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Technology Foresight:

A UNIDO-ICS initiative for Latin America and the Caribbean

Workshop, Trieste, Italy
7–9 December 1999

PROCEEDINGS

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TECHNOLOGY FORESIGHT: A UNIDO/ICS INITIATIVE FOR LATIN AMERICA AND THE CARIBBEAN

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1. FOREWORD

Within the frame of its Global Forum and the role of creator and disseminator of global industrial knowledge, the United Nations Industrial Development Organization in cooperation with the International Centre for Science and High Technology, has been requested to launch a Regional Programme for the Latin American and the Caribbean Region with the objective of promoting, encouraging and supporting Technology Foresight initiatives.

In response to this request, a workshop was held in Trieste, Italy during the 7-9 of December 1999, where the UNIDO/ICS Technology Foresight Initiative was launched. This programme aims to contribute to the dispersion of a public good that will become increasingly important for governments. The chief public good that technology foresight generates is "the new public knowledge" concerning the possible futures of national society as a consequence of technological change.

The objective of this workshop was to create an international platform of discussion to ensure that the interest in technology foresight in the region is real and backed by practical intentions and commitment. It is believed that there is a real demand for both technology foresight and for the kind of support services the Initiative would supply. This initiative seeks the establishment of a knowledge network with open-access for dialogue and exchange of expertise, interactive store of knowledge, experiences, best practices and skills inventories; looking forward to spread the techniques and know-how to the largest possible number of foresight practitioners and decision makers in the region.

The UNIDO/ICS regional network will differ from most of its predecessors by being partly owned and operated by its users. That is, the targets will be agreed and the activities will be driven by the needs and initiatives of the regions own industrial actors.

There are many benefits from technology foresight in addition to the knowledge and consensus they generate. Carrying out foresight creates linkages between all national industrial partners: the public sector, private companies and the academia, which are encouraged to work jointly for a national activity. Technology foresight can reveal social, technological, economic, environmental and political barriers to progress, and show how these obstacles can be overcome, by looking at various possible futures for society as a whole, deliberating scenarios that trace how the future might be changed by technology.

Technology Foresight is a useful initiative for society to achieve a broad consensus on the direction policies should take. With the involvement of government, political parties, academia, trade unions, NGOs, the process of developing a more natural and sustainable tool for decision making is enhanced, and a better future for the society as a whole becomes real.

With this purpose in mind, UNIDO in cooperation with ICS and in line with its Global Forum mandate is committed to play an important role in supporting the endeavours of the governments. UNIDO/ICS is willing to become the Latin American and the Caribbean (LAC) Region's depository and distribution engine of accumulated knowledge, expertise and best practices on Technology Foresight activities. UNIDO's global presence and access to worldwide expertise could generate not only economies of scale and synergies, but also a democratisation of Technology Foresight Knowledge in the Region and its wider integration into the national policy formulation processes, thus contributing to a greater social equity.

2. AGENDA

Tuesday 7 December 1999

Opening ***(Mr. F. Pizzio)***

8.30 - 9.00	Registration
9.00 - 9.15	Opening by the Managing Director of the International Centre for Science and High Technology (ICS): ***Mr. F. Pizzio***
9.15 - 9.30	Welcome address by the Mayor of Trieste: ***Mr. R. Illy***
9.30 - 9.45	Address to the participants by the Director-General of UNIDO: ***Mr. C. Magariños***
9.45 - 10.00	Address to the participants by the Secretary-General of the Italian Ministry of Foreign Affairs: ***Ambassador U. Vattani***
10.00 - 10.30	***Coffee break***
10.30 - 10.45	Address to the participants by the Representative of the Permanent Mission of Italy to UNIDO in Vienna: ***Ambassador V. Manno***
10.45 - 11.00	Address to the participants by the Director General of Cultural Relations Division of the Italian Ministry of Foreign Affairs: ***Ambassador G. Facco-Bonetti***
11.00 - 11.15	Overview of the goals and objectives of the workshop ***Mr. G. Aishemberg-Giovannini***

TF as a political "decisional tool" ***(Mr. J. Rodriguez Cortezo)***

11.15 - 12.30	Technology Foresight as a national strategic tool in a technology-based economy ***Mr. J. Rodriguez Cortezo*** ▪ National consensus building ▪ Integrated national efforts ▪ Resources optimization
12.30 - 15.00	***Lunch***
15.00 - 18.30	Significant experiences: ▪ Technology Foresight as a Strategic Tool: The European Union Experience ***Mr. V. Cardarelli*** ▪ Great Britain ***Mr. M. Keenan*** ▪ Spain ***Ms. A. Morato*** ▪ Hungary ***Mr. A. Havas*** ▪ South Korea ***Mr. T. Shin***
20.30	***Dinner***

Wednesday 8 December 1999

TF in practice: learning lessons *(Mr. B. Svensson)*

8.30 - 9.00	Germany: The new Foresight approaches ***Ms. K. Cuhls***
9.00 - 9.30	France: Strategic perspective approach in Technology Foresight ***Mr. R. Barré***
9.30 - 10.00	Ireland: Deciding on the innovation path ***Mr. J. Donovan***
10.00 - 10.45	Open floor discussion
10.45 - 11.15	***Coffee break***
11.15 - 11.45	Austria: Searching for leadership in innovation niches ***Mr. G. Aichholzer***
11.45 - 12.30	Italy: TF with focus on the benefits for SMEs ***Mr. C. Roveda***
12.30 - 13.00	Remarks ***Mr. C. Magariños***
13.00 - 15.00	***Lunch***

TF in LAC: experiences and lessons *(Mr. A. Leone)*

15.15 - 16.30 Overview of past and present activities implemented in LAC concerning Technology Assessment, Monitoring and Forecasting

a) Public Sector

- ***Mr. Luis Flores Asturias*** (Guatemala)
- ***Mr. Manuel Fernando Lousada*** (Brazil)
- ***Ms. Nydia Ruiz*** (Venezuela)
- ***Mr. Alfredo Pinto*** (Colombia)
- ***Mr. Francesco Salazar Saenz*** (Mexico)

16.30 - 16.45 ***Coffee break***

16.45 - 18.00 b) Technological Sector

- ***Mr. Ary Plonski*** (Brazil)
- ***Mr. Carlos Ochoa*** (El Salvador)
- ***Mr. Mario Fernandez*** (Cuba)
- ***Mr. Zameer Mohammed*** (Trinidad and Tobago)
- ***Mr. Carlos Aguirre*** (Bolivia)

18.00 - 19.10 c) Private Sector (Industrial and Communication Media)

- ***Mr. Nestor Bouvier*** (Argentina)
- ***Mr. Joaquin Cordua*** (Chile)
- ***Mr. Francisco Castillo*** (Honduras)
- ***Mr. Walter Rodriguez*** (Uruguay)

19.10 - 19.30 Open floor discussion and conclusions

20.30 ***Dinner***

Thursday 9 December 1999

UNIDO initiative for TF in LAC *(Messrs. G. Aishemberg-G./F. Pizzio)*

9.00 - 9.15	Presentation of the general Plan of Action for the Year 2000 ***Mr. G. Aishemberg-Giovannini***
9.15 - 09.30	Open floor discussion
09.30 - 10.15	Foresight activities around the globe: resurrection and new paradigms ***Mr. H. Linstone***
10.15 - 11.00	Good practises for the dissemination of the concept of Technology Foresight: ▪ Awareness ▪ Awareness building ▪ Different mechanisms ***Ms. A. Svensson/Ms. S. Pascual***
11.00 - 11.30	***Coffee break***
11.30 - 11.45	Open floor discussion
11.45 - 12.30	The network as learning tool and knowledge ▪ Training Activities ▪ Methodologies for training ***Mr. B. Svensson***
12.30 - 13.00	Open floor discussion
13.00 - 14.30	***Lunch***
14.30 - 15.00	The network: infrastructure, management and linkage to UNIDO-ICS Programmes: ▪ Global initiative ▪ National conditions and needs ***Mr. L. Pucci Poppi*** ▪ Decision support system at ICS-UNIDO ***Ms. S. Vranes*** ▪ Links to ICS-UNIDO programmes ***Mr. S. Miertus***
15.00 - 15.30	The network: infrastructure and management (experiences): ▪ Operational mechanisms (revolving reponsibilities) ▪ National set-ups ***Ms. V. Calenbuhr/Ms. F. Scapolo***
15.30 - 16.00	Open floor discussion
16.00 - 16.30	***Coffee break***
16.30 - 18.00	Open floor discussion and conclusions and recommendations at country/regional level ***Mr. G. Aishemberg-Giovannini/Mr. F. Pizzio/Mr. C. Chanduvi***
20.30	***Dinner***

3.TECHNOLOGIES FORESIGHT UNIDO/ICS INITIATIVE: THE REGIONAL NETWORK

a) Initiatives

Mission

To became 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 through the use and application of modern knowledge management techniques and advanced communication tools.

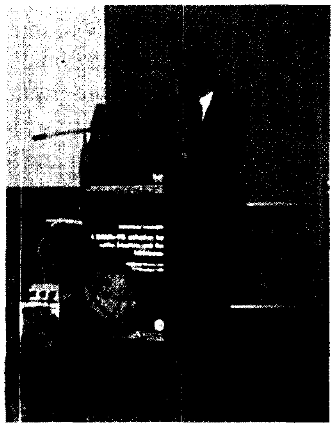
Objectives

UNIDO/ICS Network is expected to:

become a cost-effective channel for enhanced dialogue and exchange of expertise on Technology Foresight among countries of Latin America as well as between them and others international stakeholders.

become an interactive knowledge repository of regional and national expertise, best practices, skills inventories on Technology Foresight. UNIDO and ICS will be responsible for the management of the network.

become a cost-effective window for national and regional training programmes by applying modern on-line and distance-learning techniques.



reduce implementation cost of national Technology Foresight programmes by promoting and supporting Regional Partnerships Exchange Programmes of Experts and Methodologies.

become an active instrument for awareness raising, disseminating and diffusion of Technology Foresight Knowledge to a broader share of the Society in the countries of the region.

Network Knowledge Architecture:

Decentralization will be the key feature of the Network with four-tier core operations.

- Network Steering Board
- Network Knowledge Managing Centre,
- Associated National Partners,
- Local Partners and Knowledge Communities

1) Network Steering Board

Responsible for reviewing and focusing the objectives and the implementation strategy of the Network, to launch fund-raising initiatives and to establish monitoring activities.

Under the chairmanship of UNIDO top representatives of the Donor Community and Chairmen of National Foresight Initiatives from Industrialized and Latin American countries will be invited to become members of the Board.
The Network Steering Board will meet once a year.

2) Network Managing Centre:

UNIDO and ICS will have the overall responsibility for managing and disseminating the Network Knowledge. It is foreseen that a Technical Advisory Committee would be created as support instrument to the UNIDO/ICS Knowledge Managing Functions.

The members of the Technical Advisory Committee will be selected on revolving basis for a period of two years among the Associated National Partners.

The ***Technical Advisory Committee*** will provide advice on implementation strategies for the core functions of the network, such as:

- Communication and awareness raising functions to reach the widest possible share of the civil society (decision makers, trade unions, industrial partners, regional bodies, etc);
- Technical and knowledge architecture of the network including connectivity mechanisms;
- Knowledge exchange programmes including coordination of Associated Partners activities and regional observatory functions;
- Regional Partnerships Exchange Programmes of expertise and methodologies;
- Training actions, including on-line and distance-learning activities.

3) <u>Associated National Partners</u> (ANPs)

Each country participating in the programmes should identify and nominate the national partners taking part in the network. It is expected that, at least two institutions, a technical and a public policy - making body should become associated to network.

The program will assist in the training and the basic upgrading of the technical skills of the National counterparts.

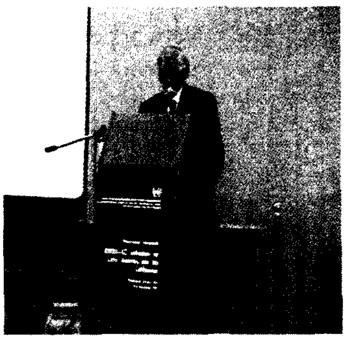
The **National Partners** with the support of the regional network are responsible for:

- Overall National Network management including identification, classification and making available to the regional network the national knowledge and experiences of potential relevant to other similar programmes in the region;
- Implementing awareness building, training and expertise exchange programmes at national level;
- Identifying and strengthening local partnerships for the programmes;
- Coordinating at national level specific tasks, surveys or studies (fee mechanisms to be established).

4) <u>Local Partners and Knowledge Communities</u>

Under the coordination of the National Associated Institutions, national partnerships will be established in concrete thematic areas or at local level.

Functions and activities of the local Partners will be similar to the National Associated Partners.



<u>Network Technical Architecture:</u>

Based upon UNIDO/ICS expertise with common platforms for the sharing of information and knowledge, a preliminary structure has been designed. It represents, nevertheless, only a basic architecture; a comprehensive project document will be prepared only after the complete identification of the system's issues from the knowledge and technical perspectives of view.

1) Functions of the network.

The system is to act as a platform for the dynamic share of information, and the establishment of a collaborative-work architecture, using the most advanced IT technologies.
Moreover, the system should contribute to the dissemination of the partial or complete results from the foresight, in an organic format and layout.
Because this knowledge base must be available over a wide geographic region, and in order to accelerate the connection and to strengthen its reliability, several replicas of the site must be implemented and maintained.
Groups of users and managers, geographically dispersed, must be able to insert and retrieve data, have access to restricted documents and manage area contents.
Discussion fora and chat rooms will be established to support the collaboration between users.

2) System's Description:
The system will be designed as an Internet web site collection constructed upon an open set of distributed databases, with both public and private areas.
The hosted information would be structured and automatically categorized and reorganized in order to provide real-time partial results of the ongoing sub-tasks, based on the properties associated to the user who submits a new document.

The language must be common and the document contents will automatically be converted to HTML (Hyper Text Mark-up Language, the format displayed by World-Wide-Web browsers).
Metadata, such as statistical reports on sectoral foresight programmes or lists of contacts, could be published as generated by the servers.
Each country could host a national server, which will replicate additions or modifications to common areas and could contain country-specific information.
These nodes will then be configured to maintain the data integrity and deployed in a progressive way creating a global network of mirrors spread all over the region of interest.
One or many remote managers could refine, create and upgrade distinct areas and propose forum improvements.

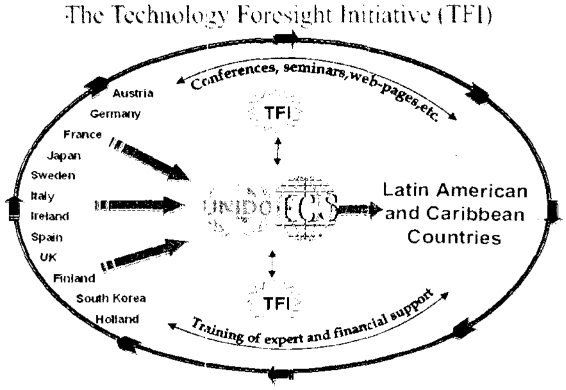
3) Technical Requirements:
Since the system must be open to many users, it is logical to utilize the Internet as the main network backbone. Therefore we will follow its standards (html/http, smtp, nntp and irc).
A client/server multi-level architecture must be taken into account in order for each user to manage the data he/she inserted.
Workflow and collaborative techniques must be developed to keep the consistency on the advance in the foresight pipeline.
An E-mail system must be integrated to send and receive automatic notifications and to provide a secure way for communication amongst members.
The system would foresee the creation of interfaces with external data banks.

Financing of the Network:

It is to be stressed that the Network will mainly have a supportive role to National Initiatives. It is foreseen that savings in National Foresight activities will be attained thanks to the improved access to expertise and knowledge for the formulation and implementation stages of the national programs.

Funds have been secured from the Government of Italy and UNIDO for the basic operation of the Network for the initial period of year 2000 to year 2002.

The Technology Foresight Initiative (TFI)



It is expected that during this period, complementary sources of finance will be identified for further improvement and expansion of network services.
National Foresight Activities are expected to be financed using local and national resources.

b) Plan of Action for the year 2000

The first year of operation of the program will include:

i. **Launching Countries Activities:**
Technical planning missions to countries that express interest on participating in the first stage of the network establishment.

ii. **Creation of Network Knowledge Management Centre:**
UNIDO/ICS will establish the capabilities for qualified technical and knowledge management of the network.
Elaboration of Terms of reference for the Network operation

iii. **Selection of Members of the Network Steering Board.**
In consultation with participating countries and the Donor community, UNIDO will identify top-officers and chairperson of National Foresight initiatives as potential members.

iv. **Selection of Members of the Technical Advisory Committee**
Participating countries are encouraged to submit candidates for each of the functional areas of the Technical Advisory Committee.
Selection will be made on a competitive basis; candidates should submit short outlines on their vision on strategic pattern of the network.
Final selection of the candidates done by UNIDO/ICS
Agreement on Technical Advisory committee statute and work plan
Meeting of the Technical Advisory Committee

v. **Selection and training of Associated National Partners:**
Participating countries should nominate ANPs
Sub-regional workshops/meetings with member of Steering Committee and ANPs in cooperation with vii
Consolidation of ANPs operation

vi. **Technical upgrading of Network infrastructure**
Identification of Network available technical infrastructure (see Annex 1: Technical Questionnaire)
Design of Network infrastructure
Upgrading and training of ANPs

vii. **Design of Knowledge Architecture of the Network:**
Design of the Network knowledge architecture
Training of ANPs

viii. **Communication Workshops and initial Awareness Events:**
Four sub regional seminars will be held in conjunction with iii and iv
- Andean Group
- Caribbean
- Central America and Mexico
- Mercosur

ix. **Inventory of Country Resources and Best practices:**
Inventories of institutions, universities and best practices in Technology Foresight in all participating countries.

x. **Inventory of Country expertise and technical needs:** Inventories of preliminary needs in terms of expertise, and training in Technology Foresight in all participating countries.

xi. **<u>Operationalization of Network activities</u>**:
Implementation of Initial National Review exercise in selected countries
Training support to National Technology Foresight Initiatives

xii. **<u>Operationalization of Expertise Exchange Partnership Program (EEPP)</u>**
Design of the collaboration mechanisms, including modalities of expertise supply, costs to be financed by the network, obligations of recipient country and others.
Creation of regional Data Bank of Expertise available

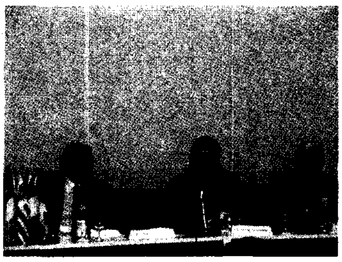
Plan of Action 2000
General Draft

Date	Objective	Activity	Milestones
[redacted]	*** Country's manifestation**		
	*** Visit of UNIDO**		
	*** Creation of Technology Foresight Programme**		
		Creation of Technology Foresight National Committee	Establishment of National Committee
		Contracting an Expert	Working plan of Expert
		Elaboration of Technology Foresight Programme:	Monthly homepage updating
		Beginning of Activities (Pre-Delphi, Local Seminars, Identifying the sectors, Training...)	Periodical information advances Training report
		Establishment of Associated National Partners	Working Plan of the Consultant Group
	*** Installation of Technological Platform**		
		Installation of Platform and Training in operational techniques	Training report
	*** Implementation of Technology Foresight Programme**		Seminar's plan of action
		National Seminar and presentation of National Programme	Final Document

4. SUMMARY OF PRESENTATIONS

UNIDO's Director General and top representatives from the Italian Government opened the Technology Foresight workshop. The Secretary General of the Italian Ministry of Foreign Affairs, Ambassador Mr. U. Vattani emphasized the support from the Government to the UNIDO/ICS initiative, underlining the consistency of this proposal with their expectations from Technology Cooperation, such as the promotion of intrinsic capacity with a bottom up approach and the identification of the most promising technologies and development of endogenous skills.

For implementing Technology Foresight exercises in Latin America, three different groups of countries were identified in this region: the countries that are already familiar with Technology Foresight and have undertaken foresight programs on their own; countries that are aware of the existence of Technology Foresight but still have not been able to decide goals, parameters and methodologies; and countries that have not been related to foresight exercises at all. Considering these differences, one of the aims of this seminar was to bring orientation, clarification and updating of this concept and its reach.



During the first and second sessions of this workshop, different countries shared their experiences in applying Technology Foresight as both, a political decision making tool and as a mechanism to reach societal needs. The cases of Spain, Great Britain, Hungary and South Korea gave a broad idea of how Technology Foresight is prepared, implemented and followed through the adoption of different approaches and methodologies, in order to achieve long-term concrete national policies and programmes to encourage development. Other countries like Germany, France, Ireland, Austria and Italy explained the flexibility of this tool in the practice, by showing the new foresight approaches, strategic perspectives, innovation paths, leadership in innovation niches, and attention to target groups such as the SMEs, respectively.

During the third session, an overview of the past and present Technology Foresight activities in LAC, as perceived by different interest groups representing the private companies, the government and the academia, was the focus of the deliberation.

Some common obstacles identified in this region were: the relatively few experts for each area to be strengthened, the concentration of available experts in government and R&D institutions and universities, the extremely short-term vision of public and private sector, and the distrust of the latter towards the Government initiatives.

The main conclusions derived from such experiences were: the necessity to develop marketing strategies to promote the foresight exercises; the interaction and cooperation of all the involved sectors and agents in this program; the identification of the specific country's needs in order to give the proper technical assistance and develop a tailored national program; and the necessity to build a National Foresight commitment to guarantee long term planning and continuity of these exercises overcoming the political administrative obstacles.

5. LECTURE NOTES

1. The Monitoring Centre for Industrial Technology Forecasting, a Tool in The Service of Technological Policy - ***Jesús Rodríguez Cortezo*** and ***Ana Morato*** (Spain)
2. Role and Effects of Foresight in the United Kingdom - ***Luke Georghiou*** and ***Michael Keenan*** (United Kingdom)
3. Preliminary Lessons of the Hungarian Technology Foresight Programme - ***Attila Havas*** (Hungary)
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THE MONITORING CENTRE FOR INDUSTRIAL TECHNOLOGY FORESIGHT, A TOOL IN THE SERVICE OF TECHNOLOGICAL POLICY

Jesús Rodríguez Cortezo and Ana Morato
Spain

The Monitoring Centre for Industrial Technology Foresight promoted by the Spanish Ministry of Industry and Energy consists of eight technological centres co-ordinated by the School of Industrial Organization. However, before discussing the Monitoring Centre and its functions, the reasons that led to its establishment approximately one year ago should be explained.

It is well known that two most important variables determine the activity of industrial enterprises: the globalization of markets and the increasingly rapid development of technological innovation. Because of those two variables, it becomes necessary to mobilize a growing volume of research and development resources in order to market competitive products with short life cycles. Consequently, the generation of return and amortization of technological investments is at least problematic.

Therefore, efforts in this direction must clearly be selective. However, selectivity requires mechanisms that make it possible to reduce risks and dispel uncertainty.

This framework for action affects not only entrepreneurial decisions and strategies but also – and very importantly – government policies. Such policies must always be aggressive in supporting the technological development of national industry as a factor for external competitiveness and the creation of wealth. In the same way as enterprises, Governments must be selective in assigning their always limited resources to any particular scientific/technological priorities.

Accordingly, both enterprises and those responsible for defining public strategies must have at their disposal instruments that give information on the development and future prospects of technology and also make it easier to link development trends in science and technology with the needs of industry. In the past decade, the Governments of the most advanced countries have decided to launch ambitious Foresight studies to which they have devoted considerable energy and resources. Such studies are designed in accordance with an internationally adopted and accepted method for the critical examination of the difficulties associated with decisions that have long-term consequences.

Foresight sheds light on technological development and its prospects in a reasonable future while making it possible to identify the position of national industry, existing barriers and measures to stimulate implementation.

What are Foresight studies, and what benefits do they bring? The OECD defines Foresight studies as "systematic attempts at the long-term observation of the future of science, technology, the economy and society, with the aim of identifying the emerging technologies that will probably produce the greatest economic and social benefits".

Nevertheless, international experience has shown that the results and benefits of technological Foresight go beyond this definition. Launching these exercises makes it necessary to mobilize a very large number of persons highly qualified in various disciplines. The mobilization of such a team and its consequences in terms of cultural, economic and social structures make the process valuable in itself, quite apart from the results obtained.

Participation in Foresight exercises generates conflicting interests, produces a change in mentality, opens new horizons for the participants and helps them to develop new strategic approaches. These aspects of the Foresight process have been summed up with the five Cs:

- Communication: Bringing together teams from different groups and providing a structure within which they can communicate;
- Long term concentration: Compelling participants to concentrate seriously and systematically in the long term;
- Co-ordination: Enabling the different groups to co-ordinate their future R&D activities;

- Consensus: Creating a consensus on the future trends and priorities of research;
- And, finally, commitment: Generating a sense of commitment to the results so far obtained among those responsible for exploiting advances in research, technological developments and innovation for the benefit of society.

As has been said above, most of the developed countries, such as France, Germany, the United Kingdom, Japan, the United States, Australia, and the Netherlands, are using technological Foresight as an invaluable tool for defining their national science and technology policies. Foresight is considered a continuous process, and institutions in which this work is centralized have been created for that purpose. These institutions are, to a greater or lesser extent, responsible to the administrations of the various countries.

In Spain, where industry must make a special effort to incorporate and assimilate technology, with the support of a number of necessarily selective public policies, there is a clear need for the availability of this type of tool. In the medium- and long-term, this will facilitate the efficient use of resources mobilized in the service of technological objectives.

Accordingly, as mentioned above, the Spanish Government has promoted the creation of the Monitoring Centre for Industrial Technology Foresight (OPTI), through the Ministry for Industry and Energy. The Monitoring Centre was set up formally in December 1997 as a network of eight technological centres with links to other industrial sectors or special fields, and is coordinated by a single integrating centre responsible for the entire Foresight Programme.

This is first large-scale Spanish Foresight experiment oriented towards industry to undertake a technological Foresight programme in different sectors, operating according to standard methodological and action criteria. The programme is intended to respond to the needs of both public and private decision-makers for information about the future. It is intended to serve as a basis for designing technological policies that are appropriate to the situation in our country and to the world development of technologies. The two objectives pursued through the creation of this Monitoring Centre can be summed up as follows:

- To place at the disposal of society, enterprises and public administrations a common basis of information and knowledge of future trends and forecasts regarding the impact and influence of technology on industries, employment and competitiveness.
- To support strategic decisions both by enterprises and the administrations on matters with a clear technological relevance.

In order to accomplish those objectives, the Monitoring Centre must undertake Foresight activities and monitor technological developments. It must also analyse the technological development of Spanish industry and promote widespread awareness in these fields. This Monitoring Centre has been designed in such a way as to embrace a variety of special fields in which there is capacity for mobilization and liaison both with the science and technology sector and with the production system. The basic distinctive elements in the design and creation of this Monitoring Centre have been the industrial sectors, preferably related to special fields, although this is not the sole criterion.

A number of criteria, not only technological but also economic and social, have been taken into account in selecting the sectors or special fields that are covered in the work: influence on GDP, employment, social impact, striking effect, etc. Based on these criteria, the following industrial sectors and specialist fields have been selected in this first phase:

- Food industry
- Energy
- Industrial environment
- Chemicals
- Basic and processing sectors
- Traditional sectors
- Information and communication technologies
- Transport

In each of these sectors, a single technological centre is competent for carrying out the activities of the Monitoring Centre and takes responsibility for the work in its sector. The centres have been chosen according to their technological specialization, their recognized excellence and the quality of their contacts with the industrial sectors. It is important to emphasize the latter aspect, which is a key factor for the success of the work to be carried out. These centres are:

- Instituto Technológico Agroalimentario, AINIA (Food industry)
- Centro de Investigaciones Energéticas, Medioambientales y Technológicas, CIEMAT (Research on energy, the environment and technology)
- Centro de Innovación Technológica del Medio Ambiente, CITMA (Technological innovation and the environment)
- Instituto Químico de Sarriá, IQS (Chemicals)
- Centro Technológico de Moldes, Matrices y Afines, ASCAMM (Moulds, dies, etc.)
- Instituto Español del Calzado y Conexas, INESCOP (Footwear, etc.)
- Instituto Catalán de Technología, ICT (Catalan Institute of Technology)
- Centro Technológico de Materiales, INASMET (Materials)

The School of Industrial Organization acts as the coordinating centre for the Monitoring Centre. The Foresight work is carried out according to a three-year plan summed up in the following table:

Sector	**Foresight study**	**Year**
Food industry	Food preservation technology The application of biotechnology to the food sector Technologies of traditional processes Technologies applied to the utilization of by-products	1998 1999 2000
Energy	Renewable sources of energy Fossil fuels. Energy production and new conversion technologies Storage of energy	1998 1999 2000
Industrial environment	Management and treatment of industrial waste Capital equipment for environmental purposes Treatment of industrial effluents Instrumentation and control	1998 1999 2000
Chemicals	Fine chemicals Agricultural chemicals Basic organic chemistry Basic inorganic chemistry Basic chemistry of plastics raw materials Processing chemistry (soaps and detergents)	1998 1999 2000
Information and communications technologies (ICT)	Digital content industry ITC and the emerging digital economy Convergence of infrastructures and services in telecommunications	1998 1999 2000
Transport	Air Rail Naval Automobiles	1998 1999 2000
Basic and processing sectors	Technologies for the manufacture of metal products Technologies for the manufacture of parts made from plastics and composite materials Capital equipment for plastics and metal manufactures	1998 1999 2000
Traditional sectors	Design technologies Automation technologies Clean and recycling technologies	1998 1999- 11-12 2000

In the course of the three years, it is intended to provide a global projection of all the relevant aspects of the sectors under consideration. Studies of parts of each sector make possible a greater level of detail than previous studies where the whole of a sector is studied. This is especially important, since the exercise is at the industrial level, in which the decisions of the players, both public and private, relate to very concrete questions. According to the plan presented, the Foresight studies made during 1998, which were completed in April 1999, were as follows:

SECTOR	STUDY
FOOD INDUSTRY	Food preservation technologies
ENERGY	Renewable sources of energy
INDUSTRIAL ENVIRONMENT	Management and treatment of industrial waste
CHEMICALS	Fine chemicals
INFORMATION AND COMMUNICATIONS TECHNOLOGIES	Digital content industry
TRANSPORT	Aviation
BASIC AND PROCESSING SECTORS	New production technologies for metal parts
TRADITIONAL SECTORS	Design

In conducting these Foresight studies, a common methodology was applied, chosen after an analysis of the various experiments carried out in other countries. That methodology can be summed up as follows:

State of the art
As preliminary information, the current situation of the sector was determined, identifying technologies currently in use and the principal economic indicators of the sector, as well as key scientific/technological areas for future development.

Selection of the panel of experts
Each Centre selected a panel of experts, consisting of between ten and fifteen professionals of recognized standing in the areas that are the subject of the study, from universities, technological institutes, the administration and enterprises in the sector. The mission of this panel is to work out the hypotheses or the subjects that have to be dealt with in the Delphi questionnaires. In all, 102 specialists participated in the first part of studies (1998).

Determination of the topics covered by the study
The topics to be submitted to the persons consulted through the Delphi survey were determined with the participation of the panel of experts.

These topics, or hypotheses, are evaluated by the persons consulted in terms of a standard set of variables in all of these studies and sectors. Those variables are:

- The level of knowledge of the person consulted.
- Degree of the importance of the topics proposed.
- Implementation date.
- Impact on industrial development, quality of life, the environment and employment.
- The position of Spain as compared with other countries in relation with scientific and technological capacity, and capacity for innovation, production and marketing.
- Existing limitations.
- Measures recommended.

The Delphi survey
When the questionnaires had been prepared, they were sent in a first round to a selection of specialists from the following fields: administration, research, industrial management, private enterprise, the academic community and consultancy. In all, 1,418 specialists were consulted in these two rounds; 462 completed questionnaires were received, corresponding to a 32.6 per cent response.

Analysis of results

The results of the surveys are analysed by the panels of experts. Priority topics are identified from various points of view and evaluated in the light of several variables: date of implementation, the position of Spain, existing limitations, and recommended measures. It should also be emphasized that these studies do not constitute an end in them selves but are the point of departure for commencing a process of reflection and analysis among all the players involved in the country's technological development.

In conclusion, some of the distinctive aspects of this Monitoring Centre should be emphasized. In the first place, its industrial character, which makes it necessary to apply very pragmatic criteria and plans of action, in view of the situation of various sectors in the country. Furthermore, the approach, which was adopted, used existing resources and infrastructure, especially technological centres operating in the various sectors, to carry out these new and no doubt bold and complex tasks, rather than to create a totally new structure. Finally, it should be pointed out that this is a single Monitoring Centre, not a network of co-ordinated centres. The results that are beginning to be obtained seem to show that this approach has been realistic.

ROLE AND EFFECTS OF FORESIGHT IN THE UNITED KINGDOM

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Abstract

The UK Foresight Programme provides a rare example of foresight becoming deeply embedded and institutionalized within the national innovation system rather than operating only at a higher strategy-making level. In this paper, we set out to explain how this state of affairs has come about. We mainly do this by tracing the conduct of the 'first cycle' of the Foresight Programme, with particular emphasis on its impact on and shaping by governmental actors, such as the Research Councils and Government ministries. We not only follow how policy makers 'react' to the priorities identified, but also how they articulate the Programme's results with their own visions of the future. This work suggests that the effects of Foresight priorities do not derive from a linear causal relationship: priority implementation is a more 'messy' business than this, depending to some extent on its 'fit' with actors' existing relationships and visions. We also briefly highlight the role of industry in the Programme, before discussing some of the Programme changes in the so-called 'second cycle'.

Technology Foresight – the first cycle

The origins of Technology Foresight in the UK

Technology (or research) foresight had been known in UK science and technology (S&T) policy circles for about ten years prior to the announcement of the Technology Foresight Programme in 1993. Ben Martin and John Irvine of SPRU conducted a review of overseas foresight exercises in 1984[1] for the Government's main advisory body on S&T matters, the Advisory Council for Applied Research and Development (ACARD). In 1986, ACARD produced a blueprint for a national foresight exercise[2] that was never implemented - sensing the political climate, they suggested that such an exercise should be left to industry without any involvement of the State. Needless to say, 'industry' failed to take up ACARD's challenge – instead, a number of Government Departments and some Research Councils started to experiment with foresight-type exercises, although these tended to be dominated by either science-push or demand-pull issues.[3] The objective in many cases was the identification of a list of priorities.

Now, in the wake of the 1992 General Election, a new ministry, known as the Office of Science & Technology (OST) was created to focus the Government's efforts in maximizing the returns from the UK's considerable efforts in S&T.[4] It should be noted that spokespersons for the scientific community had been calling for the creation of such a ministry since at least the 1970s, arguing that S&T needed to have its own Cabinet level minister to represent its interests. Successive Governments had resisted this call, mostly on the grounds that ministries were best placed themselves to decide how they spent their money on S&T. In fact, the creation of the OST in 1992 did not compromise this position, with three-quarters of the UK Government's spend on R&D remaining with the various ministries. The OST was only given responsibility for the Research Councils, which had previously been in the Department for Education since the early 1960s.[5] The various S&T advisory committees to the Government, including the Government's Chief Scientific Advisor, were also moved into the OST. The new ministry therefore saw a greater linkage between the Government's advisory structures and those parts of the Government's spend on science that were not directly tied up with supporting the effective functioning of ministries, i.e. the Research Councils.

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1 Irvine J & Martin B, 1984, *Foresight in Science: Picking the Winners*, (London: Pinter).

2 ACARD, 1986, *Exploitable Areas of Science*, (London: HMSO).

3 For an account of these exercises, see Martin, B, 1993, *Research Foresight and the Exploitation of the Science Base*, (London: HMSO).

4 Much has already been written about shifting rationales for the public support of S&T and we will not repeat this here. For examples, see Slaughter, S & Rhoades, G, 1996, "The Emergence of a Competitiveness Research and Development Policy Coalition and the Commercialization of Academic Science and Technology", Science, Technology, & Human Values, vol. 21(3), pp. 303-339; and Flanagan, K & Keenan, M, 1998, "Trends in UK Science Policy", in Cunningham, P (ed.), Science and Technology in the UK, (London: Cartermill).

5 The juxtaposition of science and education in the same ministry was a reflection of the fact that both activities were predominantly conducted in universities. Nevertheless, they were administered quite separately in the Department, and many spokespersons for the scientific community often complained that science was the poor relation to education.

The new ministry was situated in the Cabinet Office, which is close to the Prime Minister and is responsible for Civil Service matters. As such, the Cabinet Office has an overview of the workings of Government, at least in theory. It was from this 'vantage point' that the Government hoped that the OST could gain an overview of public spending on S&T, and with this information, instigate greater co-ordination. However, mechanisms had to be found both to collect information on what the various ministries, agencies and Research Councils were doing, and to bring about greater co-ordination.[6] We will see that the Foresight Programme was one such mechanism.

Now, in 1992, the OST did not have all the answers as to how to proceed. It therefore set in train a public consultation exercise, the results of which were intended to provide the basis for a new policy statement on the Government's support for S&T. More than 800 responses were received and taken into account in the drafting of the first White Paper devoted to S&T in more than twenty years. In addition to this broad consultation, committees of officials were formed to essentially brainstorm and scope the work of the new Department. One such committee, which was an interdepartmental working group of officials, was set up to explore ways in which a list of generic technologies of importance to the UK might be compiled.[7] This group decided that the first step would be to identify a methodology capable of producing a prioritized list of emerging generic technologies. To this end, PREST and PA Consulting were contracted to provide a scoping study. Their main recommendations were (a) the use of the Delphi approach, and (b) the use of co-nomination to identify a pool of experts to serve on expert panels and to act as recipients of the Delphi questionnaire. PA Consulting and PREST were retained to pilot the methodology during autumn 1992, and subsequently demonstrated its viability. We will see that these proposals remained remarkably robust throughout.

The successful scoping and pilot study carried out by PREST and PA Consulting, as well as some behind-the-scenes coalition-building by OST officials, saw proposals for a national Technology Foresight Programme forming the centre-piece of the OST's 1993 White Paper. This document essentially contained OST's mandate, and saw a number of wholesale changes in the institutional arrangements for S&T in the UK, particularly as regards the Research Councils.[8] The White Paper sought to greatly improve the connections between the national science base and its users, notably in industry. From the outset the Technology Foresight Programme combined this objective with that of informing priorities for public spending on science and, implicitly, promoting a 'foresight culture' more broadly. In other words, Technology Foresight would be more than just about arriving at a list of prioritized generic technologies – it would also bring about the creation of new productive networks, as well as instigate changes in actors' behaviour.

Phase 1 - Consultation

The first cycle of the Programme began in September 1993 with the appointment of a high-level Steering Group chaired by the Government's Chief Scientific Advisor. A large-scale public consultation exercise was carried out during the autumn of 1993 through workshops,[9] the objective being to obtain feedback on the OST's proposals for the Programme and to elicit support through a future willingness to participate. The proposals put to the workshops were essentially identical to those put forward to the OST by PREST and PA Consulting a year earlier. Whilst reservations were raised about particular features of the proposals, particularly the Delphi, these were not so strong as to warrant a rethink on the part of Programme managers. The most important benefit of the workshops from the point of view of the OST was that they raised awareness of the Programme and demonstrated an enthusiasm from all sections of the community to participate. It should be noted that this public consultation exercise was complemented by behind-the-scenes consultation of Government Departments, Research Councils, trade and industry bodies, such as the Confederation of British Industry (CBI), and learned societies. Programme managers were concerned that these key constituencies be kept on board, lest the credibility of the Programme could be questioned. To this end, an active publicity strategy was drawn up.

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6 To recall, OST controlled less than one quarter of the Government's spend on S&T, with the remainder residing within the various ministries. In fact, it is debatable whether the OST really 'controlled' their spending line at all. Most spending decisions in the OST are devolved to semi-autonomous Research Councils, with little scope for interference.

7 From the documents that we have seen, the use to which a list of emerging technologies might be put was never made explicit. However, from our conversations with Government officials, the hope was that such a list could be used to guide Government spending on S&T.

8 These were given mission statements that explicitly took account of user communities, appointed Chief Executives from industry, and in some cases set up advisory committees of users to provide input into overall strategy-setting.

9 These were organised and run by PREST and Segal Quince Wickstead.

The so-called pre-Foresight stage (to April 1994) involved identifying and briefing members of the 15 panels, which, together with the Steering Group, would be the mainstay of the Programme. There was much debate as to how the panels should be identified - should they be representative of scientific and technological areas or should they be sectoral based? A mixture of the two was finally agreed upon by the Steering Group, with substantial weight given to the views of other Government Departments, especially the Department of Trade & Industry (DTI), as to the shape of the panels. This was justified by the fact that these Government Departments and the Research Councils would be expected to take account of the Programme's outputs - if these actors could not relate to Panel identities, then such implementation would be less likely to happen.

Efforts were made at this stage to broaden the base of participation beyond that of regular advisers to government. Programme managers were determined that Foresight should be as inclusive as possible and wished to avoid a situation whereby a small group of individuals would decide on the Programme's outputs. The use of co-nomination, a form of snowball sampling, generated 6,000 names, many of which were unknown in policy circles. The exercise was therefore deemed a success,[10] although some Steering Group members complained that it had failed to identify some important names that they felt should be involved in the Programme. Yet, Programme managers never intended to rely on co-nomination alone to provide all of the names to be involved in Foresight; they expected to generate names through other means, mostly through nominations from key actors, such as the Research Councils and other Government Departments. Thus, using both approaches, some 10,000 names were generated and designated the Programme's 'expert pool'.

Panel members were drawn principally from industry, combined with academic and Government membership. Indeed a notable feature of the Programme has been the high level of support and participation from industry throughout. It has been postulated that this resulted from the increasing dependence of firms upon external sources of technology to the point where formulation of strategy, previously an internal activity, must now at least in part be carried out in the public arena. By collaborating in their thoughts about the future, organizations may be better placed to anticipate the actions of their customers, suppliers and others such as regulators, who may influence the environment in which they operate [11]. Probably because of this belief, paying people to serve on Panels was never seriously considered, except with regards to encouraging greater participation of SMEs. Individuals served, and companies and other institutions were represented, essentially out of self-interest.

Each sector Panel had between fifteen and twenty members, with close on 300 individuals committing time to the Programme during 1994.[12] In fact, time commitment was something of an issue, as Panel members had been told that participation would involve about one day per month. For some Panel members, particularly the Panel Chairmen, this was a gross underestimate, with some working every weekend to meet some very tight deadlines (remember, they were all unpaid volunteers with full-time jobs). Panel members received some very basic training as an introduction to the methods and concepts that they would be expected to employ during the main foresight stage. This included an introduction to scenario-building, the use of a Trends & Issues survey, the Delphi, and the use of prioritization criteria drawn up specifically for the Programme. Even at this time, Panel members expressed disquiet at the amount of work that they would be expected to do in such a short period of time (about 9 months). But Government ministers had stated that the Programme's results should be available to inform the 1995 Forward Look strategy document (published in May), and Programme milestones were essentially tied to meeting this deadline.

In the main stage of the Foresight activity (May 1994 – February 1995), panels identified key issues and trends, developed scenarios for their sectors, consulted widely, by means of a Delphi survey, regional workshops and contact with other parties, conducted benchmarking studies, and employed the prioritisation criteria. These were all activities that each of the sector Panels was expected to carry out. In our evaluation work, we have taken a close look at the activities of two sector Panels, Health & Life Sciences and Financial Services. Like most sector Panels, both of these employed complementary techniques for consulting their wider communities.

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10 For an overview of the co-nomination exercise, see Nedeva, M, Georghiou, L, Loveridge, D and Cameron, H, 1996, "Experts for Foresight - the use of co-nomination to identify experts to participate in the United Kingdom Technology Foresight Programme", *R&D Management* April 1996.

11 Georghiou, L, 1996, "The UK Technology Foresight Programme", *Futures*, Vol.28, No.4, pp. 359-377.

12 This figure obviously excludes the thousands of individuals who either answered survey questions or attended workshops.

In the case of the Health & Life Sciences Panel, this consisted of a two-part document, the first part asking respondents to identify where they thought their fields would be in 10-20 years and what would need to be done to get there. The second part of the document asked respondents to comment on ten hypotheses drawn up by the Panel. It was sent to several hundred individuals identified by Panel members, and the results collated by a paid consultant (each Panel was given a small amount of money to spend at its own discretion). The Panel gave much time and thought to this document, basically at the expense of the Delphi. Tight deadlines meant that, in theory, there was little scope for such an extensive 'complementary' consultation. Essentially, the Delphi was substituted by the Panel's own consultation method, and the Delphi statements generated by the Panel (in a single afternoon) were poor, according to the Panel's own admission. Accordingly, the results of the Health & Life Sciences Panel's Delphi had little influence on the Panel's final report.

In the case of the Financial Services Panel, 'expert hearings' were used to complement the Delphi.[13] These consisted of two or three Panel members interviewing senior figures in the sector, using the Trends & Issues survey as an interview guide. About a dozen such interviews were conducted and formed an important input into the Panel's efforts to draw up Delphi statements, as well as the contents of the Panel's final report. In contrast to the Health & Life Sciences Panel, the Financial Services Panel held four or five meetings devoted to the drawing up of Delphi statements, and their Delphi went through at least three drafts. Accordingly, extensive use was made of the results. Nevertheless, the Panel members that we spoke to thought that the Delphi had been rather cumbersome and indicated a preference for a more straightforward survey if the Programme were to be repeated.

The results of the various consultation exercises and benchmarking activities were supposed to be drawn together by each Panel, and priorities and recommendations arrived at using the following criteria:

- Economic and social needs;
- Scientific and technological opportunities;
- Potential to exploit opportunities;
- Scientific and technological strengths;
- Cost of investing in new science and technology; and
- Timescale within which new technology becomes available.

In theory, (1) and (2) were viewed as criteria to be plotted on the 'attractiveness axis' of a prioritization matrix: these would provide a measure of the economic and social needs or markets which would develop in the future, together with the S&T opportunities that could lead to new products, services, or social benefits to meet those needs. The other elements of the prioritization model would be plotted on the 'feasibility axis': these would provide a measure of the ability of the UK to take advantage of the opportunities identified, through the capabilities of its S&T resources and the ability of industry (or other bodies) to apply new technologies successfully.

In reality, the majority of Panels paid only lip service to the criteria, with some employing alternative systems such as STEEPV or a more basic SWOT analysis. In other cases, Panels justified their choice of priorities by claiming that they were obvious, having been highlighted time and again during their consultations. By contrast, the Steering Group attempted to employ the criteria through a complicated system of voting, in part, by way of example to the sector Panels – we will say more on this below. In all, some 360 recommendations for action were made by the 15 sector Panels in their final reports. These recommendations were derived from the priority areas highlighted, and often contained some quite detailed 'scenarios for action', identifying specific actors and actions. Indeed, Programme managers actively promoted this level of detail in the belief that this would make implementation easier. Nevertheless, some Panels preferred to stake their recommendations at a higher level of aggregation, believing that this would leave more doors open to eventual implementation.

A final point that we would make about the priorities and recommendations made by the Panels was that in many cases, they referred to areas that the Panels thought needed further strategic support. So, for example, the

13 The Financial Services Panel decided that regional workshops would be of little value to their consultation efforts, mostly because the industry is concentrated in London and because workshops were not a familiar medium for the industry. During the early stages of implementation, Panel members regretted this decision, as few in the industry had even heard of Foresight, despite the seniority of those represented on the Panel. Accordingly, one of the first steps taken by the Panel during the early implementation phase was the organization of workshops (mostly in London) dedicated to the promotion of specific Panel recommendations (see below).

Health & Life Sciences Panel saw as its task the identification of strategically important areas where it felt that change was needed. Consequently, those areas that were widely recognized as strategically important but which were already being developed were not considered for inclusion in the Panel's final report, as the assumption was that these would continue to be supported. In other words, the H&LS Panel's priorities were intended to be 'superimposed' on a diversely funded science base, and to highlight gaps that the Panel judged needed to be filled. This 'gap-filling' strategy, as opposed to an approach that would produce a complete map of sectoral priority areas, had obvious consequences for any Government attempts to generate a prioritized list of areas for future support.

In fact, debates within the Steering Group as to what their report should contain are of interest here, as they betray wider uncertainties surrounding the Programme's objectives. We have seen that Foresight was born out of a desire by Government to draw up a list of emerging generic technologies, and OST officials were keen for the Steering Group not to lose sight of this objective. Most Steering Group members were happy with this – they accepted that it would be possible to take the Panels' 360 recommendations and perhaps draw out around twenty generic technologies, although they were less happy about prioritizing them. But OST officials and ministers were no longer satisfied with the prospect of a list of emerging generic technologies: quite correctly, they suspected that such a list, to be distilled from the sector Panels' priorities, would look like any other list of generic technologies drawn up by other foresight-type exercises elsewhere. Moreover, the level of aggregation of such a list would preclude any possibility of assigning implementation roles to specific actors. The fear was that such fuzziness would essentially lead to inaction. OST officials therefore suggested that the Steering Group consider the 360 priorities from the sector Panels and identify a sub-set of super-priorities. These would have the advantage of being sufficiently focused for Government and others to act, and their identification by the Steering Group would, at least in theory, publicize the fact that these were the areas in which the Government was keen for scientists, technologists and industrialists to be working. But Steering Group members resisted these proposals, arguing that they had insufficient knowledge and expertise to make such cross-sectoral judgements. The proposals were therefore abandoned and the Steering Group stuck to identifying generic areas of S&T that were later prioritized by plotting on an attractiveness-feasibility matrix. A number of infrastructural issues, such as education and training, support for high-tech SMEs, and regulation were also highlighted in the Steering Group's report, in addition to the S&T areas. This was in recognition of the fact that many opportunities for future developments were dependent on strategic change in non-S&T areas.

What can we make of all of this? First, it should be noted that there was almost unanimous agreement that the Programme had been a success – some 10,000 people had been involved to varying degrees, and 15 sectoral Panel reports produced, together with the Steering Group report and other Foresight-related documentation. On the whole, the reports were well received and attracted little criticism. The main criticisms centred on the methods employed, particularly the Delphi, which Panels had found cumbersome to use. Yet, these criticisms should be put into context: tight deadlines within the Programme had essentially worked against the use of the Delphi results by the Panels, particularly the second round results, which did not arrive until after the Panels had already identified their priority areas. The unfamiliarity of the method had also won it few friends amongst Panel members and those OST officials whose job it was to service the Panels. As knowledge of these problems inevitably reached the wider community, the OST played down the significance of the Delphi and even failed to make the results available for electronic Web-based search until 1998.[14] When the report on the Delphi Survey eventually went on to the Web, it attracted enormous interest with an initial hit rate of around 4000 per week and a sustained high level of use. [15]

Whilst these achievements were thought considerable, Programme managers also vigorously sought to publicize the other success story of Foresight: the networking between academics, industrialists and Government. During the consultation phase of the Programme, this was confined mostly to the sector Panels themselves and the numerous regional workshops hosted by the Panels. We will see below that the networking benefits of Foresight moved to the forefront of the Programme's objectives during the implementation phases. Indeed, the Programme cannot really be considered to have produced a prioritized list of areas for support as was originally proposed back in 1992: the Steering Group's report identified 27 generic areas of S&T that were so broad as to capture much of what was already going on. Moreover, these 27 areas were not really prioritized as such, but rather they were grouped into three categories according to whether they were of immediate or

14 The results were available in hard copy from 1995, and can be ordered directly from PREST, price £25.

15 A leading figure in the academic futures field, Joseph Coates, has described the UK Delphi report as the finest exercise of its type to be conducted in English.

emerging importance. As for the sector Panel priorities, whilst these were more specific, they were so numerous that, again, much of what was already going on in the UK could be considered to be somehow 'aligned' with one or more Foresight priority area. What are of interest are the Panels' recommendations, since these were the Panels' own translations of the priority areas that they had identified. As we have already indicated, these were usually quite specific on who should do what.

As for the conduct of the Programme during this phase, it should be obvious to the reader that the sector Panels enjoyed a reasonable amount of freedom in the way that they conducted their activities, contrary to popular belief. It is true that the time taken to employ instruments such as the Delphi circumscribed anything too adventurous on the part of the Panels, and that this was often resented. Nevertheless, the OST had neither the resources nor the expertise to 'control' the activities of the Panels – it was always thought that the Panels' wider communities would be the final arbiters of their conduct. During the implementation phases, this degree of freedom increased further, with the sector Panels retained as the 'hubs' of implementation activity.

Phase 2: Implementation

After the Panel and Steering Group reports were published, and with a certain delay, the Programme entered its second phase in which the main objective was to disseminate and act upon the results through media, workshops, professional and trade associations among others. Some 600 events were held and 130,000 reports disseminated between 1995 and 1998. As we have already said, the panels were retained to drive this process, though with some adjustment in terms of reference and membership.

The most direct and immediate follow-up to the publication of the reports was a new funding initiative, the Foresight Challenge competition. This saw the Government set aside £30 million of apparent new money in 1995/96 to fund collaborative research that was aligned with Foresight priorities. As we have already suggested, the number of priorities identified by the Panels, together with the broad scope of the Steering Groups priorities, meant that many potential projects could be construed to be Foresight-aligned. Consequently, the OST were somewhat overwhelmed by the level of response. Twenty-four projects were eventually selected for funding from an initial number of more than 500, with the Government's £30 million leveraging a further £64 million from the private sector.

Existing budgets for science were also influenced, though it is much harder to establish attribution here. An official 1997 estimate gave 54% of Research Council spending as being aligned with Foresight priorities of which £300 million was said to be for new initiatives. Much of this money was spent through the Government's LINK scheme, which is the chief mechanism for supporting collaborative research between the public science base and industry. As we have already said, despite the Research Councils being part of the OST, they enjoy considerable autonomy. This meant that the OST could not simply instruct the Research Councils to shift their spending patterns in accordance to Foresight priorities. Yet, the Research Councils can be seen to have embraced Foresight. This phenomenon is undoubtedly due, in part, to the institutional changes to the Research Councils instigated by the 1993 White Paper that had also seen the announcement of the Government's intention to conduct a Technology Foresight Programme. For some people, these changes are seen to have led to a partial erosion of the Research Councils' autonomy. According to this argument, the Research Councils must now take greater account of the Government's wishes for S&T in a competitive game to maximize their resource allocation. One way for the Research Councils to 'perform' this 'fit' is to demonstrate an alignment of funding streams with the OST's Foresight Programme .[16] Thus, they will be keen to adjust their spending plans to take account of Foresight priorities. Now, the figures quoted earlier in this paragraph might suggest that this is exactly what happened. But it is also widely believed that the same dynamic, i.e. an enthusiasm to demonstrate Foresight alignment, essentially led to a great deal of re-labelling of projects and programmes that would have gone ahead irrespective of Foresight. Not surprisingly, this point troubles those Programme managers who are under pressure to demonstrate the worth of Foresight and some effort has been expended on developing standard systems of accounting.

Our own research into this Foresight alignment phenomenon has tried to avoid a concentration on what we believe to be a narrow resource dependency argument. We have detected another dynamic in operation in the Research Councils when it comes to Foresight: alignment with the Programme would seem to have some sort of

16 For a detailed presentation of this argument, see van der Meulen, B, 1998, *Science Policies As Principal Agent Games*, Paper presented at CSI workshop, Paris June 30th – July 3rd, 1998.

'cultural' value, demonstrating forward-looking organizations in tune with the needs of users.[17] Whilst this does not run counter to the resource dependency argument already mentioned, we believe that such an instrumental explanation is overly simplistic. As we have already said, the 1993 White Paper saw some major changes in the Research Council structure. For a start, the largest Council was dismantled to give three smaller Research Councils, with most existing Councils touched in some way by boundary changes. Most established user committees to play an active role in setting annual spending priorities and chief executives from industry were appointed. Perhaps more significantly, the systems put in place to set spending strategies had an in-built capacity to take account of the findings of Foresight. In other words, the ethos of these 'new' organizations meant that Foresight was viewed broadly as a resource rather than an imposition.

The success of Foresight implementation in other Government Departments was more haphazard. Many carried forward areas relating to their own remits, for example transport and environment, but these were usually done through interaction with individual sector Panels rather than at a strategic Programme level. Programme managers did, nevertheless, attempt to establish a Programme-wide discussion forum to bring together all the major spending Departments. This was known as the Whitehall Foresight Group, and its main aim was to co-ordinate Departmental responses to Foresight, particularly with respect to the infrastructural priorities identified by the Foresight Steering Group. It was set up in late 1995 and was populated with reasonably senior civil servants. Perhaps predictably, the Group had little impact, given that infrastructural problems tend to be the least easy to solve. Moreover, any hope of influencing Departmental spending patterns in a wholesale manner was always unrealistic, given that Departments tend only to fund research that meets their policy or delivery requirements. After about a year, the Group essentially ceased to exist, but was later resurrected by the new Labour Government in the wake of an audit of the impacts of the Programme across Government Departments. The aims of the new Group were similar to the old, but with two important developments: first, a new Ministerial Foresight Group was established to shadow the Group of civil servants, and would check on progress periodically. Secondly, the new Group would have the additional aim of contributing to debates on the shape of the second cycle of the Programme to start in 1999 (see below). The idea behind this was simple: if the Departments were involved in the development of the Programme at this early stage, they would be more likely to take account of its outputs.

In 1997/98 the third phase of the Programme gave top priority to the wider engagement of business, with the aim being to increase business participation beyond R&D divisions to reach those involved in corporate strategy, marketing and finance. This was one reason why the term technology was dropped from the title. In fact, for industry, the effects of the first cycle have been varied. A major problem has been encountered in reaching small firms, which often have a narrow and short-term outlook. Efforts concentrated mainly on intermediary organizations but this has been one of the most difficult aims to achieve. Large companies did not expect to gain new insights about the future for their existing core technologies. However, the existence of a stated consensus that some aspect was going to be important could help an internal argument for increased investment in an area on the grounds that competitors might move ahead. Some firms found it particularly helpful to scan the activities of panels outside their normal business areas in search of crossover technologies. Others saw Foresight as a mechanism to influence governmental priorities and support for science more generally. This last aspect provided possibly one of the most important outcomes for Foresight, though a difficult one to attribute. The Labour Government in its first 18 months of office launched a Comprehensive Spending Review across all government activities. Science emerged as a winner with a substantial spending increase, mainly for renewed infrastructure. The ability of those making the case for science to argue that they had already established and implemented priorities, and the information about future wealth-creating opportunities unveiled by the Foresight Programme were both important inputs in the case made to the Treasury.

Foresight: the second cycle

Learning from experience?

In many ways the influence of the UK programme has extended beyond national boundaries as several subsequent exercises in other countries have been significantly influenced by its approach (for example foresight programmes in Hungary, South Africa and Austria). The UK programme itself had taken explicit note of earlier experiences in other countries, notably Japan, Germany and the Netherlands.

17 To recall, there has always been a significant industry presence in Foresight.

The process of learning has been internal as well as external. The UK programme has been subject to a number of partial evaluations, though not to a comprehensive or systematic approach.[18] More extensively, a consultative exercise was undertaken towards the end of the first cycle of foresight with a view to forming a consensus on the format for the second cycle. The consultation proceeded in two stages. Initially, preliminary discussions were held with a wide variety of interested parties, including Panels, companies and industry associations, universities, government departments and agencies, Research Councils, learned societies, think tanks and regional bodies. Following these contacts, in March 1998 a formal consultative document was published by the Office of Science and Technology with specific proposals for the structure and approach to the new programme. In December 1998 a "Blueprint" for the programme was published, largely confirming the earlier proposals and setting out the plans in more detail.

It should be stressed right away that the success or otherwise of a first cycle does not necessarily imply that the same approach should be repeated. Broad socio-economic and political circumstances may change, meaning that the starting conditions and objectives may be different. More specifically, if a foresight programme is seen as an instrument to act upon a community and re-orient it in certain directions, that community may already be moving in the directions which a repeated exercise would indicate. A five-year gap might not produce sufficient change to warrant the effort. Hence, the incentive is to design a programme which addresses the gaps in its predecessor, and which uses new approaches to stimulate interest and maintain momentum.

The new round began officially on April 1st 1999. Its goals remain similar though stated slightly differently, being to:

- Develop visions of the future – looking at possible future needs, opportunities and threats and deciding what should be done now to make sure we are ready for these challenges;
- Build bridges between business, science and government, bringing together the knowledge and expertise of many people across all areas and activities; in order to
- Increase national wealth and quality of life. [Source: http://www.foresight.gov.uk]

Table 1: Foresight Panels

First Round	Second Round		
	Thematic	Sectoral	Underpinning themes
Agriculture, natural resources & the environment	Ageing population	Built environment	Education, skills & training
Chemicals	Crime prevention	Chemicals	Sustainable development
Communications	Manufacturing 2020	Defence, aerospace & systems	
Construction		Energy & natural environment	
Defence & aerospace		Financial services	
Energy		Food chain & crops for industry	
Financial services		Healthcare	
Food & drink		Information, communications & media	
Health & life sciences		Materials	
IT & electronics		Retail & consumer services	
Learning & leisure			
Manufacturing, production & business processes			
Materials			
Retail & distribution			
Transport			
Marine (extended to September 1999)			

18 The most extensive evaluation to date has been conducted by the authors on a shoestring budget.

The panel structure has been retained but with important changes. Consolidation of sectoral panels and a more supply-chain-based approach has reduced the number to ten (see Table 1). There is a tendency for these to be more application-oriented – for example the science-driven Health and Life Sciences becomes Healthcare. However, the sectoral panels represent the main element of continuity. An innovation is the introduction of the thematic panels. These address broad social and/or economic issues with cross-cutting implications for science and technology. The introduction of the thematic panels is symptomatic of a broader tendency to locate research in the context of socio-economic goals. Another example is the European Union's Fifth Framework programme. The Thematic Panels will provide a more obvious interface to public policy – for example the Crime Prevention panel is funded by the Home Office (the ministry responsible for policing) and will feed directly into its crime reduction strategy. Two devices exist to give additional dimensions to the structure: each panel is expected to consider the two underpinning themes of education, skills and training, and sustainable development; and underpinning technologies (IT and biotechnology) will be represented in the membership of appropriate panels.

In operational terms it is envisaged that panels will be strategic entities which forward their agendas by establishing task forces to address specific issues. Panel chairs have a different profile from the first round where the predominant group was research directors of major companies. Following the trend of trying to get beyond R&D to the boardroom, the second round has enlisted several company Chairmen and Chief Executives. The task forces may include non-members of panels and may span the interests of more than one panel. Currently 56 such Task forces exist, some of which are carrying forward the recommendations of the previous round (e.g. the Foresight Vehicle Programme and Clear Zones representing the Transport Panel's main recommendations).

In the present programme, Panels will not be asked to participate in common exercises such as the Delphi survey in the first cycle. They will, however, be supported by a common resource, the Knowledge Pool. This is a professionally managed library of strategic visions, views and information about the future available both on the Internet and in hard copy. Presently at a formative stage this includes results and other documents from past foresight activities in the UK and elsewhere and government reports relevant to science and technology policy from national, European and OECD sources. As the Programme proceeds its outputs will be added. All items contain details of authors and a record of comments made. The Knowledge Pool will also function as a discussion and consultation medium.

The ability of the Office of Science and Technology to support panels is limited by resources and hence a new mechanism has been devised – that of the Associate Programme. This effectively franchises external organizations to operate Foresight activities in partnership with OST and under agreed terms. Most of the operators are professional bodies or intermediary organizations. Hence CERAM Research is developing a framework for initiatives for improved competitiveness in the ceramics sector, and the Institute of Physics a programme on the impact of physics on ageing and crime prevention. Two Associate Programmes involve youth – ASSET aims to establish shadow foresight panels involving younger people and the Institute for Electrical Engineering is operating a programme on IT and education and learning for those aged under 18.

Conclusions

In evaluating the successes and problems of the first cycle Programme as a whole, on the positive side there was a clear success in attracting widespread support in industry and much of the science base. Whilst the priorities that emerged were rather broad they have been generally accepted. There is a recognition that these are priorities for follow-up action, not an attempt to second-guess scientific creativity. The networking activities have universally been seen as beneficial and become more prominent as an objective over time. Indeed, with a wide range of linkages across the whole of science and innovation policy, the Foresight Programme can be said to have been re-invented as a brand and binding agent for innovation policy in the UK.

Problems in the approach encountered included a rather rushed timescale for Phase 1 which inhibited the development of mature recommendations and the ability to take full advantage of the methodologies. While the panels mostly worked well, barriers of communication emerged between members and the rest of the community and between the panels themselves. This led to the conclusion that the next cycle should have a more cross-sectoral approach and more permeable structures. In terms of participation there was a step change upwards in the numbers involved but these still were all in the expert community and did not include the wider public. Excessive focus on technology as a driver led to over-emphasis on technical fix solutions relative to regulatory or social change.

Future evaluation of the Second Cycle will need to take account of both its intrinsic features and the changed environment in which it operates. In some senses the first cycle can be seen as a "heroic era" in which the successes were achieved through the driving force of key individuals championing particular activities. Already in the implementation phase there was a deliberate switch to a far more institutional perspective, reflected in a change in the nature of panel membership. The Steering Committee also evolved in this direction, with new members being selected to gain or secure the involvement of their organizations (for example the senior officers of the Confederation of British Industry and the Trades Union Congress). The growth of institutional linkages has continued in the second cycle. The aim has been to use the infrastructure rather than to cut across it. This strategy is not without risks. Institutions exist to promote a particular point of view and are often rather conservative in their outlook. The promotional dimension means that it will be difficult to produce a clear-cut list of priorities. Priorities within particular domains may emerge but the variety of origins of these does not facilitate any national level comparison. If such an exercise is attempted those involved will have to discount the effects of determined lobbies. There may well be a trade-off between prioritization and more and better network-building.

It is of course too soon to draw any conclusions about the effectiveness of the new Programme. Some of the innovations, for example the thematic panels, promise a genuinely creative approach to the future. Changes in the structure offer the prospect of a broader base of participation. While the first Programme represented a step change in the numbers consulted about priorities it was still very largely confined to a technical elite. Coinciding with the Millennium and the associated upsurge in interest in the future, the new cycle has a real opportunity to capture the public imagination. Many interesting questions remain. For example, will the priorities established in the first cycle still be considered valid? What will happen if contradictory views emerge between past and present panels? Panels will start to produce findings from September 1999 to allow sufficient time for debate before they prepare their reports from April 2000 to November 2000. At that point the Steering Group will draw together the contributions into an overall report while the new implementation phase begins in parallel.

PRELIMINARY LESSONS OF THE HUNGARIAN TECHNOLOGY FORESIGHT PROGRAMME

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Abstract

Hungary launched her first foresight programme in 1997. As the country is undergoing fundamental economic and social changes major institutions are currently shaped. Therefore is high time to think about medium and long-term issues. In other words, now it is possible to devise strategies aimed at improving the quality of life and the long-term international competitiveness. Foresight has seemed 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.

TEP is a holistic foresight programme, based on both panel activities (scenarios, SWOT analysis, recommendations, policy proposals, etc.) and a large scale Delphi survey. The two-year Programme will conclude in 1999.

The presentation is aimed at analysing the reasons to launch TEP, its results achieved so far and some methodological issues, namely:

- *a strong emphasis on scenarios ('macro' and panel level),*
- *the structure and composition of panels (education and learning as input of competitiveness, employment as a unique issue, broad issues as panel topics),*
- *the importance of cross-cutting issues,*
- *the organization and management of the programme,*
- *the socio-psychological legacy of planning in the foresight process.*

1. Introduction

Experts and laymen in different historical periods and in different socio-economic systems shared at least on desire: to know their future in advance or even to influence it for their advantage. They used very different approaches and methods from spiritual-religious ones to scientific investigations and various modes of planning. Hence one might bluntly claim that the past (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 the point where it is too fashionable, and too many expectations surround it, and thus it is bound to fail.

This paper, however, has rather modest aims, it does not intend to classify, characterise and analyze all the possible methods used to predict, influence or shape our future in different periods of time in different countries, not even to provide a comprehensive methodological introduction to the 'foresight' school. Its approach is fairly practical, a 'down to earth', descriptive one, to share some preliminary results – including the ones concerning sustainable development – and some tentative lessons/characteristics of TEP, the Hungarian Technology Foresight Programme.

As TEP is still going on, it would be too early to formulate firm conclusions, and hence the paper only introduces very briefly the concept of foresight (Section 2), then goes on to outline the specific aims and methods of TEP (Section 3), summarises some preliminary results (Section 4), and finally offers some methodological remarks (Section 5).

2. Foresight: definition and rationale

Our world is characterised by increasingly rapid change 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 it is widely known, firms cannot survive increasing 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 setting R&D priorities, based on thorough, comprehensive, strategic analysis, as even the richest countries cannot afford to support all research programmes. Technology foresight – a systematic means of assessing that scientific and technological development 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 realised the importance of foresight activities, and thus this relatively new, and innovative, technology policy tool is spreading across continents. [19]

3. Aims and first steps of TEP

Hungary launched TEP, its first foresight programme in 1997. As the country is undergoing fundamental economic and social changes – that is, the transition towards market economy – major institutions are currently well-shaped. The first phase of the transition process is over now. Most firms and banks have been privatised, the most important new political and economic institutions have been re-established, e.g. a parliamentary democracy based 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. In other words, now it is possible to devise strategies aimed at improving the quality of life and the long-term international competitiveness – the major goals of TEP.

Foresight was seen as an adequate tool to bring together business, science and government in order to identify and respond to emerging opportunities in markets and technologies. In short, TEP should result in a national innovation strategy based on a comprehensive analysis of:

- world market opportunities (new markets and market niches)
- trends in technological development
- strengths and weaknesses of the Hungarian economy and R&D system.

The above, demanding, aim can only be achieved if researchers, business people and government officials join intellectual forces to assess Hungary's current competitive position and impacts of likely global market and technological trends. Hence their re-aligned and re-invigorated 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 co-operate with increased commitment in devising and realising a national strategy, seems to be so crucial that it is an end in itself. In other words, the programme is also aiming at strengthening the formal and informal relationships among scientists and engineers, managers and civil servants, spreading the co-operative and strategic thinking alike.

Hungary is among the six countries about to join the European Union in the 'first wave'. 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 will be comprehensive analyses of strengths and weaknesses, scenarios based on these inquiries and likely global trends, as well as recommendations for public policies regarding how to realise the most desirable scenario. These analyses and information should also assist Hungarian firms in devising and implementing their strategies to improve their competitiveness.

TEP is a holistic foresight programme, based on both panel activities (scenarios, SWOT analysis, recommendations, policy proposals, etc.) and a large scale Delphi survey. The two-year Programme will conclude in 1999. It is being conducted in three stages, namely pre-foresight (October 1997 – March 1998), main foresight (April 1998 – October 1999) and dissemination (November – December 1999) stages.
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 (SG) of 19 leading industrialists, academics and government officials – deliberately with a majority of industrialists and academics with close contacts with businesses – was set up in October 1997 to

19 For a detailed and systematic analysis of the rationale for foresight and description of national excercises see the articles, papers and books listed in the References.

oversee the Programme. Following a thorough discussion the SG has defined the following topics for panel discussions:

- Human resources (education, employment)
- Health (life sciences, health care, pharmaceuticals, medical instruments)
- Information technologies, telecommunication, media
- Natural and built environment
- Manufacturing and business processes (new materials and production techniques, supplier networks, globalisation ...)
- Agribusiness and food
- Transport

The above panels were formed and trained in April 1998, then they started working by identifying major developments in their respective fields and devising alternative visions (possible futures) for the long run. They relied on the expertise of their members – 'representing' different schools of thought in a given field – and also commissioned reports by other experts not belonging to foresight panels. They have formulated statements for the two-round Delphi-survey, and discussed their tentative results 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 Internet, too.

4. Preliminary results

The first draft of the so-called macro scenarios – analysing the broad social and economic trends at a macro level – were developed by December 1998 and then discussed by the SG and other experts on several occasions. These discussions are to be continued, and their results are taken into consideration when revising the macro scenarios. A number of versions – alternative futures at the macro level – have been sketched, and finally three of them have been elaborated. (see a short summary below). Scenarios describing the potential developments of the neighbouring countries, broadly defined, are also being developed. The first draft has recently been finalised and discussed with the SG and experts in September-October this year.
Panels formulated the first versions of their alternative futures by September-October 1998, and have since then discussed, revised and extended them.

The first round of the Delphi survey was completed by May 1999. Some 1400 questionnaires were returned, i.e. on average 200 per panels. Each questionnaire consisted of 60-80 statements and the following set of questions:

- Respondents' degree of expertise
- Respondents' assessment of economic and social impact, and impact on natural environment
- Period within which the event/development will have first occurred (including "never")
- Hungary's current position vs. advanced European countries: S&T capabilities, exploitation of innovations, quality of production, service and regulation
- Constrains: social/ethical, technical, commercial, economic, lack of funding, regulatory standards, education/skill base
- Promotion of development, application: domestic R&D, purchase of licence, know-how or ready-made products.

The second round was to be completed in July 1999, and hence data can be processed and analyzed in September. Then the panels complete their reports, consisting of a critical description and assessment of the current situation, alternative futures (visions) and recommendations (policy proposals) to 'prescribe' the way leading to the most desirable - and feasible - future.

Taking into account the membership of the SG and panels - altogether 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 are contributing to the TEP results.

4.1. Three macro scenarios

Having discussed a number of possibilities, 3 macro scenarios have been elaborated.[20] With hindsight, they can be depicted as cells of a 2x2 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.

Figure 1: Three macro scenarios

	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 way
No major changes in the global settings	Macro Vision II: Hungary is 'grabbed' 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 characterised 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, too, as it is already part of the global and European economic and political systems. In other words, we have excluded the case of isolation (although we might have to reconsider this assumption once the regional scenarios – describing the potential futures for the EU and the Central and Eastern European region – are available).

'Activity' or 'strategy' is understood as an interplay of yet another 'magic trio', namely the civil society, businesses and the government, i.e. 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 Figure 1 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 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 states.

5. Characteristics of TEP: methodological remarks

Having summarized the reasons to launch TEP, and the preliminary results, some methodological issues are highlighted in the remaining sub-sections.

5.1. 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 UK, where 'the lawn is cut and watered for centuries'. The fundamental institutions have crystallised in the advanced countries for quite some time, whereas Hungary is still at cross-roads. Moreover, coming back from the Soviet political, military and economic bloc and attempting to join the EU, which is also in a middle of a major transition process, the wider, international institutional context (economic environment) where Hungary tries to find her place, is changing. It is of the utmost importance to analyze this turbulent environment, hence the emphasis on scenario-building, both at macro level (socio-economic framework conditions) and at the level

20 A group of experts – co-ordinated by Anna Vári and László Radácsi – drafted these scenarios in September-October 1998, which were then discussed in November 1998 – February 1999, and then revised extensively. Yet, these are still "work in progress" visions, i.e. might be revised substantially as TEP progresses (e.g. regional scenarios are developed and discussed, panels visions are revised, etc.).

of panels (micro, mezzo). Macro scenarios had not been developed in any other country engaged in foresight activities when we designed our programme. [21]

We are also devising regional scenarios, i.e. trying to identify the possible futures of that part of the Central and Eastern European region which might have significant influence on the Hungarian developments, and searching for global and European scenarios, too, as background information for our own analysis.

For the above reasons, TEP panels also devote a significant part of their interest to institutional development and regulatory issues. It is also reflected in the Hungarian Delphi-statements: quite a few of them deal with these issues, rather than technological ones.[22]

5.2. 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. [23]

5.3. Employment as a unique issue

TEP has put together Education, learning and employment into 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 has been an unknown phenomenon for decades, and suddenly it jumped to 12 per cent (in the early 1990's – by now it is down to around 8 per cent).

5.4. Broad issues as panel topics

In general, we have brought together various issues treated separately in most other foresight exercises. For example, our Health panel covers life sciences, related fields of biotechnology, health care, pharmaceuticals and medical instruments. Some of these issues are not analyzed at all in other foresight exercises, (e.g. the health care system), and others are treated in separate panels, e.g. life sciences are alone and pharmaceuticals are part of chemicals. Also, agriculture and food processing belong to a single panel in our case (as opposed to the first British exercise).

Although we have tried to set up panels around broad issues, some real-life cases are even more complex, they require expertise from many disciplines and economic sectors: e.g. our health is influenced by a number of factors, among others by one's life style, social status and diet, as well as the level of the medical care system and the environment. All these issues belong to different panels, i.e. close and well-organized collaboration is required to carry out reliable, thorough analysis and formulate suitable policy proposals. Having recognized that need, some panels have joined forces, i.e. their budget, in the early phase of our programme, and commissioned together a group of experts to analyze issues from different points of view (e.g. healthy diet: Health - Agribusiness and Food Industry panels, causes of allergy: again the above two panels). Given the legacy of the planned economy – that is, strong 'departmentalism' – and the inherent isolation of various disciplines, it can be regarded as an achievement in itself.

5.5 Cross-cutting issues

In spite of defining broad fields as panel topics to be analyzed, we have also put strong emphasis on the so-called cross-cutting (cross-panel) issues. We encourage our panels to identify, and adequately deal with these issues while analysing major trends and developing alternative visions (futures) for their field, and in doing so we have developed a list of them at the very beginning of TEP. This list includes, among others:

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

22 To compare with the first British foresight exercise, where the Delphi questionnaire had four categories: elucidation, prototype development, first practical use, widespread use – all are clearly characterising different phases of technological development.

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

- education, training and re-training
- IT
- 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 sub-systems
- research and development, manufacturing (services), marketing
- new materials.

We have organized special workshops to analyze these issues, and have put two of them 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 Britain, Germany, Japan, etc,), but – as far as I can tell – the former one is only applied in the Hungarian survey.

There are a number of 'cross-cutting' Delphi-statements, too, e.g. those concerning environmental issues but formulated by other panels (health, IT, manufacturing and business processes, etc.). We have collected these statements, and the respective panels are going to analyze them, i.e. both those panels which formulated these 'cross-cutting' Delphi-statements and those which are 'effected' by these statements.

5.6. Organization

The former socio-economic system has been influential concerning the organization and management of TEP, too. It has been a well-considered, conscious decision from the very beginning not to involve anybody from the OMFB (a government agency responsible for S&T policy) to run the programme (from a professional point of view, i.e. decision on panel topics, issues to be analyzed, priority-setting, etc.). The role of OMFB has been restricted to providing finance and methodological support. Therefore no OMFB-official sits either on the Steering Group (SG), or is a member of any panel.[24] Moreover, members of the SG and panels have been appointed as a result of a wide consultation process. All the major decisions are taken by the SG – more recently at joint meetings of the SG and panel chairs and secretaries – or the panels themselves.

5.7. Ambiguous ('double') legacy of planning

Centrally set, mandatory plan targets were abolished in 1968 in Hungary, the first time among the centrally planned economies.[25] Yet, its legacy is still rather strong among some experts, and it has had some non-negligible impacts on the foresight process, especially in the beginning of it. Two – rather different – consequences, have become visible:

- some engineers and scientists have understood foresight as just another form (tool) of (central) planning, and hence want 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 [plan]');
- some other professionals have also understood foresight – at least at the first glance – as just another form (tool) of (central) planning, and hence reject it immediately.

It is obviously changing as we go along yet not everyone shares the same understanding of the role and aims of foresight.

To sum up, the on-going Hungarian Technology Foresight Programme – its goals, methods and organization – is shaped to a large extent by the legacy of the former socio-economic systems, their impacts on the national system(s) of innovation, the size of the country and the level of its economic development.

References

24 To compare, the Chairman of the Steering Group was the Head of the OST during the first British foresight programme.
25 Central planning has not been abolished until 1989.

Cuhls, K. and T. Kuwahara [1994]: Outlook for Japanese and German Future Technologies, Heidelberg: Physica-Verlag, Springer Publishers

Fleissner, P. et al. [1998]: Recent national foresight studies, Sevilla: IPTS

Gavigan, J.P. and E. Cahill [1997]: Overview of recent European and non-European national technology foresight studies, Sevilla: IPTS

Georghiou [1996]: "The UK Technology Foresight Programme", Futures, Vol. 28, No. 4, pp. 359-377

Grupp [1994]: "Technology at the Beginning of the 21st Century", Technology Analysis and Strategic Management, Vol. 6, No. 4. pp. 379-409

Grupp [1996]: "Foresight in Science and Technology: Selected methodologies and recent activities in Germany", OECD STI Review, Special Issue on Government Technology Foresight Exercises, No. 17, pp. 71-100

Irvine, J. and B. Martin [1984]: Foresight in Science: Picking the winners, London: Frances Pinter

Irvine, J. and B. Martin [1989]: Research Foresight: Creating the future, Zoetermeer: Netherlands Ministry of Education sand Science

Kuwahara, T. [1996]: "Technology Foresight in Japan: A new approach in methodology and analysis", OECD STI Review, Special Issue on Government Technology Foresight Exercises, No. 17, pp. 52-70

Martin, B. [1996]: "Technology Foresight: A review of recent government exercises", OECD STI Review, Special Issue on Government Technology Foresight Exercises, No. 17, pp. 15-50

OST [1998]: The Future in Focus: A summary of national foresight programmes, London: HMSO

TECHNOLOGY FORESIGHT: APPLICATIONS AND ITS POTENTIAL TO THE APEC REGION

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Introduction

We are confronting the third millennium in a state of worldwide intricacy. The old order of world society is obsolete and a new one is not yet in full operation showing uncertainty to some degree. We are now faced with an unprecedented challenge upon which S&T progress has a crucial influence.

In the imminent future, we are expecting that the knowledge-based economy emerges as a new economic paradigm. The underlying forces in its emergence are advances in science and technology. A recent report from the OECD (1996) widely observes, through policies and statistical indicators, that some developed countries already stepped into the knowledge-based economy, in which production, use and distribution of knowledge and information play a critical role in its economic activities and strengthening competitiveness.

This is well reflected by recent growth in high-technology industries with showing greater investment and higher productivity. The latest change in the economic paradigm is being driven by knowledge mainly including technological advances in physical capital and increases in learning capability embodied in human capital. Continuing growth of the economy and additional job creation will be possible only on the foundation of technological progress and human resources development. By the nature of the knowledge-based economy, it is expected that a country with greater accumulation of knowledge will be better off, gaining the competing edge, relative to a country with less of it. Since the developed countries are usually endowed with greater accumulation of such knowledge, therefore, the gap of economic performance would widen between the developing and developed countries.[26]

On the other hand, under the WTO regime, the new international economic order is now being implemented, in which technological factors draw a keen interest; such as government subsidization of industrial R&D, intellectual property rights, the use of fossil fuel, and nuclear energy, etc. Such trend implies that technology or knowledge in a broad sense is already taken into account as a production resource like other factors of production which a country is endowed with. It may be said that technology transfer across the borders will cost more than before, and hence a technologically less developed country could be worse off.

Table 1: Shares of High-Technology Industries in Total Manufacturing

	Export		Value Added	
	1970	1993	1970	1994
Canada	0	13.4	10.2	12.6
United States	9	37.3	18.2	24.2
Australia	8	10.3	8.9	12.2
Japan	20.2	36.7	16.4	22.2
New Zealand	7	4.6	-	5.4
France	14.0	24.2	12.8	18.7
Germany	15.8	21.4	15.3	20.1
Italy	12.7	15.3	13.3	12.9
United Kingdom	17.1	32.6	16.4	22.2

Source : revised from OECD (1996).

Such changing environments surrounding science and technology make each country pay greater attention to science and technology by increasing investment and maximizing utilization of S&T resources. It seems that the

26 This hold valid for income levels of workers within an economy. That is, workers with higher skills will earn greater income.

S&T policy now comes into the central stage in the national economic policy. However, the S&T policy formulation is a relatively new concept. This is where the technology foresight comes into a focus.

Needs and Purposes of Technology Foresight

S&T activities are basically knowledge-creating activities.[27] However, costs of knowledge production - including transmission and dissemination - are rising. In turn, it implies that the investment in S&T activities involves greater risk and uncertainty. To minimize risk and uncertainty and to maximize the effect of knowledge-creating activities, it is necessary for the policy-maker and decision-maker to look into the longer-term future of environments surrounding science and technology, in a scientific way.

Today's technological progress does not occur naturally. It is made to happen. If the forces driving it can be identified and quantified, it should be possible to forecast the rate at which they will produce future advances. Future advances can be directly caused by the work of individual technologists, and more likely teams nowadays, which would not be made without financial supports. Thus, one would expect to find a relationship between the investment and technological progress. The S&T investment is made because benefits to be derived from the enhanced performance are expected to be greater than the cost of achieving it - the benefits are not easily measurable, however.

In general, foresight is undertaken to gain better understanding of the future environment and magnitude of the changes needed. Thus, the anticipation enables the decision-maker to move into the future in a purposeful fashion in contrast to belated reaction. In any case, the decision-maker cannot avoid making decisions which will be proved good or bad upon realization of the future event. If the foresight can assist the decision-maker to obtain a more accurate picture of the future and as a consequence improve his/her decision-making, the effort devoted to the foresight will be justified. This only justifies why one should forecast.

It can be said therefore that the fundamental aspect of foresight is in the systematic assessment of threats and opportunities, leading to strategic formulation and planning to meet the needs of the future. To summarize, Jantsch (1967) pointed out that the foresight could assist decision-making in the following ways:

- Wide ranging surveillance of the total environment to identify developments both within and outside the sphere of activities which would influence the economy's future.
- Provision of well-refined information about the possibility of a major threat and opportunity; in some cases, an early warning signal.
- Estimating the time scale for important events in relation to the decision-making and planning horizons; an indication of the urgency of action.
- Major reorientation of S&T policy to address situations which may pose a threat and opportunities by; (a) redefinition of economic competitiveness in light of new technological competition, (b) modification of economic strategy as well as R&D strategy.
- Improving operational decision-making, particularly in relation to; by priority setting, (a) resources allocation between technologies, (b) R&D project selection from the R&D portfolios, and (c) human resources development.

Thus, the foresight could provide rich decision information for S&T policy formulation of both the private and the public. It is noted therefore that foresight should not simply be an outcome of curiosity of scientists and technologists. It must be a well-controlled exercise taking into account related factors.

Theoretical Underpinnings and Applications

Theoretical Concepts of Technology Foresight

27 The knowledge here is defined in a broad sense including know-what, know-why, know-how and know-who. Know-what is referred to knowledge about the facts; know-why to scientific knowledge of the principles and laws of nature; know-how to skills and tacit knowledge; and know-who is knowing about who knows what and why, and who knows how to do what. Such knowledge in a broad sense is extremely difficult to measure.

Technology foresight as a discipline is relatively new to other foresightasting studies, such as economic forecasting and business forecasting, etc. In 1967, Jantsch had made an extensive survey on various practices of technology foresight. He collected about 400 cases and classified them into four categories, providing a conceptual framework.

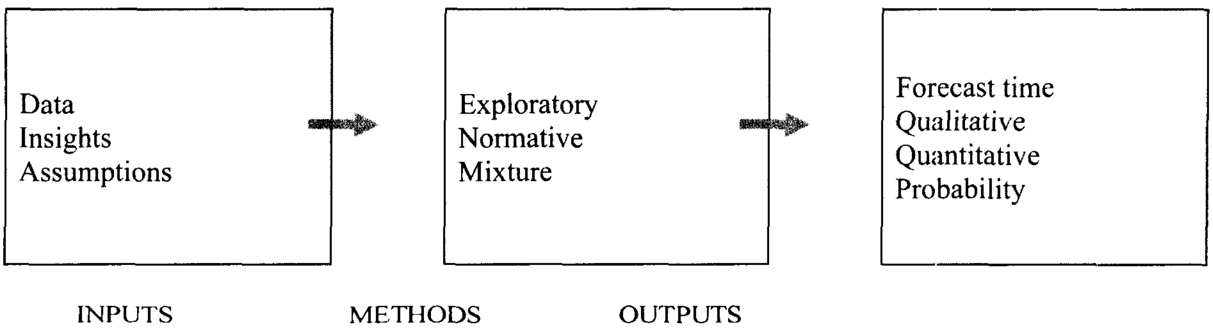
According to Jantsch,[28] the forecast/foresight is defined as "probabilistic assessment of future technology transfer." The technology transfer is referred to a vector, a move from one point to another, on the sphere of S&T activities showing both the vertical and the horizontal technology transfer. The vertical technology transfer is ranging from the scientific knowledge, basic and applied research, development, commercialization, to final effects of innovation over the entire society.[29] When a technology forecast is carried out, it is important to understand the processes of innovation. It is because the different stage of innovation has different effects and implications for S&T planning, and because the forecast does not always concern only one of those stages. By combining both the vertical and the horizontal technology transfer into one three dimensional space, the so-called "technology transfer space," a technological progress can be described by a vector in this space.

Observing such a move on the technology transfer space, what the technology foresight concern is;

- Time period moving from one point to the other
- Efforts to be made to reach the end point of the vector
- Effects of technological consequences at the end point
- Optimal starting point in view of the end point

The first three are known as the exploratory forecast taking a view from the present to the future; the last one as the normative one taking a view from the future to the present. Thus, the exploratory forecast is to address technological opportunities - S&T push or capability-oriented where technological progress takes place, while the normative forecast assumes that needs for the technology demand-pull or need-oriented is already identified. It will be more desirable if an exploratory opportunity matches social needs in addressing the path of technological progress. Therefore, it can be said that the combination of both the exploratory and the normative approach will produce richer forecasts.

Figure 1: Process of Technology Forecast



A comprehensive forecast includes four essential elements, i.e., qualitative, quantitative, time and probability. One of the most important is the qualitative elements related to "what to forecast." This is the area where insights and the general technological awareness of the expert play a crucial role. Forecast without quantification and time scale is useless by and large. This is the question about "what rate of progress can be expected." It is often relatively easy to forecast the possible development of a technology to produce an end state scenario, but it is much more difficult to assess the path by which this end state will be achieved. Without a time scale, S&T policy and planning is of little value. Since forecast is concerned with the future, it is involved with uncertainty to some degree. Therefore, it needs to be associated with a probability assessment, i.e., "what confidence has the forecast." [Martino (1993)]. Although it is most desirable that a forecast includes those four elements, all methods do not include them.

When the foresight goes into practice, several guidelines can be proposed:

28 E. Jantsch (1967).

29 In explaining such innovation process, there are various models including the linear and the non-linear models. For a linear model, see J. Bright (1978).

- Goals and purposes of the foresight must be identified before selecting appropriate methods. There are a number of methods for technology forecasting. However, selection of methods depends on the purpose of the forecast as well as availability of input factors. It is because different methods may give different answers. For example, without statistical data, any statistical method will not be applicable.
- More desirable to use methods in combinations. No one method can answer all questions in consideration. It would be more preferable if exploratory and normative methods are combined, i.e., mixture of S&T push and demand-pull approaches.
- Too much emphasis has been placed on the accuracy of forecasts and not enough on the learning and communication value of the forecasting process. The process should make participants better informed about the topic and better prepared to deal with uncertainty.[30]

On the other hand, since science and technology is responsible for the most important changes in our society, forecasting has to be very extensive if some indication is not be missed. Also, it is perceived that interaction between non-technological factors and technological factor plays an important role in the course of technological progress. It is recommended, thus, that the foresight should include a wide range of social, economic, cultural and political as well as technological factors.

Technology foresight activities at the government level

Since the late nineteenth century, novelists and science fiction writers, among others, made a great deal of predictions about inventions, technological devices and results in future worlds. However, these should not be considered as technological forecasts,[31] but as prophecies since they relied on no particular methodology other than belief in the possibility and desirability. It is known that the earliest study about the methods of technology forecasting was made in 1920 by S.C. Gilfillan. He reviewed past forecasts of technology and concluded that two methods were used. They are called today as the exploratory (capability-oriented) and the normative (goal-oriented) methods. [Bright (1978)].

Technology foresight starts from the public sector with development of methodologies through practices, and methods and techniques were then transferred to the private sector. It was not until the 1960's that the private sector made studies and exercises of technology foresight.

The first government effort for technological forecast was made in 1930s by the United States. The purpose was to encourage formal governmental efforts to anticipate technological change with a view to ameliorating its impact on society, especially on unemployment and skills training. A landmark effort was the work of T. Von Karman for addressing the course of the US Air Force research and development for the 20 years, 1945-65. In so doing, he organized a scientific advisory group to aid in fulfilling the request, which included experts from many technological fields. Using an expert group in the foresight is still a widely-employed method nowadays. In 1960, the US Army began a formal programme of long-range technological forecasts. This eventually evolved into a continuing project known as "Long-Range Technological Forecasts." [Bright (1978)]. The department of defense has continued to carry out technology foresight. During the 1980s, the National Research Council had been engaged in the technology foresight activities. The methodology was similar to what Von Karman did. A large committee with subcommittees was made up of eminent scientists and technologists. Information collection, documentation, discussions and conceptualization are the main procedures.

It was not until the late 1980's that the United States moved to an explicit technology policy. Before the end of 1980s, technology foresight had drawn relatively less attention in the public sector, and well-diversified approaches were taken by various organizations. This is a typical aspect of the US market system with traditionally emphasizing less government intervention. However, by the end of the 1980's, as concern about US industrial and technological competitiveness, particularly related to Japan, increased, it was recognized that the United States needed to have a coherent technology policy, which thus led to increasing interest in technology foresight.

The outstanding foresight work in the United States in recent years has been to take out the lists of the critical technologies, i.e., technologies critical to the future of the US economy or to national security. The Department

30 This was well argued in H. Grupp (1994), and T. Shin, et al. (1994).

31 The technology forecasting is referred to a scientific approach. "Scientific" here means that the same outputs are reproducible with the same data and assumptions.

of Defense and the Department of Commerce carried out some exercises in producing lists of critical technologies. A panel setup by the Office of Science and Technology Policy was engaged in making the lists of the critical technologies and had to report them the US Presidential Office. The list is to be revised every two years. This foresight work is now carried out by the Critical Technology Institute, affiliated to the RAND Corporation.

Such initiation of the public sector eventually led to further development of methodologies, and to stimulating and promoting the private sector to undertake foresight exercises in the United States. The private organization, SRI and Data Quest, among others, are known as prominent institutions for technology monitoring and foresight.

In the late 1960's, Japan was concerned about technology forecasts. The STA (Science and Technology Agency) undertook in 1973 an extensive Delphi survey for a 30-year forecast. It was the largest-scale Delphi at that time covering all areas of science and technology, and surveying on possible innovations or technological developments; major parameters of the survey were to forecast time, the degree of (technological) importance, and barriers to realization. More than a thousand experts participated in the foresight, from industry, universities and government organizations. It provided, to both the public and private sectors, the background knowledge on the course of S&T development in the long-run, rather than specific priority-identification.[32] These 30-year forecasts have been repeated approximately every 5 years, Japan is now undertaking the 6th survey.

Besides the STA's Delphi, it is also known that other government agencies, such MITI, EPA and Department of Transportation, among others areas, is actively engaged in the foresight activities. They employ various methods including brain-storming, scenarios and others. Japan is one of the countries whose exercises of forecasting futures are actively carried out. Forecasting is sometimes characterized as self-fulfilling (opposed to self-defeating). Thus, forecasting has an effect of expectation formulation. As the government produces a number of forecasts, the private sector tends to move towards more likely futures with their own expectation. In turn, it effects the resources allocation by guiding it in a certain direction, possibly with greater efficiency.

In other cases, Korea undertook a major study of technology forecasting in 1994, using Delphi. Like the Japanese Delphi, its purpose was to address the long-term path of science and technology in all areas, showing "where to go." It included about 1,200 technological topics, and forecast was made for a 20-year period. Unlike the Japanese Delphi, however, it was thought that the selection of technological topics had to be taken into account very seriously. It was because Korea may have stayed at a different stage of S&T development to those of other countries like Japan. At the preliminary stage, therefore, collection of ideas was made through a nation-wide survey, simply sending the blank paper to about 25,000 experts. Based on these ideas, about 1,200 topics were selected. From these, about 300 topics were the same as those of the Japanese Delphi, which made an international comparison possible later on.

On other hand, Germany and France also carried out their own Delphi, using the topics of the Japanese Delphi in 1992. Their results received a substantial response, particularly in Germany which decided to undertake it regularly. A few years ago, Germany undertook a joint Delphi with Japan,[33] looking for a possibility of the international cooperation in technology forecasting. Meanwhile, the United Kingdom made a good deal of efforts in technology foresight on a huge scale, in which a Delphi was included as part of the entire exercise. The task force made finally about 600 recommendations on completion of the foresight. It is also known that other European countries like The Netherlands, Sweden and Norway, undertake technology foresight using various methods.

Now, some interesting results of an international comparison from the Korean, Japan and German Delphi was shown in Shin (1997). It was found that there was no significant difference in the forecast time of realization over about 300 topics included in all three exercises. However, evaluation of the degree of importance was significantly different from one country to another. This gives an important implication that each country may have different concerns on science and technology, since each country has a different economic environment and different endowment of resources.

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32 Surprisingly, a review in mid 1980s by the NISTEP reported that the accuracy of the forecast time in the first Delphi turned out to be about 60%, including the partially realized cases.

33 T. Kuwahara (1996).

All in all, such extensive foresight activities at the government level are usually time-consuming and highly expensive. Martin (1996) pointed out some lessons from recent foresight activities reviewing over some countries. He wrote about the widespread recognition of the growing importance of new technology for economic competitiveness and social progress and that with research costs rising and the number of scientific opportunities expanding, no organization or country could afford to do everything - choices had to be made. Thus, needs for a systematic approach for priority-setting is on the increase.

Foresight assumes that there are numerous possible futures. Exactly which one we will arrive at depends on the choices made today. In other words, foresight involves a more active attitude towards the future through decisions they take today.

Research foresight needs to be carried out at several levels, ranging from bodies responsible for the coordination of overall national S&T policy down to individual companies or research organizations. Thus, some foresight exercises need to be holistic in scope, others more micro-level. Furthermore, the foresight activities at different levels should be fully integrated, the results from higher and/or lower levels of foresight being fed into the process, and the results in turn feeding into subsequent foresight efforts at higher or lower levels.

This is an important observation for the domestic activities of technology foresight, guiding the direction and scope of the activity.

Regional cooperation and expected gains of technology foresight

As economic and S&T environments are changing rapidly, cooperation between countries at the regional and/or global levels is inevitable not only because any country has sufficient resources, including S&T knowledge, for continuing economic growth, but also because the framework of a single nation is too narrow and too small for major undertakings.

We are now living in the world where abundant information is accessible through the nets. Decentralization of information transmission channels through various devices, e.g., the personal computers, personal telecommunication systems, CATV, and others, would never make the George Orwell's world come true.[34] It is mainly because costs of monitoring are too large. The net will develop with an acceleration and continue to weaken the centralized power such as big business enterprises and the governments, etc. In addition, the WTO regime, liberalization of international trade will be move toward promoting mobilization of production resources. Such advances in information society and new international economic order will continue to weaken the role of government.

On the other hand, people are aware of pollution, drought, deforestation, oil slicks and nuclear catastrophe, etc. People and countries are risking ecological crisis by overexploiting. Nature is no longer the eternal and generous mother giving life to human beings. She has been transformed into a techno-nature, which implies that our everyday environment is filled with artificial elements. The ecological crisis could save no country in the future.

Along these lines, cooperation between countries is necessary for better achievement and better quality of life. Without harmony and cooperation, we cannot assume coexistence and a promising future together. Cooperation built on the basis of science and technology is particularly emphasized.

Needs for the technology foresight by the APEC may come from country-specific problems as well as the regional contexts. There would be a number of issues to be met either by a single country or by the countries altogether in the region.

In Martin (1996), the OECD meeting concluded that, although "...there is a considerable scope for international collaboration in foresight to share methodological experiences and results as well as experiences how best to embed foresight in wider discussions of science and technology policy, bilateral arrangement is more appropriate at this stage in development of technology foresight than multinational foresight exercises." The reason is that multinational cooperation might not help tackle a country-specific problem which has different

34 T. Gaudin (1995).

needs and hence strategies. In addition, it argued that, "if technology foresight were to result in countries choosing similar priorities in technology and R&D, it may create problems of conservatism and more seriously of increased international competition," i.e., convergence of expectation formulation across the countries.

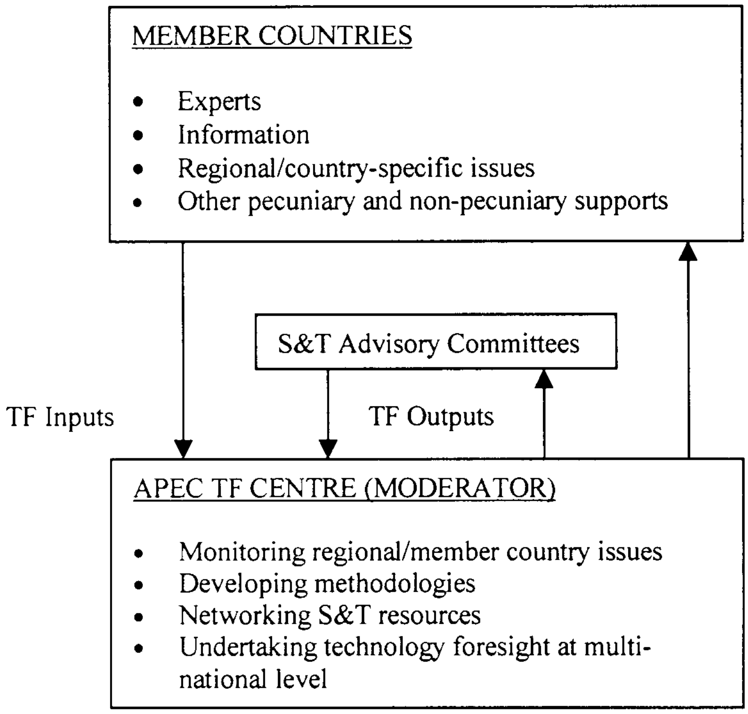
However, it may be argued that a multinational collaboration of technology foresight does not have to focus a country-specific problem dealing with exploratory opportunities. Diversification of foresight activities might avoid the convergence of expectation formulation and hence concentration of resources investment, and consequently increase in competition. But if more information is available in a systematic way, diversification of S&T efforts will be promoted. That is, without extensive information which is produced in a systematic way, information collection and strategy formulation will be limited, and consequently more countries will make more efforts for the limited areas, perhaps leading to a convergence. Extensive information will provide various niches to some countries, which may not be niches to other countries. On the other hand, as far as the comparative advantage works in a Ricardian world, it might not be possible that every country concentrates on the identical areas of technology with more resource allocation. Although expectation formulation of the business enterprises converges and hence increase investment too much, say, in the area of information technologies, the information technology is already too broad for resources to be concentrated in view of business activities, since the limit of its application is not known. As pointed out by Jantsch (1967), innovation effect of a technology is unlimited, if the technology transfer space is open, where the society has unlimited potential of innovation activities. Thus, it can be said that disadvantages can never outweigh benefits of foresight in multi-national level. What is important is to promote S&T activities in this region, and hence economic growth, which eventually brings about mutual benefits.

The foresight activities by APEC can be propelled establishing the TF Centre which will play a role of moderator or stakeholder. The operational framework is provided in Figure 3. The objective and role of the Centre could be (1) producing and disseminating S&T information between member countries following technology foresight, and hence assisting member country's S&T policy formulation, (2) Addressing S&T issues which require a regional approach and delivering the strategic assessment following the foresight, and (3) networking S&T resources between member countries and increasing effectiveness of S&T activities in the region.

Since the Centre will act basically as a moderator, it will need an advisory committee to assist the Centre activities with S&T knowledge. The role of committee could be (1) Determining the issue for foresight activities, focusing on finding the path of S&T development, (2) assisting Centre's recruitment of experts for the sub-committee and the experts panel or brain pool, and (3) reporting S&T problems to the Centre by examining S&T ideas and opinions.

As a moderator, the Centre, with an assistance of the S&T advisory committee, should have a capability to mobilize S&T experts. It would be desirable if it is able to constantly manage the expert panel or the brain pool. It also continuously monitor the regional and member country's issues and feedback to the advisory committee reviewing them. Of course the primary task is to produce and disseminated S&T information following foresight exercises regularly. The functions of the Centre would be summarized as follows; (1) studying and monitoring common interest of the members, (2) Managing the expert panels, foresight committee and sub-committees, (3) developing TF methodologies and training the forecasting agencies of the members, (4) preparing a taxonomy of science and technology at several levels, and (5) providing consulting services to members by making arrangement between experts and member countries.

Figure 2: Operational Framework of APEC TF Centre



Through regional cooperation, the following is expected:

- Harnessing member country's S&T policy formulation.
- Delivering the strategic assessment following technology foresight.
- Increasing effectiveness of S&T activities of the member countries.

First of all, what is expected to be gained through regional cooperation in technology foresight could be an exploratory technology forecast, showing "where to go." This is a necessary step before the value assessment of the forecast and strategic planning are delivered to meet country-specific and/or regional issues. Through the international foresight which is jointly funded for a common purpose, it would be extremely difficult to meet country-specific issues related to "how to go." It is because the levels of technological progress of the member countries vary widely, from underdeveloped to developed. It implies that the location of each member on the path to technological progress is different with different endowment of S&T resources.

On the other hand, however, there may be a number of issues which could be met only by the regional (or global) approach, such as environment, desertification, energy, foods and others. In those cases, foresight will also be able to provide decision information with a strategic view. This involves an intricate process. Because it is not easy for each member country to make a strong commitment to it. Without a strong commitment, multi-national foresight and subsequent S&T planning would not be effective.

It is also expected that member countries would be better off with the centres networking of experts and other S&T resources. It is likely that more information could be exchanged at the private level., rather than at the public level. Such information exchanges could be made by the Centre linking one expert to another, putting them on the network. Or by that the centre regularly hold seminars and conferences on current issues in science and technology. The effect of such a knowledge transmission mechanism may not be easily measurable, but it would promote S&T activities of member countries particularly developing countries. Martin (1996) observes that the benefits of government-run foresight exercises lies on the creation of an effective network between R&D units, universities, industries and government research institutes. Similarly, The APEC Centre may more effectively mobilize S&T resources by linking them across the member countries. This will increase the efficiency of resources allocation at the regional level.

Concluding remarks

With rising costs of S&T activities or knowledge-creating activities and with rapidly changing S&T environments, the APEC region is now faced with new challenges calling for regional cooperation built on science and technology. Awareness of technology foresight is on the increase, now that science and technology is a key element in the knowledge-based economy. The primary purpose of technology foresight is to assist decision-making in priority setting and resources allocation, by addressing technological opportunities and identifying needs in future.

Some developed countries are actively engaged in technology foresight, from which valuable lessons can be drawn. But international cooperation is still under test. The OECD is doubtful particularly for multi-country foresight, though bilateral cooperation is more preferable at this stage. Sharing information following technology foresight may not lead to such expected formulations resulting in the concentration of S&T resources in a specific area. Even though a convergence might take place, it is not likely that the convergence of business activities is universal.

Therefore, through cooperation in technology foresight, it is necessary to maximize the utilization and effectiveness of S&T activities for regional economic development. Regional issues could be met only by the joint efforts of member countries, and in view of country-specific issues, growth of individual economies has to be driven through cooperation and competition among countries. In undertaking foresight activities, the regional approach will promote national foresight activities.

Finally, the APEC Centre for technology foresight will be launched imminently. The primary role of the Centre will be producing and disseminating S&T information in a systematic way. It is recommended that, as a driving engine, the APEC Centre should take into account the diversity of national backgrounds in the region and follow up regional issues. In addition, identifying country-specific issues in a systematic way is important to strengthen the regional cooperation particularly at the beginning. For the successful performance of the Centre, it will be necessary for it to keep developing its role with regard to the suggestions discussed above.

References

Bright, J. (1978), Practical Technology Forecasting: Concepts and Exercises, Austin: Industrial Management Centre.

Gaudin, T. (1995), 2100, Our Species' Odyssey, Montiers: Foundation 2100.

Grupp, H. (1994), "Foresight in Science and Technology; Selected Methodologies and Recent Activities in Germany," STI Review, No.17, (1996), pp.71-99.

Jantsch, E. (1967), Technology Forecasting in Perspective, Paris: OECD.

Kuwahara, T. (1996), "Technology Foresight in Japan; A New Approach in Methodology and Analysis," STI Review, No.17, pp.51-70.

Martin, B. (1996), "Technology Foresight; A Review of Recent Government Exercises Summary Report of the OECD Meeting Held on 14 September 1994," STI Review, No.17, (1996), pp.15-50.

Martin, B.R. & J. Irvine (1989), Research Foresight: Priority-Setting in Science, London: Printer Publishers.

Martino, J.P. (1993), Technological Forecasting for Decision Making, 3rd Edition, New York: McGraw-Hill.

Millet, S.M. & E.J. Honton (1991), A Manager's Guide to Technology Forecasting and Strategy Analysis Methods, Columbus: Battelle Press.

OECD (1996), Science, Technology and Industry Outlook 1996, Paris: OECD

Shin, T. (1996), "Using Delphi for a Long-Range Technology Forecasting and Assessing Directions of Future R&D Activities in Korea," Technological Forecasting and Social Change, (forthcoming).

Shin, T., J.H. Park, K.H. Jung & H.S. Kim, The First Science and Technology Forecast Survey; Korea's Future Technology, Seoul: STEPI, 1994.

TECHNOLOGY FORESIGHT AND S&T POLICY MAKING: KOREAN EXERCISE

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Korea

1. Introduction

Recently, serious skepticism about rational planning methods increased due to discrepancies between real outcome and the impact of formulated plan. The reasons for failure are that planners often are more concerned with technology itself, and overlook economic consideration and ignore societal and market reactions. Another reason for the disappointing results in science and technology planning has to do with discontinuity in the scientific and technological progress, due to the fact that discoveries and inventions take place more by accident when one is looking for something else, than by well scheduled research programmes.

In the past, national programmes designed and implemented by MOST (Ministry of Science and Technology) were usually performed by the government-sponsored NPRIs (non-profit research institutes). Most researchers of NPRIs concentrate on projects funded by the government. In the bottom-up approach, thus, each researcher has to monitor technology trends in his/her field and submit research proposals, which were evaluated usually by the 'peer-review' method. Therefore, researchers tended to pay attention to what was fashionable in their field with no regard to industrial activities.

In the top-down approach, well-organized foresight studies are essential. The foresight activity includes monitoring global technology development, taking account of availability of R&D resources, and planning research agenda and interaction of various actors in the socio-economic system. National projects have been actively planned since the early 1990s by proper national goal setting at the outset and ensuing pursuit in relevant technologies. The policy-maker alone, who might be less specialized in the S&T process, could falsely set priorities and select technologies to be developed with no regard to technology capability, social needs, etc. Therefore, without well-organized foresight activity and action, it is more likely to fail or delay development.

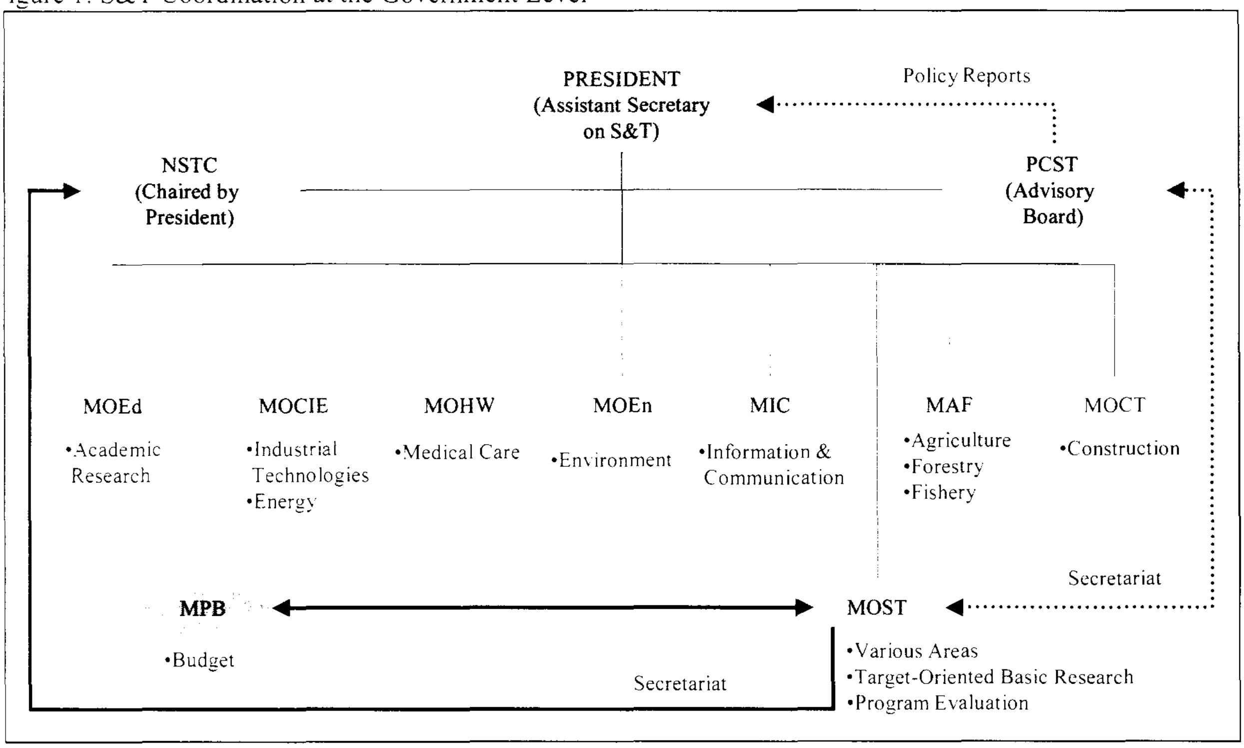
This study is organized as follows: The next chapter deals with an overview of Korea's national S&T system at government level. Recently, there have been reforms in the public sector and we summarize changes in the S&T system of the government. In chapter 3, foresight activities of various government bodies will be briefly discussed, and then in chapter 4, we will provide a foresight framework as a process of policy-making. As an example of a successful foresight, one of the national programmes, the HAN projects, will be reviewed in chapter 5. In chapter 6, some concluding remarks will be provided. Finally, in the appendix, a discussion of foresight activities in the developing world is provided for the purpose of information sharing.

2. Korea's national science and technology system

In the process of industrialization during the last three decades, the main thrust of economic development in Korea was high quality workers with lower wages, high rates of savings and protection of domestic industries. However, Korea's comparative advantage depending on these factors is no more effective as idle resources are no longer available and the economy is wide open to the world. The economic environment is rapidly changing as globalization prevails, and therefore needs for changing public policies are increasing for a successful transition to a knowledge-based economy. It is implied that Korea should look for other sources with a competing edge, particularly focusing on S&T or knowledge-creating activities; that is, innovation-based strategies for development are needed. (Branscomb & Choi, 1996).

In Korea, many ministries and agencies perform individual functions related to science, technology and innovation. The Ministry of Science and Technology (MOST) used to serve as the "lead agency," specializing in common, interdisciplinary and strategic areas, and assume responsibility for overall coordination of all other ministries and agencies. For the last three decades, MOST has been responsible for leading S&T activities in both the public and the private sectors. But as society becomes more diversified over time, and the importance of science and technology increases in wide-ranging socio-economic activities, S&T responsibilities and resources have been rendered to other ministries. Although the role of MOST is defined to carry out its own S&T operations and policies it is difficult for MOST to coordinate the policies and activities of other ministries and agencies. It is mainly because the national innovation system is in a relatively weak position, and lacks workable institutional mechanisms. The major ministries responsible for S&T activities alongside MOST, particularly in response to changing national needs, are the Ministry of Commerce, Industry and Energy (MOCIE), and the Ministry of Information and Communications (MIC).

Figure 1: S&T Coordination at the Government Level



It was pointed out that the S&T policy in Korea had lacked integrity of S&T planning. This is by and large due to the diversified system of S&T policy-making. Such diversification of S&T system increased needs for reinforcement of the coordination mechanism, to avoid overlap of investment by the different agencies of the government. In 1999, the government decided to establish the National Science and Technology Council (NSTC), chaired by the president, whose members are the ministers of the S&T related ministries. The primary function of the NSTC is to coordinate different interest groups within the government, and to set the national priorities for the S&T investment. The MOST serves as a secretariat to the NSTC.

Table 1: R&D management agencies of the government sector in Korea

Ministry of	R&D Management Agency	Area	Start year of R&D programmes
Science and Technology (MOST)	Korea Institute of S&T Evaluation and Planning (KISTEP)	Various areas	1982
	Korea Science and Engineering Foundation (KOSEF)	Target-oriented basic research	1987
Commerce, Industry and Energy (MOCIE)	Industrial Technology Policy Institute (ITEP)	Industrial technologies	1987
	R&D Management Centre for Energy and Resources (RACER)	Alternative energy	1988
Information and Communications (MIC)	Institute of Information Technology Assessment (IITA)	Information and communications	1991
Construction and Transportation (MOCT)	Korea Institute of Construction Technology (KICT)	Construction	1995
Health and Welfare (MOHW)	Korea Institute of Health Service Management (KIHM)	Medical care	1995
Agriculture and Forestry (MAF)	R&D Promotion Centre for Agriculture, Forestry and Fishery (ARPC)	Agriculture, forestry and fisheries	1995

Environment (MOEn)	National Institute of Environmental Research (NIER)	Environment	1992
Education (MOEd)	Korea Research Foundation (KRF)	Academic research	1996

According to such an evolution of the government structure and changes in policy-making mechanisms, many agencies with their own R&D management had been established, including technology foresight, planning, evaluation and control. As shown in Table 1, eight ministries are now engaged in R&D activities and have their own agencies for R&D management. Those agencies are responsible for technology foresight, planning, evaluation and resource allocation. However, most of them started their operation at the beginning of 1990s, so that their respective activities are still focusing on developing methodologies and uses. It is notable in such a situation that MOST with an accumulation of three-decade experiences in R&D management provided a framework for technology foresight activities in line with R&D management.

One of the successful models of technology foresight was made when MOST delivered, in 1992, a national R&D programme called the Highly Advanced National (HAN) Projects. The purpose of the HAN Projects was to increase competitiveness of domestic industries by increasing indigenous capability of science and technology. It was the first attempt in a systematic way, calling for inter-ministerial collaboration in S&T planning.

An evaluation of the HAN Projects three years after its initiation showed that the HAN Projects turned out to be quite successful. This can become a standard model for formulating S&T policy and planning the national R&D programme. A primary lesson from the foresight of HAN Projects places an emphasis on the concerted action among different interest groups and resource allocation by priority setting. Such a framework seems now to be inevitable and is frequently employed for major policy making, which was also employed when the MOST initiated to enact the S&T special law in 1997-targeting at a substantial increase in S&T capability through the five-year plan for S&T development.[35]

3. Technology foresight activities in Korea

As investment in science and technology is continuously increasing to cope with a rapidly changing environment, technology foresight activities are required for priority setting, R&D evaluation and control, etc. The foresight activity in Korea is historically not long-rooted, but it is recently observed that various R&D organizations actively carry out technology foresight.

The purpose of this section is to review the foresight activities in Korea. The foresight activities in Korea are undertaken by and large by the government sector. Due to lack of experience, however, the responsible organizations are still developing methodologies and uses for their own policy formulation. Only the first Korean Delphi has had substantial support from both the public and private sectors. As technology foresight or forecasting is a relatively new concept in Korea, the activities are undertaken in various ways. In formulation of the HAN Projects, the foresight process took about one year and more than 400 experts participated from industry, academia and government. The foresight procedure included three stages; i.e., preliminary stage, main foresight, and commitment stage.

In brief, during the preliminary stage, coordination and communication for the new national R&D programme took place between the ministries concerned including various interest groups. A foresight committee was also created. Then, during the main foresight activity, there were four phases. These included reviewing information about factors related to science and technology, addressing the objectives and selecting the candidate technologies for the R&D programme. A survey for the candidate technologies was undertaken for priority setting, and finally the committee selected eleven areas of science and technology. Budget allocation and control and R&D evaluation followed at the final stage. (Shin & Kim, 1994).

Besides the HAN Projects, it was not until the late 1980s that a major concern on technology forecasting at the national level was made firstly by a research team of the Science and Technology Policy Institute (STEPI).

35 However, since only limited number of experts participate in this HAN Projects-related foresight activities, it is required that the formulation of a new R&D program should be based upon more extensive information produced in a systematic way as well as supported by wide-ranging consensus among related actors in the socio-economic system. Thus, the importance of technology forecasting was recognized widely.

Since then, attention had been paid constantly, but not rigorously, to foresight, mainly due to lack of pertinent experts and research funds at the beginning. There had been a series of efforts for technology forecasting in the early 1990s.[36] In 1992, the research team was able to carry out a Delphi study for the long-range technology forecasting. (Shin, et al, 1994). A major step to the practice of technology forecasting was made in 1993. The Korean Delphi, characterized by three-round Delphi, was undertaken through three stages including preliminary activities, pre-foresight and main foresight.[37]

MOST has R&D management agencies, called KISTEP (Korea Institute of Science and Technology Evaluation and Planning), which was separated from STEPI in 1999.[38] If we consider the foresight activities in other government departments, we have to mention MOCIE, which has undertaken R&D programmes related to industrial activities for the last ten years. Under the auspices of MOCIE, the Institute of Industrial Technology Policy (ITEP) is responsible for management of R&D projects funded by MOCIE, including selection of technologies, fund allocation, and evaluation, etc. For the effective performance of industrial R&D, ITEP regularly undertakes technology foresight. Its foresight activities focus mainly on problem solving in the short term, usually less than five years. Its activities depend by and large on regular surveys of technologies needed by the industrial sector. In so doing, major criteria in selecting new technologies are the generic and core type of industrial technologies, import-substitution technologies, technologies creating high value-added, and environment-friendly technologies. ITEP also makes efforts to continuously develop various methodologies, and to refine its foresight activities.

Since MIC started its own R&D operation in the beginning of the 1990s, the investment in the information technologies has been sizable. Under the auspices of the MIC, the Institute of Information Technology Assessment (IITA) is responsible for R&D management and technology foresight in the area of information and communication technologies. IITA in particular undertakes R&D management and technology foresight activities focusing more on the normative approach. MIC has formulated a policy for information technology, making a giant investment in constructing nationwide information super highways by 2010. If such investment is on schedule, the communication services provided will be greatly improved in the near future. Therefore, with the case of the IITA, the demand side of technologies is the major factor to be taken into account when the R&D plan is formulated. Yet, (component) technologies to make new services feasible are addressed partly in terms of the S&T push approach.

Thus, we observe that the technology foresight activities of R&D organizations in Korea are closely related to their respective reality. Some place an emphasis on producing S&T information simply for addressing S&T opportunities, while some focus on strategy formulation of their R&D activities. Somehow, this type of activityis the effort to adopt a proactive and rational approach to S&T activities including S&T resource allocation. Such activities have stimulated to a large extent other institutions including industries in Korea.

4. Foresight framework for national R&D programmes

In general, MOST initiates planning the national project by organizing the committee including scientists and technologists employed in government, NPRIs, firms and universities. However, the role of social scientists was not well emphasized, although the motivation is rooted primarily in economic problems. Many studies suggest explicit procedures or agendas for technology planning. Those studies place an emphasis on how to arrive at the

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36 These were patient efforts devoted by the research team being stimulated and motivated by the Japanese Delphi. The research team invited experts, such as John Irvine from the United Kingdom, Kondo Satoru from Japan and Professor Martino from the United States, to learn more about technology forecasting, and continuous seminars and discussions were organized by the team.

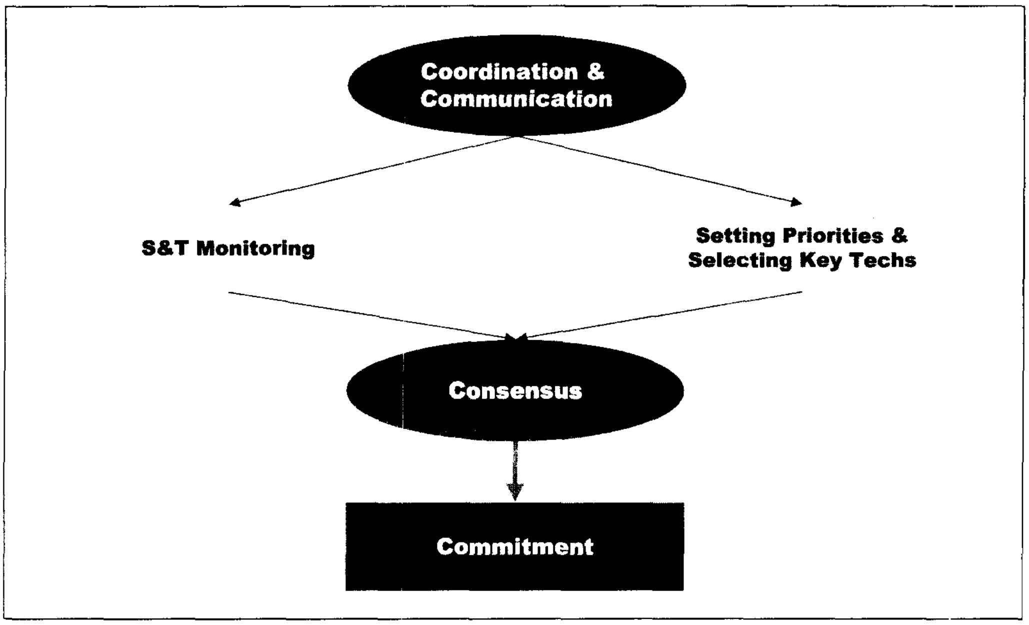
37 Martin & Irvine (1989) divided foresight activities into pre-foresight, main foresight and post-foresight. Since the Korean Delphi focused mainly on production of S&T information, the post-foresight activity was not carried out. However, the Korean Delphi provided valuable information for policy formulation afterwards.

38 The STEPI used to have two functions, *i.e.*, doing S&T policy studies and R&D management of national R&D programmes implemented by the MOST. According to recent reform in the public sector, two functions are separated. The KISTEP is under the control of the MOST, and all research institutes including the STEPI are under the umbrella of the office of the prime minister.

convergence of opinions of different actors of the socio-economic system. The foresight framework for the national R&D is illustrated in Figure 2. It includes extensive and costly activities: coordination and communication among policy-making bodies at the government level, monitoring emerging technologies and identifying problems; setting priorities and selecting key technologies; planning and implementing; and finally, control and evaluation.

The new S&T policy is the outcome of a process of coordination among different government ministries. This is no easy matter because MOST, concentrating on science and technology, does not have the political strength to pursue S&T policies in combination with other economic or industrial policies which are mainly exercised by the MPB (Ministry of Planning and Budget), MOFE (Ministry of Finance and Economy), MOCIE, MIC and others. Since the NSTC has been established, rigorous coordination is expected at government level.

Figure 2: Foresight Framework



In reality, technology planning or process interacts with various socio-economic factors. For economic consideration, the objective of technology process is placed on maximization of social welfare if it is carried out by the government; profits, if by the firm. Such behavior would lead to more efficient resource allocation.[39] Scientific and technological factors are related purely to technological attributes and capability. In general, the firm takes a 'breakthrough' and/or 'fusion' approach to research and development. The breakthrough approach can be defined as developing technologies step by step, i.e., the linear approach. For example, semiconductor replaced vacuum tube and the compact disk replaced the record album. Meanwhile, the fusion approach can be defined as a non-linear approach. It blends incremental technical improvements from several previously separate fields of technology to create products that revolutionize markets. For example, marrying optics and electronics created optoelectronics, which gave birth to fibre-optics communication systems. (Kodama, 1992). The fusion approach is increasingly emphasized nowadays. Therefore, it is important to monitor R&D activities in other areas. Ignorance in technological progress of other areas may lead to the failure of development of new technology. This leads to the recognition of the importance of production of S&T information through technology forecasting and setting priorities after selecting key technologies.

In a political environment, the planner is faced with pressure from various interest groups. On the other hand, in socio-cultural environment, the planner is faced with dilemma between individual freedom and collective dependence. All these factors interact with each other and influence the process of technology planning. Therefore, technology planning should be developed in an integrated way using all interacting forces. Nowadays, however, efficient resource allocation is increasingly important, because of the tendency of growing R&D scale and expenses. Society should demand and therefore support research and development in areas that

39 In the free market system, market failure leads to under-investment in R&D activities. This gives rise to government intervention.

are most likely to bring about solutions to the problems facing society. It is also recognized that S&T capability is the major source of competitiveness of a nation, as international trade falls into conflict. Therefore, efforts for technology planning particularly in regard to economic factors are needed today and are emphasized more than ever. Foresight activities require a process of taking into account those factors in formulating S&T policy. Therefore, building a consensus among different interest groups is critical.

Once a decision is made through the policy-making process, actions follow subsequently. In implementation of national R&D programmes, R&D management capability plays an important role, including selection of projects, control and evaluation. In most cases, government agencies are responsible for R&D management. However, the evaluation system is always controversial and requires continuous improvement. The evaluation system is complicated because it follows cultural background and social customary behaviours. The evaluation system is engaged in the process of R&D activities, and has a great influence on the continuity of an R&D project. On the other hand, national projects are getting increasingly larger in scale. Therefore, they are usually undertaken on a team basis, where the management concept has to be brought in. In many cases, heads of the teams are only scientists and/or technologists, who may not have the knowledge and skills of management. It is therefore necessary that training programmes should be provided regularly.

5. Foresight procedure in HAN projects: An example

As an example of the national R&D programme, the foresight procedure of HAN project can be divided into four phases. At Phase I, MOST collected and reviewed the information about emerging technologies. In Korea, no systematic S&T monitoring is undertaken at the government level. On the other hand, the committee studied the direction of a new programme in regard to long-term national goals.

It was recommended by the committee that the plan should pursue both product-oriented technologies and fundamental technologies. The product-oriented technologies are characterized as near-market products. They are expected to be developed and commercialized by the year 2001. These products must be developed at least five years prior to industrialization in their life cycles. On the other hand, fundamental technologies are characterized as more basic research, which brings an improvement of technological capability, although their final products may not be developed by the year 2001. Securing technological capability in those areas are critical in the future. Improving quality of life is also targeted. Research and development of fundamental technologies focus on the accumulation of experience and know-how in the area of highly advanced technologies. Based on S&T monitoring, 214 candidate technologies were selected. Those technologies were again classified into five major areas, such as microelectronics, mechanics, advanced materials and fine chemicals, energy, and life science and ecological system.

In Phase II, 214 technologies selected in Phase I were reviewed and aggregated in a similar fashion. This reduced the candidate technologies to 60 technologies. For 60 candidate technologies, the committee made a survey sending questionnaires to 439 experienced scientists and technologists. Out of 439 specialists, 42.1% sent replies. The main questions were as follows:

- Application potentials with an emphasis on economic impact
- Full cycle R&D through collaboration among NPRIs, firms and universities
- Need for support by inter-ministries of government
- Multi-disciplinary characteristics of technology
- Availability of a critical mass in the domestic economy.
- International joint project due to lack of domestic resources
- State of the art of technology worldwide
- Potential impact on competitiveness of domestic industry

A foresight study in five areas was organized and supervised by sub-committees. Each area had two subcommittees, except the area of electronics, which had four subcommittees. The function of all these committees was to monitor each technology on its research path and discuss impacts of the technology, based upon the above criteria. At this phase not only consensus about the national goal and objectives of HAN project was highly emphasized but also the involvement and commitment among the representatives of different agencies. The initiatives for the official decision for HAN projects took about one year.

In the science and technology process, an integral part is the S&T forecasting and/or foresight activities. In S&T foresight, by estimating economic, social and technological consequences of emerging technology, it usually sets priorities and selects technologies for which R&D should be carried out. It involves interacting activities among different environmental factors of technology planning. Different participants in foresight activity stand for different interests groups. Therefore, foresight can be regarded as 'planning as learning by interacting' among different interest groups.

Table 2: Key Technologies of HAN Projects

Product-Oriented Technologies	Fundamental Technologies
1. Highly integrated semiconductor 2. Integrated services and data network 3. High definition TV 4. New medicine and agricultural chemicals 5. Advanced production system	1. New materials in information service, electronics and energy 2. Next generation transportation systems including machines and parts 3. New functional bio-materials 4. Environmental engineering technology 5. New energy resources 6. New atomic reactor and verification

Technology forecasting, on the other hand, is deterministic and provides basic information for estimating consequences of new technologies. Science and technology forecasting deals with probabilistic statements on the emergence of science and technology in the future. The primary purpose of forecasting is to select technologies to be forecasted and to predict the time of occurrences of technologies. There are various methods for science and technology forecasting, such as the Delphi method and trend extrapolation. The Delphi method is widely employed where historical data of the technical approach of a specific technology is not available. It draws a convergence of opinions of panelists, sending questionnaires repeatedly with feedback.

The committee finally selected eleven technologies: five product-oriented technologies and six fundamental technologies. It was argued that the product-oriented technologies would substantially increase competitiveness of the domestic industry in the future, while the fundamental technologies would secure capability of source technologies and hence indigenous science and technology capability.

At Phase III, component technologies in each area are surveyed, and the research team and R&D budget are also determined. The agency of MOST and STEPI, calls for research proposals relevant to one of 13 areas. The applicants organize their research team and submit their proposals to the STEPI. After collecting applications, a careful review of the proposal is made by the specialist panel in each area. The coordinators in the STEPI organize ad hoc committees and panel discussion case by case in the process of evaluation of proposals. Finally, at Phase IV, the control and evaluation system was implemented, for which the government agency (STEPI at that time) was responsible.

6. Concluding remarks

At the beginning of the 1990s, the Korean government changed the direction of S&T policy from the bottom-up to the top-down approach. The bottom-up approach in the past turned out to be unsatisfactory with increasing national competitiveness. Since the firm's capability of technology is a major source of competitiveness, improving indigenous technological capability came into focus as the economic environment in the international society changed and the domestic economy is slowing down. In Korea there were trials and errors through the S&T policy in the past national R&D programmes. Thus, changing its policy direction to the top-down approach, the government set the long-term national goal and decided to pursue research and development strategically utilizing NPRIs more effectively. The newly launched national R&D programme, the national project, however, requires a careful foresight in setting priorities and selecting key technologies to be strategically developed.

Referring foresight activities so far in the national project as we have discussed, first by putting more information onto foresight activities technology forecasting should be emphasized. Since the national project covers extensive areas of technologies, global monitoring of technological development should be made at government level, and more information should be provided to individual researchers. It is also pointed out that the importance of technology forecasting is in the interaction of participants by the two-way flow of information and hence in the process, not simply in the results. (Martino, 1983). Monitoring R&D performance in other areas is very important, and an individual researcher might have difficulty following up, since the fusion approach to technology development is increasingly emphasized. Therefore, technology forecasting must be taken into account in line with foresight activities.

Secondly, in the S&T process, production and transfer of knowledge is a two-way process, which influences normative values of participating actors. Together different actors in foresight produce possible pictures of the future when they will act according to the knowledge generated during the foresight process. Therefore, it is important to include as many actors standing for different factors in the socio-economic system as possible. Since the national goal in most cases is derived from economic motivation, the S&T process in the national projects should take account of economic perspective of technologies more comprehensively. Hence, the role of social scientists should not be under-estimated.

Thirdly, at the commitment stage, the control and evaluation of research and development are critical. Various methods are available. However, development of the control and evaluation system should address in a way that ongoing projects should not be eliminated too early. Because the likelihood of success for the development of selected technologies is best estimated by researchers themselves. In addition, more emphasis could be placed on educating researchers to keep the R&D activities on the scheduled track.

All in all, it is important to note that S&T policy-making can be recognized as a social process, for which no stereotypic model exists. Different societies may have different tools and processes. Therefore, in the process of S&T policy making, a concerted action is by far emphasized at various levels of decision-making. Building a consensus in such a way will make policies effective.

References

Branscomb, L.M. & Choi Y.H., Korea at the Turning Point; Innovation-Based Strategies for Development, Praeger, London, 1996.

Grupp, H., Foundations of the Economics of Innovation. Theory, Measurement and Practice, Elgar, Cheltenham, 1998.

Kim, S.S., "Coordination of S&T Policies in Korea," mimeograph, STEPI, 1999.

Kodama, F., "Technology Fusion and the New R&D," Harvard Business Review, Vol.70, No.4, (1992).

Lim, K., Chung, K.H. & Cho, H.H., "Technology Forecast & New Technology in Korea by the Delphi Approach," Contribution to the 7th International Forum of Technology Management, Kyoto, Japan, November 1997.

Martin, B.R. & Irvine J., Research Foresight: Priority-Setting in Science, Printer Publishers, London, 1989.

Martino, J.P., Technological Forecasting for Decision Making, 3rd Edition, McGraw-Hill, New York, 1993.

Shin, T. & Kim, H., Research Foresight Activities in Korea and Technological Development; S&T Policies in National R&D Programme, Technological Forecasting and Social Change, 45 (1), 1994, pp. 31-45.

Shin, T., Park J.H., Jung K.H. & Kim H.S., The First Science and Technology Forecast Survey; Korea's Future Technology, STEPI, Seoul, 1994 (in Korean).

Shin, T., Using Delphi for a Long-Range Technology Forecasting and Assessing Directions of Future R&D Activities in Korea, Technological Forecasting and Social Change, forthcoming, 1998.

T. Shin, Soon-ki Hong and Hariolf Grupp, "Technology Foresight Activities in Korea and in Catching-Up countries", Technological Forecasting and Social Change, (December, 1998).

Sutrasno, T. et al., Indonesian Technology Foresight and Regional Technology Specialization, in APEC, MSTE, NSTDA (eds), Technology Foresight, NSTDA, Bangkok, 2nd ed., 1997, pp. 81-86.

Vilaithong, T., Future Key Technologies for Thailand: a Study Project, in APEC, MSTE, NSTDA (eds), Technology Foresight, NSTDA, Bangkok, 2nd ed., 1997, pp. 141-145.

Yanga, D.M., Technology Foresight Programme in the Philippines, in APEC, MSTE, NSTDA (eds), Technology Foresight, NSTDA, Bangkok, 2nd ed., 1997, pp. 131-134.

Yuthavong, Y., Strategic Directions for Science and Technology Development in South-East Asia, in: Anderson, Fears and Taylor (eds), Managing technology for competitive advantages, Cartermill, Financial Times, London, pp. 97-109, 1997.

Appendix: Foresight Activities in Developing World[40]

A.1 South-East Asia

Southeast Asian countries have long histories with each country showing distinctive characteristics of its own. With the exception of Thailand, all countries in the region have gone through periods of colonization, and all have developed a strong sense of cultural identity. (Yuthavong, 1997). With the exception of a few countries, the region has a very high and sustained economic growth of around 8% per year. This economic success cannot hide that the science and technology achievements are still peripheral by world standards. While there has not been any foresight exercise in Southeast Asia on the scale seen in Japan, Europe or Korea, it is nevertheless possible to report on earlier attempts to shape the future of the national innovation system of these countries and to anticipate the future role of innovation in Southeast Asian societies.

In the believe that knowledge generated elsewhere in the world can be applied for economic and social benefit, very little basic research is done in the region. Southeast Asian countries tend to perform better in applied science and technology areas than in basic science. Yet, we witness an unwillingness of the private sector to invest in technology development. Still a large number of students are on scholarships overseas and the governments in the region try to bring back their skilled staff from abroad by a number of incentives. (Yuthavong, 1997). It can generally be regarded as a problem that technology development is largely pursued in a non-business environment. What is the responsibility of the market forces in industrialized countries is considered a government task in most south-east Asian countries having economic and social development plans which typically look forward five years. When these are formulated some elements of short-time foresight on major science and technology components are embarked upon. Malaysia Singapore and Thailand, in addition, have articulated "visions".

Let us briefly have a look at selected countries. Recently in Thailand a study of future technologies has been undertaken. 400 scientists and engineers were asked to assess the likely future importance of various technologies by the Delphi method. The time of realization, possible constraints and other typical questions were raised. The technology areas chosen for the survey comprised basic technology, biotechnology, biomedical technology, metals and materials, transport, energy & environment and electronics & computer technology (software and hardware). In the questionnaire, economic benefits and welfare criteria for Thailand were broken down into five categories: farmers income and agro-industrial development, the economic value of plants, animals and microbes, the competitiveness on the technology level of industries, the emphasis for shifting labor-intensive to knowledge-intensive industries and people's access to, and utilization of, information and technology. This seems to be a very specific implementation of national, social and economic progress.

The results and conclusion from this Delphi survey, first of its kind in Thailand, will not be elaborated here as a number of identified technologies are quite similar to those expected to be of importance for developed countries. Although we noted that the five criteria to define economic and social progress were specifically designed for Thailand, and hence it could be expected that the findings of the study are equally specific, it seems from the results that the technologies that will be important for Thailand are about the same ones that are important for industrialized countries. This suggests, as Yuthavong (1997) concludes, that "global competition within the technology areas is likely to intensify as the developing countries upgrade their capabilities".

40 For the purpose of sharing information, this part is taken from T. Shin, S. Hong & H. Grupp (1998).

The most serious obstacles found in the Thai foresight survey relate to the lack of well-qualified and high-potential personnel in science and technology, to good planning procedures in S&T as well as on efficient organization with good entrepreneurial innovation management for R&D, among others. (Vilaithong, 1997) What concerns the next future, the Thai government is likely to invest a budget to the APEC centre for technology foresight over the years 1998 to 2000 in order to conduct a feasibility study. This centre is likely to be set-up in Thailand at the Chiang Mai University, which performed the first Thai Delphi study.

In the Philippines, a technology forecasting committee was created in 1995, which is composed of policy makers, representatives from national scientific and economic authorities, academia and the private sector. The committee used the panel approach but also considered to employ the Delphi method. (Yanga, 1997) However, as Delphi involves iteration of expert opinion, synthesis and feed-back, due to insufficient time and mainly because the attempt was the first technology foresight access in the country until now the outcome of this thinking stage is not known.

Likewise, in Indonesia a technology foresight project was implemented by a national agency. The project covers technology topics in eleven fields and employs the usual Delphi method with variations. In some areas investigated there was only a single survey round and also the brainstorming technique was effectively used in some cases before going into the second round and having the respondents work on a list of priority topics previously selected. This project is midway toward its scheduled completion when this article was written. A number of difficulties in collecting responses are already apparent and present a challenge towards successful implementation of the project as initially envisioned. One of those problems is that the pool of available experts is heavily concentrated in government R&D institutions and universities - a phenomenon likely to be found in other developing countries as well (see above). Among the highly rated topics of investigation are items such as the development of electric train technology for mass transportation and the development of a model for energy planning that would observe the social, economic and environmental aspects. (Sutrasno, 1997) Other topics concern natural gas fueled motor vehicles and industrial core generation technology. All these topics are less ambitious than in industrial countries but finely tuned towards the needs of Indonesia. In the future, Indonesia is likely to support the above-mentioned APEC centre for technology foresight and to share the Indonesian experience of conducting the first technology foresight activity with other developing nations.

In 1994, China conducted a technology foresight exercise to select key technologies essential to national development. Reportedly, the technology foresight has played a very important role in S&T decision-making at the national level. Likewise Chinese Taipei has been utilizing technology foresight methodologies to identify major strategies for S&T development in different stages.

A.2 South Africa

South Africa is reorienting its national science and technology and innovation system drastically. Since recent years the apartheid system was abandoned which triggered off many new activities. The National Research and Technology Audit (NRTA) is a major government initiative to assess the strength and weaknesses of South Africa's present scientific and technological base and its capacity to respond to the opportunities and risks the nation will face in the future. The audit is the responsibility of the Department of Arts, Culture, Science and Technology (DACST), which has requested the Foundation for Research Development to manage the audit. A central part of the audit is scoping the future trends that are likely to impact on the South African economy, environment and society over the next five to 15 years, against which the strength and weaknesses of the present science and technology system may be judged.

A national foresight project is running in South Africa at the time when this article was written. The foresight team is based at the DACST but staff from the Council for Scientific and Industrial Research (CSIR) is participating looking particularly at methodological instruments, for instance scenario development.

The foresight project has been divided into twelve socio-economic sectors. Working groups are now being established in each of these sectors in a similar way as in the UK foresight programme. As in Britain, a co-nomination technique is used to establish the list of respondents. When adopted, these groups will take the work to a foreseen completion at the end of 1998. The methodologies employed will include scenario development both looking at the possible futures for the South African S&T system and at individual sector scenarios and some sort of opinion survey. If this will take the form of a modified Delphi for South African conditions, was not decided at the end of 1997.

At the same time at the CSIR foresight processes to fit a knowledge-based institution are going on. The CSIR 2020 foresight exercise was initiated in mid 1997 with the objectives to incorporate long-term perspectives into the business planning process and to identify and monitor trends in science and technology. Also the establishment of a culture of future thinking within the organization is aimed at. This process is scheduled to run annually by foresight champions in each of the CSIR's divisions. The methodologies adopted include tools such as Delphi surveys, scenario development, co-nomination, trend analysis and others to various degrees.

A.3 Latin America

In December 1996, representatives of Latin American countries (Argentina, Bolivia, Brazil, Chile, Mexico, Venezuela and Puerto Rico) met in Santa Cruz de la Sierra, Bolivia, to discuss foresight activities and cooperation in foresight. The meeting was initiated and organized by the United Nations Industrial Development Organization (UNIDO). Representatives from European countries (Germany, Italy, the Netherlands, United Kingdom) and Japan were invited to present their experiences. There had been already smaller foresight activities in Latin America, especially in Brazil, but they are regarded as insufficient.

As a result of the meeting, an agenda was set up which describes the volition of Latin America countries to do foresight activities with different approaches. A core group with representatives from Argentina, Bolivia, Brazil, Mexico and Venezuela met in Madrid twice and elaborated a framework on foresight. This framework is supposed to be the basis of a project document, which was just finished, when this contribution was written.

The project shall follow the framework, i.e.

- Promote the foresight concept,
- Provide training and technical assistance to foresight practitioners,
- Give practical experience in the form of two or three multi-country studies, and
- Set up a virtual technology foresight centre.

The project will be supported by the National Science and Technology Councils in Brazil, Chile, Colombia, Uruguay and Venezuela as well as the United Nations Educational, Scientific and Cultural Organization (UNESCO) and ANEP in Spain. Some other science and technology councils still need to be convinced.

Separately, a publication is in preparation, which would provide guidelines for developing countries to help them decide for and undertake technology foresight studies as an input to policy-making and the formulation of technology strategies on the firm's level. Technology foresight in Latin American countries will in general focus on technology and products that meet the specific needs of the region and that can be produced and applied in the different countries.

GERMANY: THE NEW FORESIGHT APPROACHES

Kerstin Cuhls
Germany

Abstract

In this presentation, the new foresight approaches in Germany will be described. Germany started its foresight processes at the beginning of the nineties with two larger projects: 1. Technology at the Beginning of the 21st Century and 2. the first German Delphi study on the development of science and technology. These have already been described in a previous paper presented to the Latin American countries (Cuhls 1996).

In 1995, Mini-Delphi studies were conducted in parallel with the Japanese National Institute of Science and Technology Policy with the aim of learning about and improving the Delphi methodology. In 1996, the second large German Delphi study (Delphi 98) made use of these experiences. 30% of the topics were again comparable to Japan, in order to find out if national idiosyncrasies can be determined in a survey like this. The study concerned 12 thematic fields. A report on the results was published and provided to all interested institutions, organizations or persons. The results are now also available on the Internet. Companies especially made extensive use of the data for their strategic planning, the Fraunhofer Society based its evaluation on it, and the media also supported by publishing articles on Delphi 98.

The latest foresight approach is just starting: FUTUR involves not only "experts" but also interested persons from the general public. The platform for the exchange of information, for a discussion about the future and for creating a database of persons who can interact in a network is the Internet (www.futur.de). Additionally, in working teams, methodology is applied to explore and discuss future topics. The first two fields that are already started are: "Mobility & Communication" and "Health & Quality of Life". The first workshop already took place in June. The next larger workshops are planned for January 2000.

Introduction

The German economy is proud of its high export quotas. The German market is open to international competitors, and Germany itself is at the centre of a far-reaching innovation competition. However, many problem areas remain and make stringent requirements on the economy: setting priorities, the allocation of financial resources, and the strategic orientation of research and development in Germany are challenged. Science and technology policy had to adapt to the fact that national research and development (R&D) budgets will never be sufficient to support all suggested projects. There must be a rational process to set priorities and to concentrate the financial support on them. Non-financial support is becoming more and more important. Therefore, the desire to identify those technologies which will have the greatest impact on economic competitiveness and social welfare is expressed from various sides. These 'emerging technologies' may be science-based and are likely to need a high intellectual capacity, which has to be provided and supported by the education system.

This was the reason for Germany to start foresight activities on a national level. Science and technology shifted towards a longer-term future orientation and new strategies for policy. New methods are being tested and used to identify 'emerging' technologies and developments of science and technology as well as their general impacts. This was regarded as insufficient so that the new concepts in German foresight also look at the economy, the society, the environment and other impacts. Some of the later projects testing new methods for foresight purposes are being conducted at the Fraunhofer Institute for Systems and Innovation Research (ISI) in Karlsruhe, on behalf of the Federal German Ministry for Education, Science, Research and Technology (BMBF, until 1994 BMFT). These projects are introduced and it is described how this new knowledge is used and implemented in the national R&D system. The Latin American countries are in a different economic and social situation than Germany, but the need to conduct foresight and improve methodologies might be the same.

Change in the German Science and Technology Policy

During the eighties, German science and technology policy was not very active in foresight. It was predominantly a decade of strong support for basic research, mainly in large facilities, following the recommendations of scientific advisory committees in the seventies and at the beginning of the eighties. The federal government switched after years of technology enthusiasm 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 (for details see Cuhls/ Uhlhorn/ Grupp 1996).

The increasing technological change and the globalization of the markets, as well as the special situation after the re-unification of Germany with its severe budget restraints made the responsible persons at the BMFT (now BMBF) change their minds (Martin 1995). Longer-term perspectives and strategies to make better use of the limited resources were looked for. The selection for the support and the more goal-oriented prioritization of certain technologies seemed to be necessary. On the other hand, the state 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 in Germany had just been overcome with the unification.

Certainly, as Coates (1985, p. 30) 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.' In addition to the fact that a foresight process must be systematic and comprehensive, must be able to accommodate a wide range of information, must be public and avoid prediction, German ministries had to make allowances for suspicion in the public opinion.

Thus, it was considered a political question whether state bodies should give more emphasis to direct intervention in research matters (e.g. by financing specific R&D projects from industry) or to more indirect support (e.g. tax reductions for R&D projects or subsidies to those companies hiring new scientific and technical staff).

In the beginning of the 90s, the necessity of concentrating their resources made all parties more interested in foresight and therefore some long-term prospective studies were commissioned in 1991, in order to get some early indications of the most promising developments in science and technology. As 'awareness of potential research opportunities is not sufficient, information is also required on three other sets of factors: (i) likely trends in socio-economic needs, and demand for research; (ii) internal strengths and weakness in R&D, and relative international standing across strategic scientific and technological fields; and (iii) the domestic capacity to exploit, commercially or otherwise, the results of promising research' (cited from Irvine/ Martin 1989, p. 12).

The term 'foresight' is used in the sense of 'outlook'. This is not the same connotation as a 'prediction' which would be closer to 'forecast'. Foresight takes into account that there is not a 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' (cit. Martin 1995). Starting as 'risky projects' and earning harsh criticism in the beginning, the German foresight studies later on turned out to be widely accepted by those who could make use of them. But the methodology of the surveys and the strategic implementation into national policy and companies' strategic planning still have to be improved. Therefore, the new German activity FUTUR is the test of an Internet-based new interactive approach including not only specialist "experts" but also the general public as the users of new technologies.

There are already various methods for technology foresight available for a long time. Holistic approaches are applied to get an overview but are not sufficiently specific for details. Thus, approaches on the macro-, the meso- and the micro-level are needed in combination. The organization of the foresight process may also vary, depending on the country and its R&D system, the circumstances and so on. The most relevant methods used in enterprises, which can also be important for national foresight, and their effectiveness differ (Grupp 1996, p.74). More emphasis was posed on the qualitative-quantitative combinations of methods, not only the quantifiable part of future directions. The BMFT at first decided not to use one single approach but a broader range of studies to have a fundamental basis to make choices and to combine data.

As most of the methods are already well-known and applied in general (indicators, literature, analysis or trend extrapolation see Cuhls/Kuwahara 1994, p. 3, Cuhls 1996), in the following sections the new approaches with the relevance tree and the different Delphi studies as well a short outlook on FUTUR are described. They are - beneath the scenarios - the most useful methods for technology foresight.

The longer-term foresight activities in Germany

The three methods which are applied in Germany for longer-term foresight all fulfil the following functions, which are defined as the major classification for purposes of foresight by Irvine and Martin (1989, p.30 f.): 1. Direction-setting, 2. Determining priorities, 3. Anticipatory Intelligence, 4. Consensus-generation [1], 5. Advocacy and 6. Communication and education. Public and private institutions can make use of these foresight studies (see also Cuhls 1998).

[1] There is a new understanding of this function: Foresight is more important to find out if there is a consensus or potential conflict rather than create a consensus.

- To explore the effects of extending current policies;
- To widen the range of choices regarding current policy and to clarify their possible consequences;
- To provide early warning about potential or normally unanticipated difficulties;
- To provide an early alert to potential new opportunities; to test the consistency of a policy, both internally and with regard to other policies;
- To provide a context for planning (...);
- To explore unlikely but highly significant or seriously disruptive developments (the so-called wild cards);
- To suggest the appropriate focus for economic, technical, social, environmental, or other monitoring and research (cit. Coates 1985, pp. 32f.), and
- To facilitate communication between the different actors in the innovation system.

Technology at the Beginning of the 21st Century

Technology at the Beginning of the 21st Century (Grupp 1993 and 1994) was a BMFT sponsored project which started in 1992 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, learning from Japanese and US 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. This project is already described in Cuhls 1996 in more detail.

In the Federal Republic, the BMBF and its predecessor BMFT 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 analyze situations, in which distinct levels of complexity or hierarchy can be identified. Each successively lower level involves finer distinction or subdivisions (Martino 1983). The time horizon of the study was approximately the year 2000.

The study on 'Technology at the Beginning of the 21st Century' concentrates on (see Grupp, 1993 or 1994)

- 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 one hundred technologies has been established. In bilateral and panel discussions, this list was redefined and regrouped. The list was 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 to be considered most important by the staff of the programme operators. The form exists of four pages, one for description and demarcation of the technological topic, including product 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, and on the relation to other technologies as well as the quality of the assessment.

The project team considered two separate sets of criteria as important. One relates to basic conditions like infrastructure and financial requirements in Germany. With the notion of specialization and division of labor, the aim was to find out what makes the development of the given technology important for Germany in distinction to other countries. The second set of relevance criteria tried to cope with the requirements of 'growth by intelligence' and sought to provide information on the problem-solving capacity or potential of the given technology. This means that the traditional economic criteria on competitiveness were brought together with other criteria related to health, environmental problems and so on.

As a result of the interrelations, a two-dimensional representation of technological overlaps was worked out. By means of multi-dimensional scaling of the technologies (whereby their distances represent the closeness of the technical content as judged by the technical experts), it could be shown 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 appropriateness of technological opportunities by firms.

Finally, the dynamics during the following 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 (Grupp 1992). 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. If an estimation was not possible, the anticipated temporal development was expressed in phrases.

As this was 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, a first discussion of 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. The co-ordination and communication about these new technologies by the programme operators is facilitated.

The first comprehensive German Study on the Development of Science and Technology (Delphi '93)

The Delphi method was originally developed in the 50s by the RAND Corporation in Santa Monica, California. This approach consists of a survey conducted in two or more rounds and provides the participants in the second round with the results of the first so that they can alter the original assessments if they want to - or stick to their previous opinion. Nobody 'looses face' because the survey is done anonymously using a questionnaire (the first Delphis were panels). It is commonly assumed that the method makes better use of group interaction (Rowe et al. 1991, Häder/Häder 1995) whereby the questionnaire is the medium of interaction (Martino 1983). The Delphi method is especially useful for long-range forecasting (20-30 years), as expert opinions are the only source of information available. Meanwhile, the communication effect of Delphi studies and therefore the value of the process as such is also acknowledged.

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 acknowledged (for an overview see also Cuhls 1998). Therefore, the ISI collaborated with the Japanese National Institute of Science and Technology Policy (NISTEP), an institute of the Science and Technology Agency (STA). The German Delphi Team took the 1.150 topics prepared for the Japanese fifth survey and translated them into German. Only three of them could not be translated at all for cultural reasons. One of those topics concerned hybrid rice, one 'cosmetics especially for Japanese skin' and the last was about 'organ transplants like in Europe or the US' (for details see the publications on the Delphi in the literature list).

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 or more rounds. In order to make the two investigations independent of each other ('double blind'), it was arranged that because of this 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 (BMBF 1993). In both cases, about 3,000 experts have been addressed; the response rate in the first round was above 80 per cent in Japan and about 30 per cent in Germany. In the second round by comparison to the first, more than 80 per cent of the respondents participated in both countries.

There are three main reasons for a lower response rate in Germany only in the first round (in absolute terms, detailed and time-consuming questionnaire surveys with a response above some 15 or 20 per cent are considered successful as a rule of thumb). First, the Japanese institutes ask possible participants in advance if they are willing to fill in the questionnaire. Only the persons who agree are really provided with a questionnaire to be filled in. Second, up to very recently the German government was not very actively involved in technology foresight activities. With the notion of 'unpredictability' of events in science and technology, this activity had not been appreciated by other public science bodies either. Therefore, the confidence of the respondents in meaningful results is assumed to be low. The third reason is that - due to the pilot character of the survey in Germany - it was difficult to predetermine the most pertinent sub-area of expertise of each respondent. In an attempt to overcome these difficulties, 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), even postal delivery of some questionnaires was not possible there.

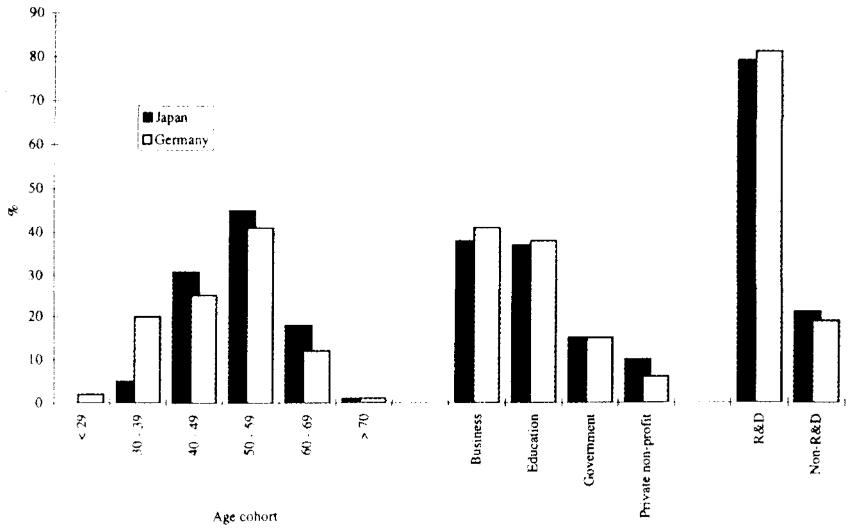


Figure 1: Who are the experts?

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 is from industry and the remainder from government laboratories, independent or non-profit institutions. The age peak of the respondents is between 50 and 60 years, the second most important age group is between 40 and 50 years in both countries. The time-consuming task of fine-tuning the German sample by age cohort and employment and matching this to the Japanese model finally paid off. No major differences in the way of answering the questions are expected from these factors.

The objective of the Delphi investigation was to find out about the degree of importance assigned to the topics by the experts, the time of realization between 1995 and 2020, major constraints on realization or reasons for non-realization, the precision of time determination and the necessity to co-operate internationally in pursuing technology progress. Also the degree of expertise of the participants was self -estimated.

As was expected, 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. 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 the first round, the German participants seemed to rate the time of realization generally a few years earlier than the Japanese and tended to downplay technical obstacles. 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 worldwide scientific and technological information (including Japan despite the language barrier). The second round underlined that the results were similar. In the final analysis of the sum of all items, there was no difference in the Japanese and German estimates. (For further details see the Japanese - German comparison undertaken in 1993/94, published in Cuhls/Kuwahara 1994.)

At the other extreme, for individual topics strong discrepancies in both surveys are found and in many details the dominance of national communities and systems of innovation becomes obvious. The main conclusion for these cases would be that Delphi inquiries on science and technology should always be undertaken with an international panel, including people from several countries and continents. But for many topics no such extreme and simple results were found, but congruent and diverging results at the same time.

There are many possibilities to use the huge amount of Delphi data for individual purposes. One example can be to draw scenarios from the data which are more application-oriented, e.g. the house of the future (see, for instance, in Grupp 1995, pp. 85). The Delphi data were available as a book and on the Internet. Many stakeholders in the German innovation system made use of them (see below), although no implementation phase was planned. But the Japanese - German comparison of the data offered rich opportunities for further analysis both in terms of priority-setting for S&T policy and innovation strategy as well as for technology analysis. One use for companies is to examine every single topic which might be relevant. Another possibility would be to identify the own market position and that of potential competitors.

The 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 (table 1). The Mini Delphi was 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 Berlin 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.

Table 1: Areas surveyed in the Mini Delphi

Materials and Processing:
• Photovoltaics (1)
• Superconductivity (2)
Microelectronics and Information Society:
• Cognitive Systems and Artificial Intelligence (3)
• Nanotechnology and Microsystems Technology (4)
Life Sciences and the Future of the Health System:
• Cancer Treatment and Research (5)
• Brain Research (6)
Problems of the Environment:
• Waste Processing and Recycling (7)
• Climate Research and Technology (8)

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.

In Japan, a higher response rate could be expected (because of previous contacts with the method), so that the questionnaire was sent only to 723 persons. They had been asked in advance (per postcard) if they would be ready to participate, so the German and Japanese response rates in the first round cannot be compared directly. In the second round, the response rates were quite similar (73.5 per cent in Japan, 74.6 per cent in Germany), so that 551 Japanese and 627 German answers from science, industry and other institutions are available (for details see Cuhls/Breiner/Grupp 1995).

One major target of this study was to improve the methodology. Not only the self estimated expertise and the time of realization was asked for, as it was 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 the price competitiveness.

In the last category, the framework conditions had to be evaluated. How are the engagement of industry, the regulations, public support, international co-operation, 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 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. But the media were so interested that they published the results without waiting for the official press release (which had to be cancelled, then).

The second comprehensive German Study on the Development of Science and Technology (Delphi '98)

As foresight gained attention in Germany and most of the restraints mentioned above still remained, it was obvious that Germany needed further concepts to develop the necessary degree of effectiveness to make innovative leaps. Especially for research programmes or companies' strategies, information about the future are requested to base general decisions on them. Therefore, the Germany foresight activities were supposed to provide more information about the future, concerning also those actors who are not able to gain this knowledge alone (e.g. small and medium size companies, research institutes, "the public"). The second aim to start the second comprehensive study in 1996 was to make the different experts in the system be aware of the future, think long-term, take their views for granted and create a certain commitment for actions in the different fields (see the 5 Cs of Martin 1995).

The Federal Ministry for Education, Science, Research, and Technology (BMBF) took the initiative and resolved to finance and carry out a foresight activity (Blind/Cuhls/Grupp 1999). The Fraunhofer Institute for Systems and Innovation Research (ISI) was again given the task of managing this project (Cuhls/Blind/Grupp 1998; Cuhls/Blind 1999). Federal Minister Dr. Jürgen Rüttgers established a steering committee made up of prominent members from science, industry , and the media. The committee was given the task of advising the Ministry in all decisions concerning the establishment of important framework guidelines. The goal was to provide answers to the following, critical key questions - and perhaps to other questions that had not previously been addressed in such an explicit way (Table 2).

- In what areas of innovation can significant advances be expected to take place during the next 30 years?
- What success concepts are linked to these?
- What impact can these significant advances be expected to have on economic development?
- In particular, what impact can they be expected to have on work and employment?
- How can technological innovation contribute to the solution of ecological problems?
- How will the development of society be affected by advances in innovation?
- Which results of research and development will produce the greatest increase in human knowledge?
- Within what time periods can the success concepts in the individual areas under study be realized?
- Which countries currently exhibit the highest degree of advancement in the various areas of research and development?
- What steps will be required to permit Germany to keep pace, or even become a leader in those areas of R&D, in which it is currently perceived as being weak, and how can this be translated into practical success?
- What problems can be expected to arise if the anticipated innovations are realized and utilized, and the resulting products must, at some point in the future, be disposed of?

Table 2: Key Questions

To answer these questions, the Delphi method was applied again. Criteria, questions and the new category of megatrends were further developments of the methods (Blind/Cuhls/Grupp 1998). The most important areas of innovation in the future were selected according to the questions mentioned above (table 3).

1. Information and Communication
2. Service and Consumption
3. Management and Production
4. Chemistry and Materials
5. Health and Life Processes
6. Agriculture and Nutrition
7. Environment and Nature
8. Energy and Resources
9. Construction and Living
10. Mobility and Transport
11. Space
12. Big Science Experiments

Table 3: The fields of the Delphi '98 survey

Expert groups of more than 100 individuals in total with specialized knowledge were contacted from such diverse areas as industry, higher education, and other institutions. They were responsible for gathering the most important information about the above-mentioned fields from the area of research and development; topics were then formulated as statements during the course of workshops and during "virtual meetings". These statements about the future were redefined several times. As a further requirement, the innovations selected were seen as likely to be realized within approximately the next 30 years, but not later.

A total of 1,070 future "predictions" were selected and formulated as positive visions - a list that, even without answers, is important and interesting itself. Based on the good experiences in the past, a portion of the developed topics were also worked out in co-operation with the Japanese National Institute of Science and Technology Policy (NISTEP), which was, at the time, organizing the sixth Japanese study on the future of science and technology. This provided a means of performing international comparisons and a means of determining whether additional surprises could be expected to come out of Asia, or whether German (or European) "blinkers" were preventing us from having an objective view of the future. A comparison with other countries would also be interesting, but very difficult because of timing and different methods. For example, the British colleagues had a different approach, and as they had just finished their first foresight programme, it was not planned to start the next one that soon. In addition, care was taken to ensure that an additional portion of the topics of the first German Delphi survey was included, in order to permit time-line comparisons, and to test whether our assessment has altered in the last five years.

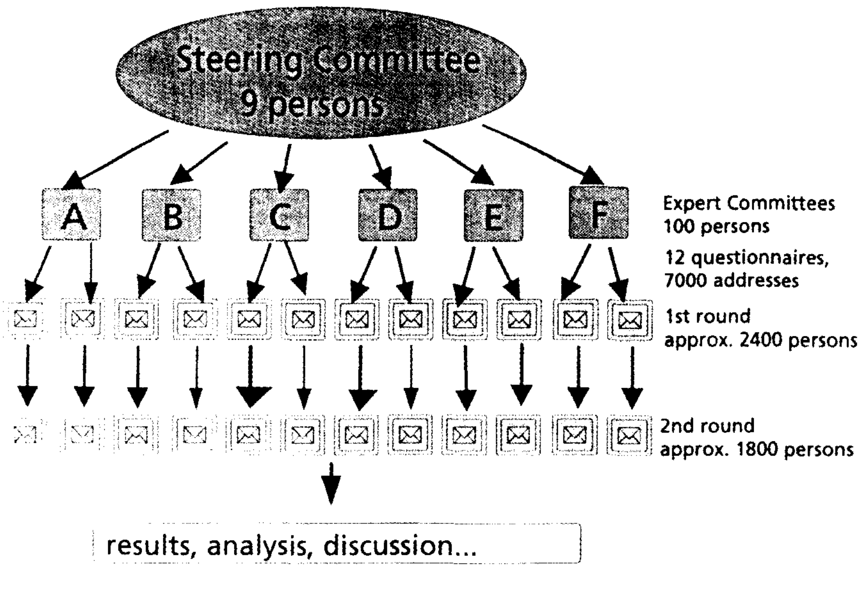


Figure 2: Organization of the Delphi-Process

All remaining assessments were undertaken by a significantly larger circle of specialists in the various areas of science and development (figure 2). Because a 30 % response rate could be expected in the first round, about 7,000 experts were approached. Around 2,400 experts answered and were contacted for the second round. 1,856 persons valid answers were received in the second round. The definition of exactly who is considered to be an expert is very broad. The individuals surveyed included those who are themselves actively carrying out research in a particular field, as well as those who regularly obtain first-hand information about the field.

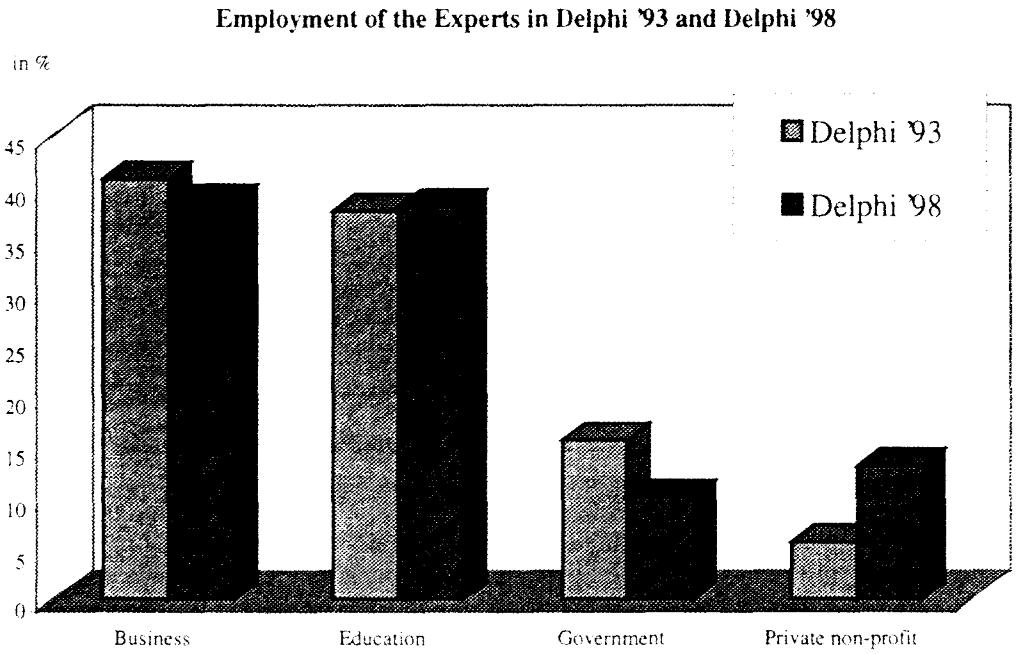


Figure 3: Who were the responding experts?

The surveyed experts come from professional backgrounds as diverse as industry, higher education, public service, private non-profit institutions (e.g. the Fraunhofer Society or the Max Planck Society), and associations. In addition, they should be involved in research and development work. None of the selected individuals will be in a position to answer every question in the entire questionnaire with "a great degree of specialized knowledge", as this would mean he or she were active in every area covered. For this reason, those individuals who regularly read relevant scientific publications, are in contact with the various researchers in the field, or were themselves active in the field in the past, were also included. In other words, those are the individuals having "average" or even "little" expert knowledge about individual topics. This provides a means of making the results more relevant, should one or more of the specialists in a given field have an extreme opinion.

A multiple choice type questionnaire (figure 4) was used, that required the experts to respond to the topics by simply ticking the box that most closely reflected their opinion. This, however, presents always a dilemma when performing a written survey of a large number of individuals: opinions about complicated topics must be reduced to simple responses (Rowe/Wright/Bolger 1991). But it can also be an advantage to force the participants to select the topics carefully and fix them in very few words. Large areas for written comments were, however, provided, should the individual wish to provide answers in greater depth.

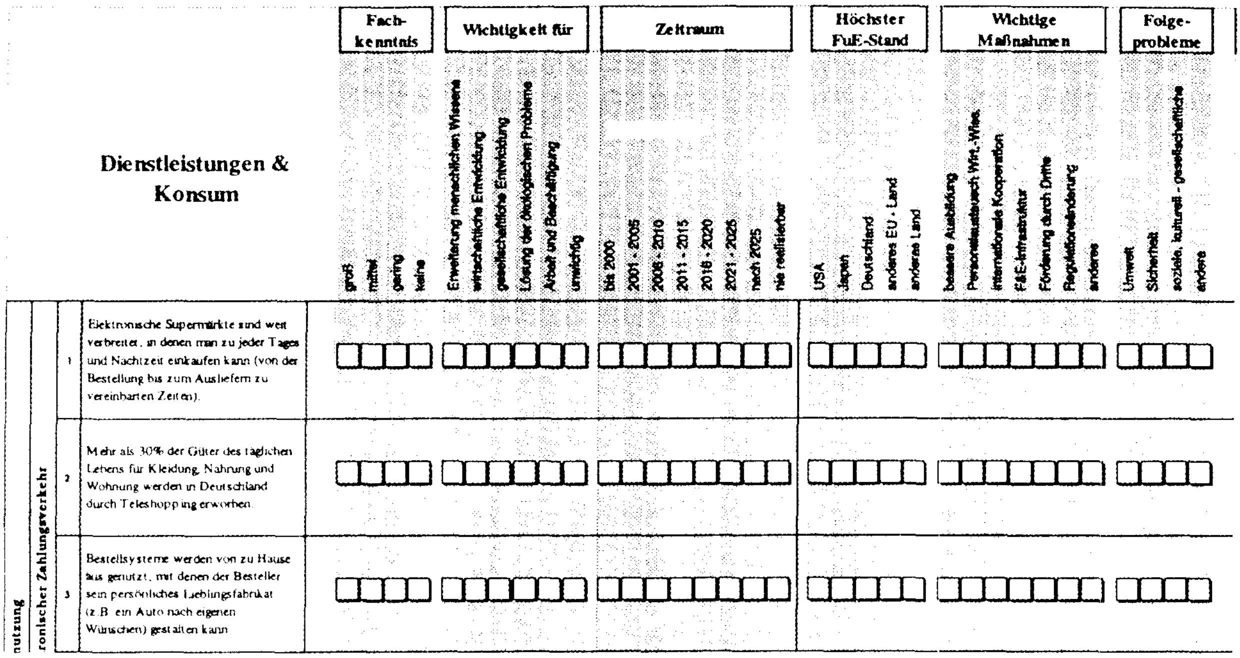


Figure 4: The questionnaire

At first, the degree of expertise of the respondent for the single item was asked for in order to evaluate the "knowledge base" of the answers. According to the questions mentioned, it was discussed, what the topics are important for: the enhancement of human knowledge, the economy, society, the solution of environmental problems, work and employment - or if they are not important at all. The time of realization had to be estimated in five year steps, or rated as "not realizable". Then, it was asked which country is the most advanced in the field, which measures have to be taken and what kind of follow-up problems could probably occur because of the realization.

The initial result of the survey was a large volume of data which is the base for further analysis and discussions. The data do not have the one addressee but are provided to all those who are interested: companies use them as an input into their strategic planning and as additional information about their future framework conditions, ministries to re-evaluate or pre-evaluate their research agenda, research institutions or associations for strategic thinking or evaluation (e.g. the Fraunhofer Society made use of the data during her systems evaluation), or the general public and the media for information and transparency in what is going on in research and technology.

The responses serve to provide an intimation of future developments, thus allowing a structured communication process about the future to be established. The fact that some areas of the future are already being contemplated today gains time to slow or halt evident false developments, or to start or accelerate necessary innovations. Thus, Delphi studies provide no immutable picture of the future, but instead, offer a basis of information for the decision of what has to be done - or not done - today. How the future will actually develop depends on the decisions made today. Therefore, the actual development can differ greatly from today's assessments.

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 co-operation with the ISI, the steering committee prepared 19 megatrends representing an outline to find out the direction of the specialists' intentions, their desires and expectations, and perhaps even their basic values (for details see Blind/Cuhls/Grupp 1998). The megatrends included topics like "The world population will surpass the 10 billion order.", "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 being 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 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 behavior. 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 (for details see Blind/Cuhls/Grupp 1998).

The aphorism: "No wind is convenient for the sailor who does not know the port into which he sails!" is attributed to Seneca (the Elder). The point is that those whose goals are unclear are unable to utilize the dynamics and driving forces to move forward. The primary goal of the Delphi 98 report is to contribute to an understanding of the objectives of science and technology. An exchange and, perhaps, even negotiations regarding such goals are to be carried out across the borders of individual specialized areas, fields and topic areas. To do this, however, requires specific materials that can be studied in order to avoid speaking of a "negotiation aggregate". Questions are not only there to be answered, but first of all to be posed, as another anonymous aphorism has it. Asking the "right" questions can already lead to many solutions and answers.

The Delphi report is therefore a representation of the future, neither complete nor comprehensive, and certainly not one that will satisfy all individual interests. But the topics as well as the assessments of the surveyed specialists should be allowed to speak for themselves in a kaleidoscopic fashion. This makes a selection more accessible. The following section can therefore only provide a short glance at some of the results. To look at 1,070 different topics and their Delphi results has always had restrictions. Many different analyses for the various stakeholders are possible, for example just by asking: "What is interesting for myself?"

Which are the earliest or latest realizations? What is important - for what? What has to be done? For more details, see the original report Delphi '98 (Cuhls/Blind/Grupp 1998). Here, I present only an overview on the most important clusters of topics. 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 5.

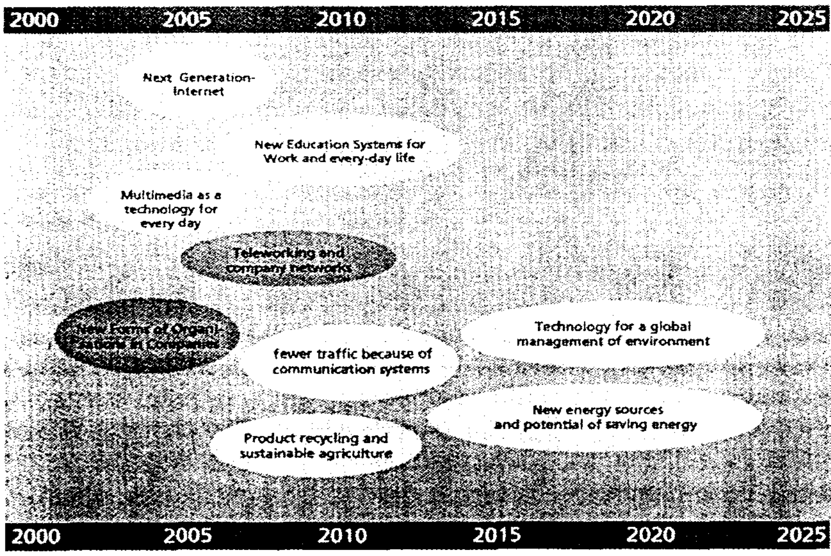


Figure 5: The Time Horizon of the Most Important Innovation Fields

Figure 5 underlines that information and communication 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 companies often select topics.

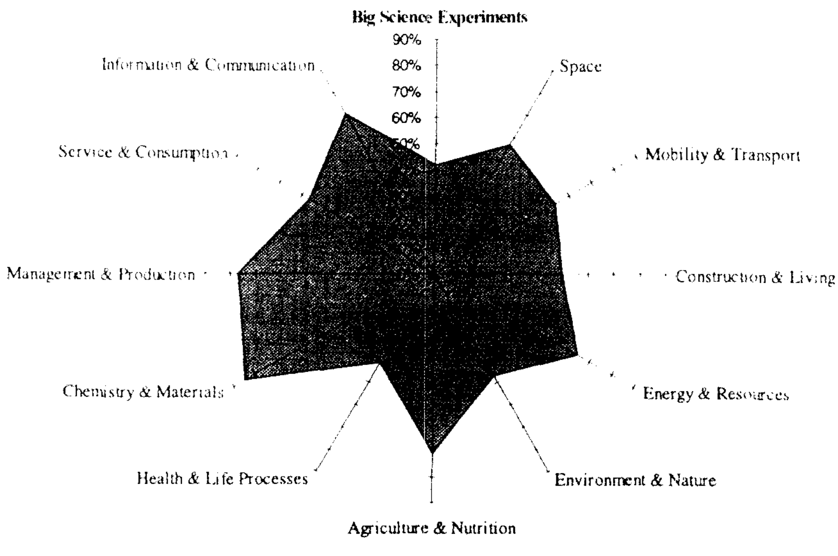
In the near future, companies will co-operate more closely with one another. In the area of research and development, this will also lead to corporate co-operation that includes input from customers and institutes as a result of the increasing time and cost intensities of R&D projects.

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 micro technology. 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.

Another possibility is to ask what is important for the economy (figure 6).

Importance for the Economy



Then, one can go more into detail to have a look at single topics in the different fields which are important for the economy. One can have a look at innovations that are not necessarily on the top of the importance list, but that become more apparent when questions touch on specific areas. Table 4 shows some concepts that will have a significant, overall influence on the economic development of Germany and the world.

Table 4: Innovations that are relevant for the economy

- New organizational structures between corporations
- New quality standards in food production
- Satellite-supported traffic control
- Electronic currency as the payment method in multimedia networks
- Photonics and new chip generations
- Satellite technologies
- New materials and processes
- Bio- and food technologies

Their realization times are mainly short- and medium-term. These solutions are expected during the next 15 years.

In Germany, many companies started to analyze the data set for their own purposes. Everyone has different targets - and so everybody looks at different fields and topics. This is what a process like Delphi is good for: everyone can make his or her own analysis of the study - depending on individual needs and questions about the future. Therefore, the data are provided to everyone who wants to use them (Cuhls/Blind/Grupp 1998). Some examples are already introduced in the reports or the newsletter "Zukunft nachgefragt" (The future in question, BMBF Eds.). Like this, everyone can make his or her own analysis - using Delphi '98 as working material, not a picture of the future itself.

FUTUR – The New German Approach

The process of looking into the longer-term future cannot be ended but has to be a continuous one. Therefore, on the international conference "Forward Thinking: Keys to the Future in Education and Research" in June 1999 in Hamburg, a process called FUTUR started. FUTUR is the new German activity in conducting foresight. FUTUR is based on the results of the German Delphi surveys and on the experiences of other countries. It is an open and transparent process that includes many stakeholders of the innovation system to anticipate future developments. FUTUR is an initiative of BMBF, in which ISI is also involved on the conceptionalization side. But many steps of FUTUR are not yet decided.

What is new: FUTUR involves not only "experts" but also interested persons from the general public. The platform for the exchange of information, for a discussion about the future and for creating a database of persons who can interact in a network is the Internet (www.futur.de; attention: the Internet page will be re-designed soon). Additionally, in working teams, methodology is applied to explore and discuss future topics. The first two fields that already started are: "Mobility & Communication" and "Health & Quality of Life". The first workshop took place in June. The next larger workshops are planned for January 2000.

The broader aims of FUTUR are to anticipate future developments, to develop common visions through a strategic dialogue, and to prepare decisions that are technologically feasible, socially acceptable, demand-oriented, economically and ecologically reasonable. Other objectives are to provide information about the future (information pool), to have more transparency on future developments in science and technology by using the Internet, to receive contributions from non experts as well as lively discussions on the wishes and needs of society. Therefore, not only science and technology but also the economy, society and other areas will be looked at. With the new instrument FUTUR, it is aimed to involve the different stakeholders in the system (participation).

Panels and working groups will accompany the process. Not all 12 subject fields of Delphi ‘98 will be discussed at the same time. For gathering experience, one area with a very large innovation potential was selected: Mobility & Communication. Other thematic areas will follow as the need arises for decision-making in science, industry and politics (for details see BMBF 1999: Zukunft nachgefragt 5). A network of experts and interested persons will be build up to have quick access to persons with knowledge on the matter and to facilitate co-operation between different actors in the field.

Users of Foresight in Germany

To open the foresight processes to any kind of experts and the general public is a new feature of foresight and for Germany a change in policy, again. Science and technology policy will not only be based on the recommendations of scientists and other experts but also takes into account the opinions of those who will apply these in the future.

The German national research system consists of ministries like the BMBF (Federal Ministry for Education and Research) and others (e.g. agriculture, environment, construction) providing funds for science and technology. Until the 1990s, the BMBF acted more on a rolling plan providing funds for the national research centres and their projects (big science) as well as for basic research projects in specific research programmes. Universities are free in their choice of research topics and are funded by the Länder. Max Planck Institutes, the Fraunhofer Society and the institutes of the "blue list" are working in the area between the basic science oriented universities and the private enterprises with their more applied research. The Delphi studies asked for basic research as well as for applied research and therefore included persons from all these institutions. The participation was already an impact as such, as these persons were asked to think about their future projects. With FUTUR it will be tried to bring together the different actors in the system (figure 7) directly and to include also those who are normally not heard.

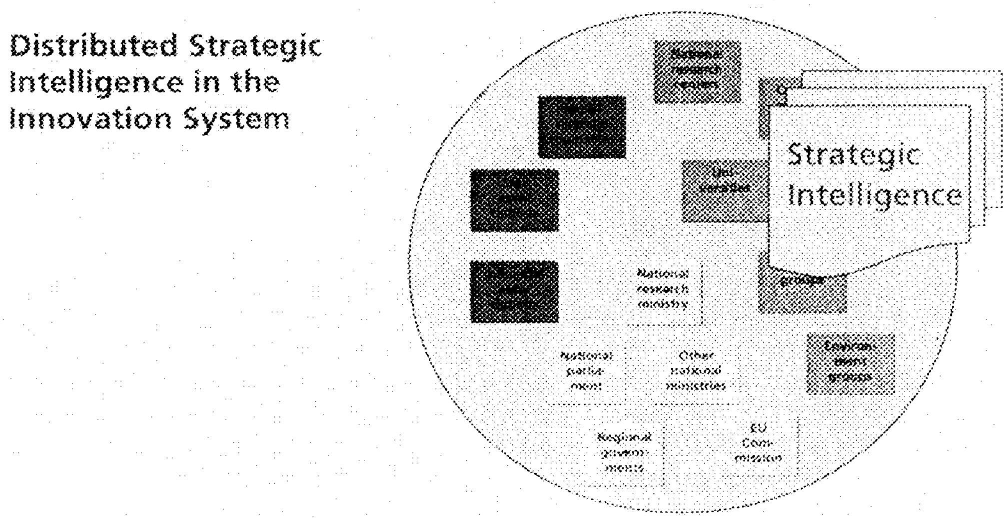


Figure 7: The German Foresight System

The main "user" of the Delphi studies in Germany was supposed to be the national government (federal level). The results of the survey already contributed to decisions like orientation of the education and research system, as well as to strategic talks between industry and large research organizations. But it were more the companies who made use of the data for their own strategic purposes. The regional administrations (Länder) are also interested in the results; they try to analyze and interpret the data from their point of view (Schmoch/Laube/Grupp 1995, Blind/Grupp/Schmoch 1997). The results of the Delphi surveys were being spread (the first and the Mini-Delphi even for free) as a book and on internet, so that private actors, too, can use them: many enterprises and R&D institutions started to exploit them for their own purposes. In addition, some firms have managed their own survey (Cuhls/Uhlhorn/Grupp 1996; Reiss et al. 1995). The Fraunhofer Society itself even made use of the Delphi '98 data for their programme evaluation.

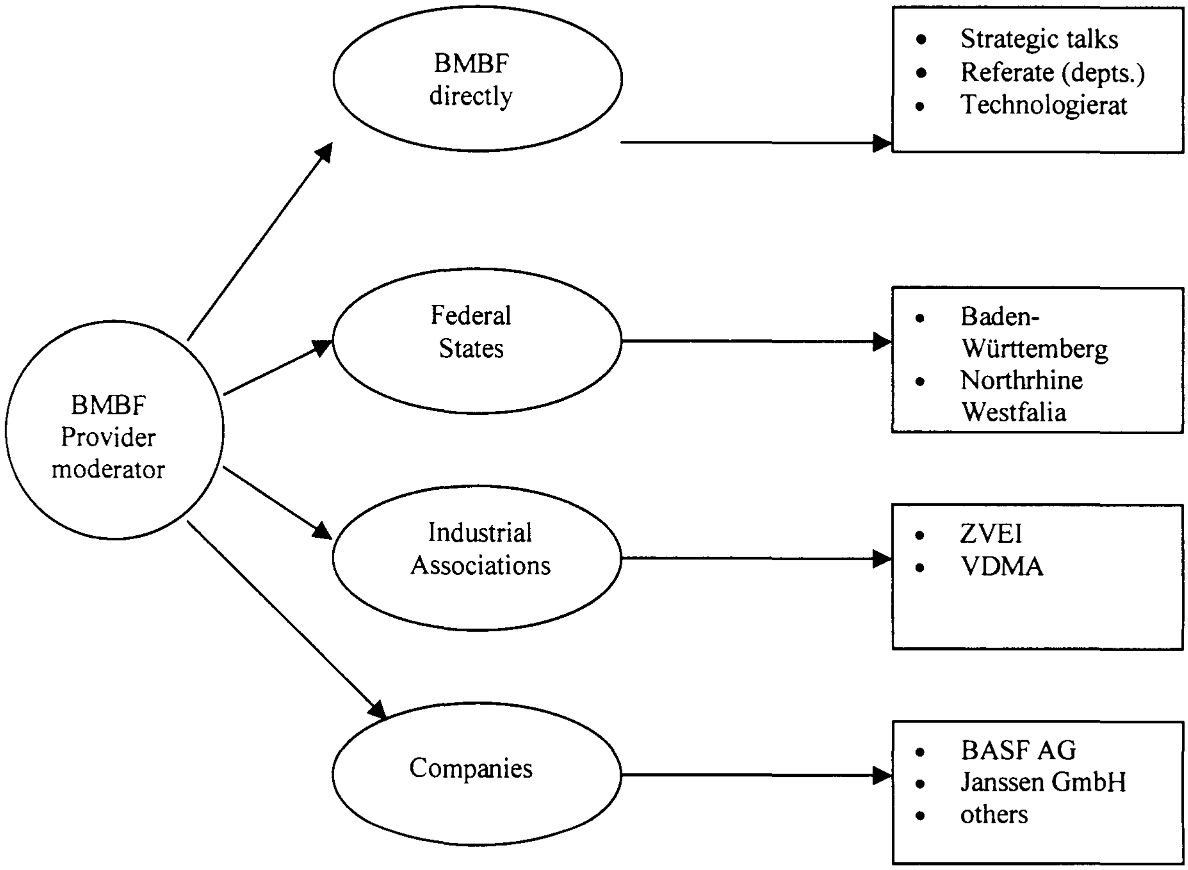


Figure 8: The use of Delphi results in Germany

As far as enterprises in Germany are concerned, a considerable improvement of the intramural knowledge base through participation in the Delphi survey is reported. (The project on the Technology at the Beginning of the 21st Century did not involve industry directly in the process, but the results are likewise relevant.) There is sporadic evidence that in some companies, during participation in the Delphi, it was felt that too little effort is dedicated towards strategic innovation management and some remedies have been taken. Some companies started own investigations in the direction of an intramural breakdown of the overall national studies towards the special interest of their business areas or establishments, both in the manufacturing and the service sector. One large chemical company started with topics of the Delphi survey, made their own evaluation of the topics and built up a strategy until 2010. In working groups, the information was discussed and distributed. 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 the ISI. These activities are largely confidential.

One pharmaceutical company has concluded its own Delphi investigation on the future of physicians in residential areas and their ability to follow the modern trends both in medical technology and pharmaceutical assuming a computerization of the health care system. The results were published by the company (Reiss et al. 1995).

Another follow-up project was a European effort in the field of biotechnology in food and food processing which was conducted on behalf of the European commission and compared the opinions of producers, consumers and other different stakeholders of five European countries in more detail. The results were especially interesting because in this conflicting area, no consensus between the different opinion groups could be remarked. This evidently shows that foresight can also be used to identify the cases in which there is consensus and in which conflict potentials are especially high.

Industry and industrial associations have their own subject-tuned activities on behalf of their member firms, either in preparation (in case of the industrial association of machinery and apparatus manufacturers VDMA) or completed (in case of the association of electrical instruments ZVEI). They used the data to structure their approaches to the future and to provide strategic analyses to their members. Some of them operated in discussion groups starting with the selection of topics of future relevance (e.g. as future markets, as competitive products or as substituting own products). Strategic planning about diversification or non-diversification, core competencies and future market segments followed.

The Fraunhofer Society even based its programme evaluation on Delphi results and checked whether the different institutes are working in future fields and therefore will be able to meet the future needs of applied research (Cuhls/Blind/Grupp 1998).

The impact on German society is also linked to the widely discussed results in the media, leading to interesting debates on the desirability of specific technologies. This is a process which will continue with the following FUTUR process.

Outlook

When summarizing the main elements of the R&D policy that are currently being implemented, there is first of all the goal to achieve awareness for the challenges Germany has to accept. This is true for any country facing a shift in policy. It needs to enter into competition on coming problems and solutions, which require concepts and visions of the social and economic future. There has to be an interdependent process of science-based creativity between the fields of emerging technologies and the problem-generated demand for science and technology.

That is why for the time being the implementation of the new policy has reached the instrumental level under the title 'Leitprojekte' (leading projects). The shift towards topics that are only indirectly related to science and technology and more towards societal problems can be observed. For these combinations, foresight is one of the instruments selected. FUTUR will be one of the major programmes in these fields. The Minister for Education and Research herself will support the process.

For by looking into the future and asking questions about what to do - or not to do - we shape the future. We all decide on it and act or desist from action. This is more than self-fulfilling prophecy. It is shaping the future. It is tried to make German policy more pro-active to support this aspect. And it is hoped that foresight will help to shape a (little bit) better future.

Cited Literature

Blind, K.; Cuhls, K. and Grupp, H. (1999): "Current Foresight Activities in Central Europe", in: Technological Forecasting and Social Change, 15-35.

Blind, K.; Cuhls, K. and Grupp, H. (1998): The Influence of Personal Attitudes on the Estimation of the Future Development of Science and Technology: A Factor Analysis Approach, in: Proceedings of the 42nd Meeting of the International Society for the Systems Sciences (ISSS), Atlanta, Georgia, 19-24 July 1998 (CD ROM).

Blind, K.; Grupp, H. and Schmoch, U. (1997): Zukunftsorientierung der Wirtschafts- und Innovationsstrukturen Nordrhein-Westfalens, Karlsruhe.

Federal German Ministry for Research and Technology/Bundesministerium für Forschung und Technologie (BMFT) (ed.) (1993): Deutscher Delphi-Bericht zur Entwicklung von Wissenschaft und Technik, Bonn.

Coates, J.F. (1985): Foresight in Federal Government Policymaking, in: Futures Research Quarterly, pp. 29-53.

Cuhls, K. (1998): Technikvorausschau in Japan. Ein Rückblick auf 30 Jahre Delphi-Expertenbefragungen [Foresight in Japan. Hindsight on 30 Years of Delphi Expert Surveys], Physica, Heidelberg.

Cuhls, K. (1996): Foresight in the German Science and Technology System, Contribution to the Expert Group Meeting on Technology Forecasting and Foresight Activities in Latin America, Beyond Latin America 2000, Santa Cruz, Bolivia, December 11-13th, 1996.

Cuhls, K. and Blind, K. (1999): The German Foresight Study '98 on the Global Development of Science and Technology in: Kocaoglu, Dundar F. and Anderson, Timothy R. (Hg.): Technology and Innovation Management, PICMET '99, Portland, S. 577-582.

Cuhls, K.; Blind, K. and Grupp, H. (eds. 1998): Delphi '98 Umfrage. Zukunft nachgefragt. Studie zur globalen Entwicklung von Wissenschaft und Technik [Delphi '98 Survey. Study on the Global Development of Science and Technology] Karlsruhe.

Cuhls, K.; Grupp, H. and Blind, K. (eds., 1998.): Delphi '98- Neue Chancen durch strategische Vorausschau [New Chances through strategic foresight] Tagungsband der Tagung in der Deutschen Bibliothek in Frankfurt/Main am 1. Juli 1998, Karlsruhe

Cuhls, K.; Breiner, S. and Grupp, Hariolf (1995): Delphi-Bericht 1995 zur Entwicklung von Wissenschaft und Technik - Mini-Delphi -, [Delphi Report 1995 on the Development of Science and Technology] Karlsruhe (Same as brochure of BMBF 1996).

Cuhls, K.; Uhlhom, Chr. and Grupp, H. (1996): Foresight in science and technology - future challenges of the German S&T system. in: Meyer-Krahmer and Krull (eds.): Cartermill Guide for Science and Technology, London 1996, pp. 63-81.

Cuhls, K. and Kuwahara, T. (1994): Outlook for Japanese and German Future Technology, Comparing Technology Forecast Surveys, Physica, Heidelberg.

Grupp, H. (1996): Foresight in Science and Technology: Selected Methodologies and Recent Activities in Germany, in: Science Technology Industry (STI) Review No.17, pp 71-99, OECD, Paris.

Grupp, H. (1995) (ed.): Der Delphi-Report, (with Breiner, S. and Cuhls, K.), dvapublishers, Stuttgart.

Grupp, H. (1994): Technology at the Beginning of the 21st Century, in: Technology Analysis & Strategic Management, 6, pp. 379-409.

Grupp, H. (1993) (ed.): Technologie am Beginn des 21. Jahrhunderts, Physica, Heidelberg (2nd edition 1995).

Grupp, H. (1992): Dynamics of Science Based Innovation, Heidelberg/New York.

Häder, M. and Häder, S. (1995): Delphi und Kognitionspsychologie: Ein Zugang zur theoretischen Fundierung der Delphi-Methode, in: ZUMA-Nachrichten, 37.

Irvine, J. and Martin, B.R. (1989): Creating the Future, Netherlands.

Mandelbrot, B.B. (1982): The Fractal Geometry of Nature, San Francisco.

Martin, B.R. (1995): Foresight in Science and Technology, in: Technology Analysis & Strategic Management, vol. 7, No.2, pp.139-168.

Martino, J.P. (1983): Technological Forecasting for Decision Making, 2. edition, North Holland/New York/Amsterdam/Oxford.

Reiss, Th., Jaeckel, G., Menrad, K. and Strauss, E. (1995): Delphi-Studie zur Zukunft des Gesundheitswesens, in: Recht und Politik im Gesundheitswesen 1:2, pp. 49-62.

Rowe, G., Wright, G. and Bolger, F. (1991): Delphi - A Reevaluation of Research and Theory, in Technological Forecasting and Social Change, 39, pp. 238 - 251.

Schmoch, U.; Laube, T. and Grupp, H. (1995): Der Wirtschafts- und Forschungsstandort Baden-Württemberg - Potentiale und Perspektiven -, ifo studien zur strukturforschung 19/I, München.

TECHNOLOGY FORESIGHT FOR IRELAND

John Donovan
Ireland

I would like to thank UNIDO and ICS for extending to me the invitation to speak at this very significant conference on Technology Foresight. I am not sure why I qualify for this honour but I am delighted to bring my observations of the Irish Exercise and its aftermath to you.

I thought to bring you first a short description of IRSA as an organization and how it fitted in with the momentous changes that Irish S&T is undergoing at the moment. I will then go over some of the history of the Irish TF exercise, through the mechanisms, through the process and finally, some of the recommendations, lessons, consequences and some final personal observations.

Before I begin, I should make it clear that neither IRSA nor myself had any part in the organization of the Irish TF exercise or in how it was planned and implemented. The exercise was organized by the Office of Science and Technology through the Irish Council for Science, Technology and Innovation and Forfás (the Irish Policy Advisory Agency). What follows is a purely personal observation of the process.

The Irish Research Scientists' Association

In the early 90s there was a crisis in Irish S&T. We had just come out of the longest and deepest recession in recent Irish history and S&T was a luxury that was not seen as necessary. The greatest priority was to get people working again and to restore confidence in business.

Against this background, the Government of the day decided to abolish, more or less all, public support for research that was not immediately relevant. The IRSA was formed in direct response to this and now has some 800 members in 19 countries around the world. In response to a sustained campaign by the researchers, the government conceded the need for a review of the way S&T was organized in Ireland.

IRSA has continued to lobby strongly for S&T in Ireland at national and EU level. Indeed some of the implications of the Irish Technology Foresight report are provoking a considerable amount of activity. The association makes no distinction between Natural Sciences and research in the humanities and social sciences.

It is impossible to overestimate the role of a strong lobby group for research in the general management of S&T. Researchers, as the key players needed to be partners in any development process.

The STIAC Process

Ireland's experience of Technology Foresight grew out of a major review of Ireland's S&T policy conducted during 1993 – 1995. This review, christened the Science, Technology and Innovation Advisory Council (or STIAC) process that was one of the key events in recent Irish economic history and represented a seismic shift in the fortunes of S&T in Ireland. The STIAC report laid the foundation for moving S&T from the periphery to centre stage. S&T was going to be a major force in the nation's future

Briefly, since STIAC is not the purpose of this conference, in 1993 the various S&T partners in Ireland realized something was fundamentally adrift with the way S&T was being administered. Researchers, Industry and Higher Education were all adamant that a root and branch review and reform was the only way forward. After a considerable amount of pressure from IRSA the then minister launched the review. After nearly three years the report was published and led eventually to the publication of a White Paper on S&T. The key recommendation of the White Paper was the establishment of the Irish Council for Science, Technology and Innovation (or ICSTI) and, critically, the need for a Technology Foresight exercise. One of the significant findings of the STIAC process was the fact that upwards of 60% of Ireland's economic growth was dependent on the generation and exploitation of knowledge and we had to be able to plan the development of that knowledge.

I'm not sure how significant this is, but the STIAC process was the first time in more than 70 years that an S&T commission was entirely composed of Irish men and women. The previous 4 reviews had all been composed of various combinations of overseas experts. STIAC represented the first time we felt our S&T infrastructure was mature enough to examine itself and come up with realistic suggestions for how the National S&T infrastructure could develop. I believe that the composition of the STIAC council lent it a very important degree of credibility that carried it through, ultimately to the TF exercise we are going to discuss.

Although far down the civil-service hierarchy, ICSTI, became a driving force in the development and implementation of a new S&T policy in Ireland. ICSTI is composed of high-level representatives of scientists, engineers, education, industry and the public service. The brief of the Council is to advise its Minister and other Departments of State on matters of S&T. Their advice by and large has been listened to and taken seriously, implementation, by its nature is a different thing.

Technology Foresight Ireland

In 1998 the Council launched its Technology Foresight exercise as a way of establishing options for the future in an economy that was beginning to grow at an extraordinary rate and which was likely to continue like that for the foreseeable future. It was a very exciting time to be involved in Irish S&T. The aim of the TF exercise was almost purely economic rather than social and sought to map out a series of possible future options for the country. It was, most definitely, not a forecasting exercise but very definitely a foresight one.

How was the exercise to be undertaken became the next problem. There are, as you know many different ways of doing TF, Delphis, Scenarios, Critical Technologies, etc. A method had to be found that was not restrictive, that allowed the development of ideas, that was compatible with a small country and economy and that the participants would have confidence in the process and, by implication, the results.

The single most important criteria must have been to ensure the confidence and support of the technology community in the process. To this end, it was clear that they needed to be engaged in the process at a very fundamental level and that their interest must be sustained over what may be a reasonably long stretch of time (12 months for the owner/manager of a small firm represents a very significant commitment of resources). Another feature, and one I hope that is built on, was the involvement of the public service in the process. This tended to be at the level of managers from semi-state companies. I personally feel that some direct input from the policy formulators into the exercise would have added just that extra depth to the exercise and perhaps their involvement will grow in the future.

Irish people for historic reasons have an ambiguous relationship with the Government and the appearance of a letter with a harp on the back would not have evoked the same response in Ireland as a letter from the Bundesfurschungs Ministerium would have evoked in other countries. In Ireland the letter would have been read and passed to the bin for attention. This would have been a very acute problem in the case of a Delphi exercise, as the response would have smoothly followed an inverse square relationship to the number of rounds in the exercise. By round three there would be nothing left to foresee with.

Delphis seem to be better suited to larger countries that have a large pool of talent and a history of S&T. They tend to remove the radical idea in a search for conformity whereas the very "radicalness" of an idea might be just what makes the idea important in a small country.

Ireland eventually opted for a scenario-writing format with expert panels and a considerably wider range of consultations. In all some 450 people were involved in the process ranging from the panel member to the person making an individual submission to the process.

Panels were selected on the basis that they represented significant groupings of activities and so covered most activities in the economy. The panel members were drawn from the various S&T partners in the country. These included Industry, Higher Education, Public Service and the Trade Unions. In essence, this is an extension of Ireland's, now almost traditional, system of social partnership government. The process was to be short (12 months) concise and relevant, there were to be no long turgid reports.

The panels were;

1. Chemicals and Pharmaceuticals;
2. Information and Communication Technologies;
3. Materials and Manufacturing Processes;
4. Health and Life Sciences;
5. Natural Resources;
6. Energy;
7. Transport and Logistics;
8. Construction and Infrastructure.

The first task was to generate a "First View" report in each specific panel area based around the development of "scenarios" that were to give some idea of what a future might be. Different scenarios were developed to reflect different possibilities ranging from a worst case to a best case.

What then are the implications for our immediate policies to ensure that we avoid the worst scenario and what are the S&T developments that are required to address future needs? Of course the strength of the TF process lies not only in the thinking but also in the structures and in the involvement of all the stakeholders in the process.

One of the immediate benefits of the process has been the development of many new networks based around the panel memberships and the wider groups that they represent. For example one of the real hindrances to research in Ireland has been the failure of industry and academia to be able to collaborate in research. The experience of co-operating in the TF exercise seems to have removed or, at least, reduced the blockade. Several new collaborations have followed out of contacts made during the process. These collaborations range from research to new company formations.

It all seems to be a consequence of TF that a range of new options opened up to the S&T partners. There is a debate on whether the real benefit of TF was the exercises and the recommendations or the networking that evolved out of it. It is more than likely that all the benefits are equally valid and legitimate consequences of having engaged in the process and that the strength of the exercise is more than just the sum of the all these benefits.

Traditionally, the relationship between researcher and civil service has been fraught to say the least. However, the results of the TF process have been dramatic in the sense that both sides now appreciate what constraints the other works under and that civil servants are not always trying to cut budget and researchers are not always living in their own little world. Indeed, for me, one of the most interesting side effects was to be able to watch the relationship between the public policy makers and the researchers in particular visibly mature.

It may sound obvious but the chance to think about the future in a structured and constructive way is a rare privilege. Most of the time we are too busy to think about what might be. Establishing an organized "future scoping" programme must be one of the most sensible things any country can do. To be able to integrate such a programme into the normal planning process can only ensure a more robust outcome to that process.

What was the outcome of the Irish Process? At its simplest the process made more than 100 recommendations across a broad range of topics in every panel area. The recommendations ranged from greater investment in R&D (and fiscal incentives), changes in the regulatory regimes, through to enhancements in the teaching of science at all levels.

In its overview report, the Science Council has picked 4 key recommendations that it sees as crucial to Ireland's future. These are,

1. All Government Departments utilize the Foresight findings in future planning;
2. Ireland is to become a centre of excellence in biotechnology and ICT niches;
3. That the government should be more proactive in the creation of an environment conducive to technological innovation and specifically in relation to regulatory and financial issues;
4. That the government is to establish a Technology Foresight Fund.

One of the first recommendations of the Irish Technology Foresight Programme was that all Government Departments and public agencies should take on board the outputs from the process and use them in all future operational matters. The TF exercise should inform all government planning from now on.

What is interesting about this recommendation is that the TF process is starting to be used by local authorities in their planning arrangements. One of the first examples of this was the establishment of a combined planning unit from three County Council areas. The members of the Transport and Logistics panel have been involved in a similar process with some of the County Councils. This recommendation has already been acted upon and TF is now feeding directly into the day-to-day work of Government Departments.

The report models the STI system as a pyramid representing a partnership between Government, Higher Education, Industry and Society. The report also identifies a gap at the apex of the pyramid. This gap corresponds to the missing, world-class research infrastructure. This gap is the essential fourth-level education, this gap is commercialisation skills and this gap is the "lack of partnership with industry in the industrial development context". The hope of the report is that by providing clear mechanisms to expand the S&T capability of the country the apex will be filled. The report states that *"This gap will only be filled if the partnership of Government, Industry, the Higher Education Sector and Society can combine to deliver the necessary knowledge framework".*

The report's recommendations have been accepted, more or less, in full and implementation has already begun through the production of a National Development Plan in the middle of November. The National Development Plan has, on the basis of the TF exercise, earmarked some £560m pounds to the development of two "world class" research institutes in the area of biotechnology and in information technology. While, in principle, agreeing with the recommendation, the mechanisms of implementation need to be more fully developed and researchers need to be asked about the difference between the possible and the potty. A commentator described the present situation as like trying to get a suntan in Antarctica, its possible but that doesn't make it a good idea.

Indeed, it is the implementation process that is undoing what had been a universally acceptable exercise and which had generated an enormous amount of goodwill towards public policy makers from the research community. For me, the debacle at the end of the road underlines the importance of seeing technology foresight, not as an end in itself, but as a process that may and should take many years to complete if, indeed, it is ever really completed.

The implementation strategy in Ireland seems to have become lost between what is possible and political reality. The proposed strategy, and it is still only a proposal but looks like being the strongest runner, is that the Government will set up a "world class" research institute in the newly created National Digital Park near Dublin. If we, for the minute, discount the difficulties such an institute might have with finding suitable staff, the principle is probably a good thing. Ireland is the second largest exporter of software in the world and is a significant player in the hardware industry. More intellectual engagement between Ireland and the IT industry can only be a benefit to all concerned. However, the process embarked on in Ireland demonstrates just how far the TF process has come off the rails. I don't want to dwell on this for too long but the Government is proposing to strip the intellectual assets of the third level to found an independent research institute with no or very little involvement in the education of the next generation of researchers. A sure fire recipe for failure and for failure of the whole TF process.

While IRSA, the Government and the Science Council are at loggerheads over this, it only serves to emphasize the essential partnership nature of the TF process. It succeeded when all the stake holders felt they were part of the process and that they could take a degree of ownership in it. As soon as the partnership approach broke down and the recommendations were being unilaterally implemented with no consultations between former partners, the process dismembered itself. The key point I am trying to make and one of the real lessons that I hope Ireland can learn is that the type of TF exercise we bought into is a total partnership one. This will be an essential part of any small country TF exercise. All the stake holders should remain on board if the process is to maintain its credibility.

This does not mean that disagreements or differences should be papered over and concealed at all costs. Quite the opposite, differences, nuances, and shades of opinion are what make the process so valuable and should be developed to tease out any details that may be relevant.

This brings me to where I think a significant error was made in the Irish Exercise. On the whole and despite the problems with implementation the TF exercise was a success. However, I feel that two specific areas were ignored and probably ignored by accident rather than design. I suppose the best way to describe these areas is "intellectual technologies" and how do we do science and how do we educate our children. How can we make these fit within the traditional remit of a TF exercise. It may be a complicated problem but in the sense that both of these intellectual technologies transcend any other technology they need to be the subject of some sort of future scoping process in exactly the same way and for the same reasons as the "harder" technologies of IT, Natural Resources or even the Environment. The Irish exercise pulled out some issues in relation to Education but it was never a central issue in the process. To my mind, this was a serious mistake on the part of the planners as by the time that this exercise dealt with ends, the children now in primary school will be planning another TF exercise. Their education is the single most significant factor in the future development of any country. Why shouldn't the educational system benefit from a bit of future thinking?

Similar arguments can be made for the inclusion of research as a legitimate area for examination. Each of the TF exercises come up with the recommendations requiring a significant investment in research and development whether by industry or publicly. That the mechanisms and processes of research are not the subject of a Foresight analysis baffles me. Research is needed for teaching, for industry and for the wider society; such an influential process deserves a bit of radical thinking in its own right. Though I'm not sure how it should be done.

Conclusion

By and large the Irish experience was a very positive one despite some early misgivings on the parts of some participants. It constructed a partnership between the different S&T stakeholders in Ireland. The Irish TF programme had crucial political backing. As a process it provided a mechanism for everybody to co-operate in analysing our future options. It helped to cement networks among the partners and between groups that may have been just a little wary of each other in the past. It produced a robust and practical analysis of where things stand and how we can move them on. It has fallen down on the implementation largely because the process seems to have been judged "finished" just at the point its most important work began. Ireland needs to learn the lessons from this exercise, needs to capture and identify the benefits of the process outside the list of recommendations, but above all needs to be prepared to undertake a similar exercise in the near future. Technology Foresight type processes are now being built into regional planning procedures in an effort to produce more clearly defined development strategies in the regions. Government Departments are using the TF findings in their day to day operations.

The TF exercise needs to pay attention to some areas in the next cycle. Scenario writing seems to be a technique that suits the Irish psyche and we do like to talk. I feel that more significant involvement of the state sector is needed if only to balance the representations. Any future TF exercise should include elements examining both the mechanism and nature of research and role and mechanisms of Education, particularly scientific education. Finally a workable implementation strategy involving all the partners is a basic requirement if the process is to remain a success.

As I said before in relation to the initial STIAC council, the composition of the panels was all Irish, and they had some advisors from overseas to establish the process. For the majority of participants this was their first excursion into this kind of work. This was, undoubtedly both a strength and a weakness, though I suspect more of a strength.

TF by its nature is a strange beast. Once you've looked over the parapet at the future you need a very good reason not to, at least, try to ameliorate the worst aspects of the options presented to you. Doubtless as time goes on the first Irish TF exercise will be seen in a clearer light. Was it a success? Did we manage to make the correct assumptions? Was it worth it? I believe that the Irish TF exercise will come to be seen as one of the key events in the shaping of our future. Whether we got it right or not (what ever that means) is almost irrelevant, it probably represents the first real opportunity for all the S&T partners to look at the same problem at the same time and help with putting the answers together.

From the perspective of the of the Irish Research Scientists' Association, I am convinced that one of the major factors in the "success" of the Irish TF exercise was the existence of a strong and vocal lobby group for research. The Association has worked closely with public policy agencies on other matters of S&T policy development and has been very successful. Irish lobbying has moved along from the old fashioned way of simply demanding more money but instead is prepared to be involved in the development of Irish S&T policy. When the call came for Irish researchers to take part in the TF exercise, the expectation was already there that researchers were going to be taken seriously. While the motivation behind the TF exercise was clearly economic researchers themselves, particularly those in the Education sector, felt that they could buy into the process and make a contribution.

At the same time industry, traditionally wary of academics, came to the process knowing that the motivation was going to be good for them and were prepared to engage with academics to make the process work. The exercise was lucky to have had access to an exceptional pool of talent that was of immense benefit to the process.

I admit that I was a sceptic in relation to TF but having seen the way the Irish process worked and the benefits, both tangible and tacit, that followed from it, I am convinced that this exercise was a useful one to have been through and one that will be worth repeating in the near future.

I hope that my reflections on the Irish TF exercise is of some use to you in planning your own exercises. Thank you for your attention.

SEARCHING FOR LEADERSHIP IN INNOVATION NICHES: TECHNOLOGY FORESIGHT IN AUSTRIA

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Abstract

There are increasing indications that Technology Foresight is of value not only for leading industrial countries but also for small and for developing countries. Austria's first systematic Foresight programme, run between 1996 and 1998, is portrayed as an example of a Foresight approach tailored to the needs of a small country. The specific goals of "Delphi Austria" are its approach (selective, demand-, problem-, and application-oriented) and its experiences with some innovative elements that are outlined as; the running of a Technology Delphi in conjunction with the Society and Cultural Delphi; the modification of the classical Delphi towards the decisional 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 "mega-trends section" in a multiple function. These elements are discussed and evaluated together with an overview on main results and effects of the Technology Delphi on the policy process.

Introduction

Looking ahead is the key element of strategic action and policy-making. What has become ever more important with the growing complexity and pace of change, especially in the economic and technological spheres, is the need to base decisions on systematically gathered information.

During the last decade Technology Foresight has been establishing itself as such a policy instrument and source of strategic intelligence. Some overriding trends become visible along with its remarkable upswing (Gavigan/Cahill 1997; Grupp/Linstone 1999):

- Foresight is no longer undertaken with the claim to forecast or predict a certain future situation but recognizes the possibility of alternative futures and also tries to shape or create certain paths of development;
- 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;
- accordingly, the function of mobilizing and "wiring up" national innovation systems adds to the function of informing science and technology policy-making, e.g. for purposes of priority setting (Martin/Johnston 1999);
- increasing attention is being paid to the socio-economic embedding and demand aspects of emerging technologies;
- 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; and
- finally, in contrast to earlier periods one can observe a proliferation of foresight activities among smaller countries as well as among developing countries, particularly in the nineties.

This paper begins by looking at the relevance of Technology Foresight for countries and economies of different sizes and different development stages before giving a brief overview of practice, particularly in smaller 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 – to tailor the design of a Technology Foresight according to the specific situation and needs of the country. Austria's approach is that of a small country which has undergone a very successful economic catch-up process after World War II. Her Foresight exercise was definitely 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.

Is Technology Foresight only a matter of advanced and big economies?

The question to what extent Technology Foresight and in particular the goals and approaches established by big countries are relevant for small as well as for developing countries is certainly important. Over decades foresight studies had been the domain of a few big players among developed countries, notably Japan with great regularity and the USA as the pioneer. In the nineties small countries have begun to move at the front stage of Technology Foresight and indeed make up a substantial part of the recent proliferation.

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 smaller 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 all 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 smaller countries.

For developing countries the situation and problems are certainly 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 these 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: Thailand, South Korea, Malaysia, Indonesia, South Africa and Brazil are examples with activities in this field. The way that Foresight is being applied by smaller countries and their experiences should in some respects be also a useful source for developing countries.

In Europe, the Netherlands was one of the first out of this group of countries to carry out a major "Technology Foresight Experiment" with a study commissioned to the Science Policy Research Unit (SPRU) at the University of Sussex in 1988. It served as a preparation for area-specific foresight exercises which were started by the Ministry of Economic Affairs 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 titled "Technology Radar" in 1997/98. It identified technologies of strategic importance for the Netherlands and focused on the needs of business and industry (Ministry of Economic Affairs 1998).

Already in the late eighties, Australia had also embarked on prospective studies and applied priority setting mechanisms. A first comprehensive foresight exercise at national level was carried out around the mid-nineties and co-ordinated by the Australian Science and Technology Engineering Council (ASTEC 1994). It "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" (OST 1998: 87). New Zealand also has some experience in applying foresight for identifying international leadership opportunities in areas of national strength and for priority setting after two exercises carried out in 1992 and 1995. Planning for a further foresight project started in 1997, this time with greater emphasis on consultation of the end-users of science and technology (Martin/Johnston 1999).

In Europe again, Ireland has just recently (April 1999) published the results of her first Technology Foresight exercise after a process of 12 months (ICSTI 1999) and in Austria the first national Foresight programme was completed in 1998 (it will be further examined in the remainder of this paper). Already in the early eighties, Sweden, Norway and Portugal have made their first steps in the area of Foresight (cf. Gavigan/Cahill 1997). Towards the end of 1998, Sweden launched a new Technology Foresight project on eight quite broadly defined areas. Finland which has started a foresight process with the "Technology Vision" project in 1996 is preparing a further sector study, after a foresight in the food and drink industry, in the chemical industry. As the first out of CEU transition economies, Hungary has already gone a good deal of its way in carrying out a major Technology Foresight project that started in 1997. Combining a panel and Delphi approach the Hungarian Foresight Programme "aims at creating sustainable competitive advantages and enhancing the quality of life by bringing together businesses, the science base and the government to identify and respond to emerging opportunities in the markets and technologies" and "should result in a national innovation strategy"(Havas 1998). A number of other small countries in Europe are currently at different stages of planning and carrying out Foresight projects, such as Denmark and Estland. Further examples could be added from other continents, e.g. Singapore in Asia.

The best way to identify the common trends in the foresight projects that were conducted in all these small countries is by using a set of criteria developed by Martin and Irvine (Martin 1995). This means by looking into the characteristics such as those of the performing organization, specificity, functions, orientation of research, 'intrinsic tensions', time-horizon and methodological approach. To put it short, evidence from a number of well-documented foresight exercises indicates that even among smaller countries the approaches are quite varied. However, as a tendency, 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 co-ordination among the actors within the 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. Stronger orientation towards the implementation, the applicability of results and the transfer to SMEs is also more typical for smaller countries. Finally, a variety of methods are 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 more typical for smaller than for bigger countries are most pronounced in the Austrian Foresight exercise.

Approach and building blocks of the Austrian Foresight Programme

Austria's decision to undertake a Foresight exercise came out of the following situation (Tichy 1999). 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 eighties, 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 on a broad range of traditional medium-technology goods – even of 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 may appear most likely.

After several steps in this direction (i.e. the design of a comprehensive strategy for technology policy, and a number of priority programmes in several high-technology fields) the 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 concentration on a top-down approach proved less and less promising. Consequently, having received interest by foreign examples, the Ministry of Science and Transport decided to plan and commission a Foresight exercise which should be tailored to the specific needs of Austria.

The task of the Austrian Foresight exercise differed greatly from that of most of its foreign predecessors. Technologically leading countries such as the U.S., Japan or Germany 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 as Austria could utilize the results of foreign Technology Delphi-studies. What was 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 could provide a good starting position 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 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 right from the outset were to build on a bottom-up flow of expertise and it was also clear that the Foresight programme should not deal with technology only. Technology Foresight should also include organizational innovations and was to be combined with a Society and Culture Foresight 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 this first initiative to a systematic Foresight process on a national level in Austria was launched. The approach that 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 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 1.

The Ministry of Science and Transport commissioned different parts of the Foresight Programme "Delphi Report Austria" to three external research teams and established a small Steering Committee at the ministerial level (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 Report 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 [41]. The selection of areas on which the Foresight 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. It was rather 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 %) [42] 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 co-operation 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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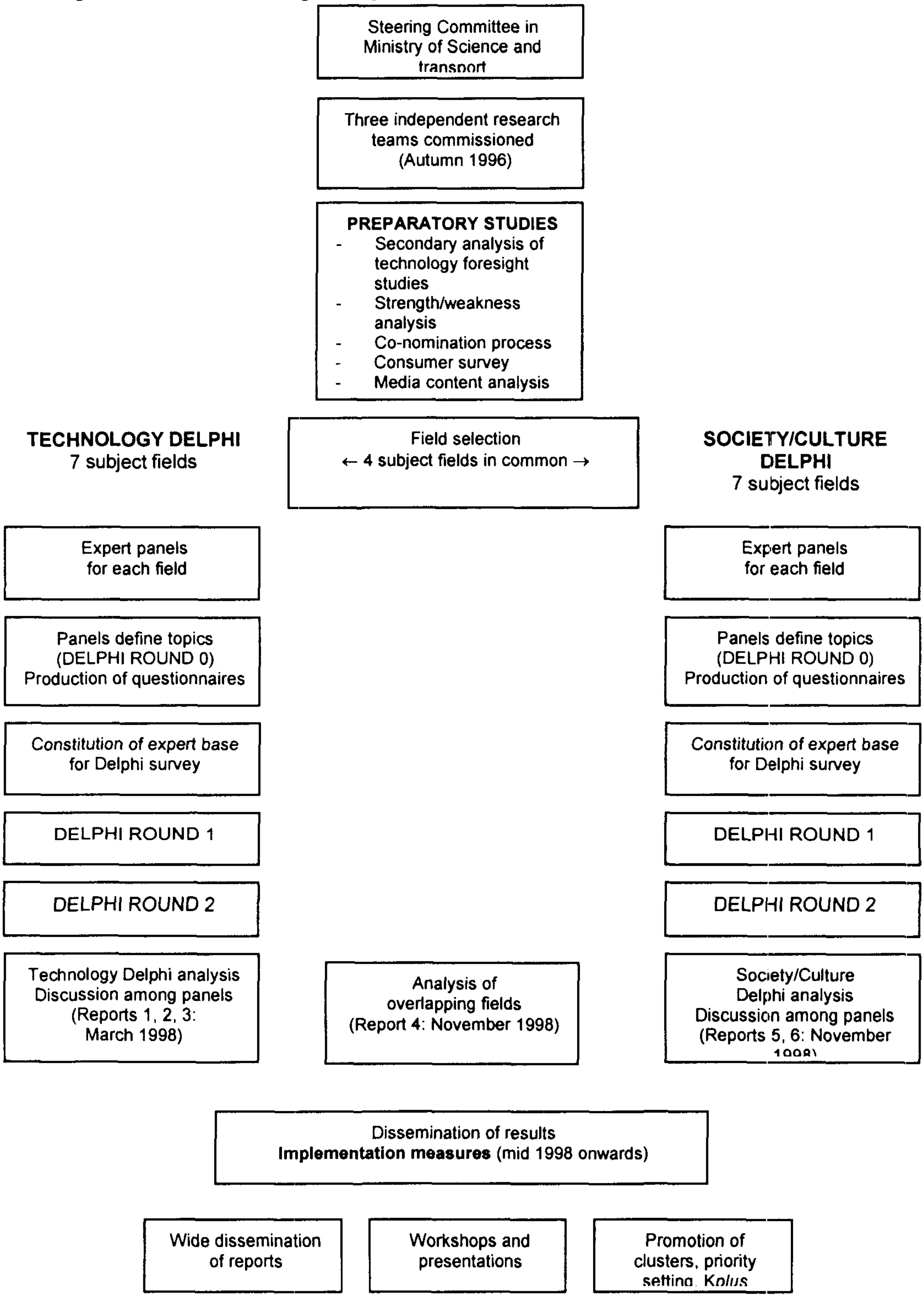
41 The Technology Foresight part was designed and carried out by the Institute of Technology Assessment (ITA) of the Austrian Academy of Sciences, while the Institute of Trend Analysis (ITK) in Vienna was responsible for the Society and Culture Foresight.

42 Of which 17 % entrepreneurs, 23 % physical scientists, 16 % technicians, 13 % social scientists, 19 % administration.

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 genetic modified food, even if it is better, and almost two fifth 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 every-day life ("Alltagspragmatik") showed up."

Figure 1: Organization of the Foresight Programme "Delphi Austria"



On the solid basis of these six studies the Austrian Foresight exercise arrived at the selection of subject fields for the Technology Delphi. The following criteria was applied in the selection process which was done in co-operation 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 wide definition of technology was applied, including also organizational innovations.

The resulting fields that were attributed highest priority and hence should be subject areas of the Technology Foresight exercise were the following:

1. New forms of housing and environment-oriented construction,
2. Lifelong learning,
3. Medical technology and support for elderly people,
4. Clean and sustainable production,
5. Organic food,
6. Physical Mobility,
7. Characteristics-defined materials.

The combination with the subject fields of the Society and Culture Delphi will be described in the course of the next chapter. 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 of 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 the 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 step was the nomination of a large amount of experts in each field (and the generation of an associated address base) who should later assess the hypothesized innovations as respondents in the large Delphi surveys. The results of these two Delphi-rounds were statistically analyzed by the research teams responsible and the outcome was summarized in a series of reports as the main products of the Foresight exercise. [43]

The Combination of a Technology Delphi with a 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, already 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" (BMFT 1993). Among others, a "Social Technology Foresight" had also been explicitly suggested in relation with decreasing acceptance of products and technology development programmes in society (Todt/Lujan 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 to match 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.

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43 The results of the *Technology Foresight* comprise volume 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* and the cross cutting analysis. All volumes are in German and available at 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 (in German) via the following Internet address:http: www.bmwf.gv.at 4fte materialien delphi index.htm=Downl

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; Clean and sustainable production (Fig. 2).

Figure 2: 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
Characteristics-defined materials		Social segmentation

The particular objectives pursued by the Society and Culture Delphi where as follow (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.

Here are a few examples of the results obtained in the subject field "Health and illness in social transformation". The most important trend is the increasing awareness of and interest in prevention. There is growing importance of research on diagnostic and therapeutic strategies in the area of chronic diseases, and a split in high-tech medicines in central hospitals and treatment of patients with chronic diseases 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 the electronically networked health centres which co-ordinate research via data networks, enabling tele-consultations and exchange results, patient related data and expertise of consultants on-line; diagnostic and therapeutic strategies in the area of chronic diseases with a corresponding upgrading of the image of chronic patients; and an intensified health education in families, schools and companies, leading to increased interest in prevention. As trends deserving highest political priority were identified: a potential break-down of the solidarity principle in health insurance (which is also seen as one of the highest conflict potentials); then again 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 also the split between central high-tech hospitals and marginalized chronic patients. Finally, further trends which attributed to major conflict potentials are growing difficulties for planning in the health care system; an increasing codification in law of the doctor patient relation as a source of rises 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 being 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 the environment policy and the education policy; and 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.

Concerning 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 Technology Foresight as a Decision Delphi

According to Rauch (1979) it is useful to distinguish the three types of uses of the Delphi-method: Classical, Policy and Decision Delphi. He called the traditional Delphi approach a Classical Delphi. The Classical Delphi seeks to obtain a group opinion through an anonymous, multilevel group interaction in the form of a conditional scientific prognosis. A precondition for the reasonable application of a Classical Delphi is developed following explicit laws or at least certain regularities. Such an environment is often lacking in social systems, but also 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: 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 co-ordinate them towards a path 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 specialisation. The results may or may not be acceptable for the governments' technology concept; however they can 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 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 years time horizon in each field (e.g. "Simulation-software for virtual optimisation of vehicles and their components with respect to weight, safety, and emissions will be developed").

Special emphasis was laid on orientating 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 in arriving 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 then designed in detail by 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:

- the degree of innovation implied in the respective vision,
- its importance (for society, economy and environment),
- the chances of realization in Austria in general,
- the chances of Austrian leadership with respect to it:
  - R&D,
  - organizational and social implementation, as well as
  - economic exploitation,
- the desirability of the development in question.

In addition, the respondents should indicate which policy measures – out of a given list – they considered as appropriate to enforce the envisaged development. Moreover, room for open comments was also provided (see Annex I and II for examples). Further to that, 17 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 administration and groups of lobbyists in equal parts. 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 by and large a composition of the sample close to 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: 3748 questionnaires were mailed in the first and 1597 in the second round, 46 % and 71 % of which were returned. Out of the respondents of the second round about one third were employed in firms, a quarter in academia; in terms of function, one third worked in R&D and management respectively, one eight's 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/Culture Delphi were not the only innovations of the design of "Delphi Austria". The broader conception was also expert based and 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 circumscribed as "practical user-", "public management-" and "market-related" expertise. However, an absolute requirement for an assessment to be taken as valid must confirm that the person has 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 Technology Foresight for the first time. This novel element aimed to control the 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, 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, it should examine and compare the world views of the respondents to the Technology as well as the Society and

Culture Delphi. 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. Finally, 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 of the German list were replaced by newly created items. Each of these items 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 and views of field experts with assessments by experts from all other fields as an – admittedly rough - check for a potential interest-based bias.

To put it short, six different types of world-views were identified among the respondents of the Technology Delphi. They largely reflected optimism or pessimism vis-a-vis economic and ecological trends, national sovereignty and societal progress. A comparison with results from the German study showed a considerable similarity of 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 impact on the assessments of particular innovations in a significant way (see Aichholzer 1999).

Technology Foresight outcomes and suggested policy measures

The analytical findings and implications derived from the results of the Austrian Technology Foresight for technology policy can be summarized as follows:
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 (i.e. in clean technologies, organic food) because of a special demand situation (shaped for instance by the 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 life-long learning (tailor-made packages for further training, intelligent information agents, electronic learning media)
- Technologies supporting an independent living of the elderly without losing personal contacts
- Substitutes for organs and functions (in conjunction with bio-compatible materials, hybrid technologies).
- Information and communication technologies are part and parcel in almost all cases of successful or potential leadership, as independent technologies they only play a role in certain niches.

A specific problem is that the time horizon anticipated and taken into account in innovation activities by firms and applied research is too short.

Isolated technological efforts are not likely to pay off. Success in achieving leadership requires a wider approach, networking, co-operation 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 realizability.

Concerning policy options, the most important measure suggested by Technology Foresight is the strengthening of co-operation 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 co-ordination 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 on organizational innovations. For each of the seven sectors their are plenty of more specific policy recommendations that can be found in the volume devoted to sector-specific results of Technology Foresight (ITA 1998b).

Summary and conclusion

It has been shown that Technology Foresight programmes are flourishing, especially among small countries, in the nineties. Such exercises have been taken up also by developing countries and seem to be a useful instrument for them indeed when tailored to the specific needs of the country. Goals and approaches are generally different and need to be adapted to the particular position in the global economy as well as they need to 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 more 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 the bottom-up approach tends to be favoured.

The Austrian Foresight Programme "Delphi Austria" is a typical example of a small country approach. Matching the Technology Delphi with a Society and Culture Delphi shed 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 had been first introduced in a German Delphi study was used as a novel element and allowed to examine the homogeneity of the expert base.

Technology Foresight definitely used the bottom-up approach including expert panels and Delphi exercises as key elements which had mainly two tasks:

1. 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,
2. to consider and assess a variety of measures for each group of innovations to support this goal.

Technology Foresight 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.

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 other 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 already been deliberately promoted and a valuable result of the whole Foresight programme.

Further steps in that direction have been undertaken. First of all with the wide diffusion of the results of "Delphi Austria" on the national level. Several thousands of copies of the reports have been 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 which also has led to the wide circulation of a number of contributions both in printed media (several newspapers and magazines) as well as on radio and TV.

The results of "Delphi Austria" have mainly had considerable impact in research and technology policy so far. They have directly influenced the start of a new programme in the field of sustainable production ("Impulsprogramm Nachhaltig Wirtschaften") in February 1999 and the policy recommendations flowing from the Foresight results have at least indirectly supported the creation of new "competence centres". A programme called "K-plus" has been introduced which plans to establish around 15 such "centres of excellence" which pursue a strategy of promoting co-operation between firms and research institutions on major innovative projects in a pre-competitive stage and to support the development of clusters in promising areas. The majority of centres already constituted within this programme work in areas suggested by the Technology Foresight results.

A further important impact concerns the new research strategy programme ("Österreichische Forschungsstrategie 1999plus") currently being developed which is planned to be adopted this autumn after the discussion of a green paper based on "Delphi Austria". Finally, more or less directly related with panel activities independent Foresight projects have been triggered in the fields of vocational training and retraining, medicine, 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.

Finally, the Foresight process itself has contributed to the stimulation of co-operation and networking. It will hopefully continue with such ongoing and future sectoral activities and lead to what is meant by "wiring up the national innovation system".

ANNEXES

Annex 1: 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 2: Policy measures (questionnaire sample page)

How high or low do you assess the suitability of the following measures to increase Austria`s chance to have success 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
- More steady and long-term oriented environmental policy ________ ①②③④⑤
- Realise of an ecological tax reform ________ ①②③④⑤
- Increase transparency of environmental regulation ________ ①②③④⑤
- Strengthen co-operation between basic research and application oriented research ________ ①②③④⑤
- Strengthen co-operation between process or material producers and users ________ ①②③④⑤
- Support co-operation between different areas of processes and materials ________ ①②③④⑤
- Strengthen co-operation 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 to the area "Cleaner Processes":

Annex 3

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

	Panel members		Delphi respondents	
	N	%	N	%
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	1285	100

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

Area	Questionnaires delivered N	Questionnaires for analysis N	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	1597	1127	71

References

Aichholzer, G. (1999) 'The Austrian Foresight programme: organization and expert profile', International Journal of Technology Management (forthcoming).

ASTEC Australian Science and Technology Council (1994) Matching science and technology to future needs: 2010. International perspective, Canberra: AGPS.

BMFT Bundesministerium für Forschung und Technologie (1993) Deutscher Delphi-Bericht zur Entwicklung von Wissenschaft und Technik, Bonn.

Cuhls, K., Blind, K. and Grupp, H. (1998) Delphi '98 Umfrage. Studie zur globalen Entwicklung von Wissenschaft und Technik, Karlsruhe: Fraunhofer Institut für Systemtechnik und Innovationsforschung.

Gavigan, J.P. and Cahill, E. (1997) Overview of Recent European and Non-European National Technology Foresight Studies, Technical Report No. TR97/02, Institute for Prospective Technological Studies (IPTS), Seville, Spain.

Grupp, H. and Linstone, H. A. (1999) 'National technology foresight activities around the globe: resurrection and new paradigms', Technological Forecasting and Social Change 60, 1: 85-94.

Havas, A. (1998) TEP - The Hungarian Technology Foresight Programme, leaflet available at National Committee for Technological Development (OMFB), Budapest.

ICSTI Irish Council for Science, Technology and Innovation (1999) Technology Foresight Ireland, Dublin.

ITA Institut für Technikfolgen-Abschätzung (1998a) Technologie Delphi I. Konzept und Überblick (Approach and Overview), Delphi Report Austria 1, Vienna: Bundesministerium für Wissenschaft und Verkehr.

ITA Institut für Technikfolgen-Abschätzung (1998b) Technologie Delphi II. Ergebnisse und Maßnahmenvorschläge (Results and Recommendations), Delphi Report Austria 2, Vienna: Bundesministerium für Wissenschaft und Verkehr.

ITK Institut für Trendanalysen und Krisenforschung (1998) Gesellschafts- und Kultur Delphi I. Ergebnisse und Maßnahmenvorschläge, Delphi Report Austria 5, Vienna: Bundesministerium für Wissenschaft und Verkehr.

Katzenstein, P. (1985) Small States in World Markets. Industrial Policy in Europe, Ithaka, New York: Cornell University Press.

Martin, B. (1995) 'A Review of Recent Overseas Programmes', Technology Foresight 6, Office of Science and Technology, UK.

Martin, B. and Johnston, R. (1999) 'Technology foresight for wiring up the national innovation system', Technological Forecasting and Social Change 60, 1: 37-54.

Ministry of Economic Affairs (1998) Technology Radar (report in five volumes), Den Haag: Ministry of Economic Affairs.

OECD Organization for Economic Co-operation and Development (1996) Science Technology Industry. Special Issue on Governmental Technology Foresight Exercises, STI Review No. 17, Paris: OECD.

OST Office of Science and Technology (1998) The Future in Focus: a summary of national foresight programmes, London: Department of Trade and Industry.

Rauch, W. (1979) 'The Decision Delphi', Technological Forecasting and Social Change, 15: 159-69.

Rust, H. (1998) Österreich 2013: Eine Querschnittsanalyse des Programmes Delphi Austria, Delphi Report Austria 4, Vienna: Bundesministerium für Wissenschaft und Verkehr.

Soete, L. (1988) 'Technical Change and International Implications for Small Countries', in C. Freeman and B. A. Lundvall (eds.) Small Countries Facing the Technological Revolution, London: Frances Pinter.

Tichy, G. (1999) 'The Decision Delphi as a tool of technology policy – The Austrian experience', International Journal of Technology Management (forthcoming).

Todt, O. and Luján, J.L. (1998) Social Technology Foresight: The Case of Genetic Engineering, The IPTS Report 26, July.

TECHNOLOGY FORESIGHT WITH A FOCUS ON THE BENEFITS FOR SME'S

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Italy

Technology Foresight in Italy - The 1st Study of the Rosselli Foundation (1994-96)

The first comprehensive and systematic exercise of Technology Foresight in Italy was undertaken in 1994 by an independent private organization, the Rosselli Foundation, which is a research institute specialising on public policies in various fields (R&D, health, education, media, etc.). The Rosselli Foundation was motivated to carry out this TF project by receiving strong pressure from the largest industrial and service companies of the country, which are permanent partners of the Foundation.

Within the business community in the beginning of the 90's, there was deep and widespread awareness that existing public structures and procedures for planning and managing R&D and innovation systems were largely unsatisfactory and inadequate to an advanced industrialized country. The most relevant negative aspects were found in:

- the lack of effective long-range national plans for applied research and technological innovation;
- the allocation of the rather limited available financial resources, on a too large set of R&D institutions, programmes and projects, encompassing a very wide spectrum of disciplines and fields of application;
- therefore, the low amount of human and financial resources dedicated to some important scientific areas, critical for the advancement of industrial competitiveness;
- the complexity of the procedures for accessing public financial incentives to R&D, which prevented SME's from receiving the so much needed external support for their innovation processes.

The largest Italian companies felt it was necessary and urgent to put a remedy to this negative situation, through concentrating on both the public resources on really relevant R&D targets and restructuring the national S&T system.

As a starting point, it was decided to provide the country, and especially the Government, with a organic and, at the same time, analytical overview and evaluation of the future trends of technology, on which decisions about R&D national programmes and allocation of human and financial resources should be based. Therefore, those companies charged the Rosselli Foundation with the task of carrying a TF project named "National priorities for industrial R&D in Italy".

The main objective of this project was to identify, within the universe of emerging technologies, those families which appeared to be both relevant, or critical, to the growth of the national industry and of its international competitiveness, and feasible regarding existing R&D and industrial capabilities, structures and resources.

The most important public research institutions of Italy, namely CNR – National Research Council, and ENEA, joined in to sponsor the TF project and to provide financial support and expertise. The national Government through the Minister of University and Research of the time, Prof. Antonio Ruberti, was involved in the preliminary phase of designing the project. After he was substituted, there was a fall of interest and the Government took a passive attitude towards the TF project.

When carrying out the project the Rosselli Foundation adopted a methodology somewhat similar to the one of the German study "Technology at the threshold of the 21st century". Three main steps were planned:

- to select, from the universe of emerging technologies, those which were considered to be of potential interest for Italian industry, and their classification according to a taxonomy, structured on Areas, Families and Components;
- to define a set of criteria for evaluating the degree of priority for each selected technology;
- to evaluate the selected technologies according these criteria.

No hierarchy of the selected technologies was to be provided at the end, as this would have required giving a weight to the various priority criteria, which is a typically political decision. The output of the study was intended only to be a collection of well structured information regarding the possible scientific and technological future of the country, based on a widespread consensus among the scientific and business communities.

All the activities were performed by technical experts from both the industrial and public sectors. They worked in panels, according to each Area of Technology. The analysis performed by each panel was based on a structured scheme, which was intended to achieve homogeneity of the output among the different panels. Consensus among the members of each panel was to be reached at the end of sometimes very long and time-consuming discussions.

Some details about the structure of the project and the selected emerging technologies are listed in Table 1. They are classified according to Areas (7), Families (57), Components (233). It's worth nothing that 86 (23%) of these Components were in the stage of fundamental research and that only 22% are supposed to reach the commercial stage by 2004.

The priority criteria or indicators were chosen according two main notions:

- Attractiveness of a technology, in terms of
  - reference to the fundamental needs of the country
  - impact on national industry
  - intrinsic relevance
- Feasibility of the development of a technology, given
  - the R&D financial and human resources in the public and private sectors
  - international co-operation.

A list of 23 indicators for Attractiveness and of 13 indicators for Feasibility is shown in Table 2.

More than 120 experts were involved in the Foresight process, which lasted until the fall of 1996. A lot of reports were produced and the results were produced in the form of a final Report that was derived and published as a book. More than two thousand copies were distributed within the scientific and business communities. Some of the main results of this Report are summarized in the matrix "Attractiveness/Technology" and the matrix "Feasibility/Technology". An example of which relates to Microelectronics is shown in Tables 3 and 4.

Apart from the specific use of these matrixes for analysing the structure and the perspectives of each Area of Technology, it is possible to use the information they carry, in order to evaluate the performance of the national R&D and innovation system in relation to the potential Technological Future of the Italian industry, made-up by the emerging technologies selected in the study. In this way, inputs can be provided for improving the planning process of national R&D, both in industry and in the public sector. One can choose any of the Attractiveness/Feasibility indicators and sketch the corresponding position of all Families of emerging technologies.

The relevance of the Technological Future for solving some of the country's problem can be assessed in relation with two indicators of Attractiveness:

- growth of employment in industry and services (Table 5)
- growth of international competitiveness of industry (Table 6).

The feasibility can be assessed through the expenditure for R&D in the private and public sectors, as shown in Table 7.

Other interesting tables regard the number of researchers, the technological infrastructure supporting R&D, the transfer of technology from public research to industry, the quality of researches and R&D projects, the overall international competitiveness of the national scientific system.

The rather gloomy picture that came out from this analysis pointed out very clearly that a radical change was needed in the organization and management of the public research sector, at all levels, including the governmental one. Reactions from the Italian Government were quite slow, and only recently have some strong actions been taken, such as:

- a new law regarding incentives to industrial and applied research
- the reorientation of the mission and the reengineering of the managerial structure of CNR and ENEA

- a reengineering of the organizational structure of the Ministry of University and Research, with the creation of two supporting bodies, one for exploring the scientific and technological scenarios and one for evaluating the performance of the national R&D and innovation system
- a 3-year national plan for S&T is going to be prepared by spring 2000, which will be revised yearly.

The results of the TF study of the Rosselli Foundation, even if, in some cases, they have been overcome by the real technological developments, will be used as a contribution to the 1st national plan.

The 2nd Study of the Rosselli Foundation (2000-2001)

The Rosselli Foundation is now starting a second TF Study. There are some major changes in this second exercise:
- first of all, there is definite commitment from the Ministry of University and Research, which is represented in the Steering Committee by its Director-General for Applied Research. They will be giving financial support and they will use the results of the Study for elaborating the national plan for S&T;
- secondly, the basic approach to foresight is widened in order to include main societal problems. In the first study, a "technology-push" approach was adopted where emerging technologies were given and foresight was used mainly to evaluate their feasible impact on the Italian industry and its performance. Now, however, we want to explore the needs of new scientific and technological results, in order to give better solutions to some of the most relevant problems of the Italian society (such as ageing of the population, pollution, transportation in large urban areas, etc.). These problems will be identified and selected by the Steering Committee, on the basis of scenarios for the Italian society, its threats and opportunities;
- on the organizational level, two types of panels of experts will be set up. One related to Technological Areas and the other to Societal Problems. The composition of the panels, specially those for Societal Problems, will be changed in order to include all the relevant actors which influence the practical outcome of technological innovations. These will include researchers, managers of firms (for marketing and product innovation), economists, sociologists, etc.

Technology Foresight and SME's

SME's in Italy account for 75% of the total output of the manufacturing industry. As mentioned before, the TF project of the Rosselli Foundation was promoted and supported by the largest industrial and service companies of Italy. One therefore might expect that the structure of the study and the selection of emerging technologies be defined according to the needs of those types of firms. Certainly the spectrum of technologies used by the universe of SME's in Italy is much wider than the 7 Areas of Technologies, taken into consideration. But these technologies are, in most cases, pervasive or horizontal and, therefore, can have a significant (potential) impact almost on the firms of all sizes in all sectors. This assumption is confirmed by the analysis of the values of the indicator "Impact on industrial firms" for all their sizes and all Families of emerging technologies, as show in Tables 8, 9 and 10. Even if the values in these indicators for large firms are higher than those for Medium and Small Firms, the impact nevertheless on these last two types of firms is in general significant.

The importance of emerging technologies for the competitiveness of SME's is confirmed by other studies, such as the one carried out at the Politecnico di Milano on "The actual level and the perspectives of the technological competitiveness of SME's in Lombardia". Six sectors were analysed in depth:
- machine tools
- textile – silk (district of Como)
- home appliances
- metalworking (district of Lecco)
- chemical commodities for pharmaceutical industry
- telecommunications.

Among other topics, the study investigated which technologies were critical for the future development of products and manufacturing processes of SME's. These came out to be:
- advanced materials
- advanced information technologies
- management methodologies for manufacturing systems

- microelectronics.

In many cases such technologies were foreseen to be able to introduce radical changes into the structure of products and processes. Therefore, the top management of SME's were required to devote strong attention to the related scientific and technical developments and to invest heavily in innovation. When facing these threats and opportunities, the top management of most SME's tended to follow the path of the past, which was:

- their approach to technological innovation was rather incremental and heuristic
- they were sure to be able to control (and to slow down) the inflow of the emerging technologies into their structure
- they felt confident to be able to keep their competitive edge in the international markets, without introducing radical innovations
- they thought to be able to perform innovation relying on their own technical resources, eventually supported by external expertise from consultants, without the need of acquiring knowledge from the science base of the public sector.

This means that TF can be very useful to SME's as they could better understand their needs of new advanced scientific and technical inputs in order to improve their level of technological and economic competitiveness in the global market. But it is apparent that the information and the know-how made available by TF are not enough, by themselves, to change and modernize the strategic approach of SME's towards innovation. Great effort must be devoted to the dissemination of the results of TF among SME's via seminars, workshops, focus groups etc that are useful tools, specially if directed to homogeneous sets of SME's on a regional basis.

The Politecnico di Milano, through that its recently founded Centre for Technology Transfer, is implementing such actions towards the SME's, with special attention to the industrial districts for which the analysis was performed. More than this, the Rosselli Foundation is starting a project, sponsored by the Government of the Piemonte Region that is aiming at setting up a continuos process for identifying emerging technologies that are critical for the future competitiveness of SME's of the main industries of the region.

The Ministry of University and Research has recently completed, in co-operation with Confindustria, a study on "Roadmaps for Italy". This study carried out an empirical investigation on a large (300) sample of SME's in various sectors and regions of the country, with the following aims:

- to identify their technological needs,
- to analyse the objectives, the models and the tools through which technological innovations are performed, the constraints that are met and the possible solutions.

The following industries were included in the investigation:

- fine chemicals
- machine tools
- textile
- food.

The results of the study show that SME's, are almost independent of the industry or area in which they operate in. They can be ascribed into two categories, according to their strategic attitude towards technological innovation - pro active or reactive.

Pro active firms either perform some kind of R&D, more or less in a structured and formalized way. They either contract out innovation projects to some engineering firms or they have international suppliers or they have contacts with universities and research centres or they participate to national or international R&D projects. They monitor carefully any developments in their technological field, as they rely on technology as a strategic tool for competitiveness. This concentration on some (in many cases, few) "core" technologies, besides being a factor of success, may also be a drawback, as the firm is unable to fully monitor "parallel" technologies, which might have a strong impact on its products and processes. More than this, in many cases the entrepreneur doesn't have enough time or even the culture to acquire a strategic view about the future of its firm and the technologies it has to develop. Therefore a key problem in supporting these firms is to improve their awareness for the need of rational management of technology in an international framework.

Reactive firms show a rather passive attitude towards technological innovation and adopt new existing technologies only when they see their competitiveness deteriorate and they loose customers. In many cases these firms have some relevant technological capabilities, but they don't pay enough attention to the new developments which might have a critical impact on their products and processes. When these entrepreneurs have to face news ways for solving their innovation problems, such as co-operation with universities, research centres or even specialized firms, they are quite reluctant to do so. They don't perceive technology as a key factor for success, but just as an asset to be acquired from outside and to be optimized in a static framework.

Therefore management of technology is erratic, when not systematic or not properly organized. These firms, which are mainly concentrated in traditional industries that manufacture final products, can survive only if the technological trajectory on which they operate, is rather stable, the changes are small, incremental and slow. The critical problem for the survival of these firms is the lack of an internal capability of monitoring and acquiring new technological inputs even in their "core" field, not to mention the "parallel" ones. In fact, these firms are more and more exposed to the competitive pressure of large and innovative international firms even in their traditional national or local markets.

All these results point out the need for creating in SME's a strategic attitude towards technological innovation with a long range perspective, and a full awareness of the overall scenarios of emerging technologies. Technology Foresight provides the basic information to be disseminated among SME'S, with a variety of tools, which should be able to involve directly the entrepreneurs and to set up operational relationships among the firms and the sources of scientific and technological know-how.

Table 1: List of the essential emerging technologies for the technological areas

Technological areas	Technological families
Advanced materials	Structural metals and metal matrix composites Structural ceramics and ceramic matrix composites Polymers and polymer matrix composites Electricity and magnetics Electronics and photonics Biomaterials Materials for packing and packaging Recycling and materials recovery
Microelectronics	VLSI micromanufacture processes VLSI design methodologies VLSI architecture for processing systems VLSI semiconductor memory appliances Microelectronics power devices High frequency heterostructure devices Quantum and nanostructure devices Flat-screen display High temperature superconductors for microelectronics
Advanced information Technology	Systems technologies and architecture Radio technologies Signal processing Terminal technology Photonics Remote sensing Calculus (Electro-optics)
Microsystems	Microsensors Microactivators Micromachining Integration of microsystems Testing for microsystems
Software	Software production software High parallelism architecture software Multi-agent systems software Interactive systems with the phenomenological sphere Interaction systems with man Co-design hardware/software End-user systems

Technological areas	Technological families
Biotechnologies	Biomimetic materials Bioelectronics and biosensors Neuroelectronic prostheses and neurone culture technologies Fermenting and biocatalysis technologies Protein engineering Animal transgenics Genetic therapy and physiopathological changes Plant transgenics Environmental and energy biotechnologies Cytometry and microscopy RNA technologies Diagnostic and vaccine biotechnologies (Nural networks)
Production and management technologies	Integration and co-ordination models New product development Production Maintenance Logistics Recycling Management technologies

Table 2: Attractiveness and feasibility criteria

1. Attractiveness
    a) The country's basic requirements
        Growth of employment
        Expansion and diversification of the industrial system
        Environment quality
        Health
        Cultural and social progress
    b) The national production system
        Impact on international competitiveness
        Impact on industrial structure (I)
        - food
        - chemical and pharmaceutical
        - machinery and mechanical equipment manufacture
        - construction of plant for the construction industry
        - electricity and electronics
        - computers
        - precision mechanics
        - transport
        - textiles, clothing
        Impact on the industrial structure (II)
        - small
        - medium
        - large
        Impact on dependency of foreign strategic resources
        Impact on Italy's position in the international production sector
    c) Intrinsic relevance
        All-embracing and generic nature
        Size of the final market (niche or less)
        Specificity and intensity of the fields of application

2. Feasibility
    a) Research resources and performance
        R&D expenditure levels and programmes for the future (state-funded research)
        R&D expenditure levels and programmes for the future (industrial research)
        Researcher skills and quality of research in progress (state-funded research)
        Researcher skills and quality of research in progress (industrial research)
        Total human resources (state-funded research)
        Total human resources (industrial research)
        R&D technological infrastructures
        Technological transfers between state-funded research and industrial innovation
        National competitiveness position
        Creation risks
    b) European- and/or world-wide co-operation
        Community programmes
        Inter-company agreements
        International division of skills

Table 3: Attractiveness of the microelectronics area

Criteria	Technological Families								
	VLSI MiFa	VLSI Des	VLSI Ar	Sem Me	PwMi De	HeHi Fr	Qnt Nan	Flt Scr	HiTmp Supcon
1. Attractiveness									
a). Main requirements of the country									
Growth in employment	H	H	H	H	H	M	L	M	L
Expansion and diversification of the industrial system	H	H	H	H	H	M	L	H	M
Quality of the environment	M	M-L	M	M	M	L	L	L	L
Health	L	M	M	M	L	L	L	M	L
Cultural and social progress	H	H	H	H	H	H	H	H	H
b). The national production system									
Impact on international competitiveness	H	H	H	H	H	H	L	H	L
Impact on the industrial structure (I)									
- food	L	-	L	L	L	L	-	L	-
- chemicals, pharmaceuticals	M	-	M	M	M	M	-	M	-
- construction of machinery and mechanical equipment	M	M	H	M	H	M	-	M	-
- construction of plant for construction	L	L	L	L	L	L	-	L	-
- electrical engineering, electronics	H	H	H	H	H	H	-	H	-
- information technology	H	H	H	H	H	H	-	H	-
- micromechanics	M	M	H	M	M	M	-	M	-
- transport	H	H	H	H	H	H	-	M	-
- textiles, clothing	M	M	M	M	M	M	-	L	M
Impact on the industrial structure (II)									
- small-scale	L	M-H	M	L	M	M	-	L	-
- medium-scale	M	H	M	M	M	M	-	M	-
- large-scale	H	H	H	H	H	H	-	H	-
Impact on dependence on foreign strategic resources	H	H	H	H	H	H	-	H	-
Impact on Italy's position in the international division of production	H	H	H	H	H	H	-	H	-
c) Intrinsic importance									
Pervasive and "generic" nature	H	H	H	H	H	H	L	H	L
Size of the end-market (niche or not)	H	H	H	H	H	H	L	H	L
Specificity and intensity of the fields of application	H	H	H			H	L	H	-

VLSIMiFa = VLSI microfabrication processes
VLSIDes = VLSI design methods
VLSIAr = VLSI architectures
SemMe = Semiconductor-memory VLSI devices
PwMiDe = Power microelectronics devices
HeHiFr = Devices with heterostructure for very high frequencies
QntNan = Quantistic and nanostructure devices
FltScr = Flat-screen displays
HiTmpSupcon = High-temperature superconductors (SAT)
H = high, M = medium, L= low
Table 4: Feasibility of the microelectronics area

Criteria	Technological Families								
	VLSI MiFa	VLSI Des	VLSI Ar	Sem Me	PwMi De	HeHi Fr	QntN an	Flt Scr	HiTmpS upcon
2. Feasibility									
a) Resources and performance of the research									
Levels of expenditure on R&D and programmes for the future (public research)	L	M	L	L	L	L	L	L	L
Levels of expenditure on R&D and programmes for the future (industrial research)	H	M	M	H	H	L	L	L	L
Skills of researchers and quality of on-going research (public research)	H	M	M	M	H	H	H	L	H
Skills of researchers and quality of on-going research (industrial research)	H	M	M	H	H	H	L	L	M
Human resource body (public research)	M	M	M	M	M	H	L	M	L
Human resource body (industrial research)	H	M	H	H	H	M	L	M	L
Technological infrastructure for R&D	H	M	H	H	H	M	M	L	L
Technological transfer between public research and industrial innovation	M	L	L	L	M	H	-	L	-
National competitive position	H	L	M	H	H	L	-	L	-
Production risk	M	M	M	M	M	H	H	M	H
b) Co-operation at European and/or international level									
Community programmes	H	M	H	H	L	M	H	M	L
Intercompany agreements	H	L	L	H	H	M	-	L	-
International division of skills	M	M	L	H	H	M	L	L	L

VLSIMiFa = VLSI microfabrication processes
VLSIDes = VLSI design methods
VLSIAr = VLSI architectures
SemMe = Semiconductor-memory VLSI devices
PwMiDe = Power microelectronics devices
HeHiFr = Devices with heterostructure for very high frequencies
QntNan = Quantistic and nanostructure devices
FltScr = Flat-screen displays
HiTmpSupcon = High-temperature superconductors (SAT)

H = high, M = medium, L= low

Table 5: Growth of employment

ADVANCED MATERIALS	MICRO-ELECTRONICS	ADVANCED INFORMATION TECHNOL.	MICRO-SYSTEMS	SOFTWARE	BIO-TECHNOL.	MANUFARTURING MANAGEMENT TECHNOL.
●●	●●●	●●●	●	●	●	●●
●	●●●	●●	●	●	●	●●
●	●●●	●	●●	●●●	●	●●
●●	●●●	●●●	●●	●●	●●●	●●
●●	●●●	●●	●	●●●	●	●●●
●●	●●	●●		●	●	
●●	●	●		●●	●	
●●●	●●	●●			●●	
	●				●●	
					●	
Mean Value: 1,87	2,33	2	1,4	1,86	1,4	2,2

Table 6: Impact on international competitiveness

ADVANCED MATERIALS	MICRO-ELECTRONICS	ADVANCED INFORMATION TECHNOL.	MICRO-SYSTEMS	SOFTWARE	BIO-TECHNOL.	MANUFACTURING MANAGEMENT TECHNOL.
•••	•••	•••	•••	•••	•	•••
•	•••	•••	•••	•••	•••	•••
•••	•••	•••	•••	•••	•	•••
••	•••	•••	••	•••	•••	••
•••	•••	•••	••	•••	•••	•••
•••	•••	•••		•••	••	•••
•••	•	•••		•••	•	•••
•••	•••	•••			•••	
	•				••	
					•	
					•	
					•	
Mean Value: 2,6	2,5	3	2,6	3	1,8	2,8

Table 7: Expenditure for R&D

ADVANCED MATERIALS	MICRO-ELECTRONICS	ADVANCED INFORMATION TECHNOL.	MICRO-SYSTEMS	SOFTWARE	BIO-TECHNOL.	MANUFACTURING MANAGEMENT TECHNOL.
		PUBLIC RESEARCH				
•	•	•	•	••	•	•
•	••	•	•	•	•••	•
•	•	•	•	•	•	•
•	•	•	•	••	••	•
••	•	•	•	•	•	•
•	•	•		•	•	•
•	•	•		•	•	•
•	•	•			••	
	•				••	
					•	
					•	
					•	
Mean Value: 1,12	1,11	1	1	1,28	1,42	1

INDUSTRIAL RESEARCH

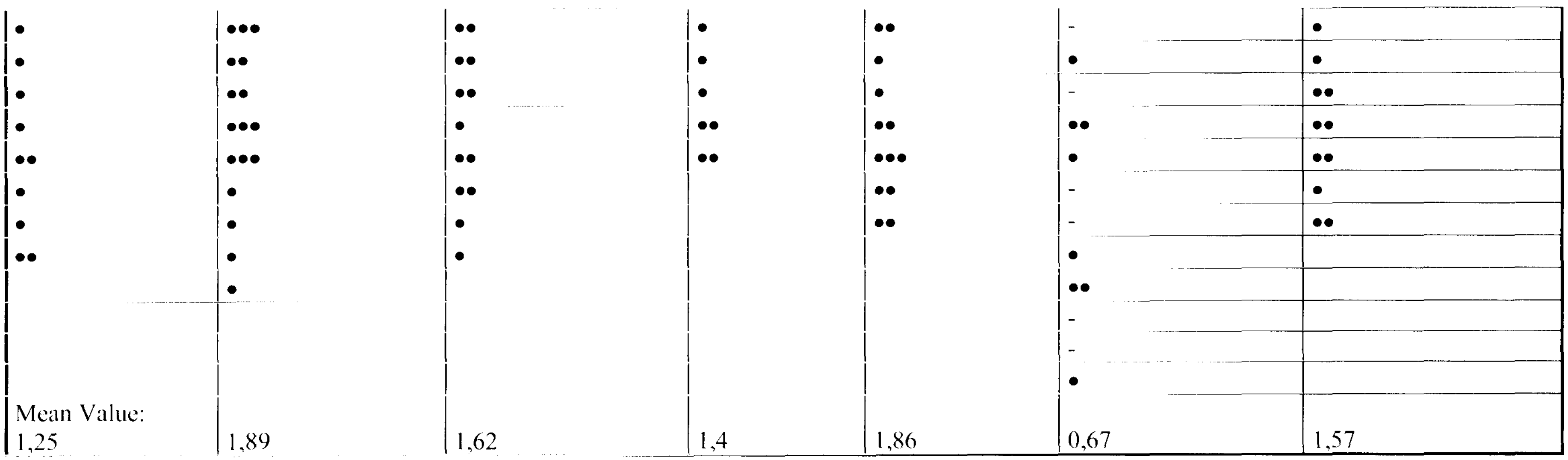

Table 8: Impact on large-size firms

ADVANCED MATERIALS	MICRO-ELECTRONICS	ADVANCED INFORMATION TECHNOL.	MICRO-SYSTEMS	SOFTWARE	BIO-TECHNOLOGY	MANUFACTURING MANAGEMENT TECHNOLOGY
••	•••	•••	NE	•••	•	•••
•	•••	••	NE	•••	•	•••
•	•••	•••	NE	••	•	•••
••	•••	•••	NE	•••	•	•••
•••	•••	•••	NE	••	•	•••
•	•••	•••	NE	••	••	•••
••	-	••	NE	•	••	•••
•••	•••	•••			•••	
					••	
					-	
					••	
					•	
Mean Value: 1,87	2,62	2,75	NE	2,28	1,42	3

Table 9: Impact on medium-size firms

ADVANCED MATERIALS	MICRO-ELECTRONICS	ADVANCED INFORMATION TECHNOLOGY	MICRO-SYSTEMS	SOFTWARE	BIO-TECHNOLOGY	MANUFACTURING MANAGEMENT TECHNOLOGY
•••	••	•••	NE	••	••	•••
••	•••	•••	NE	••	••	••
•••	••	•••	NE	•••	•	•••
••	••	••	NE	••	••	••
••	••	••	NE	••/•••	•	•••
•••	••	••	NE	••	••	••
•••	-	••	NE	••	•	•••
•••	••	•••			••	
					•••	
					••	
					•	
					•••	
Mean Value: 2,62	1,87	2,5	NE	2,21	1,83	2,57

Table 10: Impact on small-size firms

ADVANCED MATERIALS	MICRO-ELECTRONICS	ADVANCED INFORMATION TECHNOLOGY	MICRO-SYSTEMS	SOFTWARE	BIO-TECHNOLOGY	MANUFACTURING MANAGEMENT TECHNOLOGY
•••	•	•••	NE	••	•	•••
•••	••/•••	••	NE	•	••	••
•••	••	•••	NE	•••	•	••
•••	•	••	NE	•	•	••
•••	••	•	NE	•••	•	•••
•••	••	•	NE	••	•	•
•••	-	•	NE	•••	•	••
	•	••			••	
					•••	
					•	
					•	
					•	
Mean Value: 3	1,44	1,87	NE	2,14	1,33	2,14

TECHNOLOGICAL FORECASTING EXPERIMENTS IN LATIN AMERICA [44]

Antonio Leone
Venezuela

Introduction

During the 1980s and at the beginning of the 1990s, considerable efforts were made to promote technological forecasting studies. A number of institutions and individuals gave thought to the need to generate information as a valid basis for decisions by Governments and enterprises. However, most of the studies were oriented towards identifying priorities in science and technology, since the fundamental responsibility for their execution layed with the research and development centres or with the science and technology planning agencies of the region.

Owing to the lack of continuity in the departments responsible for such studies as well as to the absence of a minimum critical mass of experts, many of those initiatives did not generate the expected results. In addition, they did not provide concrete information or value for decision-making that could be linked to national, local or entrepreneurial planning efforts. Furthermore, in their initial enthusiasm, the experts undertook long-term studies that could not provide a useful basis for managers or high-level officials. Such a distant horizon was chosen that the studies were mere exercises in futurology and were rapidly discredited in favour of studies geared to short-term responses. Unfortunately, the latter still predominate or are frequently necessary in our developing countries.

In view of the evident lack of clarity of the results obtained in the developing countries, owing to the application of economic models that tended to underestimate the need to define and implement industrial and technological policies, the experts and representatives of regional and national institutions and of enterprises of a certain size have recently again pointed out the need to undertake forecasting studies as a basis for their decisions. The purpose is to face the challenges produced by globalization process, by international competitiveness, by the very rapid technological change and environmental protection, the adoption of new rules for international trade as well as new organizational arrangements and the redefinition of labour relations, at the dawn of a century in which the degree and level of knowledge will make the difference between an opportunity for continued market presence or being left behind.

In Latin America, a number of attempts to promote technological forecasting studies have been made by various organizations, at the regional, subregional and national levels. In some cases, they were the result of joint efforts between two or more institutions that had set themselves the basic aim of creating areas of awareness and of critical mass. The starting point of such initiatives was science and technology systems and action was directed towards identifying priority areas for research and development, with few links, at least in the immediate term, to production activities.

Most of those efforts were cut short for reasons that we shall attempt to explain later, when we refer to the lessons learnt. Sometimes, the unfortunate result was that the institution responsible for such studies was closed, the leadership attained in this area was lost and the working teams that had scarcely begun to accumulate the necessary experience to carry out the studies was disbanded after initial difficulties associated with this complex subject had been overcome.

In this paper, we shall present a brief account of the activities carried out in the middle of the 1980s and the beginning of the 1990s, which can be considered as the outstanding period in Latin American technological forecasting. Of course, we shall not belittle the efforts made at the end of the 1970s, when some Latin American experts trained in the French school began to disseminate forecasting concepts and methodology.

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44 Document prepared by Antonio Leone D., UNIDO Consultant. Full version of this document can be accessed at http://www.onudi.org (doing business/Technology Foresigth Programme for Latin America and the Caribbean)

a. **Studies**

1. The Year 2000 Latin American High Technology Project (ATAL 2000)

This large scale regional project with collective participation was proposed by the science and technology agencies in the region, but it did not produce the expected impact in the participating countries, despite the large volume of documentation generated. However, it can be considered that the experience accumulated in the execution of the ATAL 2000 project can be taken as a point of departure for kick-starting technological forecasting studies in Latin America and the Caribbean.

As we shall see below, several motives for proposing a project of this nature explain the enthusiasm generated. Among these motives, the following are singled out:

- Very rapid international scientific and technological developments and its impact on the production systems
- Technological changes based on high technology: informatics, microelectronics, biotechnology, new materials and fine chemicals
- Visions of the future of Latin America up to the year 2000. The first was based on an inward-looking future vision of Latin America propounded by scientists, politicians, critics and revolutionary groups. Its analysis of the current situation generally consisted of extended projections of crises, conflicts and limitations, describing a future state of overpopulation, poverty, marginalization, oppression, decline and political populism.

According to the formulators of the project, no essential market, development or co-operation strategy for Latin America had been undertaken by the countries that constitute the economic area.

The project formulated and its components were accordingly perceived as follows:

1.1. The ATAL 2000 project was considered by the principal protagonists and promoters, namely, the national science and technology agencies of Argentina, Brazil, Colombia, Mexico and Venezuela, as a strategic high technology project for the integration of Latin America into the world economy.

1.2. The background for the justification of the project was the heterogeneous political, economic, social and cultural structure of Latin America, which originated from historical and geographical relations between the metropolitan countries and their colonies and dated back to the dawn of world capitalism in the 16th century. It was believed that, fundamentally, the same relations existed in Latin America at the end of the 20th century, since its development had been based on extra-regional demand for goods, almost exclusively raw materials and primary products, and on satisfying the consumer requirements of the high-income population.

Then reference was made to Latin American development in the present century and to the characteristics of the crisis in the region at the end of the decade, despite several decades of industrialization efforts.

Within the various strategies for the development of Latin America, science and technology were considered as key variables with a dynamic of their own, whose development could be summed up in the following stages.

- Beginning of the development process: Emphasis on the role of science, particularly of the natural and exact sciences (intensification of higher education, research centres and promotion of scientific societies).
- As from the 1950s: Technological demand (State- and private-sector programmes and bodies were set up for its institutionalization).
- From the 1960s to the present: Formulation and co-ordination of policies for financing, institutional and organizational developments, applied research, scientific and technological services (for strengthening the scientific/technological infrastructure).

The most recent technological changes and their repercussions on production systems are both the cause and the effect of the world crisis, so that the new technological base becomes a strategic factor. It involves electronic data processing, the application of computers and robots in the production of goods and services, the application of biotechnology to the production of food, drugs, services, species and societies and in the production and alloying of new substitute materials that transform conventional raw materials.

These five branches of high technology (informatics, microelectronics, biotechnology, new materials and fine chemicals) possibly represent the greatest impact that the industrialized countries have had on the developing countries, by excluding them from competition in the market economy and by accelerating the growth of the recently industrialized countries.

The predicted result of the above factors is that the Latin American countries are at genuine crossroads. The Governments of the region must therefore take decisions in a short time, that is to say, within two decades at most, so as to become integrated in the world process and evaluate the other alternative development options for re-emphasizing traditional lines.

Visions of the future of Latin America up to the year 2000 corresponded to two basic scenarios. The first was founded on an inward-looking future vision of Latin America propounded by scientists, politicians, critics and revolutionary groups. Its analysis of the current situation generally consisted of extended projections of crises, conflicts, and limitations, describing a future state of overpopulation, poverty, marginalization, oppression, decline and political populism. By contrast, the most evident world trends observed were as follows:

- The growing development of the Pacific Basin.
- The concentration of North-North economic relations.
- The dismantling of regional investments by the multinational enterprises based on traditional comparative advantages, with a return to the countries of origin.
- Increasing differentiation among the countries of the South.
- Strengthening of the leadership of transnational enterprises, especially those of Japan and the United States.
- Doubt as to the regulatory action of the United States in the world economy.
- The interest of the industrial countries in maintaining bilateral agreements to exploit advantages in negotiation.
- Strategic and military hegemony of the United States.
- Continuous decline in the position of the Latin American countries, with the sole exception of Brazil, in the European and South Asian markets from 1929 to 1986.
- Flight of national and international capital

Most of the analyses corroborating the above trends agree in identifying three direct causes for such processes:

- Inward-oriented national economies.
- Lack of savings by national populations.
- The excessive and even suffocating role of the State as a producer and regulator of the national economy.

The second scenario was contained in the following alternative future vision, which is the basis for the proposed Year 2000 Latin American High-Technology Project.

1.3. With regard to the FUTURE scenario, the project assumed that, throughout the political, economic, social and cultural history of Latin America, there had perhaps never been such propitious future conditions as now. It suffices to mention the following:

- High level of human potential.
- Vast mineral resources.
- Great energy resources.
- Immense resources in flora and fauna.
- Widely varying environments.
- Expanding domestic market.

- Cultural cohesion.
- Democratic convergence.
- National experience of economic development.

1.4. Project objective. To undertake the strategic planning of multinational Latin American action to integrate Latin America into the world economy, satisfying the social demand for goods and services, strengthening the national economies of the region, and making them internationally competitive on the basis of greater technological capacity.

1.5. Technological development. The ATAL 2000 Project was based on research and technological development in new technologies: (i.e. Biotechnology, microelectronics, informatics, new materials and fine chemicals).

1.6. Project strategy. The project aimed to determine the worldwide programmes and initiatives that would produce a direct and indirect impact on the region in the horizon 1987-2000, in order to define and plan jointly Latin American action on the basis of the technologies mentioned.

1.7. Project methodology. The project adopted the theoretical, methodological and operational approaches of forecasting, whose essential phases are as follows:

1.7.1 Explanatory analysis
- The limitations and opportunities of the world crisis
- Determining factors of the current (1989) and future (2000) situation of Latin America
- Models for Latin America in the year 2000
- The role of science and technology

1.7.2 Forecasting
- Worldwide factors and trends in the year 2000
- Worldwide programmes and initiatives that will affect Latin America

1.7.3 Forward planning

Construction of alternative futures for Latin America based on:
- Informatics
- Biotechnology
- Microelectronics
- New materials
- Fine chemicals

1.7.4 Proposals for action
- Definition of joint action
- Co-ordination of joint action

1.7.5 Planning of action
- Programming, financing, execution and evaluation of projects and joint and strategic action in the field of high technology in the Latin American countries.

b. Training

Several intensive and large-scale training efforts have been made in order to disseminate the concepts and working methodology of technological forecasting. Many of these were carried out jointly by several agencies. Prominent among these were the Latin American Economic System (SELA) and its organs or action committees, specifically the Latin American Science and Technology Commission (COLCYT) and the Latin American network of technological information (RITLA), UNIDO, UNESCO-CRESALC and others, including national bodies, which took on this task with interest and enthusiasm.

Between 1990 and 1993, COLCYT launched the "COLCYT competitive management model". The basis of this model was the belief that, since technology is a strategic factor for competitiveness, it should be managed in such a way as to create closer links with strategic planning and technological forecasting, monitoring and technico-economic intelligence, quality management and technological management activities.

The relation between the production function and the time factor is indicated below.

Table 1: The COLCYT competitive management model

	Production and commercial management	Information management	Know-how management
Long-term management	Strategic planning	Commercial and technological monitoring	Technological forecasting
Short- and long-term management	Quality management		Technological management

Strategic planning

This consists in the formulation of plans, strategies and specific action directed towards guaranteeing the continued market presence of enterprises, increasing their share and maximizing profits. It is based on information related to the external environment and its effective control in line with internal capacity. The objectives, targets and strategies of the organization are based on such data. In turn, this determines the actions and specific methods of the organization for measuring progress achieved, adjusting them according to external changes.

Technological forecasting

This includes the formulation, evaluation and analysis of possible and probable future scenarios that the enterprise must face. It is based on activities directed towards obtaining information concerning the environment of the enterprise, which conditions its conduct. In-depth analysis of the information permits the formulation of future scenarios. In addition, independently of the situation, the formulation of these future scenarios promotes the re-evaluation of objectives and the possible formulation of new lines of development. It permits the identification of horizons towards which the enterprise must direct its efforts in its task of creating and generating new know-how.

Quality management

Essentially, this is the proactive management of all resources linked to production, management and the commercial aspects within the enterprise for the purpose of achieving the targets established. The information generated in all the activities of the enterprise serves as a basic input for evaluating the internal potential of the company. Proposals for changes are made to this unit as a result of activities related to the possible future scenarios identified. This makes it possible to determine the operational and commercial viability of the enterprise.

Technological management

This is the proactive management of the resources that generate know-how, and contributes to the consolidation of control over production and commercial activities. It entails the evaluation and analysis of the results of production and commercial activities, thus generating information feedback to bring about continuous improvement within the enterprise. It involves the formulation of projects that are oriented towards increasing knowledge and transforming the production and commercial base of the organization, as well as the establishment of relations with external bodies. It is the bridge between internal production processes and the environment of the enterprise and helps the latter to take decisions regarding its internal development plans. In other words, it supports the apprenticeship process of the enterprise.

Clearly, the purpose of two of the functions (strategic planning and quality management) is to meet the challenges associated with production and commercial management. Forecasting and technological management, however, are directly related to the management of know-how and information.

Moreover, quality management and technological management are fundamentally associated with short- and medium-term activities, whereas technological forecasting and strategic planning concentrate more on the medium and long term.

Technological monitoring

A third relevant aspect is the link between forecasting and technological management, on the one hand, and the factor of information (internal and external), on the other. The latter is in turn responsible for the management of know-how and data (internal and external), supporting the execution of the other two functions. All this leads to the final support function, namely, competitive management.

FORESIGHT ACTIVITIES AROUND THE GLOBE: RESURRECTION AND NEW PARADIGMS

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Abstract

The overview begins with the cluster of innovations triggered by the Great Depression and proceeds to consider two distinct periods in the U.S. associated with the Kondratiev long waves: stable growth in 1945-1970, which nurtured forecasting, foresight, and long-range planning, followed by the 1970-1995 period of disillusionment with the available tools. This, in turn, gave rise to promising new concepts for illuminating and dealing with complex sociotechnical systems, such as complexity science and multiple perspectives. Information technology also has made bibliometric analyses for technology monitoring possible and facilitates technological intelligence analysis as well as the use of Delphi in foresight projects. During this same period Asia and Europe moved on another path: national foresight projects using Delphi extensively as an interactive communication device. Japan led the way beginning in 1970-1971, undertaking a large-scale foresight project every five years. Korea, Germany, and other European countries followed this lead in both public and private sectors. As we enter the next century, the promise of new concepts to deepen our insights on complex adaptive systems provides a basis for optimism in foresight activities.

Prelude

Let me begin by taking you back to the Great Depression to point out that it triggered a cluster of very important technological innovations. In the period 1930-1945 we saw the development of radar, jet engines, nuclear power, computers, and telecommunications -- creating entirely new industries and a new age. In his book Das Technologische Patt Germany's Gerhard Mensch has discovered a regular pattern relating basic innovation clustering to the long wave cycle of prosperity-recession-depression-recovery.[1] The explanation is that in good times, particularly periods of stable growth, there is no incentive in taking large risks on new ventures; improvements in existing systems are preferred. The willingness to take risks and embark on radical innovation paths appears to come to the fore when the end of the chaotic depression phase is in sight.

1945-1970 - The United States: Methodology Evolves in a Stable Environment

Following World War II a stable economic growth phase ensued, accompanied by the onset of the Cold War. Complex technological systems, such as the SAGE air defense system and the Atlas missile project both began in the 1950s. Engineers and scientists played a leading role in their management with Ph.D.s in key roles. That is how the military-industrial-university complex evolved and the systems engineering concept emerged. The Atlas project required 18,000 scientists and engineers in industry and universities, 70,000 industrial workers, 17 associated contractors, 200 subcontractors, and 200,000 suppliers, as well as 500 military officers with technical expertise. Among the leading organizations in the development of these systems were the California and Massachusetts Institutes of Technology, the newly created U.S. Air Force, IBM, Bell Laboratories, and several aircraft companies.[2] It was in this period that operations research, management science, and systems analysis evolved to become effective tools for managers and engineers. The RAND Corporation, formed by the Air Force in the late 1940s as its own think tank, became a superb resource in developing the systems methodology.

It was also this setting which nurtured forecasting and long range planning as well as the development of technological forecasting methodologies in the United States. The Cold War provided a strong motivation to the U.S. Department of Defense, in view of its involvement with very high-tech, long-lead-time systems such as nuclear weapon systems, jet aircraft, guided missiles, and radar. We must note parenthetically that a distant horizon was not generally perceived as a crucial concern in the myopic world of business.

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Not surprisingly, government funding of the military, the aerospace industry, and non-profit institutes such as the RAND Corporation supported development of trend extrapolation, growth curves, measurement of technology, Delphi, system modelling, scenarios, and other techniques during the 1950s. Normative, or need-oriented, techniques were also developed. The methods, largely based on systems analysis, were collected in books by Erich Jantsch (1967), James Bright (1968), Robert Ayres (1969), Joseph Martino (1972), and others. The accession of systems analyst Robert McNamara to the top position in the Department of Defense quickly led to the placement of RAND analysts in key positions in the halls of the federal government. On the civilian side Harvard Professor Bright organized the technological forecasting workshops for industry beginning in 1968.

The manned landing on the moon in 1969 seemed to signal the peak of the public euphoria with technology and the onset of a new phase. Galvanized by the writing of Rachel Carson and concerns over the impacts of technologies such as the supersonic aircraft with its worrisome sonic shock wave, the need for technology assessment was recognized in the 1960s by a growing number of scientists and government officials dealing with technology. The Office of Technology Assessment was formally established as a support analysis resource for Congress.

1970-1995 - The United States: Methodology Confronts New Paradigms

The 1970s appeared to signal a change in the United States: forecasting and long range planning began to lose popularity. There was growing disillusionment with the overblown claims of systems analysts to be able to solve complex sociotechnical and societal problems with their tool kit. The limits of systems analysis became apparent and the influence of the RAND crowd waned. Models appeared to be sophisticated but their lack of transparency often hid critical assumptions. One manifestation was "assumption drag", that is, carrying along assumptions that were valid at the time the forecast was made, but were not valid for the period being forecast. For example, econometric models failed to consider key future technological changes and population forecasts assumed the birthrate would remain similar to that at the time the forecast was made. [4] Similarly, obsolescing indicators (GNP, productivity, jobs) and boundaries (national) went unquestioned.

The end of the Cold War underscored a new austere environment for technological forecasting. The downsizing of corporate staffs proceeded apace in the 1980s [5] and the termination of the highly respected Office of Technology Assessment in 1995 brought home in striking fashion the erosion of public support.

Two new paths brought the limitations of the existing forecasting techniques clearly into focus: (a) the Multiple Perspective Concept, and (b) Complexity Science. Beginning in 1977, the multiple perspective approach showed the importance of augmenting the science-based perspective of systems analysts and forecasters (known as the technical or T perspective) with others to bridge the gap between the analyst and the real world (Table 1). Sweeping in context-specific organizational and personal perspectives (O and P) with very different paradigms, for example, those underlying law and politics, was found to be exceedingly valuable, demonstrating the limits of T. [6] Note, in Table 1, the application of the multiple perspective concept to scenario types.

In the 1980s complexity science, cultivated at the Santa Fe Institute, recognized salient characteristics of the systems of greatest interest for the forecast and foresight process: non-linearity, self-organization and emergence. These systems are termed complex adaptive systems (CAS). They may be (1) stable, that is, converging to an equilibrium, (2) oscillating stably, (3) chaotic within predictable boundaries, or (4) diverging unstably. In the chaotic state the system appears to exhibit paradoxical behaviour: It is deterministic because it is fixed by equations and yet it incorporates randomness. It may be orderly and suddenly become chaotic or vice versa. The system is exceedingly sensitive to initial conditions, making the use of historical data as a basis for forecast and foresight dubious at best. [8] Non-linearity means that the total does not equal the sum of its parts; the system cannot readily be decomposed into its parts or reassembled from its parts. Each level of integration creates new characteristics.

Adaptiveness means that each system element cannot see the whole picture but has its own internal models, that is, its own perspective, which may be quite different from any aggregate model. It must base its decisions on its local information or model, but has the ability to create or revise the models or rules governing its actions. It uses feedback to "learn" and improve its internal model. The forecasters's motto "think globally but act locally" reflects this situation.

The total system behaviour emerges from the self-organization of its parts and is thus neither predictable nor optimizable. There may be no deductive rule governing a system's activity. Rational individual behaviour, necessarily based on an individual perspective, thus is not equivalent to total system optimization. Indeed, CAS continually evolve and do not have optimal end states.

One of the most promising approaches is the use of computer simulation to "grow" complex non-linear dynamic systems from the bottom up. [9,10] New worlds are created that are miniatures of the real world or true silicon worlds. The computer makes it feasible to analyze complex adaptive systems that consist of thousands of intelligent, interacting elements, or agents, each with local information only.

The creation of such electronic worlds can provide remarkable insights, such as emergent behaviours resulting from the interaction of these agents. Microlevel interactions between individual agents and global, aggregate-level patterns and behaviours mutually reinforce each other. This bottom-up simulation approach has already been used successfully to model a variety of systems.

An example of a primitive exchange-type economy model, Sugarscape, should be of particular interest to forecasters. [10] A relevant question, raised by the developers of this model, is the effect of foresight on the agents. Trading sugar and spice, they initially make their decisions based on their current holdings. If agent behaviour is modified so that they can look ahead at a certain number of time intervals, one finds that clearly, some foresight is better than none in this society since the long run average foresight becomes approximately stable at a non-zero level. However, large amounts of foresight, which lead agents to take actions as if they had no accumulation are less "fit" than modest amounts. [10; p.129]

It offers a means to sweep in various disciplines and examine their interactions, such as demography and economics.

Table 1: CHARACTERISTICS OF MULTIPLE PERSPECTIVES

	Technical (T)	*Organizational (O)*	*Personal (P)*
Worldview	Science-technology	Unique group or institutional view	Individual, the self
Objective	Problem solving, product	Action, process, stability	Power, influence, prestige
System focus	Artificial construct	Social	Genetic, psychological
Mode of inquiry	Observation, analysis: data and models	Consensual, adversary bargaining and compromise	Intuition, learning, experience
Ethical basis	Logic, rationality	Justice, fairness	Morality
Planning horizon	Far (low discounting)	Intermediate (moderate discounting)	Short for most (high discounting for most)
Other descriptors	Cause and effect	Agenda (problem of the moment)	Challenge and response, leaders and followers
	Optimization, cost-benefit analysis	Satisfying	Ability to cope with only a few alternatives
	Quantification, trade-offs	Incremental change	Fear of change
	Use of probabilities, averages, statistical analysis, expected value	Reliance on experts, internal training of practitioners	Need for beliefs, illusions, misperception of probabilities
	Problem simplified, idealized	Problem delegated and factored, issues and crisis management	Hierarchy of individual needs (survival to self-fulfillment)
	Need for validation, replicability	Need for standard operating procedures, routinization	Need to filter out inconsistent images
	Conceptualization, theories	Reasonableness	Creativity and vision by the few, improvisation
	Uncertainties noted	Uncertainty used for organizational self-preservation	Need for certainty
Criteria for "acceptable risk"	Logical soundness, openness to evaluation	Institutional compatibility, political acceptability, practicality	Conduciveness to learning, time-space distance of event
Scenario typology	Probable	Preferable	Possible
• *criterion*	analysis (reproducible)	value (explicative)	image (plausible)
• *orientation*	exploratory (extrapolative)	normative (prescriptive)	visionary
• *mode*	structural	participative	perceptual
• *creator*	think-tank teams	stakeholders	individuals
Communications	Technical report, briefing	Insider language, outsiders' assumptions often misperceived	Personality, charisma desirable

Source: [6]

A wide range of important phenomena can be made to emerge from the spatio-temporal interaction of autonomous agents operating on landscapes under simple local rules.[10, p. 153]

A case in point is the distribution of wealth in a simple sugar-consuming society. The agents are endowed with uniformly distributed vision acuity and metabolic rates. The sugar resource is distributed on the landscape in two "mountain" sites. Two results become apparent as the computer model is run: (1) self-organization is at least as efficient as top-down planning, and (2) there is a widening gap between rich and poor, that is, the bell-shaped initial wealth distribution turns into a highly skewed one [10, p.34]. A few agents accumulate much wealth and an increasing number of agents become poorer. It may come as a shock to some that the current, much deplored widening of the gap between rich and poor seems to appear naturally.

It is evident that the challenge for forecast and foresight is an awesome one. Most exciting is the potential for new advances. For example, even with its chaotic phases, such a system has "attractors" that help define the bounds of system operation, the sensitivity of the system to internal or external perturbations, and the range of possible consequences.[8] Other intriguing possibilities:

Understand and map the domains of stability, stable oscillation, chaos, and instability. What triggers the shifts from one regime to another? What can we learn from the chaotic interval? It is vital that the system state be correctly diagnosed, that is, the stability-chaos pattern be recognized. This is not always an easy task; what appears to be chaos may simply be noise.

Recognize that random-appearing data may not be random and, conversely, a perceived pattern may actually be produced by chance. [11,12] Thus a local cluster of cancers may be misinterpreted as correlated with industrial pollution at specific sites. Alternatively, the shift from chaotic to stable behaviour suggested by the recursive data may be illusory, signifying merely a brief interlude of apparent order. Or a shift from stable to chaotic behaviour is erroneously assumed to be due to disturbances external to the system.

Find ways to circumvent the limitations to provide improved insights. One example is the use of a meta-trend such as an envelope curve to anticipate the next logistic growth curve. Another is the recognition that insights and explanations suggest a means of substituting for forecast limitations. Thus the creation of high reliability organizations facilitates effective response to unpredicted crises, such as Three Mile Island, Bhopal, and the Alaska oil spill. Examples of such organizations are the Federal Emergency Management Agency, airline crisis management teams, and the US Air Force Strategic Air Command airborne readiness system. [13]

Recognize means to stimulate a phase change. Creativity and technological innovation can be triggered by creating chaos in a stagnant, stable system. Alternatively, new stable growth can be instituted by determining and supporting a promising technological approach during the chaotic phase. In other words, learn to manipulate the order/chaos phases by nudges at the right time and place. [12] We stress that the role of randomness in innovation is vital: it creates fluctuations that act as natural seeds from which new patterns and structures grow. [14]

Recognize how to delay or forestall a phase change. Inappropriate timing of the onset of chaos can be averted by cutting feedback loops in the system, and/or applying external "kicks". For example, it may be dangerous to speed up information flow when there is the potential of inducing chaos that management cannot handle. [11] On the other hand, improving feedback can enhance the agents' local information, emergent self-organization, and the bottom-up decision making process.

Work with models such as Sugarscape to develop insight on critical questions raised by the impact of technology on society. A prime example is a question raised by today's information technology: what is the desirable balance between organizational centralization and decentralization? [13,15]

The two directions discussed are not the only ones that promise new capabilities. Information technology now permits bibliometric analyses that facilitate technology monitoring. Porter insists that technological intelligence, rather than accurate trend extrapolation, Delphi, or modelling, is the most valuable means of enhancing foresight.[16] Accessing the wealth of electronic information pertinent to emerging technologies and processing both mainstream and outlier pieces of that information are the keys.

He gives as an example the microchip to advance genetic technologies (the genechip), chemical applications (microfluidics), and micro-electromechanical devices (MEMS). The breakthrough implications of these developments are along two dimensions: technology transfer and technology fusion. A hypothetical example: (1) using microfluidics to present environmental samples to (2) DNA-based sensors that identify particular toxins leading to (3) actuation of MEMS-based devices that counter the threats posed by the toxins. The technology rarely mentioned in conjunction with the focal technology may convey the critical knowledge of a novel linkage of technologies. Thus the clever use of massive electronic databases can mine information and tease out relationships that elude conventional technological forecast and foresight techniques. Clues to imminent industrial disasters, for example, hidden failure modes, and unintended consequences and impacts may be uncovered.

Thus, while the American pace of development of forecasting tools slowed down in the 1970-95 period, the stage was being set for new paradigms and approaches likely to be of fundamental importance for foresight and planning everywhere.

1970-95 - Asia and Europe: National Foresight Projects

The U.S. having served as a trend precursor, Europe and Japan now saw significant growth in forecasting activities. 1970-71 saw the first large-scale Japanese National Technology Forecast Delphi and 1972 saw the creation of the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. The first Japanese effort surveyed a 30-year period, covering 644 topics using nearly 2500 participants. [17] The exercise has been repeated every five years with the latest, in 1996, covering 1072 topics with over 3500 participants. Distribution has been wide: the fifth survey was printed in Japanese (3000 copies) and English (1000 copies) for government and industry use. The prime aim has been the identification of strategic research areas and generic technologies likely to yield the greatest social and economic benefits. As Turoff and I defined Delphi in our 1975 book on the subject, it is "a method for structuring a group communication process" [18; p. 3] and it is in precisely this role that it has been used so successfully in Japan. The surveys helped to pave the way for an earthquake disaster prevention law in 1993 and to galvanize solar cell R&D support programs by MITI.

The label "foresight" was introduced by Irvine and Martin in 1984 and is now applied to such studies. The purpose is to emphasize that the concern is with a set of possible futures rather than a single prediction. The aims usually include (1) policy direction-setting, (2) determining priorities, (3) consensus generation, and (4) advocacy. The term "foresight" should not be taken to assume that earlier studies did not consider such multiple futures. Examples of what would now be called foresight studies were the Shell scenario studies and Edmunds' Alternative U.S. Futures [19] in which four future paths were considered and compared along thirteen socioeconomic policy dimensions with the 1970 U.S. Three of the paths were "replays of the Greek, Roman, and Medieval societies, the fourth an original projection (see Table 2). Similarly, the development of relevance trees to prioritize R&D activities in connection with multiple scenarios dates back to Minneapolis Honeywell's PATTERN studies in the 1960s.[20]

Table 2: Edmund's Comparison of 1970 U.S. and Future Policy Choices

	U.S. 1970	Greek Replay	Roman Replay	Medieval Replay	U.S. "original"
1. Monetary-fiscal policy	Unbalanced (expansion) → inflation	Balanced → equilibrium	Unbalanced	Balanced → equilibrium	Balanced
2. Income distribution	Skewed → rich/poor gap	Skewed	Skewed	Skewed	Normal → equitable
3. Capital distribution	Institutionally channeled → capital concentration	Semi-open → less concentration	Institutionally channeled	Institutionally channeled	Open → competitive
4. Competitive distribution	Oligopolistic → large corp's	Oligopolistic	Oligopolistic → large latifundia	Open → small units	Open → small units
5. Price policy	Administered → profit maximized, stable	Free → competitive unstable	Administered → tribute maximized, stable	Free	Free → competitive unstable
6. Living standards	Costs externalized → less amenities more government	Costs internalized → more amenities less government	Costs externalized	Costs externalized	Costs internalized → more amenities less government
7. Employment	Labor extensive → unemployment, capital intensification	Labor intensive → service oriented economy	Labor intensive → slavery freeman unemployment	Labor intensive → service oriented economy	Labor semi-intensive → service oriented economy
8. Educational distribution	Semi-wide → specialized technostructure	Narrow → ruling elite	Narrow	Narrow	Wide → adaptable individual
9. Technological distribution	Narrow → oligopoly	Wide → open competition	Narrow	Narrow	Wide → competitive
10. Barriers to entry	Raised → Skewed incomes	Lowered → equalized incomes	Raised	Lowered	Lowered → equalized incomes
11. Voting	Narrow issue → oligarchic republic	Wide issue → direct democracy	Narrow issue	Narrow issue	Wide issue → direct democracy
12. Internal order	Semi-participative → limited conflict resolution	Participative → restive conflict resolution	Coercive → police state	Coercive → feudally policed state	Participative → restive conflict resolution
13. International order	Semi-coercive → use of economic military power	Coercive → military power, conquest	Coercive → military rule	Coercive → military rule	Participative → restive conflict resolution
Similarities with 1970 U.S.		2	9	5	0

The Japanese preference for national Delphi projects is readily understandable in terms of its cultural characteristics -- a high degree of societal cohesion, comfort with large collective group projects, and a long time horizon - unique traits not common to many other societies. However, Delphi-based "national foresight" projects, were subsequently taken up in Korea and several European countries. [21] Fig. 1 shows the evolution of these projects.

Thus the Germans co-operated in their first Delphi with the fifth Japanese project, drawing their second round questionnaire directly from the Japanese. A comparison report of the two Delphis was also produced. France, in turn, translated the Japanese questionnaire from the German translation. The United Kingdom project relied heavily on panels, with Delphi as a supportive tool. Smaller, more selective efforts have been undertaken in Indonesia, Spain, and Austria, as well as Thailand, South Africa, Hungary, and the Netherlands.

In most cases the major concern is with technology and industrial innovation rather than with science. In countries like the United Kingdom, Germany, Italy, and the Netherlands, industry participants were easier to engage than academics. Large studies enlist 2000 to 5000 respondents, in fully industrialized countries typically 40% industry, 40% academic, and 20% government or nonprofit organizations. Elsewhere, the number of industrial participants is lower; for example, for the large Korean Delphi the participants were 54% were academic, 30% public sector, and only 16% industry. Users include corporations such as BASF in Germany and NTT in Japan, and, in government, the Science Minister in the United Kingdom, and the Länder (state) governments in Germany. It is fascinating to see the cross-border Foresight interactions -- Japan and Germany, Germany and France, Germany and Italy, Japan and Korea, as well as OECD -- that clearly point to the globalization of R&D.

Such interactions are greatly facilitated by today's information technology. In fact, as one of the method's pioneers, Ted Gordon, points out, Delphi itself will benefit from its application, for example, the use of far more sophisticated data banks:[8]

Experts will be easier to find using the segmentation techniques that already are used in marketing to permit retailers to identify consumers who fit certain demographic criteria. Thus Delphi participants with research publications in the relevant area or with implementation experience can be culled from a data bank.

The self-evaluation often requested in Delphi to assess a respondent's expertise can be fine-tuned. The panelist can be asked pairs of questions, a preliminary qualifying question, then the actual question of concern. The degree of correctness of the answer to the test question will determine the significance of the weighting to be applied to the second question.

Respondents can be asked to complete a profile of their interests and expertise and questions can be directed to those with matching expertise.

Even so, it must be clearly understood that Delphi is most useful as an interactive communication device; for greater "depth perception" the exploration of the elaborate data banks and other new approaches such as those projected in Sec. 2 will be vital.

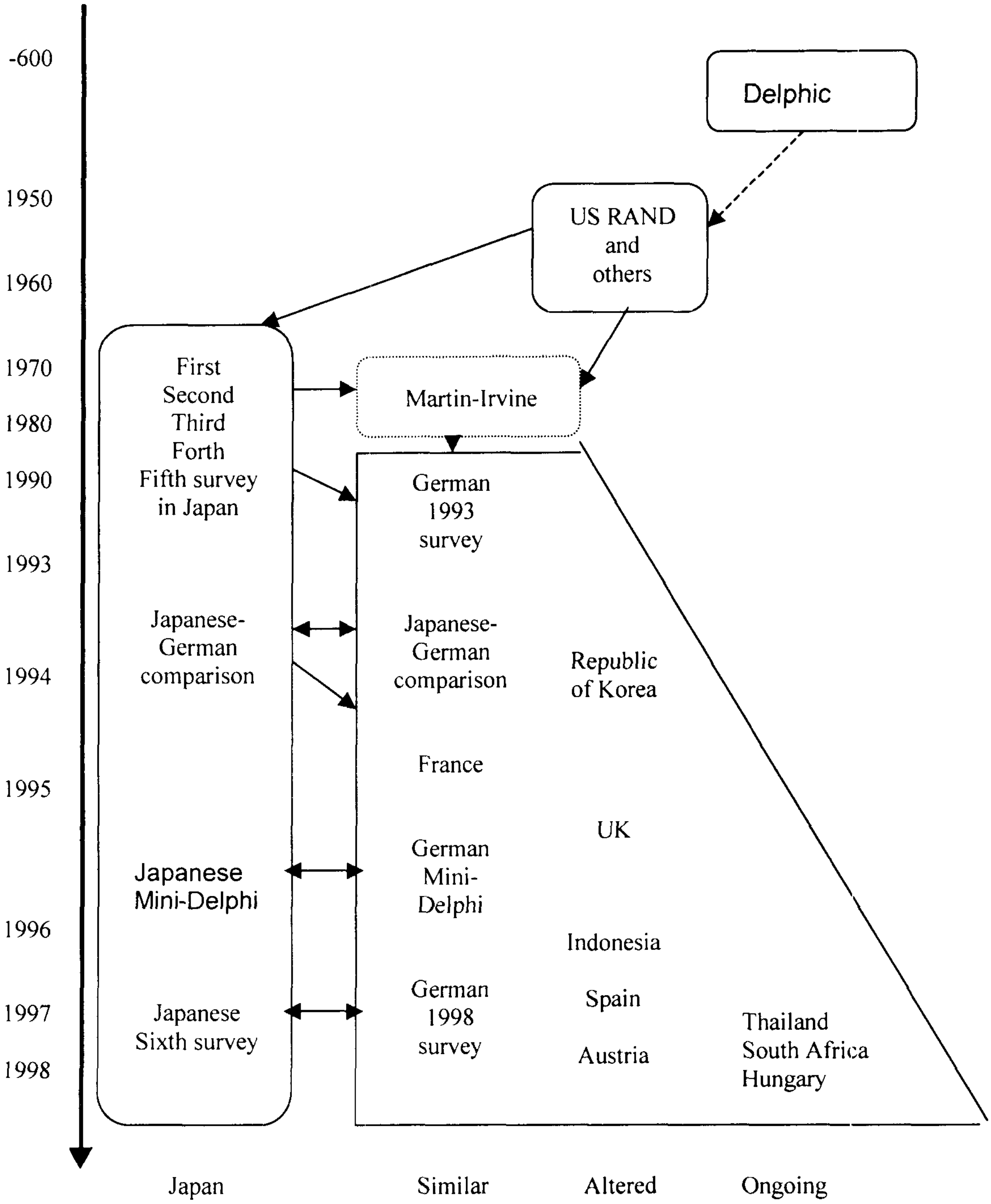

Figure 1: Career of the Delphi methods genealogical tree of national applications.

Conclusion

It should be apparent from my brief comments that we are entering the new millennium with considerable optimism. Our advances in information technology, use of multiple perspectives, and deepening understanding of the behaviour of complex adaptive systems should significantly strengthen our foresight efforts in the coming years. However, we must also become more sensitive to the uncertain and even to the inconceivable: emerging technologies will mean that the new epoch will feature forms of reality we cannot envision at present.[22]

References

Mensch, G., Das Technologische Patt. Frankfurt: Umschau Verlag, 1975. English translation: Stalemate in Technology. Cambridge, Mass.: Ballinger Publishing Company, 1979.

Hughes, T. P., Rescuing Prometheus. New York: Pantheon Books, 1998.

Linstone, H. A., "An Approach to Long-Range Planning", in Stockfisch, J. A. (ed.), Planning and Forecasting in the Defense Industries. Belmont, CA: Wadsworth Publishing Co., 1962.

Ascher, W., Forecasting: An Appraisal for Policy-Makers and Planners. Baltimore, MD: The Johns Hopkins University Press, 1978.

Moore, T., "Goodbye, Corporate Staff", Fortune, Dec. 21, 1987, p. 65.

Linstone, H. A., Multiple Perspectives for Decision Making. New York: Elsevier North-Holland, 1984; Decision Making for Technology Executives: Using Multiple Perspectives to Improve Performance. Norwood, MA: Artech Books Inc., 1999.

Brunner, R. D., "Predictions and Policy Decisions", Technological Forecasting and Social Change, vol. 62 (1999), no. 1-2.

Gordon, T. J., "The Prospects for Accuracy and Completeness in Forecasting", Technological Forecasting and Social Change, vol. 62 (1999), no. 1-2.

Casti, J., Would-Be Worlds. New York: John Wiley & Sons, 1997.

Epstein, J. M., and Axtell, R., Growing Artificial Societies. Washington, D.C.: The Brookings Institution; Cambridge, MA: The MIT Press, 1996.

Gordon, T. J. and Greenspan, D., "Chaos and Fractals: New Tools for Technological and Social Forecasting", Technological Forecasting and Social Change, vol. 34 (1988), pp. 1-25.

Gordon, T. J. and Greenspan, D., "The Management of Chaotic Systems", Technological Forecasting and Social Change, vol. 47 (1994), pp. 49-62.

Linstone, H. A., The Challenge of the 21st Century: Managing Technology and Ourselves in a Shrinking World. Albany, NY: The State University of New York Press, 1994.

Resnick, M., "Unblocking the Traffic Jams in Corporate Thinking", Complexity, vol. 3, no. 4 (1998), p. 29.

Linstone, H. A., "Complexity Science: Implications for Forecasting", Technological Forecasting and Social Change, vol. 62 (1999), no. 1-2.

Porter, A. L. "Depth Perception", Technological Forecasting and Social Change, vol. 62 (1999), no. 1-2.

Kuwahara, T., "Technology Forecasting Activities in Japan", Technological Forecasting and Social Change, vol. 60 (1999), pp. 5-14.

Linstone, H. A., and Turoff, M. (eds.), The Delphi Method. Reading, MA: Addison-Wesley Publishing Company, 1975.

Edmunds, S. W., Alternative U.S. Futures. Santa Monica, CA: Goodyear Publishing Co., Inc. 1978.

Alderson, R. C., and Sproull, W. C., "Requirement Analysis, Need Forecasting, and Technology Planning Using the Honeywell PATTERN Technique", Technological Forecasting and Social Change, vol. 3 (1972), pp. 255-265.

Grupp, H. (ed.), "National Foresight Projects", Technological Forecasting and Social Change, vol. 60, no. 1 (1999).

Dror, Y., "Beyond Uncertainty: Facing the Inconceivable", Technological Forecasting and Social Change, vol. 62 (1999), no. 1-2.

TECHNOLOGY FORESIGHT: AN INTERNATIONAL REVIEW

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Prologue

Technology Foresight (TF) can be described as a systematic approach in which various methodologies and techniques are combined in order to create a better preparedness for the future.

During the last ten years TF has been carried out in several countries around the world. A key purpose of many of these studies has been to provide guidelines for the development of industrial policies and preparation of governmental programmes on research and education.

The principal purpose of this document is to give a general notion of Technology Foresight from a conceptual and processual point of view, showing its reach and implications. With this end, a summary of TF projects that have been planned or carried out in a number of countries is presented. An ample list of references and Internet addresses that are directly related to TF are presented at the end of the document.

1. Technology Foresight

During the last years there has been a growing interest in the industrialized world to prognosticate future technologies. According to OECD, TF is defined as *"Systematic attempts to look into the long-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"*.

A central purpose of TF is both to prepare for and try to affect the future. Therefore, the estimation of future tendencies in order to early carry out all necessary actions to influence and adjust future events is an important ingredient of TF. The foresight process involves the specification of the possibilities generated by technological development and also a definition of the demands that this puts on several sectors of the society. Based on that identification, TF defines the most efficient relationships between technological possibilities and the current economical and social needs of the community. Moreover, the organization and carrying through of TF has a value in itself since it brings representatives from the industry, academy and public sectors together in the search for a common view of the future.

"Foresight is a process for discovering a route to a desirable future. It involves imaging a desirable future and elucidating strategies for creating that future. Foresight is built on a concern or care for the future and depends on the engagement of the stakeholders. It is not about centralized planning." (Foresight, New Zealand)

1.1. Methodologies

The different TF projects included in this overview differ both with respect to preferred methodologies and their temporal horizons. Several countries have carried out Delphi studies. The Delphi technique was developed by the RAND Corporation in the USA in the fifties, and it has been used regularly in Japan since 1971 with the aim of defining the direction of the country's long-term growth. Germany, France and Great Britain are other examples of countries that have used the Delphi technique.

Another common method, which has been used in, for example, USA and France consists of setting up expert panels within different significant areas of development. The task of these panels is to identify the critical technologies that are expected to have the biggest impact on the future well-being and competitiveness of the country. The panels use their own and others' expert knowledge to evaluate how different technologies are likely to develop and how this will affect the market and society in general.

Different methods are frequently combined. In the British TF programme for example, expert panels were established within 15 different areas and in the Swedish TF programme, now running, the number of panels has been limited to eight.

1.2. Outputs of the Technology Foresights

The TF projects carried out so far in several countries of the world have come to a series of important conclusions. The overall purpose of these studies has been to predict how the world is going to develop socially and economically within a time frame of 10 to 30 years. This is sometimes referred to as looking for "global mega tendencies". The ambition is to find the most important forces for growth and change. In this context, scenario techniques are frequently used.

In the case of Australia, Holland, New Zealand and Great Britain, the TF projects have attempted to predict what will be the most significant economical and social changes in the future. Among other things, the following trends and tendencies are pointed out:

- That technological development will be the key agent of change, and change will be faster and faster.
- The life cycles of the products will be shorter and shorter, and new knowledge networks will emerge. The operations of the national systems of innovation will be more and more decisive in the economic growth of the countries. The demands on education will increase, especially within technology and natural sciences.
- Information technology will be the most important single technology, exposing science to new challenges and reducing the importance of geographical distance. In developing countries information technology is expected to dramatically influence the possibilities of growth. Biotechnology is another field of science, the importance and scope of which will increase.
- Globalisation will get even more accentuated than it is today, and there will be free flow of information, investment capital, ideas, products and services between countries. The competitiveness of countries will largely be defined by their intellectual capital. International companies will offer products and services of high quality in all markets of the world. This will force local producers to enter into a process of constant development and improvement.
- The rate of economical growth in the industrialized countries will continue to be relatively low. Most countries will have a surplus of labour, and it is assumed that unemployment will remain at a relatively high level. Unemployment will particularly affect the unskilled and less educated segments of the work force. Many developing countries, especially in Asia, are expected to experience fast growth. It is predicted that by 2010 China will be established as one of the main competitors in the world market.
- The proportion of women in the work force will increase, and a series of new systems and models for child care and housing services will emerge.
- The governments' proportion of the GNP will diminish and the role of the state will change from direct intervention to provision of general framework, guidelines and the "rules of the game".
- The world's population might be duplicated within the next 50 years. The population will increase especially in the developing countries, while the population in the industrialized countries will get constantly older. The population growth will challenge the environmental equilibrium and cause enormous pressure on the ecosystems of the world. Countries in extreme poverty will not have enough access to food, water and electricity. The megacities of the world will get even bigger, and new cities will be added.

1.3. The Technologies of the Future

Identifying the principal technologies of the future is an important part of the TF process. In some countries, for example the United States and France, the principal goal of TF has been to elaborate lists of critical technologies. Other countries, like Japan and Germany, have chosen to identify critical technologies employing the Delphi technique.

The common criteria in the selection of critical technologies is their potential to stimulate or influence economic and social development, the scientific and technological knowledge base, and national security.

At a general level, these studies are relatively unanimous in their conclusions about the fields that will be most important in the future. The most important fields of technology are:

- Information technology (components, applications, networks, multimedia)
- Health and medical care (medical technology, biotechnology)
- Production technology (automation/robotics, process technology, micro/nano production, sensors)
- Materials technology (ceramics, composites, electronic and photonic materials)
- Environmental technology (clean processes, waste management, recycling, global environment)
- Energy technology (efficiency, generation, renewable energy)

The majority of TF programmes have also concluded that multidisciplinary fields such as photonics, bionics and bio-electronics will be among the important fields to pay attention to in the future.

1.4. Implications of Technology Foresights

Most Technology Foresight projects conclude with a group of recommendations to the countries' governments about how these recommendations can support emerging technologies and fields of strategic research. The recommendations are generally classified within one of the following captions: financing of investigation and development, development of specific technologies, technology diffusion and operating conditions for the industry.

1.4.1. Financing of Investigation and Development

In France the recommendation was to allocate funds to the development of high-risk technologies. On the other hand, the German government suggested to support basic research in physics, chemistry and biology within fields that might lead to technological innovations in the future. The last Japanese Delphi study recommended that the government should actively support scientific research, especially within the space field.

1.4.2. Development of Some Selected Technologies

In Great Britain, Foresight elaborated recommendations within the 15 technology fields of the panels. In Holland, the selected technologies were IT, agriculture, services, environment, traffic planning, and health.

Sometimes, the countries have received recommendations on how to work in specific ways, for example through the creation of common research projects between industry and universities. Technologies that are considered to be particularly dependent on governmental initiatives are those which stretch far into the future and/or are associated with high risk.

1.4.3. Technology Diffusion

A common recommendation is that there should be increased interaction between universities and research institutes on the one hand and the industry on the other. Another recommendation is that the government should support the diffusion of new, strategic technologies from the research sector to the industry sector.

Many countries point to IT as the field where the state should concentrate its efforts of technology diffusion.

1.4.4. Operating conditions for the Industry

The fourth type of recommendation is aimed at improving the conditions under which the industry and the private sector operate. This task frequently refers to the government as being most important in this connection, which is to support the development of a good innovation climate. Important areas for governmental initiatives and support are: standards, laws and regulations, intellectual property protection, communications, financial infrastructure, general education, literacy, infrastructure adapted to smaller companies, environment, and participation in international organizations.

Many studies suggest that the respective governments should continue their engagement in TF.

2. Technology Foresights in Some Countries

During the nineties, the interest for future oriented studies has grown in the industrialized world. The TF of Great Britain, which was initiated in 1994, is maybe the most extensive and ambitious TF realized. Other countries that have carried out some type of TF are Japan, United States, Germany, Holland and France. During the period of 1997-99 the group of countries that have carried out or are in the process of planning or implementing TF has been considerably enlarged. Among the newcomers are New Zealand, Hungary, Ireland, and Sweden. In this section, the general aspects in some of these TF programmes that have been carried out are reviewed.

2.1. Japan

Since 1971, the Japanese Science and Technology Agency, STA, has carried out extensive Delphi studies and on a regular basis. They have carried out six studies and the last study, carried out in 1997, had the following objective:
"to ascertain the future direction of technology in Japan from a long-term viewpoint, and through this contribute to the formulation of science and technology policies, and provide a basic reference point for technology strategies in the private sector."

In the Japanese study more than 4,000 experts participated and responded to questions within more than 1,000 topics in the following 14 technology fields:

- Materials and manufacturing
- Electronics
- IT
- Biological science
- Space
- Marine and geological sciences
- Resources and energy
- Environment
- Agriculture, forest industry and fishing
- Production and machinery
- Cities and construction
- Communications
- Transport
- Health, medical care and medicine

2.2. Great Britain

The British Technology Foresight programme suggested in 1993 in connection with a governmental science and technology programme called "Realising our potential", that they had three main objectives:

- To reach consensus on which generic technologies will have the strongest impact on the future well-being and prosperity of Great Britain.
- To overcome traditional barriers between the industry and academy; the public and industry; and market and technology.
- To influence the financial support of scientific research in order to guide the scientific community towards fields of industrial excellence.

The British TF project was divided into 15 fields, and a panel of twenty participants was named for each of the different fields. The selected fields were the following:

- Chemicals
- Construction
- Financial services
- Healthcare and bio-science
- Transport
- Communications
- Food and drinks
- IT and electronics
- Manufacturing, production and business processes
- Materials
- Agriculture, natural resources and environment
- Defence, aviation and space
- Energy
- Education and leisure
- Retail and distribution

The members of these panels represented companies, universities, government and various research institutions. The panels worked during 1994 and 1995 with topics like:

- What are the probable social, economical, environmental and market trends in the next 10 to 20 years?
- What fields of research within technology and natural sciences facilitate and support the development of such trends?
- What would be the optimal use of the national research funds to create a basis for innovative knowledge that leads to an increased well being and a better quality of life?
- What is the significance of laws, educational system and other factors?

The panels used several methodologies, like for example the Delphi technique according to the Japanese model. They also arranged various workshops and regional meetings. Several specialized studies were solicited within the different fields of research.

During 1995, each panel published a report that included the results of the panel's work together with proposed changes within the existing system. In total, the panels introduced 360 proposals that dealt with everything from specific efforts in a determined field of research to changes in the legal system.

A special group then compared the outputs of the several panels and identified 27 generic fields, the majority of these within biotechnology and IT.

In 1996, Foresight Challenge was initiated, a kind of competition about research resources, with the aim of incrementing the co-operation between industry and academy. A total of 92 million pounds was provided for the competition, 62 of which were supplied by the private sector and 30 million by the Office of Science and Technology.

In an evaluation of the Technology Foresight programme carried out by the Parliamentary Office of Science and Technology it was concluded that the British TF project has been successful in many aspects. It contributed to make science and technology more visible in the society. It also showed the strengths and weaknesses and the opportunities and threats of British science and industry.

The critics of the programme believe that it has been too focused on controlling rather than developing research. Moreover, many barriers remain, especially between innovators and the financial market.

It has also been mentioned that it has been difficult to involve people outside the inner circle of research and development in the process. In order not to exclude companies and organizations that lack R&D facilities, and to obtain a wider approach the next programme, which is planned to start during year 2000, will be referred to only as "Foresight".

2.3. France

During the autumn of 1995 the French ministry initiated an investigation with the title "100 key technologies". The investigation presented the technologies that were considered to be the most important in order to maintain and fortify Frances position as a leading industrialized country in the long term (five to ten years). The technologies were characterized as important either because they were among technologies where France already held and needed to maintain a strong position, or because France needed to acquire them.

The key technologies were selected by means of ten project groups. Both the industrial, research and administration sectors were represented in these project groups. The report contains evaluations about the technologies' phases of scientific and industrial development. A comparison between France and the rest of Europe was also carried out. The results revealed that France had an advanced scientific position within around 60 of the key technologies, although they only control 24 of these industrially.

In 1996, the minister of industry introduced a plan for how to proceed. The state destined a fund of one billion francs during a period of two years to develop around 50 of the key technologies. They invited companies to present, together with research institutes, suggestions of activities related to the key technologies.

2.4. United States

The Office of Science and Technology Policy in the White House carried out three studies regarding critical technologies. The most recent study was elaborated in 1995 and it contains 27 national technologies divided into seven categories. The development stage of each technology is described together with the position of the United States.

The general purpose of this study was to identify technology fields and specific technologies that ought to be prioritized in the federal programmes of investigation and development. With this purpose, the following technology fields were identified:

- Energy (efficient use, storage, distribution, transmission, and production)
- Environment (supervision and analysis of environmental impact, control of waste, and decontamination)
- Information and adaptive communications (components, handling of information, intelligent complex adaptive systems of communication, sensors, and software)
- Living systems (biotechnology, medical technology, agriculture and food technologies, and human systems)
- Manufacturing (discrete product manufacturing, continuous materials processing, micro/ nanofabrication and machining)
- Materials (materials and structures)
- Transportation (aerodynamics, avionics and controls, propulsion and power, systems integration, and human interface)

In the United States there are several alternatives similar to Foresight. It is becoming more and more common that the government, both at the federal and state levels, finance research that is carried out together with the industry. An example of this is the Advanced Technology Programme that is directed by the National Institute of Standards and Technology (NIST). The federal government may provide funds of up to two million dollars to support a project. On their side, the participant companies in the project should contribute with at least the same amount of money.

Another large-scale initiative of co-operation is the New Generation of Vehicles Project. In this project, the automobile industry is co-operating with authorities and state research institutes in the development of the automobile of the future.

A third example of future-oriented projects is the Technology Roadmaps. In this project, which was initiated by the industry, "maps" are created indicating the likely development of a technological field in a 25-year perspective. The semiconductor industry and the chemical industry are examples of industries that have carried out this type of future oriented exercises.

2.5. Germany

Germany published the results of their second Delphi study in February 1998. It contained the following fields of technology:

- Information and communications
- Services and consumption
- Management and production
- Chemistry and materials
- Health and life processes
- Agriculture and nutrition
- Environment and nature
- Energy and resources
- Construction and living
- Mobility and transport
- Space
- Large-scale experiments

In this case, more than one hundred specialists from industry, universities and research institutes developed projections within each of the twelve fields. Subsequently, a survey was sent to 7,000 people of which 2,500 were answered.

The Delphi study resulted in an estimation of the probable future of different technologies within the twelve fields. The study also pointed out some clear tendencies:

- The companies will co-operate more with customers and suppliers in research and development projects in the future. The employees will identify themselves more with projects than with companies.
- From 2003 and onwards, practically all households will have access to Internet with a very high transfer speed. The multimedia networks will provoke that a great part of business and commerce will occur over the net in the future.
- At the beginning of the next millennium, 30 percent of the German labour force will work one day or more in their home. Research and development work will be carried out, to an increasing degree, in networks where work will be divided between several people, companies and universities. More and more people will work at home and the need of public transportation will diminish with as much as 20 percent.
- Virtual world universities will develop and computers will automatically translate texts to the desired languages. Databases and highly specialized dictionaries will be available to the public via the Internet.

Germany also carried out Delphi studies in 1993 and 1995. The last one, called Mini-Delphi, was carried out together with Japan.

2.6. Holland

In early 1998, the Dutch Ministry of Economic Affairs concluded the first of a sequence of Technology Foresights that was called Technology Radar. In the future, the study will be carried out every two years.

The objective of Technology Radar is double-folded:

- To identify the technology fields that are going to have a strategic importance for Dutch business and commerce in the future.
- To determine if sufficient accumulation of knowledge and competence is taking place in the fields that have been identified as strategically significant.

The work with Technology Radar was divided into five different stages. In the first stage a list of international strategic technologies was elaborated. In the second stage, another list was put together of technologies that are important for the world of business and commerce in Holland. In the third stage, technologies with strategic importance for the country were identified. The accessibility of knowledge and competence related to these strategic technologies was identified in the fourth stage. Finally, in stage five, difficulties between supply and demand of knowledge and competence was identified.

2.7. Other Countries

A fairly large number of countries are currently in the process of planning or implementing a TF of some kind. Some examples are presented below:

- Asia: Many Asian countries have carried out or are planning Foresight activities. Relevant information can be found at: www.nstda.or.th/apec/index.html
- Korea: A major Foresight project has been running since 1992 and has resulted in, among other things, the project Highly Advanced National - HAN. The project intends both to develop specific products and to support technologies that are critical for the development of society.
- Australia: An extensive study has been carried out by the Australian Science, Technology and Engineering Council (ASTEC). Several thousand people were involved in a project aiming at identifying research needs in order to approach problems that the future society is likely to be confronted with. Specific studies were carried out about water supply in cities, IT, health, mental illness (for example dementia), youth and navigation.
- Ireland: In Ireland a Technology Foresight was carried out during 1998. More information can be found at: [www].
- New Zealand: The Foresight project of New Zealand was initiated in 1997 by the Ministry of Research, Science and Technology. The results of this foresight will serve as important input in the elaboration of the research budget for 2000-2002.
- Sweden: A Technology Foresight project divided into eight different panels is being carried out in Sweden at present. A final report will be available in March 2000.
- Hungary: A Technology Foresight project was recently carried out, inspired by the British TF project. Relevant information about the Hungarian TF programme is available at www.
- Austria: During 1998/99 a Delphi study was carried out in Austria focusing both on technology and social and economic factors. The projects were commissioned by the Austrian Federal Ministry of Science and Transport. Further information of the Austrian TF is available at www.

3. The Technologies of the Future

A central objective of Technology Foresight is usually to identify technologies expected to have a strong influence on the future development and well-being of a country. Although there are both thematic and methodological differences between the studies referred to above, there is no doubt about the preponderating role that they all assign to IT and biotechnology in the future.

The different future studies that have been presented above make it possible to form an almost exhaustive image of emerging technologies, which may serve as a source of inspiration in the future Foresight work of others. Technologies that most countries seem to consider important for the future are the following:

3.1. Information Technology

Information technology appears to be the most important future field in all programmes of Technology Foresight. The development within IT is divided into four fields: components, software, networks and multimedia.

It is expected that the accelerated speed of component development will be maintained. A reduction of the physical size of these is also expected as well as an increased storage capacity. Moreover, it is estimated that the opto-electronic components will get their break through around the year 2000.

In the area of software applications, the majority of Technology Foresight projects pointed out the development of interactive systems. These include software for interface, systems for virtual reality, picture analysis and voice recognition. The development within the area of software will facilitate progress within other science fields, such as modelling and simulation, bio-informatics, non-linear dynamics, and the simulation within production and product development.

The communication networks of the future are characterized by the digitalisation and broadband communications. The American study of critical technologies emphasized the compression of data, data routing and signal conditioning as the most interesting development fields. The British Foresight recommended that all schools should be connected to a general broadband network giving access to systems of interactive learning, including video on demand.

Many recommendations are focused on consumer applications, especially within multimedia. The future is considered promising for: tele-medicine, tele-shopping, distance education, "edutainment", environmental monitoring and control, financial services and leisure products. Personal teleconferences, tri-dimensional television, systems for virtual reality and the intelligent cards have also been mentioned.

3.2. Health and Medical Care

A field of high priority is placed on Foresights into the medicines that prevent, diagnose, alleviate and cure cancer and HIV/AIDS. The technologies of primary interest are genetic therapy, recombined DNA techniques and monoclonal antibody development. The Japanese studies also placed emphasize on the illnesses of dementia.

Within biotechnology, cellular biology will be the bridge between molecular genetics, biochemistry and medicine. Important biomedical technologies are protein technology, the recombined DNA techniques, bio-compatible material and genetically developed vaccines.

The development of bio-sensors will reach high importance within the areas of medical technology, production and environmental technology. It is emphasized that biotechnology will be highly important in many fields other than the medical. Agriculture and the forest industry are examples of this.

Many studies, especially the Japanese, have mentioned the many different problems that will have to be solved due to the ageing population.

3.3. Manufacturing

Automation and robotics are topping the list of most important manufacturing technologies in the future. The development within CIM (Computer Integrated Manufacturing) will continue and robots will take over more and more work, especially within the industry of nutrition, material management, waste management, microsurgery, etc. The development within CAD-CAM (Computer Aided Design - Computer Aided Manufacturing) has only just begun, and the development of flexible machines for the discrete manufacturing of products is also considered promising.

Within process technology, continuous materials processing and control are particularly emphasized. Other fields are continuous casting, catalysis, cleaning and finishing. The British study considers flexible production equipment as highly important. The same equipment may be used for many methods of manufacturing and materials.

The development of sensors and actuators is also considered a primordial field. Sensors of many different kinds: chemical, biological, mechanical and electromagnetic, will strongly contribute to the improvement of the manufacturing methods and products.

3.4. Materials Technology

The materials that have been pointed out as the most important for the future vary from country to country. However, a commonality is that the new materials need to be thermo-resistant, light, energy efficient and bio-compatible. The materials that are mentioned in most reports are ceramics, polymers, composites and electronic and photonic materials.

3.5. Environmental Technology

Clean processes where the use of raw material as well as the amount of waste and contamination are minimal will become more and more important in the future. Foresight reports also emphasize the importance of solving global environmental problems. The discharge of greenhouse gases such as carbon dioxide, methane gas, and hydrogen has to be diminished. Within waste management and recycling, biotechnology is going to play an increasingly important role.

3.6. Energy Technology

An increase in energy efficiency will be introduced to reduce the energy requirements in buildings, vehicles and industrial processes to half. Within energy generation supra-conductors will be used.

Other promising technologies are fuel cells and renewable energy through solar thermal energy and wind turbine technology. Another important technology is photovoltaics.

3.7. Multidisciplinary Technologies

Interdisciplinary technologies have been recognized as critical in different TF programmes. New forms of co-operation between different disciplines will develop constantly and give rise to new fields of science and technology.

According to the Australian Foresight, important interdisciplinary technologies in the future will be:

- Energy Storage (energy technology + advanced materials)
- Photonics (optics + electronics)
- Biomimetic materials (biotechnology + advanced materials)
- Bionics (biotechnology + precision manufacturing)
- Intelligent roads (IT + transportation technology)
- Remote monitoring (IT + environmental technology)
- Micromechanics (precision manufacturing + advanced materials)
- Intelligent manufacturing (precision manufacturing + IT)
- Economical vehicles (energy technology + transport)
- Bioelectronics (biotechnology + IT)

Literature and Links on the Internet

<u>*General References about Technology Foresight*</u>

Cameron H, Loveridge D et al, 1996. Technology Foresight: Perspectives for European and International Co-operation. Manchester, PREST, ANEP Spain, University of Twente

CEST, 1995. Acting on Foresight. Centre for Exploitation of Science and Technology

IPTS, 1997. Overview of Recent European and Non-European National Technology Foresigth Studies. Technical Report No, TR97/02

Martin B R, 1995. Foresight in Science and Technology. Technology Analysis & Strategic Management, Vol. 7, No. 2

Martin B R, 1995. Technology Foresight - a tool for strategic research policy? Paper for the OST/SPRU/Nature Conference on 'Research Policies for Europe's Future: Strategies and Perspectives' held at the Ministry of Higher Education and Research, Paris 28-29 September 1995

OECD, 1996. Special Issue on Government Foresight exercises. STI Review No. 17

OECD, 1997. Technology Foresight: Outlook and predictions. STI Outlook 1998

Martin B R, 1995. Technology Foresight 6: A Review of Recent Overseas Programmes,
A Foresight Article. OST, HMSO, London

Technology Foresights in Different Countries

Asia
http://www.nstda.or.th/apec/index.html

Taeyoung Shin, 1996. Using the Delphi for a Long-Range Technology Forecasting and Assessing Directions of Future R&D Activities in Korea. Science and Technology Policy Institute

Taeyoung Shin, 1997. Technology Foresight: Applications and its potential to the APEC Region. Ministry of Scinece and Technology, Korea

Australia
http://astec.gov.au/astec/future/findings/index.html

ASTEC, 1996. Developing long-term strategies for science and technology in Australia - Outcomes of the study: matching science and technology to future needs 2010. Canberra, Australian Science and Technology Council

France
http://www.evariste.anvar.fr/100tc/

F-BETA/SOFRES, 1995. Enquête sur les technologies du futur par la méthode Delphi. Paris, Ministère de l'Enseignement Supérieur et de la Recherche

Ministère de l'Industrie, 1995. Les 100 technologies clés pour l'industrie française à l'horizon 2000. Direction générale des stratégies industrielles

Ministère de l'Industrie, 1997. L´annuaire des technologies clés. Direction générale des stratégies industrielles

Holland
Ministry of Economic Affairs, 1998. Technology radar, Volume 1 - 5

Foresight Steering Committee, June 1996. A Vital Knowledge System: Dutch research with a view to the future

Japan
http://www.nistep.go.jp

NISTEP, April 1994. Outlook for Japanese and German Future Technology - Comparing Japanese and German Technology Forcast Surveys. NISTEP Report No 33

NISTEP, June 1997. The sixth technology forecast survey - future technology in Japan toward the year 2025. NISTEP Report No 52

New Zealand
http://www.morst.govt.nz/foresight/front.html

Great Britain
http://www.foresight.gov.uk/

Loveridge D, Georghiou L G, Nedeva M, 1995. The UK Technology Foresight Delphi Survey (Manchester report to the Office of Science and Technology). PREST, London

Technology Foresight Panel Reports, 1995. "Progress through Partnership". HMSO, London

POST (Parliamentary Office of Science and Technology), June 1997. Science Shaping the Future? - Technology Foresights and its Impacts.

John Midwinter, 1996. Hindsight and Foresight, Science and Public Affairs (SPA). The British Association for the Advancement of Science, London

Sweden
http://www.iva.se/tekniskframsyn

Germany
http://www.bmbf.de

BMBF, 1996. Delphi-Bericht 1995 zur Entwicklung von Wissenschaft und Technik

United States
http://www.whitehouse.gov/WH/EOP/OSTP/CTIformatted/

US Office of Science and Technology Policy, 1995. National Critical Technologies Report. National Critical Technologies Panel

RAND, 1997. Critical Technologies in a Global Context: A Review of National Reports

PLANNING MODEL FOR THE ELABORATION OF A NATIONAL TECHNOLOGY FORESIGHT

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1. Introduction

Technological development and globalisation are two phenomena that have a strong impact on today's society and that will have an even stronger impact on the society of tomorrow. Changes in attitudes and values will be an important driving force in social and technological development. It will also become more and more important to consider ethical issues in association with all kinds of technological developments.

In this context, organizations, companies and countries have tried to find useful ways of assessing technology and environment. Evaluations of the future have been frequently employed to guide decision-making processes within multinational companies (e.g. Shell). Moreover, during the last years, several countries have carried out evaluations about the future at a national scale, frequently under the name of "Technology Foresight" (TF). In this document, a set of propositions and perspectives are presented on how TF can be organized and carried out. What is presented is a general model about TF based on experiences from TF programmes carried out in a number of countries, especially Sweden. The model is intended to serve as a source of inspiration and guide in the planning of TF programmes across countries. However, when planning a TF for a specific country it is of course very important that the particular conditions and limitations of that country are taken into account.

1.1. Principal Actors

In order to achieve maximal impact a national TF programme should have as broad a base as possible. The participation of the public and private sectors as well as the academic world is considered as a necessary requirement. The latter should participate due to its central role in education and scientific research. Although it is difficult to define exactly what specific institutions should be involved in a TF project, it has a strongly symbolic effect if the participation of the public sector is supported by direct commitment from the Government Office. Regarding the industry, it is important that both big, medium-sized and small companies are actively involved, and that both the manufacturing and service sectors are represented. The academic world should be represented both by the traditional universities and the regional university colleges. As an example it can be mentioned that the Swedish TF programme has had five principal actors: the Government Office; the Swedish Foundation for Strategic Research, which is the biggest private research foundation in Sweden; The Swedish National Board for Technological Development (NUTEK); The Royal Academy of Engineering (IVA) and the Swedish Federation of Industry.

1.2. Purpose

The purpose of a national TF programme is usually to create an understanding of and visions for the technological development in a longer time perspective (10 to 20 years). These visions should be known and considered when decisions are made about the future size, organization and orientation of the country's education and R&D. They should also support choices regarding specific efforts and investments in areas where the country is considered to have or believed to be able to develop specific advantages in an international context.

1.3. Goals

Suitable goals for a national TF programme could be the following:

- To strengthen the future-oriented approach in companies and organizations;
- To identify areas of expertize with potential of growth and renewal for the country;
- To compile information and design processes for identifying high-priority areas in various technological fields for the building of expertize within the country.

1.4. Focal Areas

When carrying out a TF programme at a national level, a suitable number of focal areas should be selected. How many areas and what particular areas to focus on must be decided from case to case. For each one of these focal areas a panel of experts should be constituted. In the British TF programme there were 15 different panels, while the ongoing Swedish TF has 8 panels.

Independent of which technological fields are selected, there are a number of common issues that preferably should be considered and illustrated by each individual panel. These issues are:

- Ecology and environmental issues
- Economy and market
- Values and attitudes
- Management of the human/system interface
- Information technology and computer systems
- Energy
- Multidisciplinary R&D
- Regional development

2. General Planning of a TF

Experiences from several countries show that the time allocated to a TF programme should not be less than 20 months. Assuming that 24 months are set aside, these months can be divided into four partially overlapping stages. This stages are the following:

- Planning and preparation: months 1-5
- Implementation of panel work: months 5-18
- Elaboration of final reports : months 15-20
- Diffusion of results: months 18-24

The first stage is mainly devoted to planning and development of the activities. At this stage, a Steering Group should be appointed, and an Executive Council lead by an Executive Director should be designated. At this stage, a steering document to guide the work of the Executive Council and the Executive Director should be produced, and an Advisory Board should be appointed. Focal areas should be decided upon and chairmen and project leaders for each one of these focal areas should be recruited in order to man their panels and initiate the panel work.

The second stage is the core part of the project. In this stage, the different projects of Technology Foresight are started and carried out. The main activity is the work taking place within the different panels. In addition to this the Executive Council will initiate and carry out projects of a general and overlapping character. An appropriate way of starting the second stage is to organize a "kick-off" that functions as a common launching for all of the panels. The purpose of this event is to create interest and expectations and to get publicity for the TF. Of key importance is to attract the attention of the mass media in order for TF to be referred to in the principal channels of radio and television and the leading newspapers and magazines. It is also advisory to plan a mid-term meeting, where the panels can report their respective advances to the interested parties. Also this meeting can be used as the means to spread information to the general public via the mass media.

The third stage focuses on the elaboration of the final report, which should include evaluations, analyses and proposals for the individual focal areas as well as for TF as a whole. The final report can be presented both in printed form and through more modern and "attention-getting" media like, for example, expositions, posters and the Internet. Whether there should only be one, all-embracing report or if the panels should be allowed to present themselves individually is something that has to be agreed upon from case to case.

The fourth stage is the closure stage, where the results of TF are diffused and discussed with users and other interested parties. This can be done through conferences and symposia at national level but also, and maybe especially, in seminars and workshops at the regional and local levels. The outcome of the diffusion work is decisive for the impact that TF will have on the future-oriented activities in the society.

2.1. Project Management

It is convenient that TF is lead by an Executive Council. This Executive Council can be appointed by the principal actors of TF (government, industry and academy). In addition to the Executive Council, TF should appoint an Advisory Board of 6-8 members elected by the principal actors. Nevertheless, these members should not necessarily be selected from core groups among the principal actors but principally be chosen because of their individual capacity and suitability.

The Executive Council is lead by an Executive Director with 3-4 close collaborators in charge of the economy, administration/co-ordination, and information/communications. The members of the Executive Council should not exceed eight, including the administrative staff. Most of the services that the Executive Council requires should be out-sourced and provided by consulting firms (i.e. for web-design, conference arrangements, etc.).

The Executive Director reports formally to a Steering Committee constituted by representatives of the principal actors. The Steering Committee provides the steering document that will guide the daily activities of the Executive Director and the Executive Council. It is essential that the Steering Committee deals with activities from a general perspective giving the greatest autonomy possible to the Executive Director and his/her Council. The function of continuos advice and support should be delegated by the Steering Committee to an Advisory Board constituted by the country's principal authorities within the industry and the academic world in future-related topics.

The Executive Director (ED) has a key role in the management of the TF programme. The ED is responsible for activities related to the organization, recruitment, launching and implementation according to schedules and activity plans. The ED is also responsible for the reporting of activities and results and, even more important, the diffusion, discussion and implementation of these to interested parties at the national, regional and local levels.

The ED is the coach of the project and is responsible for the selection of the right people as chairmen and project leaders within the different panels. The ED should follow the work of the panels, making sure that the activities develop properly. Even if the panels should be given the highest possible autonomy the ED has to be able to intervene directly in their activities if this becomes necessary. Although the panel members are carefully recruited, the possibility cannot be excluded that specific panels fail sometimes. This may be caused by a panel chairman who does not commit enough time to the panel activities, a project leader who does not carry out his/her tasks appropriately, or when chairmen or project leaders have to interrupt their assignments due to unforeseen reasons. Thereby, the ED has to be a person known for his/her good common sense, high integrity, prestige, and wide experience of management.

2.2. Organization and Management of the Panels

The work in the panels is directed by a chairman and a project leader. The total time commitment of the chairman to panel work should be estimated as being 40-50 working days calculated on a yearly basis. Therefore, the people that fit this criteria should be elected as chairmen as well as being in a high position and prestiges with the ability or a good general vision of the panel field.

The project leader should be a person who is highly qualified within the field of the panel and who has extensive administrative abilities. The function of project leader is a fee-remunerated post and it involves a minimum time commitment of halftime employment. It is possible to recruit an independent consultant or a person employed by any of the principal actors as project leader.

The first task of the chairman and the project leader is to elaborate a plan and work methodology for the panel activities, and to recruit panel members. An adequate panel size is 15-16 persons. The panel members should have wide experience within the different technology and activity fields that are represented in the panels. At the same time, the panels should reflect all segments of the society. Therefore, the constitution of a panel should have a balanced age and gender distribution as well as a reasonable geographical spread. Lack of attention in this matter may risk having unilateral panels, dominated by middle-aged men with high positions within the private and public sectors.

The work in the panels is carried out step by step, with successive reports of activities to the Executive Council. Panels should deliver partial reports to the Executive Council and the Advisory Board in order to discuss and contrast points of view. Among the tasks of the panel management (chairman and project leader) the following tasks are included:

- Limit the technological field, define a working plan and identify connections to other technological fields;
- Establish a budget for the coming activities of the panel;
- Create a harmonic work unit and ensure that participants actively take part in meetings and activities that are organized;
- Regularly give reports about activities;
- Elaborate successive reports;
- Elaborate and present a final report.

It is desirable that collaboration between the panels is organized through periodic meetings (for example every second week) where the project leaders and Executive Council participate. The chairmen can take part in these meetings with longer intervals, for example every fourth meeting.

2.3. Work Methodologies in the Panels

It is neither possible nor desirable to analyse in too much detail the topics that should be treated within each focal area. This is something that must be carried out by each panel respectively. Nevertheless, some alternative approaches can be suggested. In some technological fields it would be possible to begin with a round of discussions about how radical technological innovations affect companies and organizations in a particular country. Another approach is to start from a systems perspective where the situation within a specific technological field is contrasted with limitations and possible technological developments in other parts of the technological system. A third approach is to start with technological assessments within a specific field and determine how these might influence the regional and local knowledge supply.

2.3.1 Alternative methodologies

The panels' choice of methodologies can limit the choice of fields of study, the topics that can be studied and the ways of structuring the problems of study. Table 1 shows some feasible methodologies for the work in the panels and their advantages and disadvantages.

Table 1: Methodologies possible to use in panel work and their advantages and disadvantages

Methodology	Advantages	Disadvantages
Delphi Technique	Systematic and high expert involvement	The selection of experts is critical. A risk that new trends are unnoticed.
Scenario Analysis	Creates a shared vision of the development and broadens perspectives	Arbitrarily designed scenarios can block creative thinking
Expert panels	Cost Efficient	Selection of experts is crucial
Structured work seminaries	Cheap	Can be dominated by strong extraneous interests
Cross-impact Analysis	Allows cross connections of different sectors	Sense of illusory exactitude through use of mathematics
Critical technologies	Simple and focused	Unilaterally science-oriented

These methodologies can be used to structure the evaluation process. However, they do not constitute a theoretical framework of reference but are practical tools to assist the work process in a panel. Moreover, there are several new psychological tools that can be used to stimulate groups' creativity and evaluations so that cognitive barriers are minimized and old schemes of thinking are overcome. A Technology Foresight should also use such techniques.

Box 1: A tentative working plan in seven steps

Panels function independently according to a predefined time schedule and working plan. The detailed design of each panel has to be adapted to the specific characteristics of each field. The following working plan in seven steps exemplifies how work in a panel can be structured. In many cases, the different steps can be carried out simultaneously.

1. Decide the scope of the field and formulate the work problems and the relations that will be considered. Set up a working plan and methodology (two to three preliminary meetings).

2. Data collection about the international technology developments. Determine which driving forces are central for the development of the field (one meeting). This has to be prepared by extensive analytical work.

3. Analyse the current position of the particular country within the technological field. This step may include a comprehensive analysis of the actors structure and competence profile of the country (one meeting).

4. According to point 3, contrast the position of the particular country with both global scenarios and scenarios that more directly deal with the current field (a meeting).

5. Create a shared vision of the panel regarding technological development within the field (one meeting).

6. Compile and analyse the evaluation according to point 5, especially in relation to education, research and development (two meetings).

7. Elaborate a Final Report with the panel's visions of the future and suggestions of fields of efforts and priorities (one meeting).

2.4. Some Important Aspects of the Work in the Panels

2.4.1 Organize interesting and varied panel meetings that broaden perspectives

The panel meetings should be carefully directed, and the panels may consider carrying out certain discussions through videoconferences or via Internet. It may also represent an advantage to locate meetings and two-day workshops in different parts of the country. This causes that the panel members get to know regions outside of the capitals and it also provokes that the whole TF programme obtains greater regional attention and diffusion. A practice that was successfully implemented in the Swedish TF programme consisted of letting panel members act as hosts in their home cities for some of the panels' meetings.

2.4.2 Involve, stimulate and challenge the panel members

In order for the panel to work in the best way possible it is necessary that panel management is capable of clearly delimiting the problems of study, facilitating for the panel members to overcome cognitive barriers, and avoiding that extraneous interests get to dominate the process. The panel members should have the chance to get to know several work methodologies for future assessments and participate in exercises that wake up their creativity and fantasy. Besides, it is necessary to commit time so that the panel members get the opportunity to discuss which ways of work they consider adequate and which conditions are critical to achieve an effective co-operation.

2.4.3 Make use of the Scenario Technique

Another important technique consists of confronting the panel members with alternative future scenarios. This technique uses different scenarios to facilitate estimations of how demographics, attitudes and technology may come to develop. This technique utilizes a limited number (3-4) of divergent scenarios that are supposed to give the panel members a reference framework to discuss more specific technological problems.

Box 2: Example of the work in a panel

The following example has been obtained form one of the eight panels in the Swedish TF Programme: the panel of Education and Learning. The principal activities of the panel were:

Year 1999

18 January: Launching of the Swedish TF programme. A half-day conference with participation of the mass media. All panel members were not recruited yet.

25 February: One-day seminar in Stockholm. First meeting with all the 15 panel members. The task for next meeting was to present a suggestion of 20 topics.

9 April: One-day seminar in Stockholm. Presentation of topics, clustering of topics into principal groups, and identification of possible key topics. Review of the scenario technique.

8-9 June: The first two-day workshop of the panel. This took place in an industrial and very dynamic region in the south of Sweden. Topic: development of competence and learning in small-sized firms. An outline of the midterm report was presented.

30 June: Midterm reports were presented to the steering committee. The reports were published on the Internet.

17-18 August: The second two-day workshop of the panel. This took place in a very active IT region in the Southeast of Sweden. Topic: The importance of competence development and learning in the building up of international attractiveness and competitiveness of a region.

26 August: Mid-term conference with all panels in Stockholm. Plenary seminars and panel-specific workshops.

9-10 September:The third two-day workshop of the panel. This was carried out together with the inauguration of a future centre at a Swedish multinational firm. Topic: Competence development and learning with the aid of modern technology within big companies. Homework for all panel members: to introduce their vision about one of the 16 principal topics of the panel on 1-2 pages.

21-22 October: Final two-day workshop in Stockholm. Topic: The design and content of the final report.

18 November: Deadline for the preliminary version of the Final Report (this report was mainly elaborated by the project leader and the chairman).

Year 2000

18 January: Deadline for the final reports of the panels and the general report.

28 March: Grand finale. One-day conference. Presentation of Final Reports and conclusions of the TF programme.

November 1999 - May 2000:
Panel members from specific panels participate in several diffusion activities.

The total time commitment of a panel member who has participated in all panel-specific and general activities is 14 days. It is necessary to add time for document reading and report preparation (for example elaboration of input to the final report), which adds up to a total workload of approx. 20 days. This is a very high demand of time, especially when considering that the panel members' work is not remunerated. In practice, only few panel members took part in all the organized activities. The average attendance was 70 percent, which is very high in comparison with reported experiences from other countries. A probable explanation of this high participation is

the different events that were organized within the panel were considered interesting and challenging by the panel members.

3. Diffusion of Results

As has been previously mentioned, it is very important to diffuse knowledge about the existence, objectives, organization, contents and results of TF. The responsibility of information diffusion is in the hands of the Executive Council and the principal actors when it comes to TF as a whole. On the other hand, when it comes to the specific panels, the management of the panels are in charge of the information diffusion. The information diffusion should not begin when the final reports are ready. Instead, it should begin when the project is launched. It is natural that the work of diffusion is then accelerated when the final reports of the panels and the general report of TF are finalized. The design and the updating of the homepages of TF and the different panels play an important role in these diffusion activities.

It is decisive for the reach and impact of TF that this is supported by top executives within the government, regional and local authorities as well as from the industry and academy. The diffusion strategies should be developed considering the characteristics and specific conditions of each country.

TF cannot be carried out in a vacuum and it is therefore vital to consider other technological analyses and future assessments that are planned or carried out in the country. When possible and adequate, relations of co-operation may be created with these projects.

4. Follow up and Evaluation

Each TF programme should have an independent evaluation group that continually follows up the Foresight work. The task of the group is to revise the Foresight process regarding the stated aims and objectives. The group reports to the Executive Council and the outcome of the evaluation is reported in the conference that concludes the Technology Foresight.

In parallel with the official evaluation, each panel should regularly follow-up and reflect on their work. Questions that can be posed and answered in this context are: Are we following established time- and workplans? Are the established plans likely to lead to achievement of the intended goals or is it necessary to revise the plans or the goals? Is the project management working as was originally planned? Do the panel members assign the time and commitment that were promised? What actions could be taken in order to increase the efficiency and exchange within the panel?

Within 15 months after concluding the principal study, it should be decided if the Foresight should be complemented or revised. It should also be evaluated whether, and in that case when, it would be proper to carry out a new Foresight project.

5. Budget and Financing

The planning and implementation of TF is a big and complex project. As a reference it can be mentioned that the first phase of the British TF programme costed around 24 million USD. The Swedish Foresight programme has a total approximate budget of 3,6 million USD, which would correspond to 0,4 dollars per inhabitant. Notwithstanding that the costs of TF varies depending on the particular conditions of each country. The British and Swedish TF programmes provided an indication of the financial commitment that is necessary to carry out a serious and sufficiently extensive national TF programme. The lower limit of the budget in a smaller country is probably around 0,25 USD per capita. The total budget for a country with 4 million inhabitants should therefore not go below 1 million USD. For a bigger country, 10 million inhabitants and above, the limit per capita can be reduced to 0,2 USD. For a country with 20 million inhabitants this would imply a minimum budget of 4 million USD.

A national TF programme should be financed by both the public and the private sectors as a reflection of its widespread support. It is desirable that the state and the business community contribute with equivalent funds. The academic community is normally not expected to contribute proportionally to their participation and influence within a TF programme. Since academic institutions are normally financed by public and/or private funds, a proportional financial contribution from their side to TF would only mean a re-circulation of financial resources. In the case of the Swedish TF programme, the state financed half of the costs through the Government Office and the Swedish National Board for Technological Development (NUTEK), and the private sector financed the other half through The Foundation for Strategic Research.

The total budget is distributed between the Executive Council and the panels. This distribution is carried out according to the organization and work division within the Foresight. However, the highest possible decentralisation should be strived for, why the central administration should not receive more than maximun one fourth of the total budget. For practical reasons and as a means to create confidence, the panel management should have a high degree of freedom to decide on their budgets. However, when expenses exceed a certain predefined amount, it should be necessary to ask for the approval of the Executive Director.

THE NETWORK: INFRASTRUCTURE AND MANAGEMENT

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Background

During Summer 1999, the Institute for Prospective Technological Studies (IPTS) of the Joint Research Centre of the European Commission, together with the Social Science Research Centre (WZB) of Berlin, organized a Workshop on 'EU- Enlargement: Science, Technology and Society - a Perspective dialogue'. The objective of this Workshop was to set-up an informal network of high-level experts in the pre-accession countries, with the aim to activate a prospective dialogue on science and technology developments and their interrelationships with socio-economic issues of mutual interest to the pre-accession countries (PAC) and the European Union (EU). Among the issues debated, relevance was given to the structure and priorities of the enlargement process in relation to technology employment and competitiveness, within a ten year time horizon. Special emphasis was given on the role of foresight activities for dealing with the enlargement process, and how these activities could be linked together. At the end of the workshop the participants decided that it was important at this stage of development in the enlargement countries, to set-up a Thematic Network on Foresight activities on science and technology interrelated to socio-economic issues.

Relevance of Foresight for the pre-accession countries

In the last decade, Foresight activities have been used world-wide at National level as an instrument to systematize a national debate on future prospects and desires, both driven by and derived from Science and Technology (S&T) developments, and, in turn, to influence present-day decisions and actions.

Foresight helps people to develop a more strategic mindset, to look beyond managing the present. Specifically, it stimulates those involved in the sectors to be more focused to the longer-term future. It encourages different sectors to communicate more systematically with each other, to consider alternative perspectives and to generate a shared sense of direction. It also helps to anticipate any negative consequences arising from technological change.

Foresight is undertaken by national authorities with the aim of securing the technological and knowledge components of a sustainable and competitive economy and of enhancing quality of life for citizens. Underlying this is the rationale of 'national' competitiveness and the fact that individual countries find the basis of their prosperity ever more vulnerable to outside influences. In this sense, countries see themselves increasingly competing with each other to get to or stay at the frontier and retain their relative strengths in the same way that a firm does vis-à-vis its competitors.

These could vary from measuring the degree of consensus in the scientific community on the importance and rate of scientific developments within a given country, to the establishment of an economy-wide process for developing strategy and priorities, and taking commensurate action.

The objective of Foresight refers to the establishment of some more or less consensual views about which of the possible future states is the most desirable one for a given group of actors. It does not necessarily include views on how to get there, though this national extension is sometimes made. The idea behind building such a common vision is that the process of doing this, which has to be highly participative and inclusive, forces an alignment of views of stakeholders - though not necessarily a coincidence or consensus. However, one of the main advantages of this process is the building up of forward looking/thinking in people participating in it. Thus, Foresight can be seen as educational both for those directly involved in the process as well as for those informed of the debates and their implications via dissemination and communication actions. Foresight studies, whether based on scenarios development, Delphi, and/or expert Panels, contribute to develop a forward thinking culture about market and technology opportunities and threats.

The Foresight approach also provides, from governmental to firm level, a framework for strategic forward planning, especially valuable for those actors who normally cannot engage in such activities in a systematic way.

Foresight can be considered as a way to cross-fertilize ideas and knowledge. The direct participation in a Foresight activity provides the possibility to learn from other participants' experiences. In fact, most of the time, Foresight is conducted in a multi-disciplinary environment where information and knowledge exchange and transfer takes place normally.

At a more general level, Foresight findings can be considered as a useful way to assess skills and knowledge requirements in diverse S&T areas, regions and business sectors.

In a more targeted way the main features and issues of foresight related to the pre-accession countries can be described as follows:

- Implementation of a 'good practice' approach for Foresight studies for the pre-accession countries. These objectives can be achieved if supported by an analysis and evaluation of the existing experiences in this field (i.e. including experiences already done in these countries such as the Hungary foresight). During this phase an identification of the structural problems of S&T systems in these countries will take place. In order to meet its target, Foresight should be used in these countries as a process mechanism to address the structural problems identified. The process should be able to address trade-offs between different objectives (growth, competitiveness, and sustainable development).
- Benchmarking of existing Foresight. It is important to establish a set of criteria to measure the existing foresight approaches of the pre-accession countries to develop a good practice approach with the aim to implement this at a National level in all pre-accession countries to improve their articulation of S&T priorities.
- Implementation and link of Foresight studies at a National level. National Foresight Exercises are established and done in an inter-comparable way. Effort must be made to link them together. On a national level it will already need considerable work for understanding the various inter-linkages, inter-dependencies and feedback loops. However, it will be even more complicated, if one has to go into the sub-national and regional level. In order to get a real integrated picture, it is necessary to identify and spell out the cross cutting issues that have to be considered in border-crossing regional foresight studies.
- Pre-accession Foresight: Considering the numerous interdependencies and border crossing issues one only gets one aspect of the overall problem. The other side is the common geopolitical situation of the pre-accession countries. How is the chasm of the pre-accession countries in respect to the EU going to develop? How will the differences between the pre-accession countries that are already existing be amplified by the step by step integration into the EU?
- How to put pre-accession foresight into an EU wide foresight programme The Enlargement process is going to have repercussions both on the pre-accession countries as well as to the current Member States of the EU. Neither side will be unchanged. Therefore, the implementation of foresight at the level of the pre-accession countries has to take immediately into account the inter-dependence of the EU in respect to that. It is, so to say, a must of going a step further and develops an EU wide foresight programme, including the pre-accession countries.

The network management: timetable and roles

The Thematic Network on Foresight in the pre-accession countries was set-up formally in September 1999. The goal of the first meeting of the Thematic Network was to identify terms of reference and methods of operation of the network. The following dimensions were taken into account:

- Exchange of information on prospective studies among network members, by focussing on results and methods;
- Identification of issues of common interest;
- Raising awareness and deepening of understanding of prospective activities.

It was important in order to start the activities of this network, that the representatives of the pre-accession countries manifested their commitments in terms of willingness of dealing with Foresight issues at a National and/or regional level in their countries. Moreover, members of the network had to share their common vision on how Foresight could be used and which are the advantages of such process.

It is possible to define the role of IPTS in the network as role of adviser. In fact the main objectives was to catalyze and fertilize ideas and to assist the setting-up of the network and its development in the future. However, IPTS is not financing the network neither is it financing Foresight studies in any of the pre-accession countries. The first stage of development, will of course act as source of relevant information on Foresight studies and issues. For example, IPTS has implemented and will continue to manage an interactive website where relevant links and databases on Foresight related issues are provided. Moreover, IPTS will facilitate the mobility and exchange of young scientists that can specialize on prospective studies by informing them about grant opportunities under the Fifth Framework Programme of the European Commission. Finally, IPTS will assist and advise those countries that are embarking in Foresight studies, by providing a relevant summary of the outcomes of Foresight studies undertaken in other countries and by indicating how to tailor prospective methods and techniques to specific needs.

The role of members in the network is to promote the relevance of Foresight in their countries by involving the key stakeholders into a series of thematic workshops. Of course, in the different countries there is a different level of knowledge and practical experience of Foresight. Some countries (i.e. Hungary) have already engaged in a Foresight study, whereas some others are starting this activity. However, there are also other countries where the debate on whether or not to conduct a Foresight study is still very much under discussion and where there are not clear commitments from stakeholders. As it is possible to see, the state of discussion is very varied and the main objective of the Thematic Network in its first years is to raise awareness on prospective activities in the various countries. For this reason, the network has started its activities by scheduling a series of workshops to be hosted in the pre-accession countries - with the assistance of IPTS - on Foresight related issues, but also on cross cutting issues of common concern that could be dealt in a prospective way. Currently, the Thematic Network has a Calendar of activities up to November 2001.

Other experts on Foresight of Member States of the European Union are assisting and participating in the works of the network. Their main role is to provide and put at disposal the knowledge and experiences on Foresight related issues.

Conclusion

This contribution aimed to illustrate an example of a thematic network on Foresight related issues. It should be seen as a starting point to stimulate discussions both on the usefulness of Foresight activities in the various regions of the World and on the possible utility of this type of network on this subject. The personal opinion of the author is that Foresight is a process that can facilitate dialogue among different stakeholders and certainly it contributes to increase the flow of knowledge on science and technology issues and their interrelationships with socio-economic issues. Having said that, the author is not implying that embarking in a Foresight process is neither a simple process, nor will Foresight provide the definitive answers to how future developments will evolve.

References

Gavigan, J.P.; Scapolo, F. (1999) 'Increasing the Impact of Foresight – Tailoring Methods to Objectives' (forthcoming)

7. ANNEXES

- **List of Participants in the Technology Foresight Initiative**
- **Conclusions submitted by participants**

LIST OF PARTICIPANTS IN THE TECHNOLOGY FORESIGHT INITIATIVE

Country *Argentina*

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Country *France*

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Country *UK*

Organization	***Participant***	***Title***	***City***
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Organization	***Participant***	***Title***	***City***
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Mr. Ghislain Robyn	Director, IPC/SIN
Mr. Paul Makin	IPC/ITKM
Mr. Carlos Magariños	Director-General
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Mr. Peter Ellwood	ODG/EXO
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Embajada de Chile en Austria	Sr. Jose Luis Balmaceda	Minister Adviser	Chile
Embajada de Cuba en Austria	Ms. Georgina Fajardo	Adviser	Cuba
Permanent Mission of Italy to UNIDO in Vienna	S.E. l'Ambasciatore Vincenzo Manno	Permanent Representative of Italia	Italy
Embassy of Colombia in Austria	Dr. Hèctor Charry Samper	Ambassador of Colombia in Austria	Colombia
Direttora Ufficio Commerciale Uruguay	Ms. Germaine Barreto	Ambassador Uruguay	Uruguay

CONCLUSIONS SUBMITTED BY PARTICIPANTS

1. Most relevant learning points from the presented country case studies:

ARGENTINA

Acknowledgment of the necessity to integrate the actions of the different sectors participating in the economy, such as Research Institutions, Enterprises, Media and the Public sector; obtain political commitment at the highest level possible; establish long run objectives for the industry.

Specifically from the country case studies the most relevant for Argentina were:
Ireland, because it involved scientific research
Spain, for its methodologies and organization
France, because it focused on the micro-enterprises
Brazil, because it structure was focuses on governmental problems such as labour and monetary policies

BRAZIL

Learning about the different methodologies that can be implemented in a Technology Foresight Exercise and about the creation of the "Network steering Board"

CHILE

Flexibility of the Foresight Concept that goes beyond technological issues, and the existence of a methodological framework with an emphasis on the process and outcome of the exercise.

COLOMBIA

Need for methodological precision, institutional commitment and financial resources accessibility; experts of high level, adequate number of participants, orientation towards entrepreneurship strategies. Specifically, the country case study of Spain was the most relevant for Colombia.

CUBA

Technology Foresight as a dynamic element for socio-economical integrated development, as a part of the reproductive chain of "science-technology-investment-production-realization-accumulation and satisfaction of the quality of life
Specifically, the most relevant country case studies were:
Spain, for its organization
Austria for its methodologies
Brazil, for its recent initiatives

COSTA RICA

Necessity for financial resources to implement the Technology Foresight exercise, technical assistance to define the best model according to the country's needs

ECUADOR

Learning the real meaning of Technology Foresight as a tool for Industrial policy,
Specifically the case of Spain, due to its focus in selected sectors and the identification of the strategic elements to develop in the SME's environment.

SALVADOR

Learning about the different methodologies

HONDURAS

Specifically, the country case studies of Spain, because first it recognized its reality and afterwards the technological requirements for the industry, Hungary and Austria, because they adapted the exercise according to the resources they have.

JAMAICA

Importance of identifying the future technologies and their impact in society, recognizing the relevance of this technological advances to specific niches in the country

MEXICO

As in Argentina, Mexico acknowledges the necessity to integrate the actions of the different sectors participating in the economy; as well as the establishment of a long run planning perspective and commitment from the government

Specifically, the country case study most relevant was Spain, due to its sectoral focus

PANAMA

Internalising the concept of TF as an advance tool for development

Specifically, the German Experience for its organization and structure

PARAGUAY

Conceptualising TF as a tool for elaborating economic and social polices in the short and long run, impulsing the national multi-sectoral and multidisciplinary dinamization, identifying the relevant sectors of the economy, Adopting the different working methodologies according to the size, economic development and interests of every country

TRINIDAD AND TOBAGO

Learning about the different methodologies to develop a TF exercise, and the benefits of implementing such a tool.

Specifically, the Irish and Austrian models are most relevant for the country's needs.

URUGUAY

Relevance of understanding previous definitions of Foresight in order to bring a basis to create a National Programme. In other words, create a framework of reference useful for the political decisions in a real time and a pragmatic way.

Specifically, the country can learn from the different thematic areas in every case presented

VENEZUELA

Learning about the different existing methodologies presented and the different opinions of the most important actors of each participating country in this initiative

Other countries

Suggested the case of Italy for being so practical, and agreed upon the interaction of different sectors of society working together towards the future, going beyond election cycles, applying methodologies, principles, and results already experimented by other countries.

2. Areas to be strengthened for a technology foresight exercise

ARGENTINA

There is a need for:

Commitment at a political level in order to support the programme with assigned long term funds and not only voluntary attitudes

Participation from the productive sector, specially the SMES,

Establishing the net and the methodology of the programme

Coordination and interaction among the different organizations and institutes and the insertion of a TF exercise in the decision making process for the structure of the country.

The specific sectors to be strengthened are: Agriculture, agro-industry, biotechnology, petroleum and gas, food, design, transportation (by train and water), environment, and mining.

BRAZIL

Regional institutions such as CEPAL and SELA have to be part of this programme.

Methodologies to implement the exercise must be clearly defined to externalise the interaction between politics and C&T.

CHILE

As well as in Brazil, there is a need to structure methodological aspects
The achievement at high-level governmental and entrepreneurial commitment and the participation of the relevant actors of society.

COLOMBIA

Financial resources to support the foresight systematic competitively and strategic role of the SME's.
Need for experts and foresight training programs

CUBA

Need for political will to develop foresight studies as a tool for integral development
Coordination of all the decision-making elements
Formation and training of personnel, information (written and internet), technical base (computer and software), as well as coordination with participants

COSTA RICA

Financial support to develop the exercise
Technical assistance so to define the best model to maximize the benefits

ECUADOR

Strengthen the productivity and competitively of the industry, specially in environmental issues

EL SALVADOR

Strengthen information sources about the technological trends
Methodology to integrate the exercise with other national initiatives (competitive programs, innovation technology, planning etc.

HONDURAS

Add a strategic vision to the National Development Programme
Specialized training for the implementation of the TF exercise
Commitment from the decision makers to avoid short time policy planning

JAMAICA

Give special focus to networking, partnerships, collaboration between all stake holders particularly between the scientific community and the industry.
Need to develop a conductive innovation environment

MEXICO

Sectoral integration
Long Term planning and policy making

PANAMA

Focus efforts on Biotechnology and Banking

PARAGUAY

Training of human resources
Funding
Strengthen the productive sector, specially the agro-industry

TRINIDAD AND TOBAGO

Increase awareness among the wider stakeholders
Development of entrepreneurial culture,

Capacity building workshops for other stakeholders inside the country

URUGUAY

Methodological support (International expertise) to guide the program and funds

VENEZUELA

Integration of all stakeholders, not only government, enterprise and academia but also the generations that have worked with this topic in the past and must integrate with the emerging generations

Other countries

Suggested institutionalization of the organizations, flexible and adaptable methodologies, and careful selection of participants. In other words, a net formulation, awareness raising, training and diffusion of the programs in order to concentrate and develop capacities in the area of foresight, specifically the industry, science nee Technology and environment

3. Main constraints of a TF exercise during the implementation stage

ARGENTINA

Lack of confidence, trust, will and resistance towards change
Mentality to overcome the abandonment of different sub sectors
Short run perspective
Lack of continuity
Election of an appropriate methodology
Involvement of all the sectors
Responses to the network
Selecting appropriate panel of experts
Internal coordination
Difficulties in channelling the interests or demand for knowledge from the private sector
Effective commitment from the country to allocate the resources.
Weak interaction and competence among the different sub sectors and lack of trust from society

BRAZIL

Lack of interaction between the sectors
Budget and social capital problems

CHILE

Absence of sectoral diagnosis
Concerns about state interventionism through these exercises
Lack of trust in the short-term results

COLOMBIA

Lack of specialized information, experienced personnel and funds
The political-military conflict prevailing in the country

CUBA

Lack of political will and the monopoly of the Technology Foresight activities by the ministry in charge
Time, competence, Institutional barriers and restrictions in the information management

COSTA RICA

Lack of funds and political will
Short Term perspective

ECUADOR

Lack of knowledge and sensibility for using this tool
Assignment of resources to survival priorities, especially in the industrial sector
Lack of credibility for projects based on change

Lack of commitment
Weak private sector
Limited financial resources

SALVADOR

Lack of experts
Lack of knowledge for the methodology and objectives to define
Lack of basic information about the international trends that will influence the national scenarios in the future

HONDURAS

Lack of qualified people
Need to allocate resources for health purposes, education and infrastructure,
Division of the sectors to be involved

JAMAICA

Resource constrains
Determining the appropriate methodology

MEXICO

Cultural, structural and political obstacles
Lack of funds
Conflict of interests between the parts involved in the exercise

PANAMA

Lack of credibility from the public sector
Small Science and Technology sector

PARAGUAY

Lack of teamwork experience between the participating sectors
Lack of teamwork vision in the formulation of the National Development Plan
Lack of training programs and articulation of human resources, institutes and organizations of the public and private sectors Necessity for the high political commitment
Lack of knowledge in the Technology Foresight field
Lack of information in the sectors involved concerning Technology Foresight
Lack of financial resources for the implementation of the exercise
Lack of expert personnel in this field

TRINIDAD AND TOBAGO

Financial constraints
Lack of expert personnel and intellectual resources

URUGUAY

Lack of credibility about the practical responses of an exercise
Lack of experience and knowledge to reach objectives
Selection of experts

VENEZUELA

Short time perspective and planning due to political reasons
Weak industrial base in the SME's
Gap between universities and the private sector

Other countries

Financial constraints
Political changes
Lack of a high political level commitment
Short run perspective
Timing of the training and preparation programmes

Motivation and incentives for the participants

4. Initial actions that the UNIDO/ICS should support

a) Regional level

ARGENTINA

Awareness raising, making clear the advantages but also the limitations of the Technology Foresight
Training of the personnel, specially the leaders of the panels
Information through electronic means
Sending experts
Create commitments from each country
Diffuse the prior experience and methodologies in the topic
Develop the action plan how it is stated in the initiative
Establishment of the electronic-information network

BRAZIL

Make a detailed report of all the past TF exercises developed in Latin America
Impulse the creation of the network
Access to the global information
Impulse the elaboration of the Green Paper

CHILE

Exchange of information

COLOMBIA

Sensibilazion process
Facilitate the technical operation of the network
Supply information from experts, institutions, and participants of the seminar
Promotion of the concept

CUBA

Consciousness, diffusion, culturization about TF
Creation of normative methodologies
Supply information
Establish the terms of reference and select of specialist for the different committees
Prepare and execute the programs of diffusion and training
Create data base and information

COSTA RICA

INCAE's initiative about competitiveness in Central America

ECUADOR

Exchange of experiences from the Andean Countries
Support to the already established Andean Foresight projects in a pre-selected area
Impulse Technology Foresight actions in the countries of less technological development
Technology Foresight Studies at a regional level to identify integrated projects

EL SALVADOR

Select a regional organization as a bond of the exercise for the other countries
Identify all the topics of regional interest in Central America

HONDURAS

Creation of the organization that will implement and monitor de foresight exercises in each country, as well as the assessment and normalization among all.

JAMAICA

Storage of the data

MEXICO

Comparison of experiences
Obtain commitments, motivations and incentives
Development of the regional net
Financing
Assessment and technical assistance
Promotion and distribution in case that it is required

PANAMA

Creation of a selected group of Latin-American experts that will support the Foresight activities in each country

PARAGUAY

Financing of the diffusion regional seminars and the exchange of experience in Technology Foresight
Exchange of expertise and Human Resources in the region
Facilitate de information and interrelation of the responsible persons in each country
Facilitate the training of the people to be responsible for the Nation's Foresight Exercises through scholarships
Organizations of seminars by the countries with similar socio-economic conditions

TRINIDAD AND TOBAGO

The Caribbean must be treated as one entity

URUGUAY

Identify the national leaders of the region and establish the communication means between them to create the network

VENEZUELA

Create panels of experts at a supranational level (Mercosur, Central America and the Caribbean as one entity, Andean Community, etc.)

Other countries

Bring unanimous methodological criteria
Facilitator of the inquiries and exchange of information and knowledge
Diffusion, awareness raising and concentration
Training of Human Resources to unify the criteria and nomenclatures
Regional seminars
Training, information, communication and exchange of expertise between countries
Create a normative structure that monitors the exercises

b) <u>Country level</u>

ARGENTINA

Awareness raising, making clear the advantages but also the limitations of the Technology Foresight
Training of the personnel, specially the leaders of the panels
Information through electronic means
Sending experts
Create commitments from each country
Diffuse the prior experience and methodologies in the topic
Develop the action plan how it is stated in the initiative

Establishment of the electronic-information network
Diffuse what has already been done (experience and methodologies)
Assessment in the elaboration of national programmes with the support of an international expert
Organization of the awareness raising seminars: The presence of UNIDO would get the attention of the stakeholders.

BRAZIL

Stimulate the realization of a national study of prior experiences in Technology Foresight and other correlative areas

CHILE

Methodological support
Training of the Human Resources
Source and access to the background information of foresight exercises around the world
Openness to entities in developed countries

COLOMBIA

Creation of a National Foresight Study
Support the creation of the National Foresight Plan in Colombia with experts, information, and exchange of experiences from other countries
Awareness raising

CUBA

Stimulate the creation of an internal consensus
Create national niches with an integrated focus on organization and communication matters
Discuss with the authorities the support for the initiative
Support the presence of organizations and experienced persons interested in the project

COSTA RICA

Support planning for the industry and the C&T development

ECUADOR

Create consciousness
Support the specific project proposed by MICIP concentrated with the industrial sector and technically assisted by the UNIDO

EL SALVADOR

Sell the project to the politicians
Training
Integration with other on-going complementary initiatives

HONDURAS

National awareness raising process
Defining and diffusing the concept of Technology Foresight
Training of Human Capital

JAMAICA

Technical assistance to facilitate an initial project before beginning with the Technology Foresight Exercise

MEXICO

Identify responsible persons that respect the commitment towards the exercise
Design the panels
Financing
Technical Assistance

PANAMA

Formulation and revision of the proposals for the network and the Foresight Exercise
Training
Follow up of the implementation

PARAGUAY

Awareness raising and diffusion seminars
Training of Human National Resources about methodologies
Assistance in the creation of national programs of Technology Foresight
Institutional Infrastructure
Funding for the TF seminars

TRINIDAD AND TOBAGO

Commercialisation of the TF model identifying the particular characteristics of each country

URUGUAY

Support for the presentation of the project at the highest level of decision
Transmit credibility about the initiative

VENEZUELA

National Conference about the topic with the intention of diffusing and involving the national actors

Other countries

Assistance in the methodology
Instruments to analyse the advances
Financial support
Diffusion and awareness raising
Diffusion inside the country (seminars and workshops)
Develop a national consciousness of the importance of the exercise to obtain funds for the implementation
Create a data bank
Train human resources
Support the creation of the national forum for the beginning of the program

5. Opinions about the UNIDO/ICS initiative for Latin America

a) Strengths

ARGENTINA

Good initiative
Satisfies a necessity for knowledge
There is a high incentive due to the experience of UNIDO and ICS
Organization, motivation, initiative and the example of concrete country cases motivates to think strategically
In Latin America there is a real demand for this decision tools

BRASIL

The Initiative is attractive for the countries

CHILE

Commitment from the previous learning experiences

COLOMBIA

The initiative gets the countries attraction
Strengthening of the national capabilities in foresight
Renovation of the interest for Foresight

Credibility

CUBA

Flexibility
Action plan proposed
Global and dynamic
Accumulated prestige
Financing capacity

COSTA RICA

Useful tool for decision making and long term planning

ECUADOR

Knowledge of the concept of Foresight and the different studies developed by other countries
Accessibility to this information through UNIDO
Concrete plan of action

EL SALVADOR

Applicability demonstrated by practical experiences

HONDURAS

Serious commitment from UNIDO
Accumulated experiences by European countries and Brazil

JAMAICA

UNIDO's role as a mechanism to give access to the countries that are not involved in the concept of TF

MEXICO

Successful experiences at a country level
Personnel with experience in communication and transmission of experiences
Support the logistics of the exercise
The initiative is attractive and has financial resources to support its infrastructure

PANAMA

Experiences from the countries that have previously developed and executed a foresight plan of action
Looks forward to accomplish objectives in the short, medium and long term

PARAGUAY

Accessibility of national experiences from many different countries
Have support from high level of experts and consultants
Favourable to inform and promote the new technologies
Support to diffuse the concept of Technology Foresight

TRINIDAD AND TOBAGO

Creation of discussion groups
Fora to share the information

URUGUAY

Experience
Knowledge
Methodologies
Financial support

VENEZUELA

Attractive initiative
UNIDO's know-how to gather experts, establish networks and prepare basic documents, such as forecasts, methodologies, etc.

Other countries

Interesting decision-making tool
Creation of technological sectoral centres
Methodology
Financing
Experience
Access to Knowledge and results of other countries experiences

b) **Weaknesses**

ARGENTINA

Limited resources
Lack of experience and industrial representatives
Lack of commitment
Reduced technological investment
It does not take into account the differences between the countries to establish this exercise
It might be only a trend, which does not consider the country's particular needs

BRASIL

This project might stay in the first stage of the action plan

COLOMBIA

The level of commitment from the LAC countries
Lack of experts in this field in the region
Lack of knowledge of the different regional foresight efforts

CUBA

Bureaucracy from the international organizations

COSTA RICA

High financial costs that could undermine the implementation of TF in the smaller countries
Political limitations towards the implementation of a long-term programme
Difficulties to convince the participating actors

ECUADOR

Lack of funds and socio-economic stability
Lack of diffusion for this concept
UNIDO/ICS commitment towards all the countries, without a special support programme for the countries with the most need for technology

EL SALVADOR

Need for a tailored TF exercise for each country according to its particular needs.

HONDURAS

Differences of knowledge and experiences in the field of TF between LAC and the Caribbean
Commitment and support for this initiative by the participating countries

JAMAICA

There is a need to take in to account the level of development of each country in the region

MEXICO

Lack of credibility and optimism
Few successful models in this field
Lack of interest by the governments
Lack of information about UNIDO

PANAMA

Use of Technology Foresight Exercises in the developing countries

PARAGUAY

TRINIDAD AND TOBAGO
Not too much emphasis in the Caribbean region

URUGUAY
The diversity of the countries imply a difficulty to implement this project in the whole region

Other countries
TF would not mean the solution to all the problems in LAC and the Caribbean
Lack of a clear financial structure to support the interested countries
Lack of negotiation with the political authorities of the countries
Difficulties to obtain local funds, Involvement of the participating actors
Lack of specific result from the country case studies presented in the seminar