, management-secretariat groups, and facilitators who are expert in the use of foresight techniques. Finally, we will discuss the role of intermediaries, particularly with regard to implementation. It should be noted that we will not consider the role of business, academics, government officials, etc., separately here—it is assumed that they could (and probably should) be involved in most of the roles outlined below.

Foresight champions and experts

From the national exercises that we have examined, foresight champions within government ministries seem to be important in getting something off the ground, although such individuals may also come from the business or academic communities. These people tend to become aware of foresight through the international policy forums offered by organizations such as the EC, OECD and UNIDO (see below), as well as through policy advisers in their own countries, particularly academics (the latter phenomenon is perhaps best demonstrated in Germany, where ISI has had considerable influence in persuading the BMFT and its successor of the merits of foresight). Foresight champions will often meet resistance from others in their ministries, as well as from other government departments, although the current popularity of foresight has seen such opposition wane—indeed, if anything, foresight champions need to be careful to keep in check "unrealistic" expectations for such exercises.

A common approach to convincing others of the merits of a foresight exercise involves employing "experts", who sometimes come from other countries, to conduct or advise upon a programme feasibility study. Thus, in Japan during the late 1960s, some of the American pioneers of forecasting were invited to give lectures. These forecasting experts convinced senior Japanese industrialists that the appropriate means for identifying fields of research was to conduct a comprehensive Delphi exercise on the nation's technological future. In Germany, cooperation with Japan was important in convincing ministers of the merits of conducting a Delphi survey, given the extensive Japanese experience. And in the United Kingdom, a foresight scoping study, conducted by both British and German experts, was important in convincing ministers of the merits of including foresight in the new science and technology White Paper. Even in those countries where a formal feasibility study has not been conducted, informal advice was sought from resident or foreign experts, which undoubtedly shaped the nature of these programmes.

Yet, most of what we have just said concerns initiating national foresight exercises in countries that have never undertaken such programmes before. In Japan, for instance, the five-year Science and Technology Agency (STA) forecasts are now an institution, where there is little need to build alliances and coalitions for an exercise to get under way. The forecasts have, in a sense, become routinized. Elsewhere, the explosion in national foresight activities during the mid-1990s means that a number of countries have now acquired considerable experience in the area, and this is shaping their subsequent activities. The role of so-called "experts", both in designing the shape of programmes and in terms of participation, has somewhat diminished, as an increasing number of actors have sought to own these exercises. Thus, in Germany, criticism that only "experts" were involved has led to a broadening of the participation base in the new FUTUR Programme, and this has led to innovations in the approach taken. Similarly, the wealth creation rationale of the first round of the United Kingdom Foresight Programme has been joined in the second round by a greater emphasis on quality of life and sustainability issues. This has been coupled to a more problem-oriented approach, in an attempt to move away from a solely disciplinary science or industrial sector panel-based focus. Moreover, rather than following a programme design dictated largely by "expert" consultants, as in the first round, an extensive consultation exercise was undertaken to form a consensus on the format for the second programme.

Steering committee

Without exception, the national programmes that we have examined have all had steering committees composed of the "great and good". As the name suggests, these groups are supposed to provide guidance to the overall exercise and often play an important role in determining the scope of an exercise, as well as the methods to be employed (although the extent of this role will depend on whether the committee was appointed before or after these factors were determined). In some exercises (e.g., Hungary and the United Kingdom), steering committees have gone on to prepare their own overarching foresight reports, perhaps drawing upon the outputs of sector panels, as well as their own analyses. But steering committees populated with the "great and good" also provide foresight exercises with authority and status, assets that should not be underestimated. Moreover, the existing connections that such individuals have can be a useful resource to be exploited by those managing a foresight exercise.

Management or secretariat group

While steering committees often play essential roles in a foresight exercise, they are rarely involved in its day-to-day management. This task typically falls to a dedicated team of people who are charged with the smooth running of an exercise. It is common for such teams to be located in sponsoring organizations, such as government ministries, although as we have already said, this need not be the case—this function can be contracted out to consultants, academics, intermediary organizations, etc. The size of such a group will vary according to the scope of the exercise and the methods to be employed—the more ambitious exercises, such as those conducted in the United Kingdom, have had as many as 35 people employed full time on an exercise, although much smaller groups are more typical (3-8 people). The number of people within a management group may also vary with time. Again, considering the United Kingdom Programme, the initial stages saw 5-6 people employed, a figure that swelled to around 15 once the sector panels were appointed and in need of servicing. With the adoption of a proactive implementation strategy, the number of people who were working on the Programme rose to around 35 by 1998, although this is unusual—most exercises that we have examined see a contraction in the size of the management group once the main foresighting activities have finished.

Panels

As we have already mentioned, the scale of most national level exercises demands that they be "vertically" divided in some way so as to be manageable. How this is to be done depends upon a number of factors already discussed under framing scope, but what results is normally 6-20 expert/stakeholder panels. Panels tend to be around 12-18 people, with members typically drawn from academia, business, government, and other groups in civil society—the mix depends upon the area or problem being addressed by the panel. Panel members are usually nominated by government ministries, companies, intermediary organizations, the management/secretariat group, and the steering committee, and would normally serve for the duration of the exercise (typically 9-24 months). They tend to meet regularly (perhaps bimonthly) where futures methodologies (such as Delphi, scenarios, megatrends, etc.) will be used within the panel and/or developed for wider consultation. Panels then usually produce reports of their findings, and in a few cases, they may be retained to spearhead dissemination activities.

Experts as process facilitators

We have already discussed the importance of experts in futures techniques and thinking as a resource for convincing others of the merits of a foresight exercise. If an exercise is given the go-ahead, then this expertise tends to be utilized later down the line, both formally and informally. In the formal sense, experts may be contracted to carry out certain tasks, such as the conduct of a Delphi (e.g., ISI in Germany, PREST in the United Kingdom) or the organization and running of scenario workshops. Experts may also be drafted into management/secretariat groups or onto steering committees. In an informal sense, expert individuals are often at hand if advice is needed.

Role of intermediaries

We have already touched upon the important role of intermediaries when we discussed "infrastructural" resources for foresight (see the section on sponsorship and resources). While our definition of "intermediaries" is broad, we focus here on organizations like research councils, industrial associations, chambers of commerce, government ministries, regional authorities, etc. If a foresight exercise is designed and managed intelligently, the activities of such organizations can be leveraged in support of the exercise. For example, intermediaries can be useful for *(a)* raising awareness amongst their members and/or user groups, *(b)* identifying foresight participants, *(c)* organizing and hosting workshops and events, and *(d)* even taking the lead in later dissemination activities. But for any of this to happen, it is essential that intermediaries are brought into the process as early as possible, so that a greater sense of ownership can develop.

Research elements and methods

Foresight exercises invariably see a number of different methods employed in dealing with the multifarious tasks offered up by such undertakings, although it is not always clear why one particular method was chosen over another, or even whether a systematic options assessment was ever made. Moreover, while these choices tend ultimately to reside within the sponsoring ministries, steering groups and external contractors have had considerable influence on the directions pursued, although there are signs that this may be changing. For instance, the German FUTUR Programme sees a number of different organizers involved, and these will be responsible for selecting the research elements and methods in what has been described as a self-learning exercise, although final decisions will still reside with the ministry responsible, the BMBF. Going back a decade, the foresight processes employed by the Dutch Ministry of Education have left panels the discretion to choose their own approach, a path currently being followed in the second round of the United Kingdom Programme. The reason for the significant change in the British approach can be traced, in part, to the criticisms levelled at the cross-programme methods employed in the first round, such as the Delphi, as well as a belief in the power of the Internet, which dominates the second round in the form of the "knowledge pool". The main limitation of giving panels so much autonomy lies in the difficulties faced when trying to combine outcomes, or when trying to set priorities across the board.

Perhaps the best way to provide an overview of the various methods used in foresight is to account for the different tasks that are typically undertaken. These are numerous and include: scoping/feasibility studies, the identification of participants, awareness raising, benchmarking, the deployment of futures methodologies, consultation, priority-setting and results dissemination.

Scoping/feasibility studies

In most of the exercises reviewed, scoping studies have tended to take the form of getting "experts" (whether foreign or home-grown) to *(a)* review foresight experiences elsewhere; *(b)* provide an overview of the national research system; and *(c)* arrive at possible options for a national foresight exercise. These scoping studies typically play an important role in convincing a variety of actors of the merits and feasibility of a foresight exercise, particularly as they refer to what other countries (competitors) are doing in the area. The methods used in their construction include desk-based literature searches, visits to other countries, and limited consultation, usually through interview, of key actors in the research system. Even where a foresight exercise may already have taken place, some sort of scoping study is often carried out, since changes are more often than not desired in light of experience. This was the case in the second round of the United Kingdom Programme, although this was also marked by a mass consultation on the shape of future foresight activities, reflecting the presence of a foresight-aware population that did not exist at the time of designing the first Programme.

Identification of participants

We have already discussed participation in terms of a programme's scope, but the mechanics of identifying individuals to take part in a foresight exercise is not always straightforward. Much depends on the extent and nature of the consultation processes to be used later: programmes based solely on expert panels have few challenges in identifying participants. However, if a consultation tool like a Delphi is to be employed, then thousands of potential "expert" respondents must be sought. The time-honoured tradition for doing this is through the recommendations of key organizations in the research landscape, such as professional societies, industry associations, government departments, etc. An alternative way is to take names and addresses from pre-existing databases. But perhaps the most ambitious method is a form of snowball sampling, known as co-nomination. This was used in the first Austrian, Hungarian, South African and United Kingdom Programmes, the objective being to identify experts without having to rely on only the "usual suspects". The advent of foresight exercises with broader participation remits has seen the adoption of IT-based methods, with both the German FUTUR and second United Kingdom Programmes relying to a large extent on web-based approaches to engender participation. In theory, the Internet allows anyone to participate in foresight exercises, although its effectiveness in eliciting responses remains largely to be tested.

Raising awareness

This can be particularly important for those exercises where a number of people are required to complete questionnaires, such as Delphi. Thus, in the German, Hungarian and the first United Kingdom Programmes, open seminars were held to raise awareness of what was going on, as well as to elicit feedback on and commitment to the planned processes. More broadly, virtually all exercises expend resources ensuring that key actors are kept informed of progress, for example, through verbal briefings or newsletters. The latter can be distributed more widely and a targeted media campaign is not uncommon.

Benchmarking

As we have already seen, an objective of many foresight exercises is to identify areas where action is needed, e.g., the deployment of resources, the development of capabilities or expertise, etc. In order to make such an assessment, existing national strengths and weaknesses of a given area are normally "calibrated" or "benchmarked" with other similar areas, or more commonly, with the same area in other national settings. The data for this assessment can be qualitative, relying on the opinions of key figures in a particular area, for example, through a Delphi, or they can be quantitative, relying on things such as bibliometrics or comparative gross expenditure on R&D (GERD) statistics in the case of S&T, and on any number of competitiveness measures in the case of industry. A combination of the two is not uncommon, with this decision often being left to the discretion of panels.

Constructing scenarios and Delphi topics

Constructing scenarios and Delphi topics is nearly always done through deliberations within panels, although the French and first German Delphi exercises directly translated the topic statements from the Japanese. Some exercises have used macro-scenarios to guide panels in their deliberations (e.g., South Africa), or have sought opinions on megatrends, as in the Austrian and 1998 German Delphi exercises. There are multiple approaches to eliciting views on the future, and these are covered extensively in the futures literature. We will not therefore devote further space in this paper to foresight methods.

Consultation

As we have already remarked, the breadth of consultation in a foresight exercise can vary greatly. Attempts at wide consultation have more often than not led to the adoption of the Delphi method, as in Austria, France, Germany, Hungary, South Africa, Spain and the United Kingdom, although the reasons for its popularity have probably more to do with international precedence than any intrinsic qualities of the method itself. Another common approach for consulting beyond the confines of an expert or stakeholder panel is to use workshops and seminars, where scenarios and brainstorming are the dominant methods used. Such events may also be staged in the wider community, as in Australia. As we have already said, one of the rationales for the use of the Internet in the most recent German and United Kingdom Programmes is to "up-scale" the involvement of the wider stakeholder community beyond the limited boundaries of the "experts" who answer Delphi questionnaires. Thus, there is a trend towards opening up foresight exercises to many more people.

Priority-setting

Priority-setting normally involves some sort of variation on a SWOT (strengths, weaknesses, opportunities and threats) approach. The strengths and weaknesses elements are determined through stock-taking, benchmarking and evaluation exercises of different components of the national innovation system (see above). The opportunities and threats aspects govern the more explicitly forward-looking parts of foresight, and give rise respectively to targets for proactive and reactive public policies or business strategies. In some exercises, explicit ranking of S&T options has been carried out, which requires the articulation of ranking criteria. Moreover, these criteria need to be weighted, as some are likely to be more important than others.

Dissemination

Dissemination commonly takes the form of written reports, workshops, and presentations. This is where a proactive awareness strategy, as well as a wide consultation approach, can pay dividends, since a receptive audience to a programme's outputs can be ready-made. Yet, experience shows that dissemination is an ongoing activity, since even well-publicized exercises such as the United Kingdom Programme enjoy only limited recognition amongst many actors, particularly SMEs. In this respect, it is important to co-opt respected figures to "champion" foresight in their own constituencies.

Outputs and intervention

Outputs, in the concrete sense, refer to things like critical technology lists, priorities and recommendations, scenarios and written accounts of future trends and issues. The distribution of such outputs varies from one foresight exercise to another, and depends most crucially on the design approach that was adopted. Programme managers will commonly seek to shape a programme's outputs according to the perceived information needs of a given target audience, and this might involve translating raw results into something more palatable. For this reason, such shaping activities may be devolved to panels or intermediaries, where local knowledge of a particular sector or problem can be brought to bear.

At its simplest, intervention refers to activities undertaken in response to the outputs of a foresight exercise. It is in fact remarkable to note the number of exercises that claim to be non-interventionist. For instance, in the French, German and Japanese Delphi exercises, there was no strategic implementation nor priority setting or binding decisions based on the outcomes. This has been interpreted as a non-interventionist approach, since the aim was for organizations to decide for themselves their own technological priorities. But it could be argued that foresight exercises are weak policy instruments in any case for telling organizations what to do, which is where the process benefits of taking part become significant, since actors choose of their own accord to utilize foresight outputs or methodologies in their own organizational settings. That said, some exercises have taken a more overtly interventionist stance, most notably the United Kingdom

Programme, which, as we have seen, employed more people during the Programme's implementation phases than during the consultation phase. Yet even here, neither officials nor panel members could ignore existing dynamics at work in the innovation landscape, and Programme activities have sought to fit with these wherever possible through complex processes of negotiation.

Outcomes and reflexivity

Foresight "outcomes" is a slippery concept, referring to any number of things. For example, a Delphi exercise with an above-average response rate might be considered a successful outcome, as might the level of attendance at a scenario workshop, or the publication of a panel report on schedule. While these outcomes are considerable and should not be underestimated, for most people, they are not as important as consideration of the eventual impacts of foresight priorities and processes on things like strategic planning and, ultimately, increased national competitiveness. However, it should be borne in mind that foresight exercises can generate some widely differing expectations for both the process itself and the outputs generated vis-à-vis the national innovation landscape. Most of these can be accommodated within the "space" offered by foresight, which is one of the main strengths of the process, but some can be unrealistic and overly optimistic and should be kept in check. Moreover, the desired impacts of a foresight exercise may be a long-time coming, and even if they do arrive, there are serious attribution problems.

By reflexivity we mean monitoring and evaluation activities. Very few evaluations, in the more traditional sense, have been carried out on national foresight exercises, although there is an explanation for this: for most countries, foresight has been a new and exotic tool, but there is little understanding of its dynamic across the national innovation landscape. The one country that has had extensive experience of foresight is Japan, but there is an almost total lack of an evaluation culture in this country, so few insights are gained from the Japanese experience. Doubts over the ability to anticipate or model the impact trails of foresight has meant that programme managers have been less than keen to undertake evaluation work: it has been considered too difficult a task. Rather, they have mostly taken a "wait-and-see" approach. Moreover, even when evaluation has been seriously considered, as in the accountability-conscious United Kingdom, the costs associated with a risky evaluation venture have been considered too prohibitive to proceed.

The few ex-post evaluations that have been carried out are hardly sophisticated, having been based on simple questionnaire surveys. But this situation is now changing: for instance, the latest United Kingdom Foresight Programme and the new German FUTUR Programme are both attempting to incorporate evaluation capacity in the process itself. The emphasis in both cases is on learning rather than accountability, reflecting, in part, the considerable uncertainty that still remains as to the impact trails of these activities. But the high profile and, at least in the British case, the pervasiveness of foresight, has meant that the calls for evaluating these activities have grown so loud and so widespread that programme managers now consider evaluation as one of their core tasks, demanding considerable attention.

Quality controls, in terms of whether an exercise is said to be "delivering", have tended to draw upon other international exercises and the expectations of key actors as their referents. Thus, value (or otherwise) has tended to be assigned to exercises through the views expressed by their audiences, although few systematic approaches have been employed to elicit these views. Indeed, most of this evidence exists in anecdotal form, although some countries, such as Germany, have organized specific workshops in order to elicit feedback on the approaches used and their impacts.

If our country reviews tell us anything about reflexivity, it is the need for milestones to be set throughout the life of the exercise, particularly during the more intensive consultation phases. Milestones are usually intrinsic to the exercise, being largely dependent upon the methods used. They are typically laid out in project plans that are usually widely distributed to those closely involved in an exercise, so that they can see its overall rationality and use it as a yardstick to measure their own progress. But milestones can also arise externally, for example, in the United Kingdom, where ministers demanded that priorities be identified in time for inclusion in the annually published *Forward Look of Government-Funded Science, Engineering and Technology*. This can lead to tasks being rushed, although such externally imposed milestones can also have the benefit of concentrating minds.

The final aspect of reflexivity to be considered here concerns reporting lines. Management-secretariat groups tend to be answerable to both sponsors (often government ministers) and a steering committee, and often constitute the official conduit between expert panels and the sponsor/steering committee. Expert/stakeholder panels are commonly given milestones, and progress towards meeting these is often reported at regular intervals through written or oral reports to the management-secretariat group. Thus, a hierarchy of reporting lines, from the panels at the bottom to the sponsor (ministry) at the top would seem to be the norm. However, this view is overly simplistic, since it ignores the fact that most participants in a foresight exercise are volunteers who commonly expect something in return for their time and efforts. This may simply be the kudos attached to participating on a panel, or more realistically, the opportunities offered by being "on the inside". But in the first United Kingdom Programme at least, these volunteers went further than this, making demands for action to be taken in light of their findings. In a sense, they became the "customers" for government commitment to a proactive implementation strategy, with ministers and senior officials called upon time and again to report on what the Government intended to do about emerging panel recommendations. Reporting lines can therefore be considered to be multi-directional.

Possibility of applying foresight to regional support programmes

The next section will outline some of the activities of a handful of international organizations, including UNIDO. Such organizations seem to be engaged in three broad types of activities:

- The support of national level exercises through active assistance and facilitation, e.g., UNIDO;
- The support of regional level strategic planning through the commissioning of regional foresight exercises, e.g., the EC-wide Futures Programme (and its successor for pre-accession countries) managed by the EC's Institute for Prospective Technological Studies (IPTS);
- The production of futures reports that might have regional, national or global focus and be targeted at national Governments and/or international organizations, e.g., OECD.

There are opportunities to be had and constraints to be faced when conducting foresight-type activities at the supranational level, although it is beyond the scope of this paper to investigate these in any meaningful depth.

International cooperation and joint development

Bilateral cooperation and joint development of foresight activities is still in its infancy, although there are some notable exceptions. The best-known example is the cooperation between Germany and Japan on the 1998 Delphi exercises. This was the second large-scale Delphi to be conducted by Germany and the sixth for Japan. The first German Delphi had simply translated the topic statements from the fifth Japanese survey. While, overall, this exercise was viewed favourably in Germany, it was criticized for the inclusion of topic statements that were largely irrelevant, as well as for the absence of areas that were central to German competitiveness. It was therefore agreed with the Japanese to work together on the development of future topic statements, which resulted in about half the topic statements on both 1998 Delphi questionnaires being the same. Not only did this give the Germans a more relevant Delphi, but it also allowed both countries to benchmark their results against the other.

On a less ambitious scale, the British Council has been supporting units, such as PREST, to provide bilateral assistance to other countries embarking upon a foresight exercise. For example, PREST has provided foresight advice and assistance to the Czech Republic, Hungary, the Russian Federation and South Africa through this route over the last few years.

Perhaps of greater potential is the scope for multilateral cooperation and joint development of foresight activities. This is the territory of the big international organizations, such as UNIDO, UNESCO, the World Bank, the EC, OECD and APEC, all of which have been involved in foresight activities during the recent past. We will now discuss some of these activities in more detail.

Foresight in the European Community: the case of the Institute for Prospective Technological Studies

Established in Seville in 1994, the main mission of the EC's Institute for Prospective Technological Studies (IPTS) is to provide techno-economic analysis to support European decision makers. To do this, it monitors and analyses S&T-related developments, their cross-sectoral impacts, and their interrelationships and implications for future policy development. The Institute has adopted an interdisciplinary prospective approach in all its activities, with the intention of providing European decision makers with a deeper understanding of emerging S&T issues, and has been conceived as fully complementary to the activities undertaken by other institutes of the EC's Joint Research Centre (JRC). IPTS also acts as a prompt reaction force for the EC, servicing on ad-hoc issues, such as providing information to support the EC's case in the recent hormone dispute between the EU and the United States. It also aims to support policy-making at the level of the Commission as a whole through a truly horizontal policy support function that cuts across administrative vertical lines.

The IPTS Portfolio has been recently restructured along the lines of the Fifth Framework Programme (FF5) set-up. As a result, the Institute's activities are arranged within three closely related units: *(a)* Technologies for Sustainable Development; *(b)* Life Science/Information and Communications Technologies; and *(c)* Technology, Employment, Competitiveness and Society. In addition to its own resources, IPTS makes use of external advisory groups, such as a group of highly eminent economists led by Nobel-Prize winner Bob Solow, to work for and with IPTS on a long-term basis. It also operates a series of networks, such as the European Science and Technology Observatory (ESTO) Network, which draws on the resources of 35 institutions, including all the major European think tanks (e.g., PREST), the Techno-Economic Analysis Network for the Mediterranean (TEAM), and a Network to involve pre-accession countries in prospective issues.

Organisation for Economic Cooperation and Development

The OECD International Futures Programme is designed to help decision makers in government and industry come to grips with the challenges of the future. The Programme offers a number of distinguishing features: improved monitoring of the long-term economic and social horizon, with early warning on emerging domestic and international issues; more accurate pinpointing of major developments and possible trend breaks; greater analytical appreciation of key long-term issues; and better dialogue and information sharing to help set policy agendas and map strategy.

Established in 1990, the Programme consists of four interrelated and mutually supportive elements:

- OECD Forum for the Future: a platform for informal, high-level meetings with the aim of testing new ideas, developing fresh perspectives on problems and advancing the understanding of strategic economic and social issues;
- OECD Futures Projects: focused, multidisciplinary research and policy analysis on special themes, largely as spin-offs from Forum for the Future conferences;
- OECD Futures Studies Information Base: a documentation system providing in succinct form the key findings and conclusions of published and unpublished literature selected from the world-wide output of futures analysis;
- OECD International Futures Network: a global network of some 600 people in government, industry and business, and research institutions who share a common interest in long-term developments and related policy issues.

The OECD International Futures Programme is only partially financed through the ordinary budget of the organization, and a major part of its funding is based on voluntary contributions from Governments of OECD member countries and on grants from enterprises and foundations.

Asia-Pacific Economic Cooperation (APEC)

The APEC Centre for Technology Foresight was established in 1997 and is supported by APEC, through the active cooperation of Thailand and other APEC member economies. The Centre's objectives can be summarized as follows:

(a) Promote the adoption of foresight across APEC member economies;

(b) Provide a means for comparison of technology foresight exercises and implementation in APEC member economies and across the world, with a view to stimulating best practice in appropriate methodologies for foresight in APEC economies;

(c) Conduct technology foresight exercises on an APEC-wide basis, and between relevant member economies;

(d) Improve the quality and effectiveness of technology-related planning and development and priority-setting for research, across APEC member economies; and

(e) Develop a technology foresight research and application capability available to APEC member economies and international agencies.

To date, the Centre has produced a series of reports on issues such as megacities in 2020. It also frequently organizes workshops on specific issues and provides training sessions on the use of futures techniques. A core team is located in Bangkok, with other Centre associates dispersed around the Pacific Rim in their home institutions.

United Nations Industrial Development Organization

In December 1999, UNIDO launched a technology foresight regional programme for Latin American and Caribbean countries at a three-day meeting on technology foresight attended by top public and private sector representatives from over 30 countries. When participants confirmed their interest to initiate action for conducting such activities in their respective countries, UNIDO, in cooperation with the International Centre for Science and High Technology (ICS), came forward with a proposal that stressed UNIDO/ICS industrial knowledge broker functions. The goal has been to provide a platform for a continuous, open and enhanced exchange of knowledge, expertise and best practices on foresight, with the aim of helping Governments and other authorities promote, prepare and mount national foresight exercises and to link them to UNIDO's foresight knowledge network. Through its foresight programme, UNIDO aims to become a permanent vehicle for a continuous, open and enhanced exchange of knowledge, expertise and best practices on technology foresight among Latin American and Caribbean countries, strengthening the cooperation and integration of regional efforts in this field.

At the regional level, UNIDO plays the role of technology foresight "regional knowledge manager" in Latin America. The programme aims to:

(a) Become a communication channel for dialogue and exchange of experience;

(b) Provide an interactive knowledge repository of expertise, best practices, skill inventories and case studies;

(c) Become an easily accessible knowledge base of technology foresight tools to facilitate the national foresight programmes (experts, methodologies, manuals, software);

(d) Establish cost-efficient training programmes (on-line and distance-learning techniques, videoconferences, multimedia); and

(e) Support the national technology foresight programmes.

At the national level, UNIDO is a technical partner in the respective national technology foresight exercises, which include the following five stages:

- Inventory stage: identification of experts, institutions, methodologies and studies;
- Preparatory stage: elaboration of plans of action, identification of participating institutions, preferential areas, national contributors, panel of experts and estimated costs;

- Awareness building through seminars and training on methodologies and case studies: elaboration of secondary panels, Delphi exercises, scenarios, future perspectives and policy recommendations;
- Dissemination stage: diffusion of results and recommendations of the technology foresight exercise; awareness raising through regional and local training; and
- Promotion and monitoring of results.

The countries currently participating in the inventory stage are Argentina, Bolivia, Brazil, Chile, Colombia, Mexico, Peru, Uruguay and Venezuela. Argentina, Brazil, Uruguay and Venezuela are also involved in the preparatory stage.

Aide-mémoire and pointers for newcomers

To finish, we provide some pointers for those anticipating a foresight exercise, based around the elements (checklist) already presented in this paper.

(a) Rationale and objectives: These should be clearly stated and internally consistent, although they should avoid being too specific, at least in the first instance, since the usual aim is to get as many groups as possible to sign up to the exercise;

(b) Framing scope: Decisions need to be taken on the technological orientation of the exercise, the themes/sectors to be covered, the time horizon, and the degree of participation and consultation. These decisions will be highly political and will require negotiation and compromise on the part of all concerned;

(c) Sponsorship and resources: It is important that funding lines are in place before the main activities are started, although feasibility studies can be carried out and steering committees appointed beforehand. An assessment of the human, infrastructural and cultural resources base should, ideally, be carried out for each theme/sector, so that identified opportunities can be exploited and constraints taken into account;

(d) Role and mandate of main players: We have seen that there are a number of "structures" associated with the conduct of foresight exercises (e.g., steering committees, panels, secretariat groups, etc.), and their roles need to be thought out. The importance of intermediary organizations for the successful conduct of an exercise should not be underestimated, and their positions should be actively exploited in pursuit of goals of the foresight exercise;

(e) Research elements and methods: The methodological choices facing foresight programme managers extend beyond weighing the relative merits of Delphi over scenario workshops. We have seen that there are a number of tasks associated with foresight and different ways of addressing these, and we would recommend that the full scope of options be considered. There is

also the question of how much autonomy to give to the participants of a foresight exercise in deciding the methods to be used. Finally, some newer exercises have tried to exploit ICT in their approach, although with mixed results. Therefore, the use of Internet-based tools should be carefully considered;

(f) Outputs and intervention: The presentation of outputs from a foresight exercise should be tailored to the needs of its target audience, which may require the use of a number of different formats. Linked to this, consideration needs to be given to follow-up activities-the available resource base (financial, human, infrastructural and cultural) will be an important limiting/ enabling factor here;

(g) Outcomes and reflexivity: The outcomes associated with foresight still remain relatively poorly understood, with attribution claims particularly problematic, yet the expectations held for such exercises sometimes know no bounds. It is important that expectations remain realistic—foresight is no panacea—although the approach should not be undersold either. Finally, it is essential that milestones be set throughout the process, especially since the outputs of one stage often constitute an important input into the next.

To conclude, by starting with consideration of these elements of foresight, we believe prospective organizers of foresight exercises have a platform from which to build.

3 The most commonly applied methodologies in technology foresight

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Abstract

Since the times of ancient Greece, humans have made efforts to be cognizant of the future. The famous Greek oracles are a faithful testament to this. In today's world, the possibility of having at least a general idea of what may occur or the manner in which the future may present itself (possible scenarios) is not only a desire, but also an essential requirement to anticipate any threat or opportunity.

The first informal attempts to gain knowledge of the future were made through the use of conventional mathematics and statistics. Powerful quantitative techniques have been developed for this purpose such as the time series, regression analysis (both simple and multiple), econometric models and stochastic simulation models. These are quantitative forecast techniques, which are employed to "predict" the behaviour of a variable or of a system (a package of interrelated variables) in a fixed time horizon.

Irrespective of the high degree of utility of forecast techniques and the very nature of their power, their use is limited to applications where quantitative historical data exists. In this sense, applications are limited to descriptions of the future when it is, in essence, an extension of the past. This, of course, presents major limits, since we live in a world where changes occur constantly and with great speed, and many of these changes are so drastic that they can be interpreted as true quantitative leaps in our societies.

Within this context, an attempt is made to visualize a future which cannot be understood as a simple extension of the past since it can adopt forms and structures different from anything known previously.

Efforts have been made to create techniques, which could be applied to the challenge of knowing, at least in an approximate form, a future of an essentially uncertain nature. In the 1960s, the RAND Corporation (United States) developed a technique to simplify the visualization of future scenarios in technological aspects influencing weapon design. This technique was christened "Delphi" after the Delphic oracle in Greece.

The technique was originally used by experts for "explorations to the future", thereby gaining an idea as to how technologies would evolve, and, with this, have the ability to design systems in accordance with the advances that could be made.

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Following the Second World War in Europe, Gaston Berger introduced the futures concept (known as *la prospective*) in the magazine *Two Worlds.* Nonetheless, all of the techniques available today for undertaking this sort of study were developed subsequent to the Delphi technique.

Requirements and purposes of technology foresight

Is technology foresight necessary?

No one doubts that technological changes have a significant impact on change in our societies. The revolution in the fields of information and communications technology is substantially changing the structures of international commerce, in addition to the universe of economic activities. We know that in economics the "traditional" factors of production are capital, labour and land. Today, knowledge plays an even more critical role as a production factor. In the field of information technology, software development is the "backbone". We can see, therefore, how the development of information technology has opened up new fields in the universe of economic activities, the software industry being the most obvious example.

It becomes not only necessary but indispensable for any country to approach this issue of prospective or technology foresight as a fundamental tool for the design of policies and strategies. Every organization, public or private, and every country, irrespective of its political and economic model, requires knowledge or must at least have a general idea of feasible future scenarios of technological development. There are two major reasons for this:

(*a*) To avoid being distanced from technological progress;

(*b*) To provide access to the benefits of technological developments in order to maximize the comparative and competitive advantages in our countries.

Overview of methodologies available for technology foresight studies

The following section gives a brief description of the various techniques which can be used for achieving prospective studies. Such techniques can be used in combination, that is, using two or more to undertake specific studies. This will assist in completely satisfying the requirements of the study in question.

All of the techniques presented are based on the use of expert opinion in a determined area. The basic inputs of these studies are "value judgements". For this reason they are considered qualitative techniques, irrespective of the use of mathematical models or quantitative tools for processing the information.

Delphi technique

This technique is used[1] to elicit the opinion of a group of experts regarding the future behaviour of one or more variables of interest. From the results obtained, exploratory scenarios can be constructed.

In the construction of exploratory scenarios, questionnaires are used to gather value judgements of the experts in the most appropriate manner possible. The questionnaires are designed with questions to closed answers, in order to be able to articulate and focus on such answers, and to synthesize the opinions. The use of the Delphi technique in undertaking a prospective study involves the application of the following steps:

- Select the group of experts according to the topic or nature of the study;
- Provide a clear and precise definition of the objective of the study;
- Design the questionnaire for the group of experts;
- Distribute questionnaires to the group of experts;
- Conduct statistical processing of the information obtained in order to synthesize results;
- Present the results to each expert in order to give him/her the opportunity to review and reflect upon their responses, taking into account the opinions of the entire group;
- Reprocess the information obtained in the second round of questions (step 6) in the event that an expert will modify his/her opinion;
- Repeat the process as of step 4 should it be deemed necessary (e.g., there is no consensus of opinion), or end the process (for technical or other limitations);
- Construct exploratory scenarios and interpret them.

Cross-impact matrices technique

The methodology of the cross-impact matrices technique for the construction of future scenarios is a completely different approach from that of the Delphi technique.

The first step in the use of this technique consists in eliciting from a group of experts their opinion regarding the events whose occurrence can characterize the explored future within a fixed time horizon. For instance, if an attempt were made to explore the future of the industry of telecommunications, an effort would be made to visualize what events might emerge to characterize future scenarios of that sector of the industry.

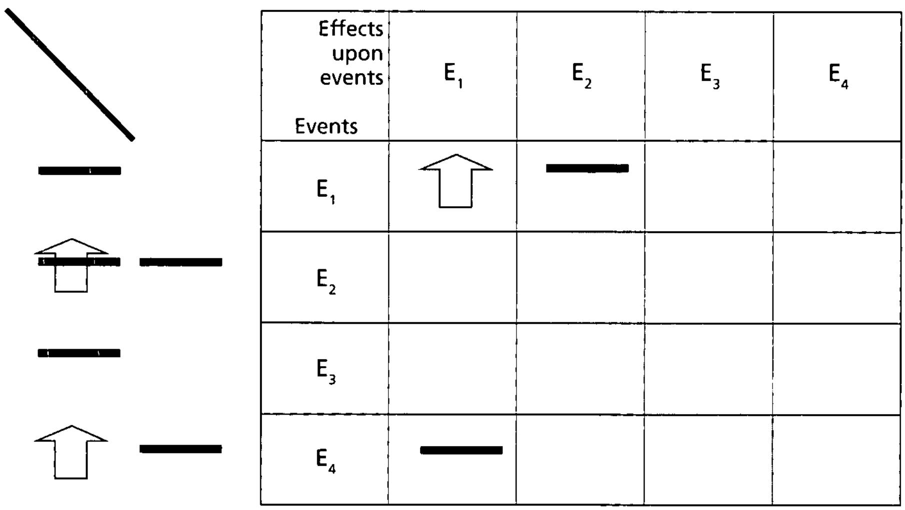
[1]The description here is in the context of the technology foresight studies, since it can have other uses.

A hypothetical example of an event could be the disappearance of the mobile telephone. An event of this nature undoubtedly would impact that sector of the industry since billions of dollars are currently invested in the production of this type of telephone system.

Once the relevant events have been identified which can characterize the future scenarios of the sector in question, the probability of occurrence of each of these events is estimated. These are known as simple or initial probabilities.

The next step is to construct the so-called cross-impact matrix. This produces a N × N matrix (where N is the number of identified events) which specifies which event will prompt or impact other events. Figure I is an example of a matrix used in a study identifying four future events:

Figure I. Example of a cross-impact matrix for four events



The matrix in figure I shows that, based on the judgement of a group of experts, event number one (E_1) has an effect on the occurrence of event number three (E_3); event number two (E_2) has an effect on the occurrence of event number four (E_4), which in turn has an effect on the occurrence of event number two (E_2).

The following step will consist in "refining" the value of the probabilities of the initial occurrence of each event ($P^0(E_i)$). A stochastic simulation exercise is used, based on the initial value judgements by the experts.

Once the reviewed probabilities ($P^*(E_i)$) have been obtained, another exercise in stochastic simulation is conducted, this time with the objective of obtaining the probability of occurrence of each possible scenario. The number of possible scenarios is determined as the number of events (N) which were previously identified. For example, if N = 4, the number of possible scenarios will be equal to: $2^4 = 2^4 = 16$.

Such possible scenarios are characterized by 4-uplas: (0000); (1000); (0100); (0010); (0001); (1100); (1010); (1001); (0110); (0101); (0011); (1110); (1011); (1101); (0111); (1111). In this way, the scenario characterized by 4-upla: (0101), represents the scenario where only events (E_2) (second position of the 4-upla); and (E_4) (fourth position of the 4-upla) occur. By the same token, the scenario characterized by the four-upla represents the scenario where events E_1, E_3 and E_4 occur.[2]

Each one of these scenarios is referred to as futuribles.

The estimated probability of the occurrence of the events will be determined by the results of the simulation exercise of the occurrence of corresponding events. This is, in a nutshell, the description of this important support technique for prospective studies.

Analytical hierarchy process

The analytical hierarchy process (AHP) can be used to describe scenarios in terms of indicators. This technique was developed by Thomas L. Saaty, a North American mathematician who specialized in modelling problems pertaining to non-structured decision-making. Although fundamentally created as a backup tool for decision-making, the technique has also been applied to problems of future visualization. It is an interesting approach to problems relating to prospective technology.

Unlike other techniques used in this field, it focuses on the behaviour and decisions of multiple actors rather than on spontaneously occurring events. In this sense, the technique gives a causative perspective of the processes creating future scenarios.

The technique uses so-called hierarchical networks for constructing a model of the probability or the occurrence of each possible scenario. The team responsible for the management of the study must identify what these possible scenarios actually are.

The establishment of the probability of occurrence (reduction of uncertainty) of each scenario considered is determined by applying algorithms of the hierarchical-network model. The hierarchical-network model, which is of a generic character applied in prospective problems, adopts the form illustrated in figure II.

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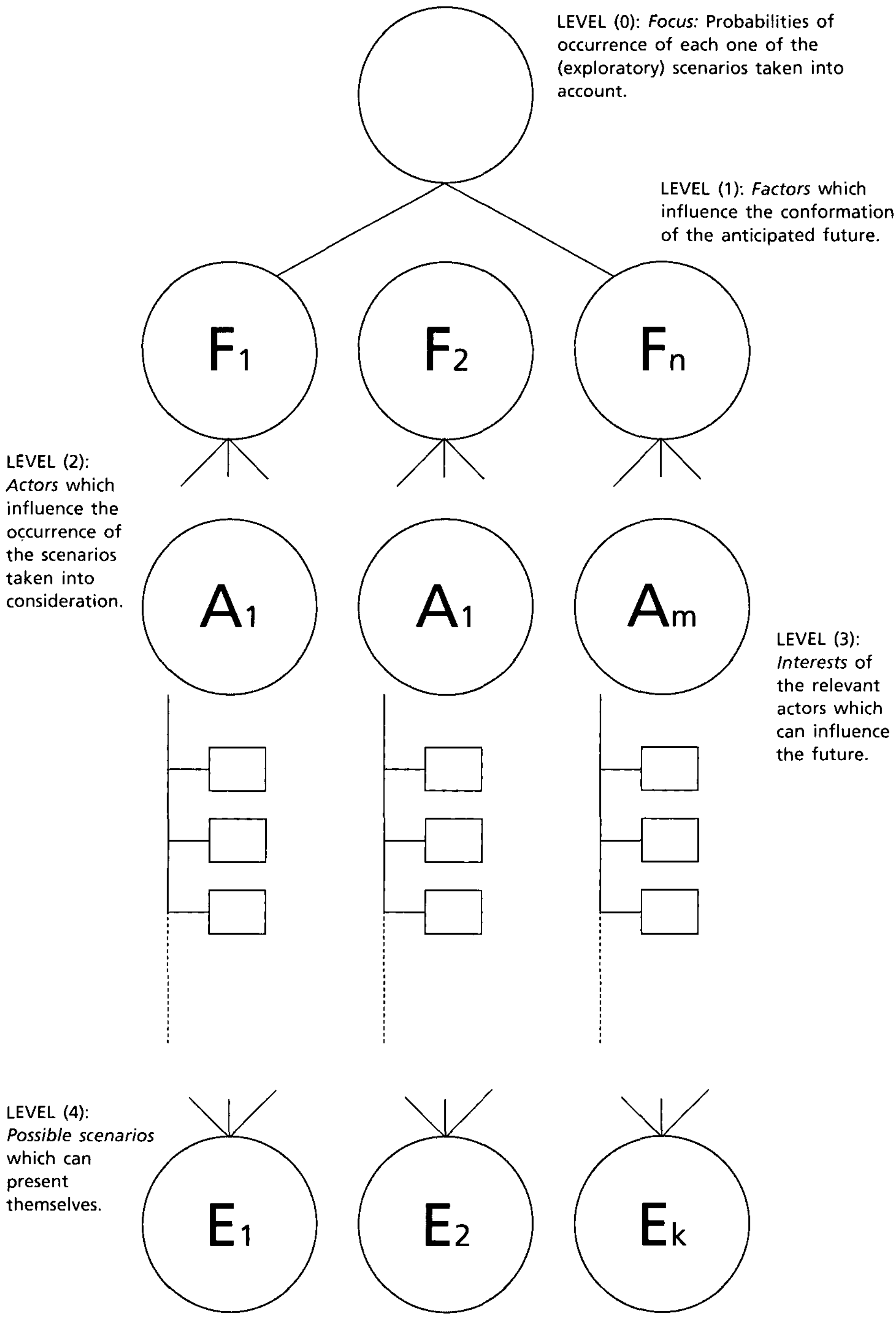
[2]If a zero appears in the -2 of the 4-upla, this means that event 2 (E_2) does not occur.

Figure II. Generic hierarchical-network model for applying AHP techniques in prospective studies



The Bayesian model

The Bayesian model is not a technique to facilitate the construction of future scenarios, but one which allows us to understand which of the possible future scenarios will become a reality, based on observed evidence. It is a powerful tool for anticipating tendencies in a specifically determined scenario. The technique serves as a decision-making support tool which alerts us to what might occur in the future.

The technique involves the following steps:

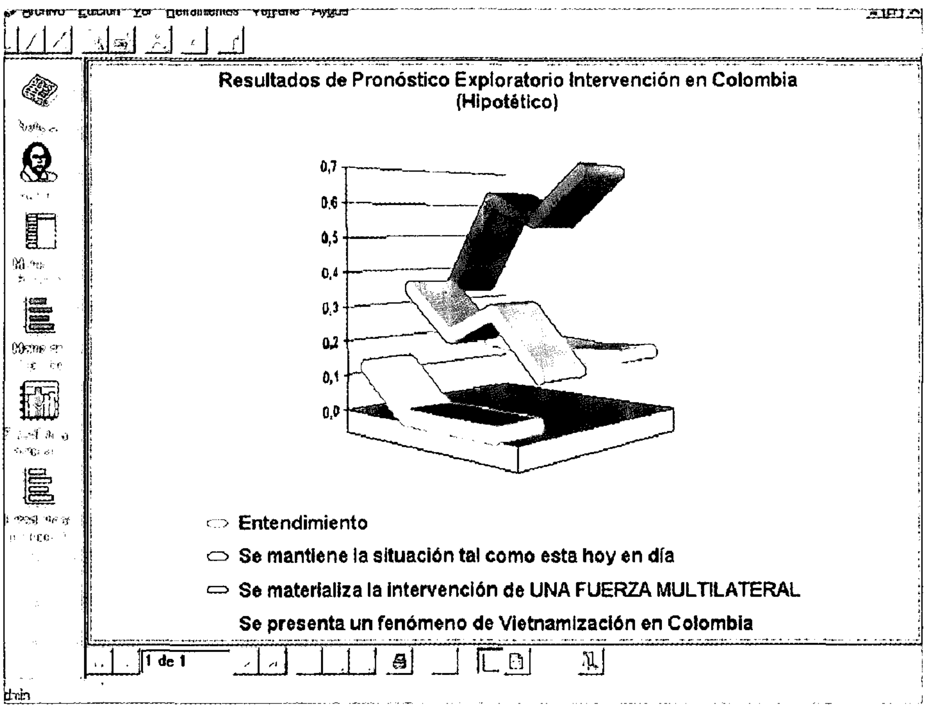
- Formulate the possible scenarios in the established time horizon for the technology foresight study. This is usually done verbally, with a description of what may occur. Such scenarios must be mutually exclusive—that is, the occurrence of one scenario necessarily implies non-occurrence of the other scenarios that have been introduced. The other requirement is exhaustiveness—that is, the formulated scenarios must conform to the spectrum of everything which might possibly happen;
- Assign the a priori or initial probabilities of each scenario in relation to the information available at the time the exercise is initiated;
- Register the events which start to occur, i.e., those events constituting observable evidence;
- Adjust estimates of the probability of occurrence of each scenario, based on observed evidence. These are known as "revised probabilities;
- Graph the results obtained in order to visualize the tendencies of probability of occurrence in every one of the scenarios.

Although the calculation of the revised probabilities involves rather complicated formulas, software tools actually make the application very simple.[3] The formula for the calculation of the revised probabilities of each scenario is the following:

$$P\left(\frac{H_i}{E_1,E_2,\ldots E_n}\right)=\frac{P^0(H_i)\times P\left(\frac{E_1}{H_i}\right)\times P\left(\frac{E_2}{H_i,E_1}\right)\times\ldots\times P\left(\frac{E_n}{H_i,E_1,E_2,\ldots,E_{n-1}}\right)}{\sum_{i=1}^{K}P^0(H_i)\times P\left(\frac{E_1}{H_i}\right)\times P\left(\frac{E_2}{H_i,E_1}\right)\times\ldots\times P\left(\frac{E_n}{H_i,E_1,E_2,\ldots,E_{n-1}}\right)}$$

[3]One type of software package available on the market for this type of technique is RADAR®, produced by Visión Grupo Consultores (www.visiongc.com).

The following presents the results of an example of the application of a technique, using the appropriate software tools:



Morphological analysis

The morphological analysis technique was developed by Fritz Zwicky, a Swiss astronomer. This technique was originally directed at exploring new forms that systems could adopt from a technological point of view.

The technique is founded in the systems approach and requires the identification of the parameters of the systems under study. For example, in the design of automobiles of the future, the analysis would stipulate the type of parameters that characterize this type of transport system.

Some of the parameters for automobile design could be the following:

P1: Wheels;
P2: Brake system;
P3: Engine;
P4: Transmission;
P5: Engine type;
P6: Power source.

Once the characterizing parameters of the system have been defined, the possible forms for each of these descriptive parameters are identified. In the case of parameter P5—engine type—possible forms could be internal combustion, external combustion, turbine, electric, etc.

Based on the number of possible forms which each parameter can adopt, the possible morphological field is determined. If in the case of the automobile system, the number of possible forms of its descriptive parameters are: P1 = 2, P2 = 3, P3 = 4, P4 = 3, P5 = 4 and P6 = 5, then the morphological field will comprise 1,440 possible solutions ($2 \times 3 \times 4 \times 3 \times 4 \times 5 = 1{,}440$). Of this "possible" morphological field, the "feasible" morphological field should also be determined, where only feasible elements will remain as solutions. For a solution to be considered feasible, the elements or forms in their different characterizing parameters must be compatible.

Critical evaluation of methodologies

Table I summarizes techniques to be used for types of existing problems and conditions in order to satisfy a requirement which has already been determined. It provides an orientation which, in addition to other more specific elements of information pertaining to the proposed requirements, will facilitate the selection of the technique or techniques to be used.

It is important to reiterate that it is perfectly feasible to make simultaneous use of two or more techniques in order to satisfy a requirement which has already been determined. For instance, applying the Delphi and Bayesian models for morphological analysis is a perfect example of employing two techniques simultaneously. The technique identified as "phase 1" in table 1 pertains to the exploration of future scenarios. The "phase 2" technique pertains to follow-up exercises to determine which of the possible scenarios will actually materialize as based on evidence presented.

Table 1. Techniques applied in foresight exercises

Technique	*Type*	*Application in forecast and/or prospective exercises*	*Requirements for application*
(1) Delphi	(Phase 1) Exploratory technique	Construction of exploratory scenarios Forecast of the behaviour of variables or systems	A group of experts must be available for the subjects of interest; Simplicity is required in order to gather information; Specialized software is useful.
(2) Cross-impact matrices	(Phase 1) Exploratory technique	Construction of exploratory scenarios	A group of experts or specialists in the subjects of interest must be available; Specialized software required to conduct the simulation of events; The group which participates in providing the information must handle the concepts of simple and conditional probabilities with precision; The probability of occurrence of each possible scenario is sought.

Table 1. *(continued)*

Technique	*Type*	*Application in forecast and/or prospective exercises*	*Requirements for application*
(3) AHP technique	(Phase 1) Exploratory technique	Construction of exploratory scenarios Forecast in the behaviour of variables and/or systems	A group of experts or specialists must be available in the subjects of interest; Specialized software is required to process the information; Participants must be familiar with the the AHP technique; Information sought on which group of scenarios is the most likely to occur; Elements of causation in the contemplated scenarios can be determined.
(4) Morphological analysis	(Phase 1) Exploratory technique	Construction of exploratory scenarios	A group of specialists or experts must be available; Specialized software is required.
(5) Bayesian techniques	(Phase 2) Anticipatory techniques based on evidence	Forecast which of a group of scenarios will occur	A group of analysts with knowledge of subject-matter must be available; Specialized software is required; A group of analysts must be trained in the use of the Bayesian model.

Conclusion and recommendations

All of the methodologies used in technology foresight exercises, irrespective of the complex mathematical models (as in the case of the Bayesian technique), numerical techniques or simulation techniques (cross-impact matrices) are, by definition, techniques of a qualitative nature.

The reason for this is that all of them take as inputs the opinions (value judgements) of the experts and/or analysts who participate in the study. Such opinions and value judgements are sustained by knowledge, experience, intuition and common sense. In this regard, all results obtained are approximations of what is possible; however, at no point are the numerical results to be treated as if they represent exacting accuracy. The techniques are a powerful and efficacious tool for approximating the future in a specific field, but none of the results should be viewed as fact.

The following is a list of recommendations for any institution or organization which conducts prospective studies:

(a) The technology foresight studies must focus on "critical" problems for the institutions or organizations;

(*b*) A team must be relied upon which has developed expertise in this type of activity;

(*c*) An information technology platform should be readily available which ensures the fulfilment of such exercises (software packages);

(*d*) It is essential to define with the greatest possible precision the objective, scope and use of the study;

(*e*) The technology foresight exercise must be an activity which is intimately linked to the process of formulation of politics and strategies of organizations, and in particular, both public and government institutions. It should not be viewed as an isolated activity nor should it be considered to be an academic exercise. The results of the technology foresight exercise should serve to assist the decision-making process.

4 Delphi as a technology foresight methodology: experiences from Germany

Knut Blind*

Abstract

Delphi studies became important as a foresight method in Europe in the 1990s. The Delphi method was originally developed in the 1950s at the RAND Corporation in Santa Monica, California. This approach consists of a survey conducted in two or more rounds, providing the participants in the second round with the results of the first so that they can either alter their original assessments or not. The Delphi method is especially useful for long-range forecasting (20-30 years), since expert opinions are the only source of information available for such forecasts.

Delphi studies now have a certain tradition in Germany. The first German Delphi study made use of previous experiences in Japan where a large Delphi study has been conducted every five years since 1971. Therefore, on behalf of the former Federal Ministry for Research and Technology (BMFT), the Fraunhofer Institute for Systems and Innovation Research (ISI) collaborated with the Japanese National Institute of Science and Technology Policy (NISTEP), an institute under the auspices of Japan's Science and Technology Agency. The German Delphi team took the topics prepared for the fifth Japanese survey and translated them into German. The ensuing Mini-Delphi was a test to develop the Delphi method further, to meet some criticism from the first German Delphi survey and to gain more detailed data about some of the internationally problematic areas. Expert committees in Japan and in Germany selected the major topics jointly. The whole procedure of the survey was conducted parallel to that in Japan.

The second German Delphi study—Delphi '98—started in 1996. It was supposed to update the first Delphi study by incorporating methodological achievements and German particularities. In order to make international comparisons possible, joint topics with Japan's parallel sixth long-term forecast study were agreed upon. The topics are addressed consecutively. At first, a steering committee was founded by the Federal Ministry of Education and Research (BMBF). The detailed preparation of the study (topics, etc.) was done in six specific committees with more than 100 specialists from industry, university and other research institutions. In this way, both mobilization and consultation prior to the foresight survey were guaranteed. A report on the results was published and over 10,000 copies were

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provided to all interested institutions, organizations or individuals. The results are also available on the Internet. Companies and institutions made extensive use of the data for their strategic planning. The latest foresight approach, called FUTUR, was initiated in 1999, and is currently being restructured.

Introduction

During the last several years, rapid changes have occurred in Central Europe. Starting with the transformation and restructuring of the Eastern European economies and the unification of Germany, the new political and economic context of Central Europe has made a reorientation necessary. Parallel to this, the occurrence of accelerated technological changes, more global competition and new markets as well as national budget restraints brought about new national processes for setting priorities in science and technology. The desire to identify those technologies which will have the greatest impact on economic competitiveness and social welfare was expressed from various sides.

This development made new foresight approaches attractive. The term "foresight" is used in the sense of "outlook". This is not the same connotation as "prediction" which would be closer to "forecast". Foresight takes into account that there is no single future. Depending on action or non-action at present, many futures are possible, but only one of them will happen. To select the most desirable future and to make it possible is one of the tasks in technology policy. Foresight is the "process involved in systematically attempting 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 generic technologies likely to yield the greatest economic and social benefits".[1]

The purpose of this paper is to illustrate the history of foresight exercises in Germany with an explicit focus on the Delphi studies, to derive some methodological lessons and give some recommendations for the implementation of the Delphi methodology in the countries of Central and Eastern Europe. The remainder of the paper is structured as follows: the first section briefly illustrates the most important government-funded foresight studies; the second section summarizes the lessons learned from the various Delphi exercises; and the final section gives some recommendations for its implementation in Central and Eastern Europe.

Foresight exercises in Germany[2]

During the 1970s and at the beginning of the 1980s, German science and technology policy was not very active in foresight. It was predominantly a

[1] B. R. Martin, "Foresight in science and technology" *Technology Analysis and Strategic Management*, vol. 7. No. 2 (1995), pp. 139-168.

[2] This section draws strongly on K. Blind, K. Cuhls and H. Grupp, "Current foresight activities in Central Europe", *Technological Forecasting and Social Change*, vol. 60, No. 1 (1998), pp. 15-35.

period of strong support for basic research, mainly in large facilities, following the recommendations of scientific advisory committees. The federal Government switched after years of enthusiasm for technology to a more reluctant policy, formulating technological goals for the S&T system only in those sectors where a key role in world markets has been commonly recognized. In Germany, responsibility for science and technology is decentralized and split between the federal and the state *(Länder)* levels.

Projects were predominantly generated by researcher initiatives and supported, if they fit into the programmatic policy lines, if there were enough financial resources available, and if the projects were selected as being of high scientific quality. The most promising proposals to the leading institutions of the country (e.g., the BMBF and its agencies, the Deutsche Forschungsgemeinschaft) were approved after evaluation in a peer system and got financial support.[3] Evaluation of the programmes as a whole has been a rather new venture.[4]

The BMBF and its predecessor government departments played a major role in S&T policy, first, by organizing and funding research in "high technology" sectors subject to State procurement such as nuclear energy or aerospace; second, by supporting industrial R&D through a variety of mechanisms, including direct and indirect subsidies to firms; and third, financing special initiatives by maintaining a scientific infrastructure.[5]

The increasing technological change and the globalization of the markets, as well as the special situation after the reunification of Germany with its severe budget restraints made the responsible persons at the BMBF change their minds. Longer-term perspectives and strategies to make better use of the limited resources were sought. The selection for the support and the more goal-oriented prioritization of certain technologies seemed to be necessary. On the other hand, the Governments had to be careful not to intervene too much in the market and its self-regulating forces nor in the self-organized science system. There is always the danger of confusing technology policy with technology planning in the sense of socialist planning, a kind of socialism which had just been overcome with the unification.

Certainly, as Coates has noted, foresight is defined as "... a process by which one comes to a fuller understanding of the forces shaping the long-term future which should be taken into account in policy formulation, planning and decision-making. Foresight is, therefore, closely tied to planning. It is not planning-merely a step in planning."[6] In addition to the fact that a foresight process must be systematic and comprehensive, it must be able to accommodate a

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[3]J. Irvine and B. R. Martin, *Foresight in Science. Picking the Winners* (London, Dover, 1984).

[4]G. Becher and S. Kuhlmann (eds), *Evaluation of Technology Policy Programmes in Germany,* Economics of Science, Technology and Innovation, vol. 4 (Dordrecht/Boston/London, Kluwer Academic Publishers, 1995); S. Kuhlmann and D. Holland, *Evaluation von Technologiepolitik in Deutschland,* Technik, Wirtschaft und Politik, vol. 12 (Heidelberg, Physica-Verlag, 1995).

[5]F. Meyer-Krahmer, *Science and Technology in the Federal Republic of Germany,* Longman Guide to World Science and Technology (Harlow, Longman, 1990).

[6]J. F. Coates, "Foresight in federal government policymaking", *Futures Research Quarterly* (1985), pp. 29-53.

wide range of information, must be public and avoid prediction. German ministries had to make allowances for suspicion in public opinion.

In the beginning of the 1990s, the need to concentrate their resources made all parties more interested in foresight and, therefore, two major prospective studies were commissioned in 1991 in order to get some early indications of the most promising developments in science and technology. Starting as "risky projects" and earning harsh criticism at the beginning, the German foresight studies only later were accepted as successful. But their methodology and the strategic implementation into national policy and companies' strategic planning provide opportunities for improvement, which will be discussed later in this paper.

There are already various methods of technology foresight available. Holistic approaches are applied to get an overview but are not necessarily specific for a particular national system of innovation. The organization of the foresight process may also vary, depending on the country and its R&D system, the circumstances and so on. In Germany, after internal discussion, the former Ministry for Research and Technology (BMFT) decided not to use one single approach and certainly not to launch any sort of "national programme", but to work in the direction of a broader range of studies in order to have a basis for political choices and to be able to combine data.[7]

The four major approaches which are applied in Germany all fulfil the following functions, which are defined as the major classifications for purposes of foresight by Martin and Irvine:[8]

(*a*) Direction-setting;

(*b*) Determining priorities;

(*c*) Anticipatory intelligence;

(*d*) Consensus-generation;

(*e*) Advocacy; and

(*f*) Communication and education.

The "T 21" report

"Technology at the Beginning of the 21st Century" (T 21) is a BMBF-sponsored project which started late in 1991 with a study of the international literature concerning technology foresight. The main motive behind this study was to complement economic growth criteria by the idea of growth using intelligent new technologies. Secondly, as learned from Japanese and United States sources, a stricter and more transparent methodology should be tested. The approach also aimed at a mobilization of the in-house expertise of German research administrators for foresight purposes. Although it comprehends a result-oriented, independent foresight process, it may be regarded as a pre-foresight activity as well.

[7]H. Grupp, "Foresight in science and technology: selected methodologies and recent activities in Germany". *Science Technology Industry (STI) Review*, No. 17 (Paris, OECD, 1996). pp. 71-99.

[8]B. R. Martin and J. Irvine, *Research Foresight: Creating the Future* (Netherlands, 1989).

In Germany, the BMBF is assisted by several so-called *Projektträger* (programme operating agencies), agencies mostly located within the national laboratories *(Großforschungszentren)*. Representatives from these programme operators set up a task group and worked face to face on an assessment of critical technologies for the Federal Republic of Germany. The Fraunhofer Institute for Systems and Innovation Research (ISI), which took the overall responsibility for this task, was asked to devise a comparatively new methodology based on relevance trees.

The relevance tree method is known as a "normative" method. These kinds of methods have their foundation in the methods of systems analysis. They start with future problems and needs and then identify the technological performance required to meet those needs. Relevance trees are used to analyse situations in which distinct levels of complexity or hierarchy can be identified. Each successively lower level involves finer distinction or subdivisions.[9] Yet, for this investigation the classic pattern process was not organized but rather trees were constructed for each of the critical technologies. These trees relate to an area of application (like civil engineering, transportation), scientific preconditions (like breakthrough in memory capacity), hierarchical positions (sub-themes, umbrella topics) and technical similarities to other entries on the list. As the new element, instead of plotting the trees, they were encoded binarily and analysed by use of multidimensional scaling techniques. In doing so, "maps" of similarity were obtained and these were further investigated by the panel group. The time horizon of the study was approximately the year 2000.

The study on "Technology at the Beginning of the 21st Century" concentrates on:[10]

- The selection of critical technologies;
- The criteria to assess these technologies (relevance trees);
- The interrelation between the technologies; and
- The time scale.

Scanning all available studies from abroad and making use of the internal expertise of the programme operators, an initial list of about 100 technologies has been established. In bilateral and panel discussions, this list was redefined and regrouped. The list is relatively detailed and contains items like biochips, data network safety, genome analysis, fuzzy logic, flat displays and the like.

A common report form has been worked out which is filled with information on the technological item which is to be considered most important by the staff of the programme operators. The form has four pages: one for description and demarcation of the technological topic, including product

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[9]H. Grupp (ed.), *Technologie am Beginn des 21. Jahrhunderts* (Heidelberg, Physica-Verlag, 2nd edition, 1995).

[10]H. Grupp, "Technology at the beginning of the 21st Century", *Technology Analysis and Strategic Management*, vol. 6, No. 4 (1994), pp. 379-409.

visions around the year 2000; the second is related to the determination of basic frame conditions; the third is dedicated to statements related to criteria assessing the technologies' potential to solve economic, ecological or social problems; and the fourth contains codified information on the anticipated dynamics of development until the year 2000, on the "tree" information (relation to other technologies) as well as the quality of the assessment.

Because of the fractal structure of nature, it is impossible to find a hierarchical classification of technology. There are broad and small fields of technology in the early or late stages of development. Some are application-oriented, some are more basic. Therefore, the interrelation of the items from the list of technologies was examined starting from the "tree" information.

It could be shown by using the advanced statistical tools mentioned above that the current borderlines between individual technologies will become less distinct in the next decade. New disciplines are being shaped outside the classical research areas. This certainly has dramatic effects on the necessity of technology monitoring, on technology policy implementation of R&D programmes and the appropriation of technological opportunities by firms. Also, finally, the dynamics during the next 10 years were examined. It is well-known that there is no linear progress in science and technology but rather several feedback and cyclic effects. A standard scheme differentiating eight typical phases in the research, development and innovation process was agreed upon. On the report forms, it was specified for the given technology which phase may be assigned now and which phase is probable in the year 2000.

As this is a new methodology with some traditional elements from the relevance tree approach, the outcome of this study is difficult to summarize briefly. The growing interdisciplinarity in technological development which, for the first time, was discussed between the programme operators who can make use of the new knowledge generated and the establishment of new methodologies, may help to make "better" and more effective decisions about the support of R&D projects. In this sense, the study is push-oriented. Such trends are also described in more theoretical work, but here they are the result of a foresight exercise which gives them empirical importance.

The coordination by the programme operators was facilitated. This means that more important than the isolated results of the study are the process characteristics with a lasting impact on a—however small—executive science and technology community. In this sense, the study turned out to be comparable to an "unintended" pre-foresight phase. Let us just mention that in the course of the expert consultations the usefulness of the Delphi approach, already commissioned by the same ministry, was discussed.

The first comprehensive study on the development of science and technology: Delphi '93

The first comprehensive German study of the development of science and technology made use of previous experiences in Japan where a large Delphi study has been conducted every five years since 1971. Therefore, ISI collaborated with the Japanese National Institute of Science and Technology Policy (NISTEP), an institute of the Science and Technology Agency. The German Delphi team took the 1,150 topics prepared for the Japanese fifth survey and translated them in early 1992 into German.

The German-based survey was conducted principally along the same guidelines as the fifth technology forecast survey in Japan, although it took place with a one-year delay from September 1992 to March 1993. The questionnaires were sent out to a group of experts from industry, universities and Government over two rounds. In order to make the two investigations independent of each other ("double blind"), it was arranged that despite the time lag, the German experts did not know any results from the Japanese sample because the translation into English was not published until the German survey was already finished. In case of the German inquiry, the compiled data were published in August 1993.[11]

In both cases, about 3,000 experts have been addressed; the response rate in the first round was above 80 per cent in Japan, in Germany about 30 per cent. In the second round, more than 80 per cent of respondents participated in both countries. There are two main reasons for a relatively low response rate in Germany in the first round.

First, up to very recently the German Government was not very actively involved in technology foresight activities, as was stated above. With the notion of "unpredictability" of events in science and technology, this activity has not been appreciated by other public science bodies either. Therefore, the confidence of the respondents in meaningful results is assumed to be low.

The second reason is that—due to the pilot character of the survey in Germany—there was no explicit pre-foresight phase, and no mobilization of interested parties. Furthermore, nothing was done to predetermine the special interests and competencies of the experts consulted as, for example, the British programme did with the co-nomination approach. In an attempt to overcome these deficiencies, more than one questionnaire was sent out to some experts in order to let them choose their special fields by themselves. Regarding the enormous structural changes in the eastern part of Germany (e.g., addresses, names of institutes and companies changed), even postal delivery of some questionnaires was not possible there.

About 40 per cent of the consulted experts in Germany as well as in Japan are employed at universities or other higher education facilities, another 40 per cent are from industry and the remainder from government laboratories, independent or non-profit institutions. From this distribution, the German Delphi, other than the T 21 study, is quite balanced between science and technology push or supply thinking, and pull or demand preferences.

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[11]Germany, Bundesministerium für Forschung und Technologie (BMFT), *Deutscher Delphi-Bericht zur Entwicklung von Wissenschaft und Technik* (Bonn, 1999).

Among the complicated points, we have to mention the translation of the topics grouped into 16 separate questionnaires from the Japanese into the German language. Specialist translators experienced difficulties in grasping the general idea of the topics as the questions are not embedded in an overall context. Even the best technical specialist translators could not provide a version acceptable to technology experts in the field. Thus, the raw translations had to be revised by German scientists in each case, who were not capable of understanding the Japanese original. Their version was checked again by the translators to prevent major discrepancies from the original version.

As was expected, the strong side of the Delphi lies in the processes. Not only did the analytical part of the Delphi survey provide important information for German S&T policy, but there was also an impact on the participants themselves. By answering the questions and checking their opinion with the anonymous assessments of the other experts, a learning effect occurred among the participants in the survey even without the pre-foresight phase.[12] They were all provided with the estimates of the other participants in the course of the study and could make free use of the information in their laboratories.

As for the analytical part of the study, two principal results were found. First, many results of the German survey are more or less the same as in Japan. In these cases, there is evidence that the Delphi procedure does not depend on national influences and peculiarities very much. Progress in science and technology seems to be of really international nature in many fields with practically no information deficits in one of the major industrial countries. This leads to conclusions on the openness of world-wide scientific and technological information (including Japan despite the language barrier).[13]

At the other extreme, for individual topics strong discrepancies in both surveys are found and in many details the dominance of national communities, systems of innovation, and of strategic thinking become obvious. For example, the necessity for international cooperation is rated rather differently in Germany and in Japan. Why? Germany has an open S&T system with exchanges of knowledge to and from its neighbouring countries, as we have argued in the introduction. Further it is a member country of the European Union benefiting from joint R&D ventures within Europe. Japan's S&T system is closer to "splendid isolation" not traditionally engaged in close R&D joint ventures.

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[12]M. J. Bardecki, "Participants' response to the Delphi method: an attitudinal perspective", *Technological Forecasting and Social Change*, 25 (1984), pp. 281-292.

[13]For further details, see the Japanese-German comparison undertaken in 1993/94, in K. Cuhls and T. Kuwahara, *Outlook for Japanese and German Future Technology, Comparing Technology Forecast Surveys* (Heidelberg, Physica-Verlag, 1994) and S. Breiner, K. Cuhls and H. Grupp, "Technology foresight using a Delphi-approach: a Japanese-German co-operation", *Research and Development Management*, vol. 24. No. 2 (1994), pp. 141-153.

The main conclusion for these cases would be that Delphi inquiries on science and technology should always be undertaken with a broad panel, including people from several countries and continents. On the other hand, for many topics no such extreme and simple results were found, but congruent and diverging results occurred at the same time.

Methodological foresight developments: Mini-Delphi

The Mini-Delphi was a test to develop the Delphi method further to meet some criticism from the first German Delphi survey and to gain more detailed data about some of the internationally problematic areas.[14] The Mini-Delphi is more oriented towards the technical solutions for current or emerging problem fields which were identified as the most important in the previous Delphi survey. Expert committees in Japan and in Germany selected the major topics jointly (in a conference in the former Japanese embassy in Berlin in 1994, and as "virtual groups"). Between the first and the second round, some of the topics had to be reformulated more precisely because of expert suggestions, and some new topics were introduced.

The whole procedure of the survey was conducted parallel to that in Japan. The cooperation partners were again the Fraunhofer Institute for Systems and Innovation Research (ISI) on behalf of the BMBF in Germany and the National Institute of Science and Technology Policy (NISTEP) in Japan. In order to match about 100 answers per topic, 2,300 experts were contacted in Germany in the first round. They were identified from public databases, associations, trade exhibition catalogues, conference participation lists, literature, personal contacts, etc.

One major target of this study was to improve the methodology. Not only the self-estimated expertise and the time of realization were asked for, as in the previous survey, but also alternative solutions. The importance category was split into importance for science and technology, for the economy, the environment, developing countries and the society. This time, a scaled evaluation between good (+), medium (0) and bad (–) had to be written down. The same is true for the assessment of conditions like the scientific-technical solubility, the likely demand on the future market and price competitiveness.

In the last category, the framework conditions had to be evaluated. How are the engagement of industry, the regulations, public support, international cooperation, public acceptance, the R&D infrastructure, the availability of personnel, the starting conditions (such as venture capital) and the current R&D level? Are they positive or negative?

There are many data gathered as a result. They cannot be summarized here in general, but the most interesting were the framework conditions for

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[14]Germany, Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF) (ed.), *Delphi-Bericht 1995 zur Entwicklung von Wissenschaft und Technik—Mini Delphi* (Bonn, 1996).

the selected topics: They were estimated to be better in Germany than in Japan. The only exception was that a better engagement of Japanese companies is foreseen. It is also interesting that the public acceptance of key technologies, which is publicly said to be generally low in Germany, is estimated to be better in Germany than in Japan for the selected "mini" areas. But one cannot conclude as a general statement that people in Japan are less euphoric about technology, as this assessment is specific to the problem-oriented technologies such as climate and cancer research or renewable energy, which are met with sympathy in Germany.

As the Mini-Delphi study was mainly regarded as a test and an improvement of methodology, no direct implementations were planned. However, the media had a high interest in the results.

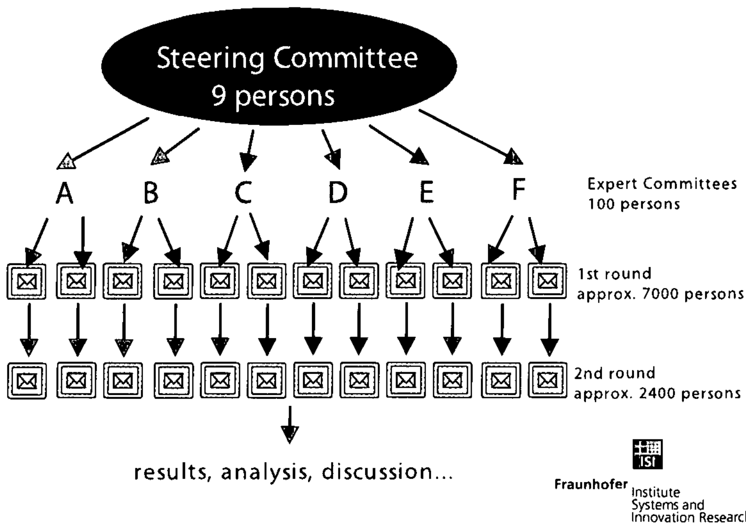
The second comprehensive study on the development of science and technology: Delphi '98

The new Delphi '98 started in 1996 and finished in 1998 by the publication of the results.[15] It is supposed to be an update of Delphi '93 by incorporating methodological achievements. This guarantees that the specific German situation is reflected. In order to make international comparisons possible, joint topics with the sixth Japanese long-term forecast study which is conducted parallel to the German, were agreed upon (about one third of all topics). The chosen fields and questionnaires of the Delphi '98 study are:

- Information and communication;
- Service and consumption;
- Management and production;
- Chemistry and materials;
- Health and life sciences;
- Agriculture and nutrition;
- Environment and nature;
- Energy and resources;
- Architecture and living;
- Mobility and transport;
- Space;
- "Big" science.

[15] K. Cuhls, K. Blind and H. Grupp, Delphi '98, Unfrage. Studie zur globalen Entwicklung von Wissenschaft und Technik (Karlsruhe, ISI, 1998).

Figure I. Organization of Delphi '98



How was Delphi '98 organized? The topics which are discussed in the fields are worked out in several steps. At first, a steering committee was founded by BMBF. This committee consisted of nine prominent persons from industry and academia, including one science journalist. The chair was taken over by an electrical engineer who is now Chief Executive Officer of an insurance company. The preparation of the study (topics, etc.) was done in six specific committees with more than 100 specialist persons from industry, university and other research institutions (see figure I). In every group, one person from the steering committee participated as a moderator. The committees met in April 1996 for a kick-off meeting and then started to work separately. Every committee member was responsible for two fields (which means two questionnaires) in order to facilitate the interdisciplinary exchange of information and to formulate more problem-oriented visions. In this way, both mobilization and consultation prior to the foresight survey were guaranteed this time. Finally, 1,070 statements were agreed upon to constitute the twelve questionnaires. The whole process was, again, coordinated by the Fraunhofer ISI.

One major target of the second comprehensive study was to improve the methodology further. The self-estimated expertise and the time of realization divided in seven, five-year intervals were asked for, as in the previous surveys. Thereby, a 50-50 chance of occurrence was not asked for as in the more traditional Delphis, but rather the survey specified that the five-year interval be indicated in which the event will "most likely" occur. However, in the second round, each individual received a time distribution showing the 25 per cent, median and 75 per cent quartiles of the distribution. From this one could conclude whether the distribution of the individual assessments is narrow or broad, the latter indicating disagreement of the group over the expected time window.

The category for importance was split into importance for the enlargement of human knowledge, for economic development, the development of the society, the solution of environmental problems and—for the first time—for labour and employment. This time, a scaled evaluation was substituted by yes- or no-options. The survey asked for the leading nation in R&D to be identified (choices were among Japan, Germany, another EU-country, another non-EU-country and the United States).

In order to get closer ties to science and technology policy, one prominent new part of the assessment criteria were the kinds of measures that should be taken to improve the situation:

- Better education and qualification of scientists and technical personnel;
- Exchange of personnel between university and industry;
- International cooperation on project level or for mutual knowledge and personnel exchange;
- An improvement of the R&D infrastructure, e.g., the foundation of institutes, databases or providing venture capital;
- Support by third parties (state, foundations, etc.) for. more financing of lead projects *(Leitprojekte)* and immaterial measures; or
- A change of regulation. This can be deregulation, strengthening existing regulation, re-regulation (new regulation) or other changes in the national frame conditions (laws, norms, decrees, technical guidance, charges, etc.).

Finally, in order to integrate aspects of the traditional technology assessment, the survey was asked for follow-up problems for the environment, for personal safety and for society or culture, in case the statements will be realized.

The last part of the questionnaire included—only in the first round—so-called megatrends. They were discussed to find out which global developments are expected by the (technical) experts and if this point of view influences their assessments of the development of science and technology.

To receive about 100 valid questionnaires or—if possible—100 valid answers per item, about 7,000 persons were asked to participate. These persons could apply for an additional questionnaire or exchange the questionnaire if they felt more competent in another field. Questionnaires were sent back by 2,453 persons in the first round and 1,865 persons in the second round. This seems to be a sufficient response rate and in some fields of Delphi '98, there were more than 200 valid answers. Of course, in a field like "Space" or "Big science" so many answers cannot be expected because there are not as many researchers in the field as in other areas.

About one third of the participants are from industry, one third from universities and one third from other organizations. Most of them are employed in R&D-connected workplaces. Only 5 per cent of the participants were women, which approximately represents the share of women in German R&D. The age of the experts shows a peak in those 50 to 60 years old and the same number of answers from persons in the age groups of 30 to 40, of 40 to 50 and of 60 to 70 years. Very few persons younger than 30 years and older than 70 years answered. The younger people are not yet in the publicly accessible databases, and therefore, are not asked to participate. It is difficult to identify them.

Due to limited space, a brief survey of methodologically interesting results will be given. First of all, we witness the desired effect of convergence between the results of the first and the second round in most of the statements. For all the 1,070 statements, the average time span between the first and the third quartile of the answers decreased from over 10 years to below eight years. Convergence was also found in answers for other categories like the R&D position of the leading countries, policy measures or follow-up problems.

The methodological innovation of Delphi '98 has been the introduction of so-called megatrends into the questionnaire in order to generate information about the scenarios of the general future. These have the surveying experts in mind when assessing the future of their areas of expertise. In detail, which megatrends will determine the world's economic, societal, political, and social conditions during the coming decades, and will thus exert a significant influence on science and technology? Some will have decisive effects on research and development, while others will influence these areas to a lesser degree. In cooperation with ISI, the steering committee prepared 19 megatrends representing an outline to find out the direction of the specialists" contemplations, their desires and expectations, and perhaps even their basic values.[16] The megatrends included topics such as the following:

- "The world population will surpass the 10 billion mark";
- "The globalization of the economy will make national economic policy almost insignificant";
- "Low birth-rates and constantly increasing life expectancy will in industrialized countries lead to over one third of the population being older than 60 years"; or
- "After reforms are realized, Germany will again become an internationally attractive location for investment".

More than 2,000 specialists from science and technology submitted their opinions as to which megatrends they felt were possible, when they could be expected to become significant, and which influence they will have on the future of science and technology. The trends affect social, political or economic developments. Opinions were both optimistic and pessimistic. The

[16]K. Blind, K. Cuhls and H. Grupp, "The influence of personal attitudes on the estimation of the future development of science and technology: a factor analysis approach", *Technololgical Forecasting and Social Change* (publication pending).

experts exhibited consensus with respect to some trends, while opinions diverged strongly on others.

The megatrends were brought to the table for discussion in order to examine which images of the future guide the experts. By a factor analysis, certain "types" were worked out as differing extremely from the general thought patterns: local optimists, population optimists, environmental pessimists, and progress sceptics, whereas others were "neutral" and exhibited no apparent response behaviour. This allowed extreme responses to be filtered in order to examine, for example, whether individuals who are very optimistic or pessimistic perhaps view the future of science and technology differently than those whose responses were more indifferent.

The following section provides a short glance at some of the most important results. To look at 1,070 different topics and their Delphi results has always had restrictions. An overview on the most important of topics is done by clustering them into major themes. For these, the topics with the highest importance indices (resulting from all importance categories) are ranked, clustered and then grouped according to their context and their realization times. Are they early, mid-term or longer-term innovations? The result is shown in figure II.

Figure II. The time horizons of the most important innovation fields

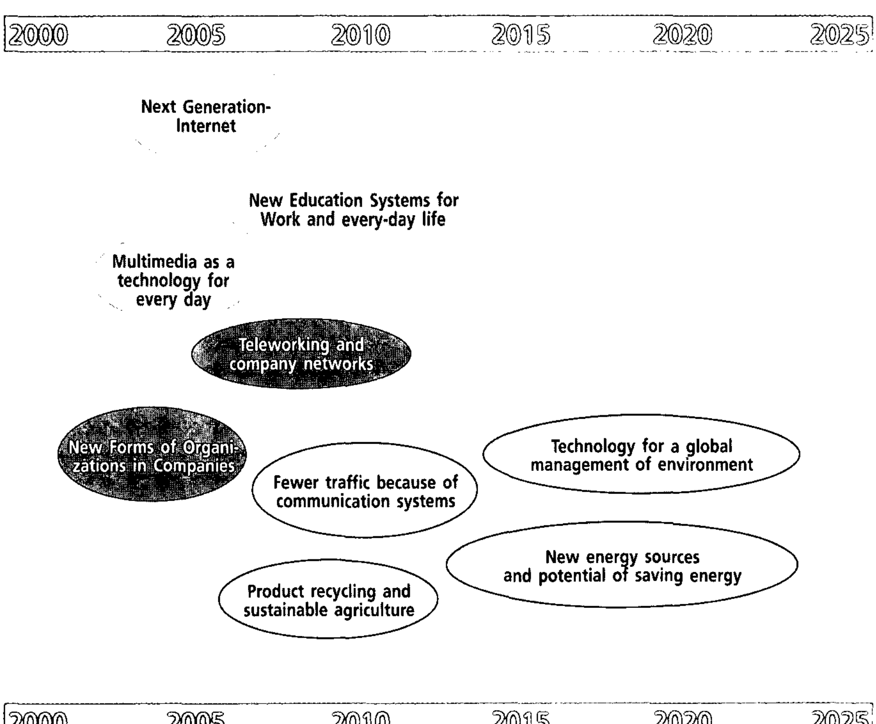


Figure II underlines that information and communications technology is entering all fields, e.g., the organization of the workplace, education and training as well as a global management of the environment. Some topics that concern new forms of intra-company organization, like more responsibilities for the employees, the next generation Internet or multimedia for everyone can be realized in the near future. Others need more time. But for a more complex approach, one has to go more into details. One example would be to look at new forms of organizations in companies. This is the way that companies often select topics.

In the near future, companies will cooperate more closely with one another. In the area of research and development, this will also lead to *corporate cooperation that includes input from customers and institutes as a result of the increasing time and cost intensities of R&D projects.* (The original wording of the survey topic is written in italics in this section.)

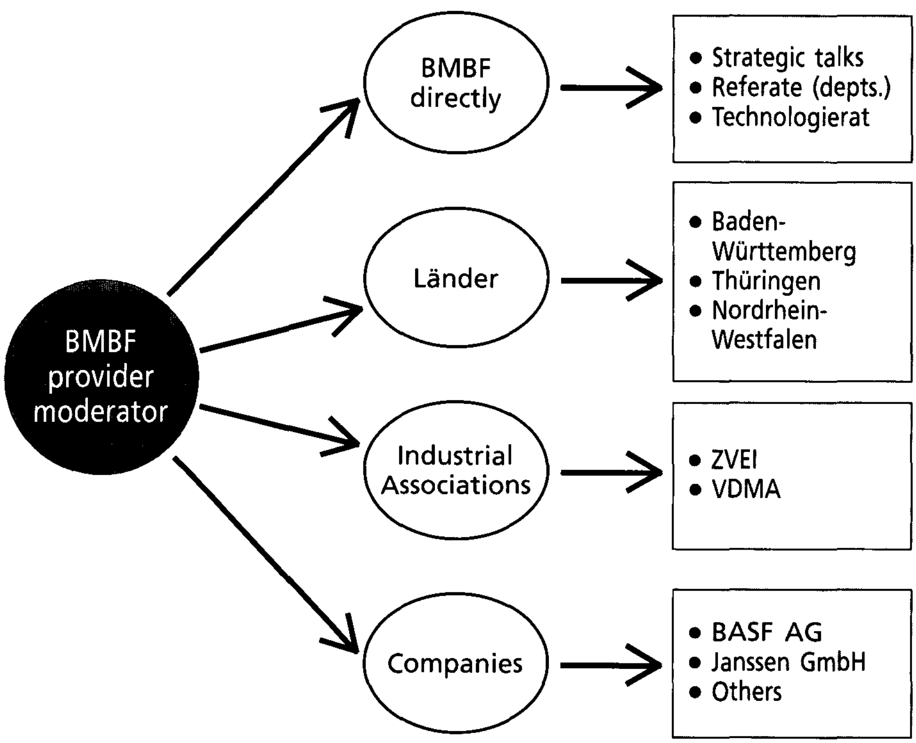
Based on everything we know, the significance of the employees will increase through the formation of independent, autonomous areas of responsibility, in order to promote their identification with changing corporate goals. For this reason, the assumption of responsibility by employees of defined portions of the process chain will become a scientifically grounded management goal of personnel development. Identification with individual projects is more important for the purposes of motivating employees than an identification with the corporation, and will thus become a problem to be addressed by top management. The compensation system will be adjusted to reflect these developments with that portion of the wage based on work results no longer being based solely on the performance of the individual, but rather on the performance of the group or the overall corporate performance.

From the perspective of technology, microtechnology will increasingly expand throughout corporations. *Components able to integrate sensors, controllers, and actuators have practical applications in microtechnology.* This will alter not only manufacturing operations, but also hospitals and other service providers. The experts estimate that this bundle of cited visions should be realized between 2001 and 2007. These visions already form a kind of scenario for that specific time and for the question how companies will be organized in the future. They are only one example of how to use the Delphi data and what can be learned.

Users of Delphi

The main "user" of Delphi in Germany was supposed to be the national Government (federal level). The results of the Delphi surveys already contributed to strategic decisions like the restructuring of federal responsibilities in the education and research system, as well as to strategic talks between federal Government, industry and large research organizations. But the regional administrations *(Länder)* are also interested in the results; they try to analyse and interpret the data from their point of view.[17] The results of the Delphi surveys were being spread as popular, good-selling paperbacks[18] or hardcopies and on the Internet so that private actors, too, could use them: many enterprises and R&D institutions started to exploit the database for their own purposes (see figure III). In addition, some firms have managed their own survey.[19]

Figure III. The use of Delphi results in Germany



As far as enterprises are concerned, a considerable improvement of the intramural knowledge base through participation in the Delphi surveys became obvious through many very detailed inquiries. There is sporadic evidence

[17] H. Grupp, U. Schmoch and K. Koschatzky, "Science and technology infrastructure in Baden-Wuerttemberg and its orientation towards future regional development", *Journal of the American Society for Information Science*, vol. 49, No. 1 (1998), pp. 18-29.

[18] H. Grupp (ed.) (with S. Breiner and K. Cuhls), *Der Delphi-Report* (Stuttgart, Deutsche Verlags-Anstalt, 1995).

[19] T. Reiss, G. Jaeckel, K. Menrad and E. Strauss, "Delphi-Studie zur Zukunft des Gesundheitswesen", *Recht und Politik im Gesundheitswesen*, No. 2 (1995), pp. 49-62. See also H. Grupp and T. Reiss, "Foresight in German sience and technology", *Managing Technology for Competitive advantage*, J. Anderson, R. Fears and B. Taylor, eds. (London, Cartermill, 1997), pp. 58-73.

that during participation in the Delphi process, some companies felt that too little effort has been dedicated towards strategic innovation management and some remedies have been taken. Some companies started their own investigations of an intramural breakdown of the overall national studies regarding the special interest of their business areas or establishments, both in the manufacturing and the service sectors. One large chemical company (BASF) started with topics of the Delphi 1993 survey, made their own evaluation of the topics and built up a strategy through 2010. The information was discussed and distributed in working groups. Some smaller-scale comparisons of the business portfolios to the future-oriented areas are also being done in other companies, sometimes assisted by external consultants or the Delphi team at ISI. In general, the activities inside the companies are largely confidential.

Strategic planning about diversification or non-diversification, core competencies and future market segments followed. One pharmaceutical company has concluded its own Delphi investigation on the future of general practitioners in residential areas and their ability to follow the modern trends both in medical technology and pharmaceuticals assuming the informatization of the health-care system. The results of the study, which have been summarized elsewhere, highlight many different options for the future development of the German health-care system. Subject-tuned activities by industrial associations on behalf of their member firms were also conducted (in the cases of the German Machinery and Plant Manufacturers Association [VDMA] and the Electrical and Electronic Manufacturers Association [ZVEI].

Finally, ISI even based its programme evaluation on Delphi results and checked whether the different institutes are working in future fields and will therefore be able to meet the future needs of applied research.

Conclusions and recommendations for future foresight activities

In Germany, there is presently great interest in foresight studies because they can be used to motivate persons, have a lasting communication effect and strengthen strategic activities. In particular, several lessons can be learned from the application of the Delphi method. First, the surveys confirmed very clearly an observation which had been made earlier and in other countries: the process of the survey itself is very valuable since a great number of experts are motivated to think critically about future scenarios which are being favoured or rejected by their peer colleagues. In particular, it became evident that the willingness to participate actively in the shaping of the future (e.g., of the health-care system) is much higher than previously expected.

Second, the benefits of the Delphi survey for firms were not only in terms of gaining information and reputation among clients, but also extended to the internal situation: the strategies for dealing with challenges of the future became broad company issues which were discussed and supported by many employees of these particular companies, thereby contributing to an increase of in-house motivation and identification. Third, the data gained with foresight activities can be used by many actors, by companies as well as by public institutions or even by private persons to support their decision-making process concerning what discipline to study or to identify trends relevant for long-term investment plans.

Methodological criticisms have also to be taken into account for future Delphi exercises. One critical issue very often raised points to the fact that experts are not the right persons to judge "the future", because they are often already relatively old and are influenced strongly in their assessment by very technologically oriented thinking. Furthermore, researchers and scientists are lacking an adequate needs-orientation. On the other hand, they tend to overestimate their own research field.

In consequence, these justifiable arguments point to an explicit need for a "corrective". One obvious way to solve this bias is to involve stakeholders from more interest groups, like consumers, the labour force, and environmentalists but also managers involved in daily business. Furthermore, the results have to be communicated across both institutional and disciplinary borders because the interdisciplinary exchange is also able to promote collaboration and to spread the "thinking about the future" broadly over the whole of society.

Further critical comments were related to the low degree of innovativeness of the visionary statements. This critique is indeed legitimate, because it was difficult to find experts with long-term oriented visions and therefore to generate visionary statements.

Finally, there is a danger that the whole foresight process will break down into different phases which are difficult to connect. Whereas in the first Delphi exercise an explicit dissemination and implementation phase was not foreseen, in Delphi '98 such elements have been explicitly integrated. However, while the dissemination of the results has been very successful, the implementation of the results in science and technology policies has not been accomplished due to insufficient promotion in the governmental organizations.

Based on the different dimensions of criticism, the following general recommendations can be derived for future Delphi exercises, which are also relevant for the countries in Central and Eastern Europe and the newly independent States. A prerequisite for a successful Delphi process is the quality of its input. Therefore, the mobilization of innovative persons, including those outside of the established science and technology system, should be emphasized.[20] Furthermore, a balance between technology-push thinking and demand-pull has to be realized by involving equally researchers in basic and applied research and marketing experts, as well as representatives of consumer associations. The dimension between public sector (ministries, public research institutes, universities) and private sector (industry, private research

[20]K. Cuhls, "Wie kann ein Foresight-Prozess in Deutschland organisiert werden?" *Gutachten* (Bonn, Friedrich-Ebert Foundation, 2000).

institutes, non-governmental organizations, private consumers) should also be balanced. The demographic distribution of the whole population should be taken into account by involving more young people. Finally, the gender dimension has to be considered.

Besides the balanced involvement of the various groups in society, the thematic areas of a Delphi process should be oriented towards the national innovation system especially in the countries in Central and Eastern Europe. In contrast to the large science system of Germany which is more or less actively involved in all science fields, smaller countries should focus on areas with their own strengths or strong needs. From the first Delphi in Germany, we have learned that copying irrelevant topics reduces the participation in the surveys and finally also the acceptance of the results.

Finally, a long-term planning of the process is necessary which includes an extensive dissemination and implementation phase. The dissemination should be directed towards both the public and private sectors. The implementation should be focused on public science and technology policy. However, a rearrangement of governmental funds according to a prioritization derived from the results of a Delphi survey needs a fundamental backing from high-level executives inside the relevant ministries.

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