Delphi method*

Abstract

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.

During the last ten years, the Delphi method was used more often especially for national science and technology foresight. Some modifications and methodological improvements have been made, meanwhile. Nevertheless, one has to be aware of the strengths and weaknesses of the method so that it cannot be applied in every case. It is useful for an assessment of new things to come and in cases, which can be explained very shortly. This means for complex themes, it is better to use other methodologies like scenarios and to take into account what Delphi results can provide as single information pieces. Thus, Delphi studies were mainly applied in science, technology and education contexts, but one can think of different occasions.

Delphi studies are rather complex procedures and require some resources depending on the breadth of the study planned. Delphi studies are processes that include the preparation, a survey in two or more rounds and some analyses and application (implementation) when the survey is finished. All three phases are important and are addressed during the course. For the preparation phase and the implementation, some practical exercises in small groups are conducted so that the participants gain a feeling for a Delphi procedure.

* *Prepared by Kerstin Cuhls, Fraunhofer Institute for Systems and Innovation Research, Germany*

What are Delphi procedures?

On the History of Delphi

The Delphi method belongs to the subjective-intuitive methods of foresight. Delphi was developed in the 1950's by the Rand Corporation, Santa Monica, California, in operations research. The name can be traced back to the Delphic oracle, as Woudenberg (1991, p. 132) reports that the name 'Delphi' was intentionally coined by Kaplan, an associate professor of philosophy at the UCLA working for the RAND corporation in a research effort directed at improving the use of expert pre-dictions in policy-making. Kaplan et al. (1950, p. 94) referred to the 'principle of the oracle' as a 'non-falsifyable prediction', a statement that does not have the property of being 'true' or 'false'. Thus 'Delphi' for the modern foresight method seems to be more than a simple brand name.

The foundation of the temple at Delphi and its oracle took place before recorded history. Thanks to archeologists and historians we have extensive knowledge on the functions and benefits of the oracle (Parke/ Wormell 1956). For a thousand years of recorded history the Greeks and other peoples, sometimes as private individuals, sometimes as official ambassadors, came to Delphi to consult the prophetess, who was called Pythia. Her words were taken to reveal the rules of the Gods. These prophecies were not usually intended simply to be a prediction of the future as such. Pythia's function was to tell the divine purpose in a normative way in order to shape coming events.

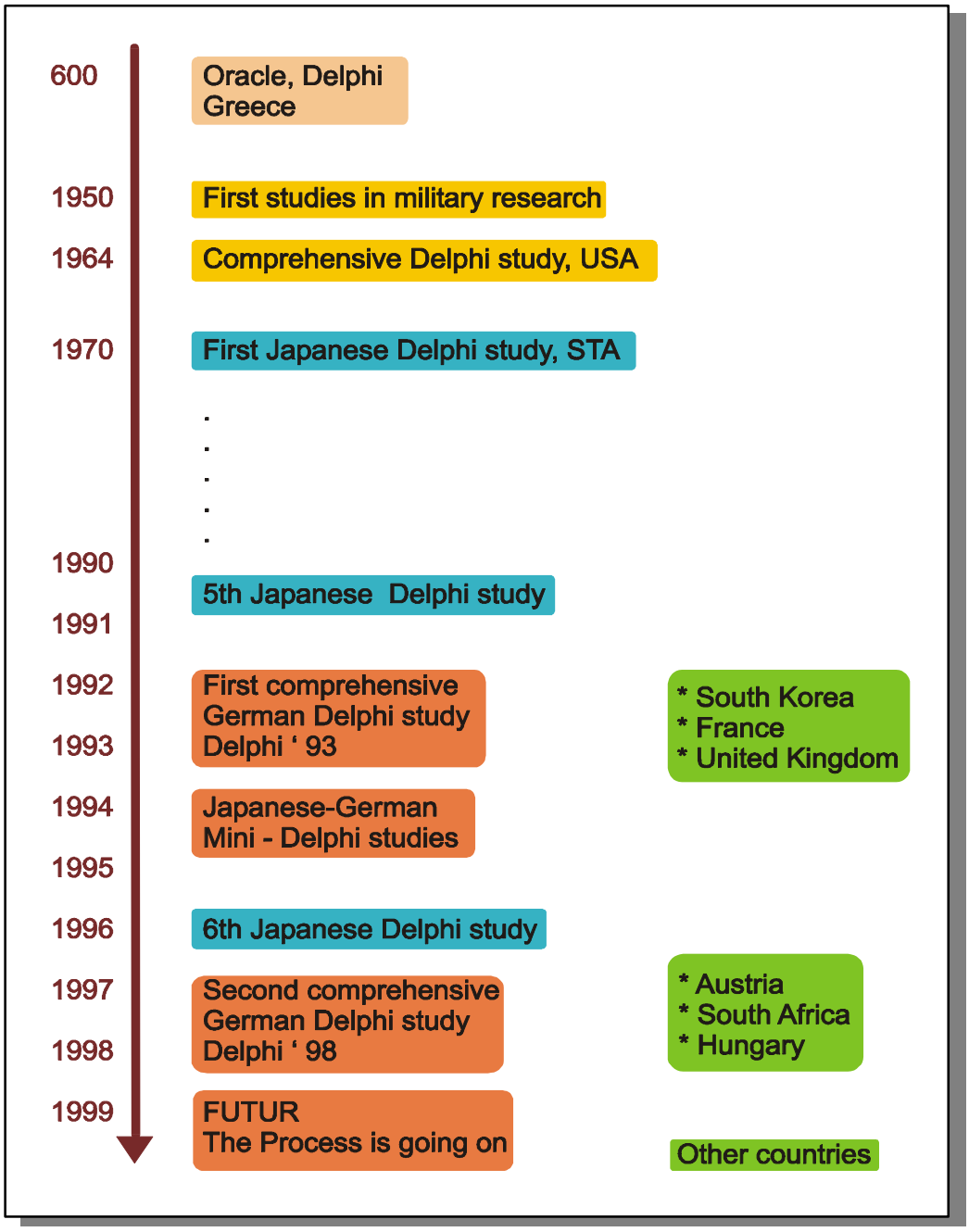
One should consider that the Delphi monastery was one of the very few spots on the earth where knowledge was accumulated, ordered and preserved. The information came in from the ambassadors through their queries and the answers were written down on metal or stone plates, several of them found by archeologists. The temple was the locus of knowledge, or, if we put it more mundanely, the Delphic oracle was probably the largest database of the ancient world. The priests could read and write; who else could do so in Greece? If due allowance is made for these circum-stances, modern psychology will find no special difficulties in accounting for the operations of the Pythia and of the priests interpreting her utterances. Knowledge was intended to be used and disseminated to make the world better.

Certainly, the consultations were religious in form and not mere inquisitive speculations on the future or attempts to obtain practical shortcuts to success, but at least in earlier periods religion entered into every aspect of Greek life and there were few subjects on which the advice of Apollo was not sought (Parke/ Wormell 1956). There is no doubt that the oracle acted as an international arbitrator. It shared the rise of Hellenic civilisation to which it contributed no small part. It is no wonder that a witness of that time, Socrates, around 400 years before our time, judged: 'The prophetess at Delphi (...) turned many good things towards the private and the public affairs of our country' (Socrates ca. 400 BC).

Thanks to the oracle, the Greek people learned over many generations to abstain from bloody vendetta, to apply to courts when quarrelling in private life occurred, and to solve disputes in a fair way. It can be traced back to the oracle that one should not poison the well of one's enemy and should take care of the olive trees in war. Thus the idea of the long-term oriented development of landscaping achievements we owe to the Delphic oracle. Based on this impressive historical material, let us turn now to the routes of the modern Delphi method.

In figure 1-1, as an illumination of the 'genealogical tree' of the Delphi technique, the major steps achieved in a chronological manner are listed. The major national endeavours using the Delphi technique are taken into account, but not for example the many experimental or scientific applications where, say, 20 students are engaged in the frame of a master or doctoral thesis. Also not included are business applications on a more focussed and less sophisticated level. It has to be stressed here that the focus lies intentionally on large holistic surveys with a likely impact on society. For the other type of Delphi application, refer to business management text books or monographies on strategic planning where Delphi applications are mentioned among the other tools (compare Linstone/ Thuroff 1975; Martino 1993; Jantsch 1967; Cuhls 1998).

Figure 1-1: Genealogical tree of Delphi



As already stated, the initial work was performed at RAND after 1948. In 1964, for the first time, a huge Delphi survey in the civil sector was published (Gordon/ Helmer 1964). Shortly after this, the lead in further development and broader application of the Delphi technique was taken over by Japan. Japan started its development of S&T later than Western countries and was nevertheless immensely successful. There are many success factors for this story – and one of them was the adaptation of large foresight studies at the end of the 1960s. In Japan, the Delphi method was selected for foresight activities, and the Science and Technology Agency in 1969 started to conduct a large study on the future of science and technology. Before, in a systematic attempt, foresight knowledge from the USA was invited. Although the first large Delphi study in Japan did not correctly describe the oil price shock and was conducted and published just before that happened, the Japanese Delphi process continued every five years. It is regarded as an update of data concerning the future. In 1997, the sixth study was finished, the seventh was published in 2001, the eighth is in preparation.

With the resurrection of foresight in general and the possibilities to filter all these 'options' of different actors, the Delphi technique was taken out of the toolbox and implemented in Europe in a different manner than in the early years. In the new wave of large-scale government foresight in Europe, Dutch and German government agencies and similar bodies were among the first, with France and the United Kingdom joining in quickly. The Germans organised a learning phase starting both from the 'mediating' publication of Irvine and Martin (1984) as well as from Japanese experiences and co-operated in their first Delphi with the Japanese fifth endeavour (Cuhls/ Kuwahara 1994). France in turn followed in just copying the Ger-man approach. In none of these countries was a sole resort to the Delphi technique considered useful. In the Netherlands, Delphi methods were not embarked upon at all, whereas in Germany parallel approaches are reported, some using the Delphi method, others not. The same is true for France where a Delphi survey and the critical technologies approach (see figure 1-1 or Grupp 1999) were pursued in parallel and organised by different, even competing ministries. Again in co-operation between Japanese and German institutions, joint methodological developments were achieved in the frame of a 'Mini-Delphi'.

Definition of Delphi

The *Delphi method* is based on structural surveys and makes use of the intuitive available information of the participants, who are mainly experts. Therefore, it de-livers qualitative as well as quantitative results and has beneath its explorative, predictive even normative elements. There is not the one Delphi methodology but the applications are diverse. There is agreement that Delphi is an expert survey in two or more 'rounds' in which in the second and later rounds of the survey the results of the previous round are given as feedback. Therefore, the experts answer from the second round on under the influence of their colleagues' opinions. Thus, the Delphi method is a 'relatively strongly structured group communication process, in which matters, on which naturally unsure and incomplete knowledge is available, are judged upon by experts', so the definition of Häder and Häder (1995, p. 12).

Wechsler characterises a 'Standard-Delphi-Method' in the following way: *'It is a survey which is steered by a monitor group, comprises several rounds of a group of experts, who are anonymous among each other and for whose subjective-intuitive prognoses a consensus is aimed at. After each survey round, a standard feedback about the statistical group judgement calculated from median and quartiles of single prognoses is given and if possible, the arguments and counterarguments of the extreme answers are fed back...'* (Wechsler 1978, pp. 23f.). This sounds a bit complicated but the essentials are:

- Delphi is an expert survey in two or more 'rounds'.

- Starting from the second round, a feedback is given (about the results of previous rounds).
- The same experts assess the same matters once more - influenced by the opinions of the other experts.

Characteristics of Delphi are therefore specified as (see e.g. Häder/ Häder 1995):

- Content of Delphi studies are always issues about which unsure respectively incomplete knowledge exists. Otherwise there are more efficient methods for decision-making.
- Delphi are judgement processes with unsure aspects. The persons involved in Delphi studies only give estimations.
- For the participation experts are to be involved who on the basis of their knowledge and experience are able to assess in a competent way. During the rounds, they have the opportunity to gather new information.
- Especially the psychological process in connection with communication and less in the sense of mathematical models have to be stressed (Pill 1971, p. 64, Dalkey 1968 and 1969, Dalkey/ Brown/ Cochran 1969, Dalkey/ Helmer 1963, Krüger 1975).
- Delphi tries to make use of self-fulfilling and self-destroying prophecies in the sense of shaping or even 'creating' the future.

When does the use of a Delphi make sense?

The Delphi method is mainly used when long-term issues have to be assessed. As it is a procedure to identify statements (topics) that are relevant for the future, it reduces the tacit and complex knowledge to a single statement and makes it possible to judge upon. Therefore, the use in combination with other methodologies like scenarios, technology list or others can be interesting. On the other hand, in more complex issues, when the themes cannot be reduced that much or when thinking and discussions in alternatives are the major target, the Delphi is not the method of choice. It is also suitable if there is the (political) attempt to involve many persons in processes (Eto 2003).

For the Japanese policy, it was especially interesting to answer the following question (and this question is also asked by other governments, too, now): How should we proceed with the long-term application-oriented basic research of the hyphenated type? This extension is no mistake, it is really meant *long-term application-oriented basic research*. This is the research where one does not know what will be found out in the laboratory in the next month or year, but it is research which does not only satisfy scientific curiosity and the enhancement of knowledge. It is re-search with a definite long-term economic or social perspective. Let me mention climate research, health research, environmental research and so forth. In days of low budgets many business and policy-makers think it is impossible to support each piece of interesting research only for the sake of good quality. One has to discuss the long-term orientation in which we invested our precious money. The public is convinced that science and technology are partly responsible for modern bottle-necks and problems and hence has a right to learn about priorities in technology and also the opposite, the non-priorities, what is down at the end of the list of priorities.

Consider the situation in which a company or a ministry has to decide which of two research programmes to support, A or B. Programme A is proposed from faculty A and industry A and the peers from discipline A have given their reviews. Programme B in conjunction with industry B originates from faculty B and the peers of discipline B made up their minds. Everybody did her or his best. But how to decide between them?

Do the peers know each other? Our science and technology system of tomorrow needs, alongside with disciplinary peers, new instruments to mediate between A and B, and here is another function of foresight, across the board. A second argument here is that they all have their stakes in the matter. They come from the technology provider side. But do they really know what is needed?

The Delphi technique as a foresight tool seems to possess certain degrees of invariance to survive in the changing challenges of the past 50 years. The method could serve different understandings of forecasting or foresight and was probably under-stood by the users as being relevant for covering technical perspectives, organisational perspectives, but also personal perspectives. The individual could express a distinctly different opinion as compared to the group perspective and this to a differing degree between the technical details under scrutiny. As multiple perspectives are recommended for decision-making, (Linstone/ Mitroff 1994; Linstone 1998) the Delphi technique seems to have appeal in quite diverse situations which touch the long-range scales. As it can be shown in controlled scientific experiments that the position of Delphi estimates is not better than those of other consensus-oriented methods (Woudenberg 1991) it must be the communicative force of Delphi approaches that facilitates the switching between different perspectives. What users especially like are the sets of data about the future that are gathered. Writing down future topics seems to have an immense psychological effect because it transfers implicit to tacit knowledge to the more visible, explicit, and therefore transferable knowledge.

Nevertheless, the danger that many persons regard this as 'the future' that 'will come true' cannot be neglected. When the media in Germany used Delphi '98 data for an outlook into the next century, they often made the mistake of arguing that the future will be like it is described in Delphi '98 disregarding that the decisions of today (or non-decisions) have a strong effect on the things to come and that Delphi can only provide 'potential answers' to problems that can already be identified today.

How to organize a Delphi process?

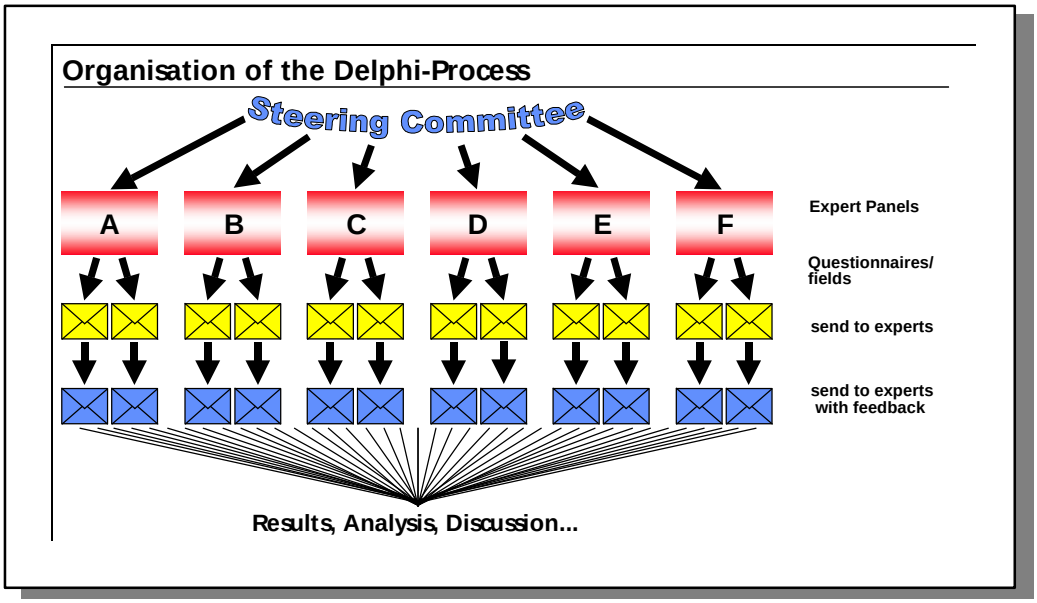
There are certainly different possibilities to organise a Delphi process. Before starting, you should answer the following questions:

- What is my objective?
- How many resources (manpower, money...) do I have?
- Is Delphi the right choice?
- How can I formulate the statements?
- What are my questions?

The formal organisation of a Delphi process

As mentioned before, the usual way is a combination of methods as especially the topics have to be formulated, a process that already needs methods like creativity procedures or can even be combined with scenarios or future workshops. In the following, a more 'standard' procedure is described. It starts with the organisation of the process as such. In Figure 2-1, this is illustrated by the 'real' example of the Del-phi '98 in Germany (Cuhls/ Blind/ Grupp 1998 and 2002).

Figure 2-1: Organisation of a Delphi survey



The first step is to found a steering committee (if you need one) and a management team with sufficient capacities for the process. Then expert panels to prepare and formulate the statements are helpful unless it is decided to let that be done by the management team. The whole procedure has to be fixed in advance: Do you need panel meetings or do the teams work virtually. Is the questionnaire an electronic or a paper one? This means, that logistics (from Internet programming to typing the results from the paper versions) have to be organised. Will there be follow-up work-shops, interviews, presentations? If yes, these also have to be organised and pre-pared. Printing of brochures, leaflets, questionnaire, reports have also be considered. The last organisational point is the interface with the financing organisation if this is different from the management team.

How to formulate topics

When the organisation is roughly defined, the fields of the Delphi should be decided on. In some cases, one thematic field is enough, in many cases it is wished to get an overview so that more fields are decided on and handled in a flexible way. There is always the possibility to add or disclose or re-name fields. To give some examples, the Delphi '98 (Cuhls/ Blind/ Grupp 2002) fields were:

- ❑ Information & Communication
- ❑ Service & Consumption
- ❑ Management & Production
- ❑ Chemistry & Materials
- ❑ Health & Life Processes
- ❑ Agriculture & Nutrition
- ❑ Environment & Nature
- ❑ Energy & Resources
- ❑ Construction & Dwelling

- ❑ Mobility & Transport
- ❑ Space
- ❑ Big Science Experiments

Then, the topics have to be formulated. This is a time consuming process. It has to be clear, where the topics stem from. The easiest way is desk research and to take over topics from literature and surveys that are available. But the more creative way is to found working groups who have the task to structure the field and formulate topics. One can start from scratch, but it is very difficult to focus the themes, then. Therefore, the more efficient way is to feed in already existing material from re-search. Then a brainstorming, brainwriting or other creativity activities can add themes. When there is the critical mass of topics, then you need a filter system. What are the topics that are relevant for your specific Delphi with your specific objectives? Here you can already make some formal or informal judgements (from discussion to giving points or school notes, even computer semi-anonymous topic selection is possible). It is recommended not to have more than 50 topics per questionnaire but it also depends on the questions you intend to ask.

It is also helpful to start with structuring the field a bit before the creative phase and then flexibly adapt the structure of a field, figure 2-2 is one example from Services and Consumption in the Delphi '98:

Figure 2-2: Structuring Example from the German Delphi '98

New services (based on new media)

Teleshopping

- electronic supermarkets
- biometric technics for the authentication of trade transactions

Finance services

- digital money for electronic money transactions
- permanent monitoring as deterrence against money-laundering and fraud
- robot-leasing

Leisure

- pay-TV
- virtual reality for journeys, sports events, film shows etc.

Therefore, it is often necessary to filter twice or even three times because often, the experts in your working groups add topics instead of reducing the number. The last step is the fine formulation. Often there are stereotypes of verbs (e.g. for science and technology foresights), that indicate innovation phases (is elucidated, is developed, is used, is in widespread use) or others so that the topics fit. The topics have to be formulated in a way that misunderstandings are impossible. It is also necessary not to have two different things mixed in one topic. And the topics have to fit to your questions, so that the questions can be answered or the criteria you have can be judged upon.

The next step is to develop the criteria. It depends on the questions that should be asked but one of the major criteria or questions is always the one about the estimated time of realisation. Others are necessary for the assessment of the validity of sample and answers like the self-estimation of the 'expertise' of the participants. Here are some examples from national Delphi studies (e.g. the German Delphi '98, Cuhls/ Blind/ Grupp 1998 and 2002, or the 5th Japanese Delphi, NISTEP 1997).

Are they important for

- the enlargement of human knowledge,
- the economy,
- the development of society,
- the solution of environmental problems,
- work and employment?
- Or are they unimportant?

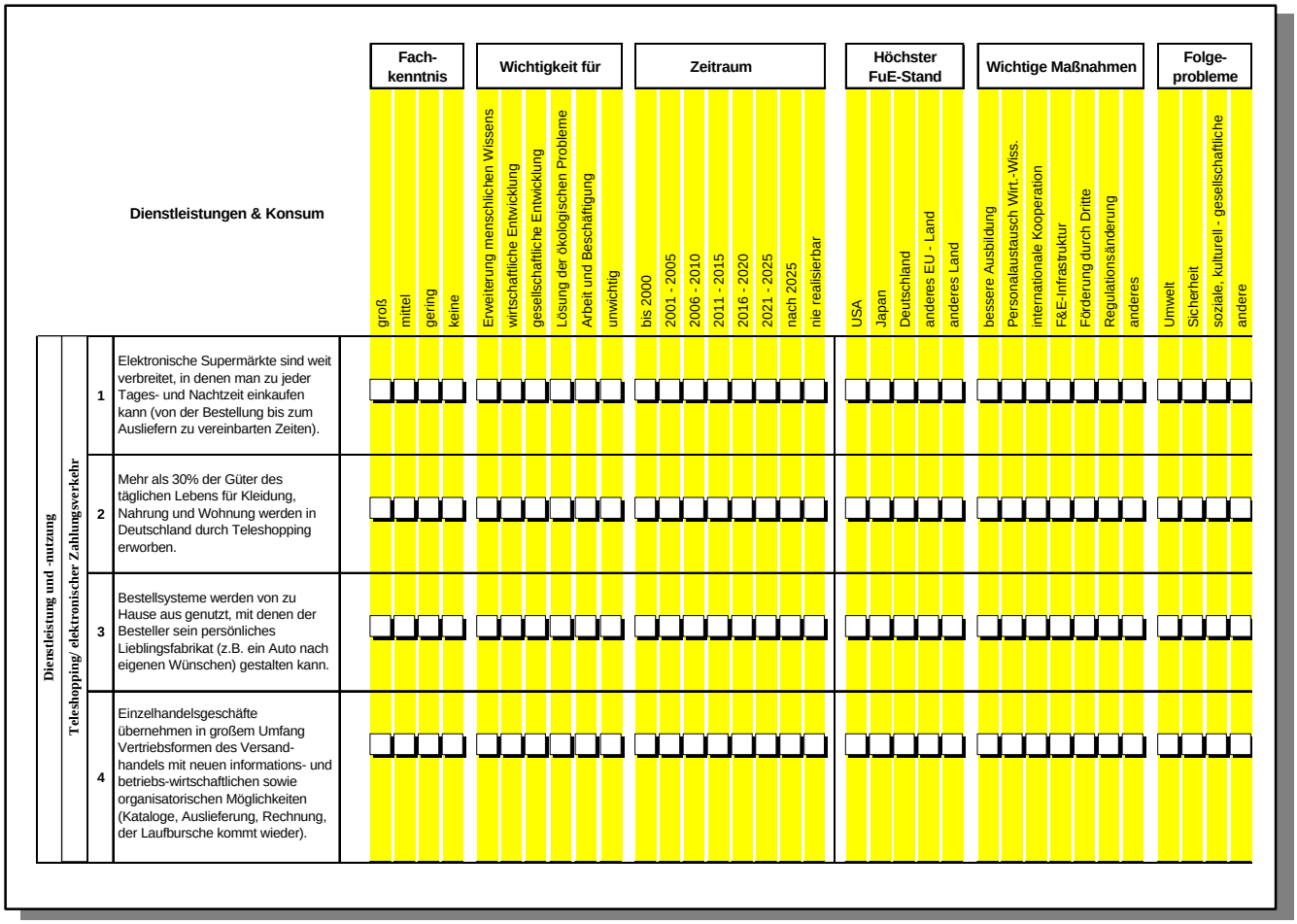
Other criteria can be:

- What is your expertise on the specific topic? Is it very high (you work on the field), is it high, medium or low?
- Which country is leading in the field?
- What measures should be taken? Here, also options can be given, e.g. better education, more financial support...

The time of realisation is normally asked in five year steps because single years would be so exact that nobody would be able to estimate. The normal time horizon of Delphi studies is 30 years ahead (e.g. from now to 2033), but it is also helpful to ask for a later time (after 2033) or 'never'. The analysis is often done in percentiles (lower quartile, median, upper quartile) in order to show the breadth of the opinions. But simple graphics or percentages can also be used, especially if there is the hypotheses that 'statistical camels' occur (there are two opposing groups of participants, one part judges an early time, added normally by high importance, and the other with late time horizons and low importance, representing different lobbies, or different schools of thought). The presentation of the data should be thought of in advance and depends on the 'clients' or users.

It is always useful to have open questions, too. The illustration of the design of the Delphi '98 questionnaire is only a part and the 'comments' are missing. What is of-ten done, is to have a part on comments or to ask for new questions, topics and alternatives to the statement given (e.g. in the German Mini-Delphi, see Cuhls/ Breiner/ Grupp 1995).

Figure 2-3: Example of a questionnaire design



When designing the questionnaire (for an example see figure 2.3), it is important to consider from the beginning, how to give feedback to the participants during the second round. A usual way is to provide percentages or graphics from the accumulated data in a similar form as in the first round questionnaire. But that gives often the impression of a very 'full' picture and too many information have to be shown on one page. The new electronic media provide many more possibilities. Here is much room for creativity.

Dimension of a study, resources needed

As in all processes, the resources are the crucial point: Is there enough money, time and personal capacity available? Therefore, one has to calculate from the beginning, which resources are needed. Delphi surveys belong to the more resource-intensive foresight approaches, but also here, there are differences. A Delphi survey with statements from literature and an already existing database for addresses in one field sent by e-mail is relatively cheap (cheaper than e.g. workshop approaches). Huge processes with preparation workshops, a database that still has to be created and a larger range of fields is rather expensive. In many cases, printing costs make a huge part of the overall costs (e.g. if you print questionnaires, leaflets and reports).

Public relations activities and awareness campaigns can also be very costly. Here, no estimates can be given as especially costs for staff vary a lot between countries. Just to

give a number: The raw German Delphi '98 cost about 700,000 Euro including the end report (re-financed via selling it, only for participants, it was free). Follow-up additional expenses were paid for international comparisons, presentations, newsletters, conference etc. Thus, it is recommended to answer in advance the following questions which determine the costs:

- Do you intend many workshops? How many? They can be calculated easily.
- What do you intend to print? Do you need designers?
- How much programming is needed?
- How many participants do you have? This determines the number of questionnaires but also the number of persons to nominate and addresses you have to deal with in your database.
- Do you pay for participants?
- Do you need to type the results (e.g. from paper questionnaire)?
- What are the management costs? What are your salaries? And how many external persons contribute to the process so that they have to be paid, too?
- How much follow-up/ PR do you intend? How do you intend to present the end results? ...

Delphi processes are rather time consuming. Therefore, a Delphi needs some time especially when postal delivery is planned. But also for an Internet or electronic version, the participants need time to answer the questionnaire. Preparation time, analyses and implementation should also be calculated. Therefore, for a larger Del-phi with different fields, at least one year should be calculated.

Who is involved? Who is an expert?

This question sounds trivial but it is not. Most sociologists of science assume that there is a positive relationship between involvement in a research area and assessments of it and that this relationship derives from the tendency of scientists to select problems in areas where there is high pay-off for successful solutions and career. The tendency to overrate fields in which a person works may be termed 'bias'. Not only a tendency toward positive bias for fields in which researchers have been active was found, but also that this bias is stronger in less innovative sub-fields. As market signals fail to be useful for business strategy in the long run and expert assessment is not always objective, Delphi surveys may play a part in science and innovation management.

There are three examples from the first German Delphi '93: first, in the field of volcanoes, there were so few specialist experts, as this is not a direct danger for Ger-many, that the topic could not be analysed as a single item. Secondly, specialist experts and thus future knowledge may not be available in some countries. The availability of experts in the case of biotechnology in Germany was mixed. Among the 73 respondents who were all experts in biotechnology, many did not answer in particular sub-areas (most expressed for tissue and organs). The largest number of specialist experts (i.e. those working in the sub-area) among all experts in Germany is found in molecular biology, but not in the sub-area of tissue and organs. An al-most perfect correlation was found between the number of experts and their rating of German research performance. In sub-areas where we know more, we are good. In sub-areas where we are not advanced, we know little of the opportunities.

A test for Delphi expert bias in the energy area from the German Delphi '93 tends to support this view. Top experts rate the importance of their own research speciality significantly higher than the other experts - both in Japan and in Germany. At the same time, the top experts downplay technical constraints in Germany (less so in Japan) in their own working area (see Cuhls/ Kuwahara 1994). An unwanted test also made clear that the 'higher level' experts also do not tend to change to the direction of the mainstream answers and remain with their opinions in the second round (see Cuhsl/ Breiner/ Grupp 1995).

In the Delphi '98, this is not so obvious. There are topics for which the specialist knowledge experts see more problems (or ask for more measures to be taken), but for others all other persons ask for more measures. In some cases, the special experts rate the topic to become reality earlier than the 'medium' and 'lower level' experts, in other cases, they are much more reluctant with a prognosis on the time horizon. What can be observed is that in the first round, more experts claimed to work on the field (13.5 %) than in the second round (10.18 %). This can have several reasons. New foresight approaches tend to involve more and different stakeholders of the innovation systems to provide multiple perspectives (Cuhls 2000, Linstone 1999) on the issues. Therefore, more and more, the expert definition is broadened. Often persons are involved, who know about the subject, wherever they stem from. But they have to be selected carefully according to the themes asked for. It is recommended to invite a mixture of persons from industry/business, academia, re-search institutions, and others.

As in all surveys, the sample in the end needs to be large enough to draw conclusions, therefore the number of answers per topic has to be high enough. The sample as such also has to be selected and additionally to the already mentioned criteria, the sample mix should comprise e.g., persons from different age cohorts, sector groups, etc. Often, female participants are under-represented, which is always a problem that has to be dealt with. Lobbying should be avoided or dealt with (e.g. involve the same number of persons from the different lobby groups).

To identify addresses is less and less difficult: Internet, data bases, trade fair catalogues, members lists etc. can be obtained rather easily. To structure the database in order to facilitate mailing, storing data and at the same time meet data security standards is more difficult but has to be considered, too.

How many participants do you need? That depends on the number of topics, the fields, the expected response or participation rate and other issues. If a small Delphi in a computer groupware room is used, the sample will be very small. If a national foresight with a specific representativeness is asked for, many persons are needed and it is often attempted to achieve about 100 answers per topic. But this also depends on the country: In a small country, you cannot expect so many experts in the field. And in some future-oriented fields, there are only a few persons available, even in large countries. To involve the general public in such an endeavour is generally possible, but then, the questions have to be rather simple and easy to under-stand. In Internet surveys, it is very difficult to hold the control on the sample, this should also be taken into account.

Analysis of results

As in most Delphi surveys, you gather a lot of statistical data, which can be used in very different ways. But also comments are often asked and can help to interpret the statistics or be analysed in a qualitative way. Especially the combination of Delphi and scenarios makes many qualitative presentations possible. The following examples are

just a few from the selection. Looking at the different international reports, there is a wider range of possibilities. What a Delphi manager should do is to think about the way to analyse in advance because this has implications on the criteria and the whole design of the questionnaire as described above.

Rankings

Simple rankings of statistical data are the easiest way of presenting results. Of course, the data have to be aggregated first, sometimes an index has to be built. Of-ten, the importance categories are used to figure out the most important topics. But also the measures or other assessments can be ranked. Especially, the older Japanese Delphi studies worked a lot with rankings (e.g. also NISTEP 1997). Figure 4-1 stems from the Delphi '98 but is of different character. Here, the megatrends asked for are ranked according their agreement (persons could agree to a topic personally or not), which was important because the megatrends were used to figure out a per-sonal opinion of the answering participant cohorts by a factor analysis (for details, see Blind/ Cuhls/ Grupp 2001).

Figure 4-1: Ranking of agreements on megatrends

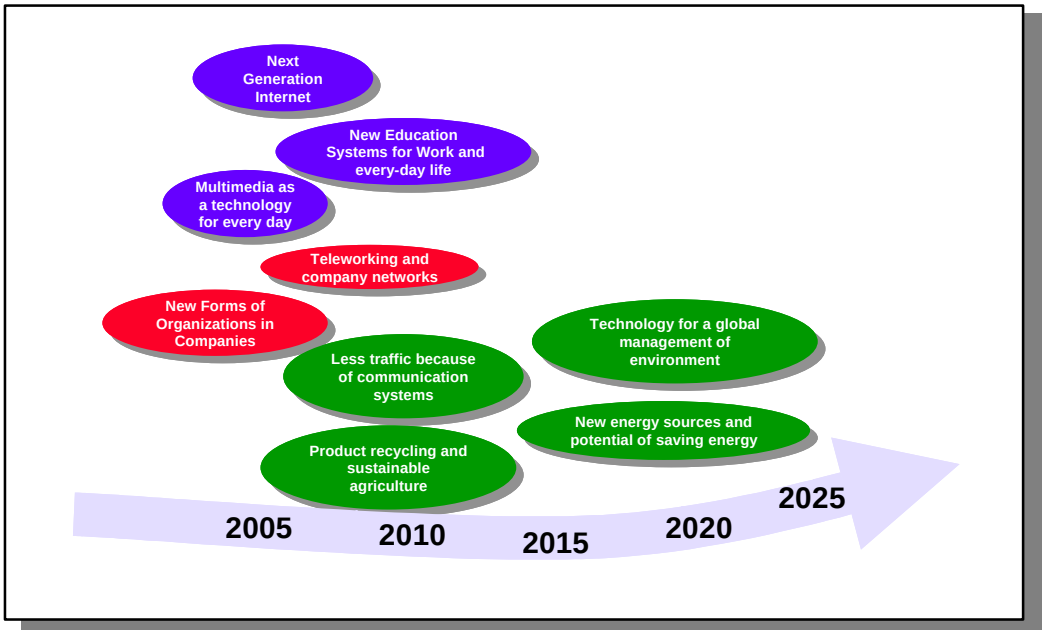
Megatrends

Megatrend	Agreement	Time Frame	Disagree-ment
In industrialized countries over 1/3 of the population will be older than 60 years.	89	**2008 - 2019**	7
The unemployment rate will increase permanently in the developed countries.	74	**1999 - 2006**	22
World population will surpass the 10 billion border.	72	**2010 - >2025**	19
Germany will again become an internationally attractive location for investment.	61	**2003 - 2009**	27
Women will at least keep one-third of all executive positions in business.	57	**2008 - 2020**	32
Rationing of energy consumption for private households will be enforced.	54	**2011 - >2025**	41
Increasing environmental problems will negatively affect the health of most people.	53	**2003 - 2015**	42
A European government will be developed that will substitute national sovereignity.	52	**2010 - 2024**	42
Increasing individualization hamper the functioning of representative democracies.	49	**2003 - 2012**	33

Qualitative Clustering

Another possibility is a half quantitative and half qualitative way of analysis. In the Delphi '98, the most important topics from the different importance categories (for the economy, the society...) were ranked and those which were often highly scored were clustered qualitatively and described under a joint headline. This was done to provide a very compact picture on results. Figure 4-2 illustrates this. It can be argued that this is a bit arbitrary, but the fact that ICT technologies invade all other fields and other clusters could easily be backed up by statistical data. The arguments for clustering were described in detail in the results.

Figure 4-2: The most important topic cluster



Different graphics

Like in every report, graphics are welcome to illustrate and make understanding easier. Figure 4-3 shows an example for the different importance categories of the Delphi '98 (all data compared with the innovation field Big Science Experiments).

Figure 4-3: Importance categories

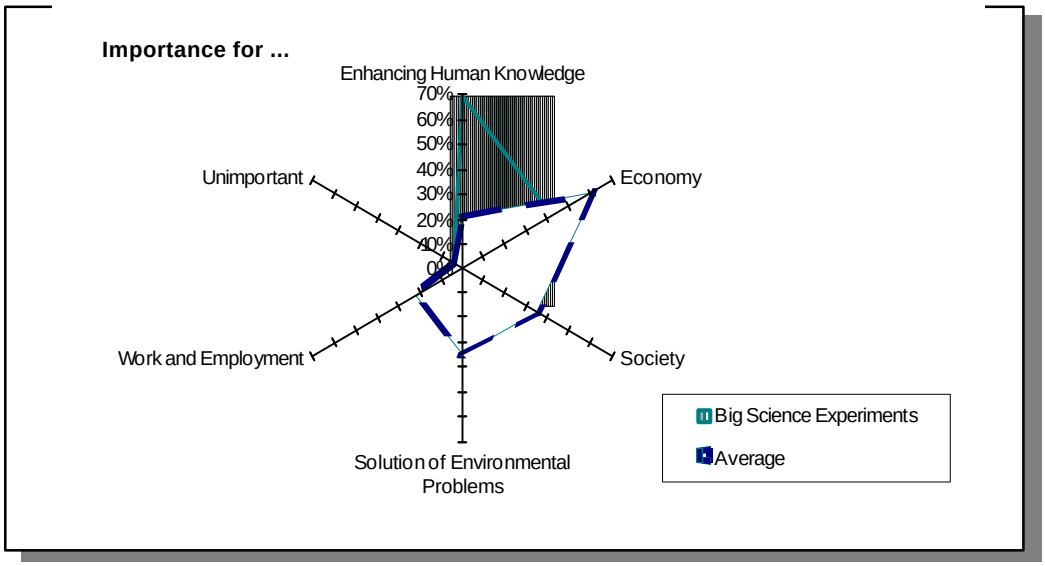
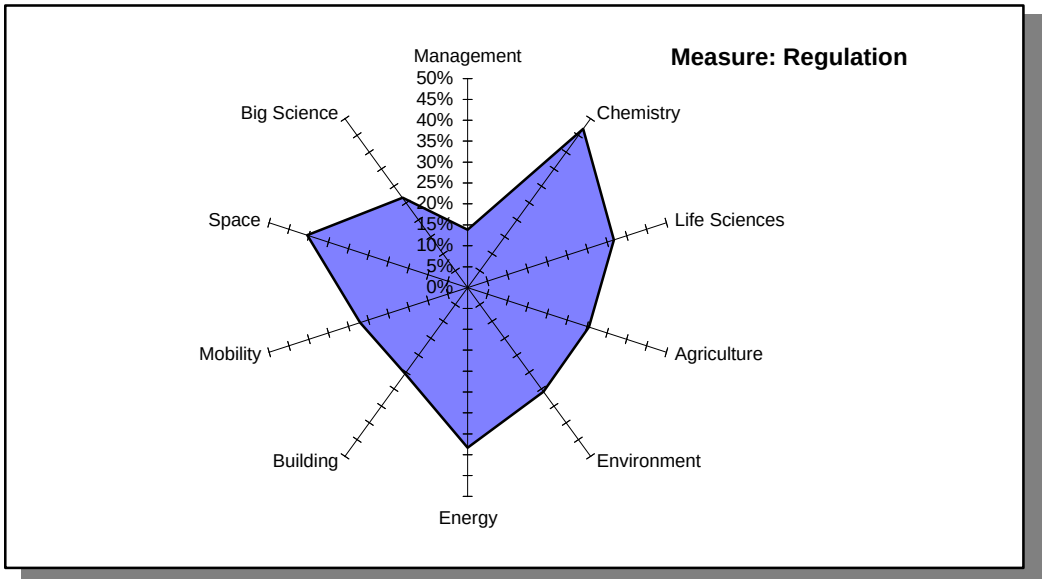


Figure 4-4 shows a different approach. Here it is not asked for the categories but asked, in which innovation fields, there is the highest demand for new regulation, different or less regulation (category: measure regulation). The result is not shown in a simple ranking but in a graphic which is scaled only up to 30 % because (interestingly for Germany), this measure was not really often asked for. The results can be interpreted in more detail by the comments. Later on, we figured out single topics and deepened them in interviews.

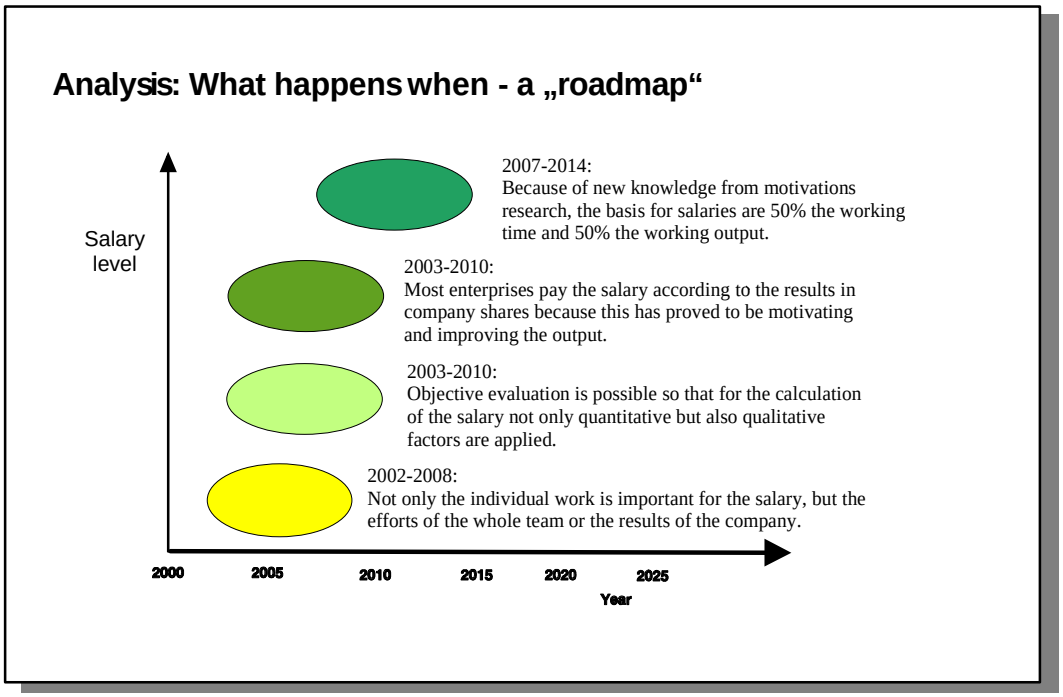
Figure 4-4: Measure Regulation judged in the different innovation fields



Scenarios or roadmaps

As in most Delphi surveys, it is asked for the time of realisation, and small roadmaps can be drawn from the field. If the categories and statements fit to each other, also small scenarios can be derived from it. Figure 4-5 shows a kind of roadmap concerning the development of paying salaries in Germany. This analysis can also help to identify breaks in the assessment of the statements. It can be checked, if it is plausible if one development is realised earlier than another, it could also be the case that a technology is not yet developed that would be necessary for the development of another one – but the experts judge the second one earlier, which would lead to the question of plausibility. In the German Delphi '98 we found breaks, especially in the field of Management and Production, but no implausibility.

Figure 4-5: Example of a 'roadmap' from the field Management & Production



To be able to compare topics, it is important to formulate them in an identical way. Figure 4-6 gives you an example from the Delphi '98: It is a comparison of the German most important topics for the economy in the field of Agriculture & Food with the identical topics of the same field in Japan (ranked according to the difference).

Figure 4-6: Comparison of identical topics in the field of Agriculture & Food

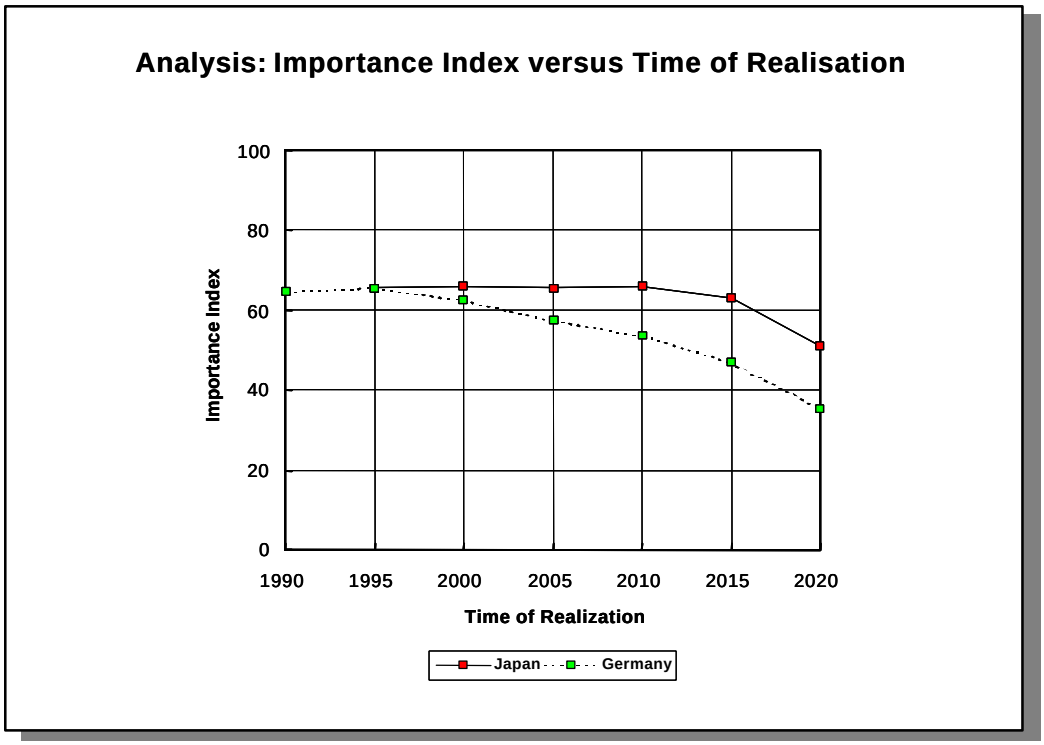
Agriculture & Food	Germany	Japan
	Importance for the economy	Importance for the economy
Plants which are specially cultivated for resistance to drought and salt and provide barriers to desertification are in practical use.	78.3	25
Cell fusion and gene technology will make possible the cultivation of new breeds of fish which are very suitable for fish farming due to their strong resistence to disease and fluctuations in water temperature.	93.8	56.3
The cloning of prize-winning, high-performance cattle by core transplantation is practised.	95.0	46.1
In order to achieve certain breeding goals (resistence to disease, fertility) in domestic animals, gene transfer to fertilised eggs or to early mammal embryos is practised.	91.3	44.4
Techniques are widespread, e.g. using microorganisms, which enable earth-bound phosphorus to be absorbed by cereals.	79.8	22.4
The use of transgenetic animals, into which genes that hamper or prevent the defensive reactions in xenotransplantations were transplanted, is widespread for the transplantation therapies of inner organs.	50.0	37.2
A system to utilize marine organisms and their environment is achieved which can keep the balance between the exploitation by the fishing industry and the habits of fish shoals under the prevailing biological and ecological conditions.	61.5	25.7
Biological control systems are widespread which offer protection against disease and vermin through biological pesticides (natural microbial enemies, pheromones etc.).	74.3	26.2
Biodegradable packaging manufactured from renewable raw materials are in common use.	70.5	50.8
After the mechanisms of forms and functions of the ecosystems are understood, rational monitoring and exploitation procedures for rainforests, including the presently existing life forms, will be implemented in tropical regions.	50.7	10.6

More sophisticated calculations and matrices

More sophisticated calculations and matrices are possible. The Japanese colleagues even tested fuzzy logic and in the Japanese-German comparison a kind of input-output model with a specific software (DEA) was applied, for details see Cuhls/ Kuwahara 1994. There are different questions that can be tested. One check concerned if there is a correlation between the importance and the time of realisation in a Japanese-German comparison. In Figure 4-7 this graphic is shown. It demonstrates, that the hypotheses 'the higher the importance, the earlier the topic' cannot be proven in general and not in

Japan, although there is the tendency in Germany that earlier topics have slightly higher importance rates.

Figure 4-7: Importance Index versus Time of Realisation



But as already hinted at: With creativity, a lot of different analyses and results can be gained. These were just very few examples...

Implementation

The second problematic point remains the interface to implementation. In some surveys, it is already enough to provide some results in form of graphics or statistical analyses as 'information about the future'. But how can the 'results' further be used? New foresight processes are more than just providing data and results. As the providers of foresight results and the users, which means the decision-makers, are in most cases not the same persons, there remain the difficulties

1. of bringing them together
2. of linking the needs of the users and the concepts of the methodologies very early
3. of making potential users aware of the possibilities (marketing) so that they have the choice
4. of establishing mechanisms of transfer
5. of delivering results that are useful
6. of involving persons who have the power to decide and implement.

Until now, the use of foresight results in Germany and other countries was based on ad hoc activities. There are different possibilities (see Cuhls/ Blind/ Grupp 2002): One of the most interesting was the use for an evaluation of the Fraunhofer Society by an international panel (SWOT analyses). The different ways of implementation were very useful and there were a lot of them, especially by companies, but a more strategic approach would certainly bring more results. The Delphi '98 was aimed at information for those who are interested in.

The question if one works closely together with the financiers has to be thought about very carefully. Sometimes, a more neutral look-out is asked for or suits the situation better. On the other hand, the interface between Delphi and the financier is more difficult, then. But this is true for nearly every foresight approach that can be conducted externally.

Some recommendations

The major recommendation is to clarify the objectives of the foresight approach at first. The second point is to check if a Delphi is the right choice and if there are enough resources for a Delphi (rarely possible without the combination of creativity methods and those for the formulation of statements). If you considered all pro's and con's, and you decide to conduct a Delphi, then consider at least the following:

- What should be the breadth of the study?
- How many and which fields should I ask for?
- How will the organisation be? Who manages the process?
- Who will be invited to participate (active or non-active)?
- What results can be expected?
- What are the questions asked?
- How is the questionnaire designed?
- What kind of analysis need to be possible?
- How do you intend to implement the results?
- Will there be follow-up activities (public relations, publications, workshops, presentations, conferences etc.)?

These questions should be considered as early as possible.

Delphi is a very interesting tool, especially for companies but also research organi-sations who for example in Germany were the major users of data and who also conducted own Delphi processes. Delphi has its advantages and disadvantages that are described above and elsewhere but the major danger is – as in all Foresight pro-cesses – to regard the results as facts because they are presented in the form of data. They are working tools and although information about the future are provided and worked out, the future cannot be predicted and will always be different from what you expect.

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