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Shaping the Future: Science and Technology Foresight Activities in Japan, with Special Consideration of the 10th Foresight

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Summary
Japan has to date 50 years of experience of national Foresight activities, being performed for science, technology, and for innovation policy formulation purposes. Will Foresight in Japan, as a way of pursuing activity-oriented science and technology (S&T) studies and of contributing to policymaking, be continued? Is it even worth the huge effort? Is it really oriented toward societal issues? Combining the classic approaches and databases that exist, the Foresight procedure can be said to be unique in the world and to have the chance to indeed give answers also to societal questions — and further more to link these answers to the policy system. Whereas the first Forecast/Foresight studies were Delphi surveys only, the methodology has broadened from the 7th Foresight program onward. The year 2001 marked a strong reorganization in the S&T policy landscape, which made a stronger link to the policymaking of the Council of Science and Technology Policy (CSTP, later Council of Science, Technology Policy and Innovation, CSTI) possible. The Japanese strategy "Innovation 25" was also underscored with Foresight results, and the scenarios that had been formulated during the program. Foresight is thus more than prediction; it is rather about shaping the future. This links it directly to S&T studies and gives them a futures drive — instead of only analyzing past experiences. In 2015 the 10th Japanese Foresight was published. The paper describes this new Foresight in brief, and links it to S&T studies broadly — with another connection also made to Japanology, as the backbone of being able to analyze the original sources and to understand the wider Japanese background. Some of the Foresight results are also summarized, and an overview of previous activities in Japan given. Whereas in different countries all over the world Foresight and Horizon Scanning activities are flourishing at present, the Japanese national activities are currently at a crossroads — as policymakers there are not convinced anymore that their model of performance is still necessary in times of the internet and of an information overflow. Therefore, this contribution goes back and forth in time and ends with a brief outlook for Foresight and its actors in Japan.

Keywords: Foresight, forecasting, forward-looking activities, science and technology policy, innovation policy, visions of Japan

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Introduction

For 50 years now, Foresight has been accompanying policy formulation in Japan. The first Delphi surveys were published in 1969 (Cuhls 1998; Helmer 1967) in the United States. Delphi was originally designed as a method of assessing science and technology (S&T), especially in respect to the realization horizon (time of realization). It is conducted across two or more rounds and gives the previous assessments as feedback so that the participants of the survey can judge twice or more often. Now, there is a lot of experience with Delphi surveys (online and offline), and of more broadened Foresight with accompanying scenarios. Foresight in Japan is repeated in different ways every five years on the national level, and provides a huge amount of data not only for Foresight but also for Hindsight. Foresight can be performed with different methods — depending on the objectives or questions asked. It is necessary for long-range planning.

The 10th Foresight was published in 2015, in Japanese (NISTEP 2015a, b; available in English from 2016). But will Foresight in Japan be continued? It has already been broadened from classic assessment studies (for example Delphi surveys about S&T) to more activity-oriented S&T identification methods and networking in workshops. Has it — until now at least — really had greater orientation toward societal issues? Is it even worth the huge effort? Combining the classic approaches and databases that exist, the procedure — as currently undertaken — is unique in the world and has the chance to indeed give answers also to societal questions and link these answers to the policy system. The following describes this new Foresight in brief, and links it to S&T studies broadly — with another connection also made to Japanology, as the backbone of being able to analyze the sources in their original language and to understand the wider Japanese background. This section gives an overview of previous Foresight activities in Japan.

Whereas in different countries all over the world Foresight and Horizon Scanning activities are now flourishing (Cuhls et al. 2015), in Japan meanwhile such pursuits are currently at a crossroads — as policymakers there are not convinced anymore that their model of performance is still necessary in times of the internet and of an information overflow (remarks of the Foresight performance team when critically reflecting on the evaluation that was handed over to the Council for Science, Technology Policy and Innovation (CSTI); one critical point in it was that policymakers do not know about Foresight at all). Information about S&T is available from many different sources — which was not the case when the Japanese Forecasting activities first started. There were also times when the results of the Delphi surveys were more "popular" and commonly known.

Consequently this contribution goes back (first section) and forth (description of the 10th Foresight) in time, and ends with a brief outlook for Foresight in Japan, its application as an identifier of trends for science and technology, as well as its degree of connectivity to societal questions — as well as its actors in Japan. What is presented here is thus a contribution to forward-looking science and technology studies in Japan, one that demonstrates how new science and technology paths are identified, assessed, selected, in some cases supported, and of course later implemented. Foresight provides ideas and assessments about the most important future topics, and thus is a tool of communication among science and technology stakeholders. From a Science and Technology Studies' perspective it is interesting to obtain a deeper understanding of who is involved in related Foresight activities, regarding its basis for governmental policymaking, how it is organized, and what kind of ideas are being developed and communicated.

What is Foresight?

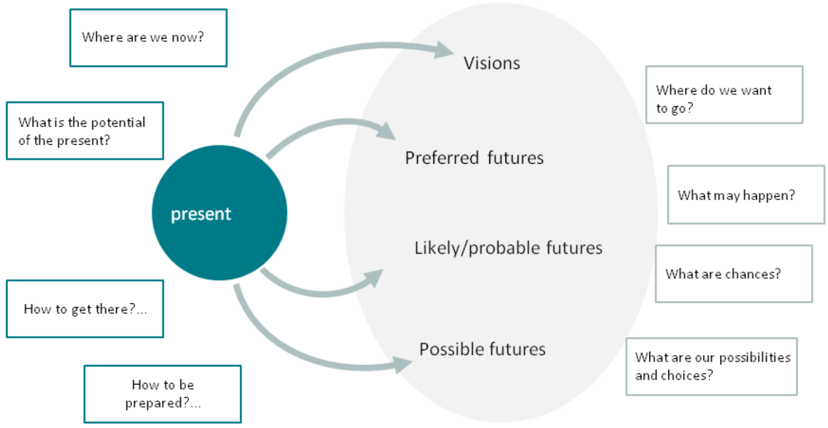
In Japan a large-scale science and technology Foresight project has been carried out every five years since 1969 (published in Kagaku Gijutsuchō Keikakukyoku 1971), to give an overview of the mid- to long-term developments to be expected at each point in time. NISTEP, the National Institute for Science and Technology Policy, an institute of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), has been the implementing entity of the survey ever since its 5th iteration (1992). This survey gained a lot of attention internationally, also because it was also performed in Germany with a one-year delay (BMFT 1993; Cuhls and Kuwahara 1994; for an overview of this, see Cuhls 1998, 2003).

In Japan for a long time Foresight was the same as "Forecasting." In Japanese, the same word "yosoku" 予測 was originally used for both. However since the start of the differentiation between Foresight, with its systematic and open peering into different futures, and Forecasting as the extrapolated view into the future of a selected topic (see Cuhls 2003), the official English translation turned into "Foresight" with the 8th Japanese approach. This term was coined with a broadening of the methodology from a Delphi survey alone to the combination instead of different methods: needs survey, Delphi survey, indicators/science maps, scenarios, and a takeover of the definition of Ben Martin "(technology) 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 of generic technologies likely to yield the greatest economic and social benefits" (1995a, b:141, and 1996).

When more and more workshops were introduced as Foresight "methods," the definition broadened. The Japanese one is very close to the one used by the team at the Fraunhofer Institute for Systems and Innovation Research (Fraunhofer ISI, the cooperation partner in the 5th and 6th Japanese surveys of 1992 and 1997 respectively), of the "structured debate about complex futures" — which means that it is a systematic approach taken by applying methods of futures research, science-based investigation, and being based on new theories of futures research (see Cuhls 2012c). It comprises the interaction of relevant actors, active preparation for the future or different futures, and an orientation toward shaping the future. It takes into consideration systemic interdependencies, and has a holistic perspective. Foresighters do not talk about "the" future but different possible ones, "futures": an open view on different potential paths ahead, thinking in alternatives.

There is no "theory" about Foresight (or futures studies or futures research), even if some attempts are being made (for example Bell 2009) and quality criteria are being discussed (such as in Gerhold et al. 2015; Kuusi et al. 2015). In any Foresight we learn more about today, and we also have the possibility to shape the future — at least partly.

Figure 1: Different futures



Foresight takes the long- and medium-term view. It is not planning, but a step on the way to planning (strategic Foresight); it is also clear that we cannot predict. As such, direct evaluations of the measurement results — the "prediction" — are nonsense. It is more important to discuss the different S&T topics, make them available for discussion, and with this initiate their realization or put a stop to any undesired developments. It is possible to work with assumptions and different options: the possible, probable, and preferred (desirable) future (see Figure 1 below). In German, Grunwald (2012) uses the word "Technikzukünfte" (technical/technology futures); the use in the plural of "futures" is also gaining ground elsewhere to demonstrate that there are always different options (see for example the journal *Futures*). People are able to choose and thus shape their future.

Foresight activities in Japan: Decades of Delphi surveys on science and technology

Since Foresight activity first began in Japan in 1969, it has been based on a large-scale Delphi survey addressed to experts in a wide range of fields. The national technology forecast has been repeated approximately every five years for 50 years now — a wholly unprecedented level of continuity. In the meantime, the scope of inquiry and the range of methods applied have also been expanded. The stability of practice in Foresight has masked a gradual evolution and adaptation to Japan's position in the world.

Kuwahara Terutaka (1999), one of the major Japanese Foresight specialists and previously one of the directors of the NISTEP, has presented the Delphi survey as the core element underpinning a four-layer model of Foresight in Japan, providing a holistic foundation on which the other activities depended. The second level was that of macro-level surveys, which were carried out by many government ministries and agencies. For example the former Ministry of International Trade and Industry (MITI) released mid- to long-term visions regarding the direction of Japan's industrial technology development every two to three years. Another example mentioned was that of the Economic Planning Agency (EPA), with an economic and social outlook. Survey fields in such studies are limited within the mandate of ministries or agencies, and time horizons are usually ten or 15 years long. The third level is performed by groups of private firms or semipublic organizations. The fourth level is the Forecasting activities of private firms, done to support their own business decisions. Usually, the survey areas are limited and the time range is only short (Kondo 1993).

When Foresight was first introduced, essentially as an import from the US, the political attitude was one wherein Japan was in a process of growing from an economic point of view, and indeed catching up with the industrialized nations. Industry was the major and most active research and development (R&D) player. The Japanese government perceived there to be a lack of strategic vision in the area of science and technology, and the initial motivations for Foresight were thus to form a common vision/consensus on future priorities and perspectives — and through this guide national industry through "long-term visions." There was no explicit public policy role of Foresight, but nonetheless a moderate link to the government's S&T policy existed — with indirect effects therefrom on R&D resource allocation.

Hence it can be seen that the Delphi report did not target one single group or policy. NISTEP, the institute which for many years has conducted the survey in collaboration with the Institute for Future Technologies (IFTECH, since renamed the Institute for Future Engineering, IFENG), believes the Delphi process provides a number of advantages (Cuhls and Kuwahara 1994):

- The S&T community must periodically think seriously and in detail about significant science and technology trends relative to important socioeconomic priorities and obstacles.
- Participation of science experts outside of government helps to maintain information flows into the government, and improves the ability to assess future demands on national infrastructure.
- The Delphi survey and the report provide a disciplined way to handle a broad range of topics, including new and/or crosscutting areas of science.

A further factor in favor of this particular approach, in the Japanese context, is that it provides a vehicle for developing consensus while at the same time avoiding any direct confrontation between participants, any conflicts of judgment over topics which are resolved "on paper." The first Delphi survey and report looked at areas such as the development of society, information, medicine and health, nutrition and agriculture, as well as industry and resources (see Cuhls 1998). In all fields, the issues chosen for consideration were identified and formulated by experts. By the time of the 5th Japanese Delphi survey, the methodology was well established; however the organizers at NISTEP were of the opinion that improvements were still necessary. Therefore, cooperation with the German Fraunhofer ISI was initiated (see Cuhls and Kuwahara 1994; Cuhls 1998; Kuwahara et al. 2008). Over the following years, through Mini-Delphi studies, this cooperation was enhanced and the Delphi methodology improved. The 6th Delphi study was also performed in cooperation with Germany, with about 30 percent of the topics and some of the criteria being the same. Nevertheless, there were also separate German and Japanese reports (Cuhls et al. 1998; NISTEP 1997).

The major changes in the next surveys were additional features, the Delphi itself remained similar: For the benefit of the general public and of companies, from the 4th Delphi survey onward an easy to read publication was produced. Later on, it even included *manga* (comics, see Kagaku Gijutsuchō Kagaku Gijutsu Seisakukyoku 1986; NISTEP 1992ff.). The 6th study in 1997 was set in the context of economic stagnation (NISTEP 1997).

An interesting question is that of why the activity has persisted over such a long period of time. A very early challenge came with the 1970s "oil shock," which was felt acutely in Japan — a country with a scarcity of exploitable natural resources. Although in most other countries Forecasting activities fell into oblivion in the 1970s because they had not foreseen the oil shock and the "limits to growth" that it would present, the Japanese Delphi process nevertheless still continued. In Japan it was observed that it was even more important to make the future happen, and to shape it actively by using the information gained in Foresight activities. This required setting stable framework conditions for development in certain fields, and making use of Foresight procedures to update the available information. Given the unpredictability of the future, it was considered important to update the knowledge and information that was available about it.

A consequence of the longstanding continuity achieved in the Delphi survey has been the possibility of assessing whether the statements of the early exercises have been realized, by way of asking the experts in later cycles to make that judgment call. To evaluate this, the percentage of topics fully or partially realized has been calculated. For the first four surveys (up to 1986) the picture is mixed, reflecting perhaps both the relative pace of advancement between fields as well as the improved knowledge base of Japanese experts over time. Taking the more generous measure of “fully” or “partially realized,” the scores for the surveys in chronological order are 69 percent, 68 percent, 73 percent, and 66 percent for the first four surveys. These are very consistent at around the two-thirds accuracy mark. Fields with high realization percentages include the ones of life sciences, health and medical care, agriculture, forestry and fisheries, environment and safety, as well as cities, civil engineering, and construction. Low realization percentages were obtained for issues of traffic and transportation and energy and resources. On the other hand this measure of evaluation (counting realizations) is not the right one, because actively stopping to support certain subjects due to a change of mind about priorities is also an important “success” for self-destroying prophecies — but it makes the calculation or evaluation based on “predictions” erroneous. Some realizations can be traced back to policies (see Cuhls 1998); others are indifferent. An example for explicit policies based on the Delphi results was the clear signal from the government ministries to companies to bet on the fax machine (in 1972).

Introducing considerations of socioeconomic needs into Foresight

Science policy has been undergoing a fundamental change in Japan ever since the mid-1990s. The first Science and Technology Basic Law was introduced in 1995, and implemented through the first Basic Plan — which ran from 1996–2000. Among the many changes this embodied was a growing emphasis on the socioeconomic dimensions to S&T. The 5th and 6th surveys had of course embodied assumptions about socioeconomic needs, but those had been framed specifically by the technological experts responsible for selecting the topics of the Delphi survey in the first place. Hence in the 6th survey topics relating to four areas of interest were extracted (NISTEP 1997):

- Counter measures for an ageing society (creating a barrier-free environment, maintaining quality of life, assisting aged people to be independent, and so on).

- Maintaining safety (prevention of natural disasters, reducing crime including computer crime, and the like).
- Environmental preservation and recycling (developing new energy sources, low energy consumption initiatives, recycling).
- Shared fundamental technologies (design techniques, processing technologies, handling systems, and techniques for observation and measurement).

Technology subcommittees were asked to include considerations of these areas when they set the topics to be investigated, and also subsequently when they reported back on findings (NISTEP 1997). The 6th Delphi survey was then followed up with a separate study, published in 1999 as a report entitled *The Analysis of Future Needs for Science and Technology based on National Lifestyle in 2010s*. An analysis was made of Government white papers to extract factors impacting deeply on human lifestyle, housing, and diet. The resulting "Citizens' Lifestyle" had 12 categories, including for example Education and Social Insurance. Further input was collected from public opinion surveys and overseas comparisons, with maximum consideration given to the views of ordinary citizens.

Against this issue a list of comparisons was made with the technological topics and their assessed importance as well as expected time of realization. Seven aspects of lifestyle were identified as fields closely related to science and technology, covering a total of 326 technological topics in the Delphi survey. These seven dimensions were health, diet, housing, water, information, safety, and infrastructure. While most were well covered by the topics of interest, some were not — indicating either a need for new technologies or an area where the solution was non-technological (for example a lifestyle change).

In the 7th Delphi survey (NISTEP 2001) a different approach was adopted, building in the consideration of needs from the start. Again, 14 "classical" technological fields like information and communications technology (ICT), electronics, life sciences, health and medical care, agriculture, forestry, fisheries and food, distribution, transportation, and services were at the center of the Delphi survey. This time, however, three subcommittees discussed future "needs." These subcommittees comprised experts from the cultural and social sciences who were asked to identify possible future trends in socioeconomic needs over the coming 30 years. The fields that they selected were: (1) new socioeconomic systems; (2) aging society; and, (3) safety and security. The committee handed in three reports about the perspectives in these fields, and about the achieved results of the technological fields in light of these perspectives.

Government reform and the new integration of Foresight in 2001

In January 2001 a major reorganization of central government ministries took place in Japan. For Foresight the most significant development was the establishment of the Council for Science and Technology Policy (CSTP, later + Innovation, CSTI) within the Cabinet Office. This council, chaired by the prime minister and with a Minister of State for Science and Technology positioned in the Cabinet Office, discusses comprehensive national measures and other issues concerning S&T. It compiles the Basic Plans that structure S&T spending in Japan. At ministry level, the Science and Technology Agency in which NISTEP previously sat was integrated into the MEXT in a rationalization process which reduced the cabinet from 22 to 13 ministers.

The Second Science and Technology Basic Plan was approved on March 30, 2001. It built upon the first plan, which had doubled government R&D expenditure but which had also concentrated on S&T fundamentals — with priority setting being non-explicit, though technological fields were favored. By the time of the second such plan, the budget had again increased and four broad areas were presented as priorities: life sciences, ICT, the environment, and nanotechnology/materials. From a Foresight point of view, eyes were already on the content of the Third Plan (CSTP 2005) — due to commence in 2006, and with the new structures the possibility of a stronger top-down influence was in place. In order to deliver necessary data, the 8th Japanese Foresight was performed earlier than the usual five-year interval would have suggested.

NISTEP adapted its structures to meet the enhanced need for future-oriented policy guidance. The group which had produced the Delphi surveys was reconstituted and strengthened to form the Science and Technology Foresight Center (STFC). This brought together researchers from government, academic, and industry backgrounds, and associated together some 2,800 experts within a wider network. A key mission was to support the development of the Third Plan. NISTEP (including the STFC) was also engaged in an evaluation of the First and Second Plans, known formally as the “Study for Evaluating the Achievements of the S&T Basic Plan in Japan” — or “Basic Plan Review” in short. This was a comprehensive exercise in benchmarking the Japanese S&T system in an international context, and identifying the changes and impacts derived from S&T activities. However here I will focus rather on the parallel exercise of the Foresight Survey. Both of these exercises were supported financially by “Special Coordinating Funds for Promoting Science and Technology.”

The inputs to the top-down prioritization of the Third Plan came from four distinct elements of the Foresight Program. The aim here was to obtain a spread of different approaches, ones that would cover the spectrum from basic research through to the application of findings to broader societal issues (reflecting a continuation of the earlier exercises' concern with societal needs). Specific exercises in the 8th Foresight Program were (detailed description in Cuhls 2010; NISTEP 2005a, b, c, d):

Study on Rapidly Developing Research Areas (Bibliometrics)

This study aimed to identify rapidly developing research areas through the use of citation databases, and to examine the presence of Japanese papers in these areas — with a focus on science, and in particular on basic research.

Study on social and economic needs

The aim of this exercise was to collect information on the needs of society and the economy, to link them with specific areas of S&T, and then to assess the potential contribution of S&T to the satisfying of those needs. The timeframe covered the next 10–30 years. Building on the "need categories" identified in the 7th Delphi survey, a detailed draft list of needs from citizens' perspective was compiled. This also drew upon the needs identified in other documents, such as government white papers. A literature survey was also pursued to identify industrial needs, and the list was completed by consulting with academics. Examples of main headings were (NISTEP 2005a):

a) Society is peaceful, safe, and provides peace of mind (preventing traffic accidents, crime, and terrorism)
b) The country actively contributes to solving global problems

The resulting list was put into three (discussion) panels, consisting of academics, the public, and business executives respectively. They were asked to summarize needs over the identified time period. In addition, a trial survey of 109 experts was conducted on how much science and technology might be able to contribute to meeting the listed needs.

Delphi Survey

The 8th Delphi Survey centered on applied technology, but also contained topics relating to basic science and societal impacts. It addressed the 30-year period between 2006 and 2035. In the survey and the report, thirteen fields were covered, which were similar to in previous exercises but with structural differences. Respondents were asked questions at multiple levels. At a general level they were asked to identify fields where fusion and collaboration should advance; at an area one the focus was on expected impacts (now and in the medium term); and, at a topic level the more "traditional" questions of importance, time of realization, leading countries, and necessity of government involvement and measures were posed. The question of "time of realization" also broke with the past by separating judgments on when technological realization would be achieved (technology is available) and judgments on when the technology would become publicly available as products and services (social realization/realization in society/the market). In this way, experts' assessment of the time taken to commercialize technologies was made clear. Early applications were most frequent anticipated in information and communication and industrial infrastructure. Between the 7th and 8th surveys the biggest increase was in "disaster-related" topics, with over half of them related to earthquakes — a natural and understandable Japanese preoccupation.

Scenario analysis

In response to concerns about the consensual nature of Delphi surveys, there was a desire to have an element in the Foresight exercise that highlighted subjective and normative future visions for wide areas of basic science, technology, and societal impacts. It was decided to pursue this by inviting distinguished individuals, outstanding in their research area, to write out a scenario on a related theme. Before engaging with the writers, "progressive scenario themes" were first identified. In order to identify the draft themes a committee used the interim results of the "Study of Rapidly Developing Research Areas," the work of the Delphi analysis subcommittees, and external suggestions too. These were S&T areas with the potential to make major social and economic contributions, or to bring forth groundbreaking knowledge about likely developments 10–30 years into the future. Forty-eight themes were eventually developed from these inputs, being divided into two rounds. Examples of these themes are "regenerative medicine for a long-lived society," "reconstruction of S&T evaluation models," and "energy conservation." Scenarios included an analysis of the current situation, a progressive element indicating key developments and dates, and a list of actions that Japan should take.

The 9th Japanese Foresight I have already described and discussed elsewhere (Cuhls 2012b). The methodology herein was similar to in the 8th approach (see NISTEP 2005a, b, c, d), and was published at an international conference just a few days before the large earthquake and tsunami of March 2011 hit. Thus, afterward, it was often asked if the results were already outdated when published. However as Foresight is not prediction, there were changes (even in the Basic Plan) — but it was not questioned whether Foresight is unnecessary in the aftermath of a natural disaster (Cuhls 2012b). One has to keep in mind that earthquake prediction and prevention has always been kept on the agenda in Japan — even at times of lower seismic activity (see Cuhls 1998).

Objectives and process of the 10th Foresight in Japan

The 10th S&T Foresight was started in 2013, envisaging the S&T development span until 2050 — with the year 2030 being the midpoint thereof. The 10th Foresight in

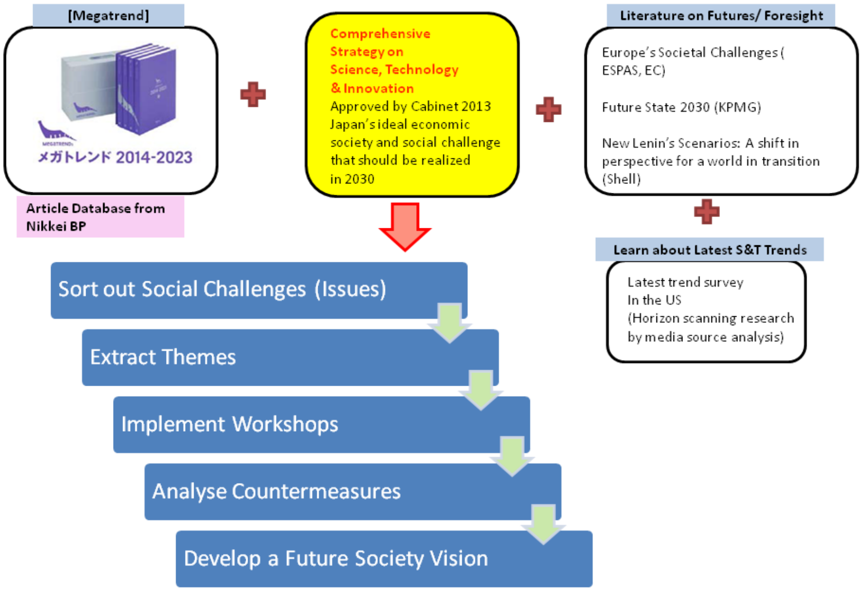
Japan is viewed in line with the activities that employ a systematic view into the future or different futures, for the purpose of integrating S&T with innovation policy. The focus shifted from the problem–solution and backcasting orientation of the 9th Foresight toward instead a more application-oriented outlook, although nonetheless in all Japanese Foresight activities the application of anticipated technology has continued to play a major role (see for example Cuhls 1998). This shift can be observed internationally as well, and reflects the developments taking place in the S&T policies of the industrialized countries. However the Foresight performing institutions felt that it was necessary to understand the interpretation of S&T Foresight results and policy developments in multifaceted ways, instead of directly delivering them one-sidedly as a report only. It is also necessary to provide the results in time as more optimized strategy examples, in order to respond to the extremely rapid changes currently unfolding in society, technology, the international environment, and the economic situation worldwide. Therefore the new Foresight intended to situate S&T Foresight as a platform that provides concrete strategy examples, doing so by practicing the following tasks continuously and sustainably (NISTEP 2015a):

- Thoroughly computerizing and statically processing the Delphi survey in real time.
- Understanding weak signs of social change, considering discontinuous and distractive changes (wildcards), and conducting trial workshops for different fields and Horizon Scanning.
- Considering international relations, including S&T diplomacy — such as leadership, international harmonization, as well as collaboration and autonomy.

The major elements of the 10th Japanese Foresight process were the development of a future vision (in the sense of a joint picture of a desirable future), the “classic” Delphi survey (as in all previous exercises but performed with adaptations), and also scenario work. First, considerations on a future vision from a social perspective were carried out. Second, a “classic” S&T Foresight by field was performed with the help of a Delphi survey from an S&T perspective. In the third phase, the results of the first two phases were then consolidated. Issues of the future society were extracted, and the directionality of solutions considered (for details, see NISTEP 2015b). The approach resembles the one taken by the German BMBF Foresight (BMBF is the Federal German Ministry for Education and Research), Cycle II, which started in 2012 and was completed in 2014. In fact the practitioners from NISTEP actually took a close look at the BMBF Foresight, and consulted the researchers from Fraunhofer ISI who were part of the consortium on the German side.

By screening databases and analyzing the literature, factors for future social challenges in Japan for the years 2030 to 2050 were identified. The findings were separated into macro changes that will certainly happen, including demographic ones as well as the shift to a service economy. Uncertain changes, including the small-scale social and technological ones that are expected but not guaranteed to happen, were discussed in workshops and connected to a future society vision. Figure 2 illustrates the procedure.

Figure 2: Development of a Future Vision for the Society



Source: NISTEP 2015a, presentation provided by Yokoo, Yoshiko; also NISTEP 2015c: 2

The development of Japanese society was discussed from different perspectives, with a view specifically to drastically changing aspects like:

- Globalization: Japan in the world
- Rapid advancement in networking: Connection
- Human distribution: Population composition, “City, region, community”
- Industrial strength: Knowledge society and service-oriented, food

The second phase of the 10th Foresight involved collecting the opinions of experts and analyzing mid- and long-term developments in S&T up to the year 2050. For this, a committee was established for each subject field. The STFC of NISTEP supported the process and worked in subcommittees (Delphi committees) for each of the eight identified fields (see Table 1 below). Altogether 932 topics were identified. In cooperation with relevant academic societies, associations, and the like, a questionnaire was developed to assess the topics according to importance, certainty/uncertainty, discontinuity, “morality” (ethical questions and values, see

Ogasawara 2015), international competitiveness, the expected year for technical realization and application in the real world, as well as challenges/policy measures.

Table 1: Delphi Fields in the 10th Foresight

Science and Technology Fields	No. of Topics
ICT and analytics	114
Health, medical care and life sciences	171
Agriculture, forestry and fisheries, food and biotechnology	132
Space, ocean, earth and science infrastructure	136
Environment, resources and energy	93
Material, devices and process	92
Social infrastructure	93
Service-oriented society	101
Sum	**932**

Source: NISTEP 2015 a; Ogasawara 2015

Whereas online surveys are rather common nowadays in other countries (see Aengenheyster et al. n.d.; Bioeconomy Council 2015; Cuhls 2009, 2012b Friedewald et al. 2006;), this was the first time that the Delphi survey was performed online (done in order to save money). For this, a platform called “Delphin” was developed. The new survey tool is able to visualize and conduct the survey, process mass data efficiently, manage the registration process, monitor the status of the survey, and identify the characteristics of the respondents. It is possible to aggregate the data for the second round of the Delphi survey quickly, and to show the representative values to the other participants. Correlations can be calculated, and topics statistically analyzed.

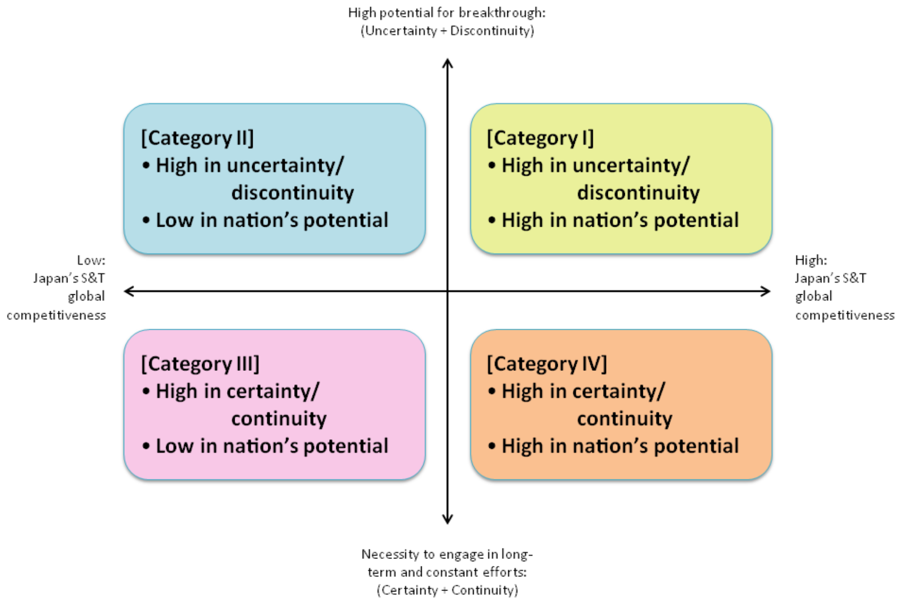
It is rather astonishing that technology-affine Japanese scientists waited until 2013 to make use of automation in surveys. It was previously always argued that people are used to paper questionnaires, and so they would not answer online. In fact, in German surveys it can be observed that the response rates are much lower when the survey is performed online: in times of an overflow, information about future issues are available in many places and the Foresight results are no incentive to participate anymore (we got the feedback of potential respondents or those who refused to respond that higher incentives would be needed if they are to be motivated to participate); response rates drop anyway because of people’s general “lack of time.” Meanwhile, in Germany printed surveys are rather the exception.

Outlook on future topics in Japan (10th Foresight as of 2015)

Different analyses were made on the basis of the results of the Delphi survey. Simple statistical analysis ranks among the most important topics (for an impression of technologies that score high on the importance list, see NISTEP 2015 or Ogasawara 2015). Examples are, in the ICT field, the “development of data utilization techniques with theoretically guaranteed preservation of privacy,” “technology to develop software without security holes which allow remote exploitation,” and “technology to improve the performance to power ratio of super large-scale supercomputers and big data IDC systems with more than one million nodes by a factor of 100 compared to current systems.” In the Health field an example is “a cheap, easy-to-introduce dementia care assistance system”; in Agriculture, Forestry and Fisheries, “technology to remove radioactive substances in order to revitalize fishing in coastal areas.”

Of the 932 topics assessed, 312 items with high importance (top one-third as scored for importance) were analyzed. The scores were combined with those for uncertainty and discontinuity to extract items within the top 10 percent (30 items) and the bottom 10 percent (30 items). As a next step, global competitiveness was taken into account to finalize the ranking of both the top 10 percent and the bottom 10 percent. Figure 3 below demonstrates how the different topics were grouped together. This way of grouping is very important for their later selection and priority setting in policymaking.

Figure 3: Categories for clustering the results of the survey



The selection of topics was similar to how it was done in the German BMBF Foresight (in Cycles I and II, technical parts; see Cuhls et al. 2010 and Zweck et al.

2015a, b), which was performed at a similar time and served partly as an input stimulus. As the international Foresight and S&T communities know each other and are in reciprocal contact (for example via final conferences or the regular FTA (Future-oriented technology analysis) Conference, European Commission expert groups, the OECD network GFN, several advisory boards to the different Foresight approaches, and so on), similarities are not astonishing. In the Japanese Delphi survey (NISTEP 2015 or Ogasawara 2015), the following topics are examples of ones assigned high ratings in the different categories:

> Category I: for example regenerative medicine, fuel cells and rechargeable batteries for automobiles, earthquake forecasting, and so on.
>
> Category II: for example cybersecurity, mental disease drugs or therapy, infectious diseases, simulation techniques, and the like.
>
> Category III: different network technologies, utilization of medical data, forestry, surveillance, assessing the safety of genetically modified crops and animals, and similar.
>
> Classification IV: beam application (material, treatment), highly efficient power generation, recycling of resources, new materials with specific functions, among others.

Specific observations when matching the data were:

- Characteristics of "ICT and analytics" and "health, medical care, and life sciences" that show high importance but low global competitiveness.
- In ICT and analytics, there were topics in the quadrant of "high importance, high global competitiveness." However ICT also contained topics about "cybersecurity" and "software" with high importance and low global competitiveness.
- In the fields of "health, medical care, and life sciences," topics were found in "regenerative medicine" of high importance, high global competitiveness. In contrast are the topics in "emerging and re-emerging infectious diseases" with high importance but low global competitiveness.

All these topics will be scrutinized to derive policy recommendations. Top topics come from "ICT and analytics," but also other fields (see Table 2 below). Looking at the highest scores for *rinrisei* ("morality": ethical and moral considerations, values, also security and safety included) then "ICT and analytics," "health, medical care, and life sciences," and "service-oriented society" are on the list (Table 3 below), but still unspecified. The scoring of importance in Table 3 can only be regarded as input to further debate. It has to be viewed from different perspectives, and worked out in more detail to be successfully used in priority setting for real-world decisions.

Table 2: Field Topic Selection

(Software and theory in the ICT field as well as modeling and simulation in material field; half of the topics overlap with technological achievements; data: Selection ratio: in percentage of respondents; Importance: quadratic index/ responses are coded as very high=4, high=3, low = 2, very low = 1; When to be achieved: lower and upper quartile)

Field	**Topic**	**Selection ratio*1**	**Import-ance*2**	**When to be achieved*3**
ICT	Software development technology that reduces the frequency of bugs occurring in code to less than one per million lines of code	52% (57%)	3.4	2025 2025
ICT	Development of a new computation model to understand the difficulty of calculations: A theoretically solvable model for computationally difficult problems (i.e. interactive computing, quantum computing, probabilistic proof verification model, etc.) as the foundation for construction of a realistic and marginal problem solving platform (including theoretical exploration of innovative model building)	47% (80%)	3.5	2027 2035
ICT	Technology which automatically inspects and fixes minor bugs in large-scale software	47% (58%)	3.5	2024 2025
Material	Dynamic simulation technology that allows for the analysis of the selection rates, environmental effects (temperature, etc.), and many-body effects in catalytic reactions	47% (65%)	3.3	2025 2029
ICT	Technology which ensures that widely used compilers, OSes, or basic libraries operate in accordance with specifications	47% (55%)	3.5	2025 2029
Environment and resource	Establishment of a two-way risk communication process to enable consensus on energy supply technologies and systems	46% (44%)	3.4	2022 2025
Material	Technology to estimate the structure or creation process of materials through materials science inverse problems by applying statistical mechanics techniques for information such as Bayesian estimation and neural networks	46% (56%)	3.2	2025 2029
Material	Multiscale simulation technology to project how chemical reactions at the electron-scale affect macro-scale physical properties, functions, degradation, and destruction of substances	44% (57%)	3.4	2025 2030
Agriculture, forestry and fisheries	Evaluation of toxicity caused by the interaction of multiple harmful factors in food	44% (31%)	3.4	2020 2023
ICT	Improved scalability of the problem-solving paradigm using mathematical programming (Developing mathematical programming technology to solve global-level optimization problems in real time)	43% (65%)	3.5	2022 2025

Source: NISTEP 2015 a; Ogasawara 2015

Table 3: Topics with high scores on "morality"

(Morality and Importance: quadratic index/ responses are coded as very high=4, high=3, low = 2, very low = 1; When to be achieved: lower and upper quartile)

Field	Topic	Morality	Import-ance	When to be achieved
Health	An infertility treatment that uses reproductive cells that have been induced to differentiate from human iPS cells	3.9	2.9	2025 2036
Service	To achieve a healthy aging society, information about the hobbies, health, medical records, and daily activity of elderly people will be managed and analyzed in a single database	3.7	3.3	2020 2025
Service	Development of a system that can automatically determine the relationships between employees from their behavioral histories	3.7	2.5	2025 2026
Service	New businesses that manage customers" personal behavior information in a manner similar to credit card companies and banks will emerge and become commonly used by the public.	3.6	2.6	2018 2021
Health	An artificial uterus which enables the growth of a fetus	3.6	2.8	2030 2040
Health	Organs for transplant derived from human stem cells but produced by animal embryos (in other words, produced from chimeric embryos based on animal embryos injected with human cells)	3.6	3.0	2022 2032
Health	Regenerative medicine technologies using the transplantation of embryonic stem cells	3.6	3.0	2020 2025
ICT	A service to provide predictive and preventive medicine based on analysis of various personal data such as health, diet, and exercise	3.5	3.5	2021 2025
ICT	Technology that integrates evidential information such as provenance into data utilized for big data analytics to allow for safe analysis and the protection of personal data	3.5	3.6	2020 2024
ICT	Social consensus about the relationship between machines (e.g. robots) and humans (By establishing a new "three laws of robotics", legal developments will proceed, and we will achieve a stable society and economy where humans and robots cooperatively coexist). As a result, the contribution of robots to the economy will reach 40%.	3.5	3.4	2025 2030

Source: NISTEP 2015 a; Ogasawara 2015

When clustering the health topics (Ogasawara 2015), it became obvious that Japan is approaching an "Advanced Knowledge Society." A lot of challenges will stem from "Reverse Innovation" (an innovation seen for the first time, or likely to be used first, in the developing world before spreading to the industrialized world) in the years to come. In the long run, with improvements in medical care, life sciences, brain sciences, artificial intelligence, and robotics, a "deepening of human beings" with new brain and body functions may be observed. Some scientists in the studies assume that we are approaching a "singularity" (when artificial general intelligence will be capable of recursive self-improvement or of autonomously building ever smarter and more powerful machines than the machine itself; for details, see Kurzweil 2013) manifesting after 2050. The idea of singularity is seen very critically by many experts in the studies mentioned (also in the international Foresight community), and does not play a practical role in Foresight but does mark a shift in technical possibilities. Maybe it is just another buzzword to bring attention to the field. But however the opinions on singularity may differ, after 2050 Japan is expected to be a "Super Knowledge Society" with challenges for national security, for safety, and also for G7 Horizon Scanning.

It can be noted that these Japanese results are similar to findings of the German BMBF Foresight Cycle I (Cuhls et al. 2010), especially for health and digitalization/health systems, for services and manufacturing, as well as for artificial intelligence/robotics/brain sciences and human–technology cooperation. We see these similarities worldwide by now — which means that national technology policy is often being copied from industrialized and technologically strong countries (of course mainly from the US, Japan, or Germany, but also from others). It also means that — especially in high-tech fields — the developments in all countries, even developing ones, are heading in similar directions. Therefore it is often feared that "monocultures" within the S&T field are emerging. "Betting" is taking place globally on the same research and technologies, with the same specific technologies being funded in all countries — even if they do not fit, or even if others would make more sense in the specific local context; a prominent example is all countries betting on nanotechnologies. This diminishes diversity and the distribution of labor in global R&D. Furthermore, in most of the countries, the consumers are not integrated into the development of new S&T or products, so that experts are often astonished that popular resistance to them occurs later on.

The 10th Foresight tried to take this into account, but represents just a start. For example in some fields the results were also clustered in an interdisciplinary way, and the likely impacts for Japan were worked out. A number of consequences for Japan specifically might evolve from the technology issues described in the reports (NISTEP 2015b, c):

- Based on societal changes and the new directions of S&T developments in the future, future issues, strategies, and precautionary measures have to be identified and developed.

- Relevant policies and strategies, images of future society derived from the survey of societal developments and the Delphi surveys need to be considered.
- Situational changes involving S&T, derived from Foresight by specific field, determine considerations.
- Themes from the viewpoint of their long-term nature, fusion of fields, and interdisciplinary nature are to be identified.
- Information needs (in the sense of "What kind of information is missing?") to be gathered through Foresight workshops, interviews, literature reviews, and so on were analyzed and summarized at NISTEP.
- A "Japan in global context" workshop was held to deliberate on S&T-triggered scenarios, from the viewpoint of placing Japan in the global context and toward an overall integration of thematic scenarios.

In addition, the societal topics identified in the Foresight report are:

- Connected society
- Knowledge-based society
- Service-oriented society
- Healthy long-life society
- Sustainable regional society
- Manufacturing-based society
- Resilient society

For Japan in the global context, the most important issues are:

- Open science/innovation
- Data science
- Applied use of big data
- Support for decision making
- Artificial intelligence
- Ethical, legal, and social implications (ELSI) issues
- National security and safety

Manufacturing, services, ICT, health & medical information/brain and mind, regional resources, agriculture and food, resilient social infrastructure, energy, environment, and resources were chosen as the topic fields for working out scenarios about Japan in the global context. In these fields, discussions and scenario planning are organized based on the results of the "Study on the Future Vision of Our Society" (Part 1) and "Foresight in Science and Technology for Each Field" (Part 2). One of the workshops conducted was entitled "Japan in the World — Consider Japan's Role in the World," where the main points were picked up and discussed from international perspectives and not only with a limited Japanese one (in terms of: leadership, international harmonization and collaboration, and autonomy). During the workshop, the following discussions about "science diplomacy" came up (NISTEP 2015a, b) — ones that still have to be filled with more substance:

1. Related to "leadership," a scenario in which Japan will have a strong ability to make proposals based on not only the technological strength that provides greater international competitiveness but also on its cultural advantages — including Japanese-style hospitality, the so-called "O-Mo-Te-Na-Shi" (original transcription). A second scenario is one in which Japan, as a developed country facing many serious challenges including aging society issues, will present an exciting location for research, form an international hub to attract superb researchers and companies, and lead technological innovation.
2. Related to "international harmonization and collaboration," a scenario in which Japan will make great contributions to resolving global challenges related to natural disasters, the environment, or energy. A second one is that multinational harmonization and collaboration will facilitate resolving challenges such as the necessary measures against intractable/infectious diseases. A third scenario demonstrates that the best response to the challenge Japan or a counterpart faces will be possible only under bilateral harmonization and collaboration.
3. Related to "autonomy" (which here means retaining personal autonomy in Japanese society, also taking into account the advent of machines/robots), a scenario was built that contributes to resolving the issue of the decreased production/consumption associated with a decreasing population. A second scenario responds to the urban and regional challenges that arise as a result of a decrease in population (including aging infrastructures, depopulation of hilly/mountainous regions, and the like). A third scenario contributes to the improvement of quality of life and mental health benefits. To compare: in Germany we have a debate about autonomy when talking about autonomous machines (see Gransche et al. 2014).

The scenarios in this study are implemented not by exclusively selecting one of them as the desired one, but by assuming that the individual scenarios will be achieved through striking a proper balance between the situations mentioned in them. These correspond to the future situations that people in Japan may face. One example for an assumption or situation is limited available resources. In the political arena, it was decided to "establish a position in diplomacy to take leadership for the solution of global challenges by using science, technology, and innovation, to achieve desirable international circumstances and clearly deem S&T diplomacy as a new axis of Japanese diplomacy" (NISTEP 2015a, b). This is supposed to be done by setting the agenda for international challenges, offering solutions, and taking the lead in the development of international rules. Japan's politicians are asked to contribute to the fostering of the intention to build an open, liberal, peaceful, and prosperous world through S&T diplomacy. Japan intends to take the lead in promoting S&T innovation based on values such as academic freedom and freedom of expression, and respect for human dignity in the face of cyber society and open science (all defined as relevant by policymakers). For this, it is intended to propose to the international community "a suitable set of diplomatic agendas" (NISTEP 2015a, b). and to start the discussions about certain critical issues. This is envisaged as liable to improve Japan's reputation worldwide, and to enhance the country's influence within international society. Occasions to start this kind of diplomacy are intended to be the 2016 Tokyo International Conference on African Development (TICAD) or the Olympics and Paralympics of 2020 (see Ogasawara 2015; cited from MOFA 2015).

In and for Japan, the following scenario themes were further developed in detail:

1. Advanced Manufacturing Platform toward Future Industry Creation and Social Reform
2. Future Co-Creating Services
3. Improvement of Physical and Mental Health toward the Realization of a Healthy Longevity Society
4. Maintenance of Food Production and Ecosystem Services by Using Regional Resources
5. Resilient Social Infrastructure Addressing Large-Scale Natural Disasters and an Aging Population with Fewer Children
6. Energy, Environment, and Resources that Contribute to Building a Sustainable Future

Conclusion: Challenges for (Science and Technology) Foresight in general — and outlook for Japan

The history of Japanese Foresight has found continuity in its setting in, and its adherence to, the Delphi survey methodology. Although in most other countries forecasting activities fell into oblivion in the 1970s because they had not foreseen the oil shock and the "limits to growth" that it would present, the Japanese Delphi process continued. This was because it not only bet on the predictive part of Foresight, but also on the communication of futures issues and on shaping of science and technology futures.

In Japan it was observed early on that it was important to make the future happen. It was also recognized as important to shape it actively by using the information gained in Foresight activities, setting stable framework conditions for developments in certain fields by way of science and technology policy, and by making use of Foresight procedures to update the available information. Foresight provides the "working material" for this, setting objectives that have been under reevaluation every five years — instead of putting faith in “predictions” and a fixed plan. Mirroring the story of the Japanese economy, the Delphi methodology was imported, adapted, and improved to suit local circumstances. Certain features of Japanese society were propitious, notably the willingness of experts to make serious time and effort available for the collective good — as demonstrated for example in the high response rates that were always achieved. Certainly, experts also have the intention of bringing their own topics onto the agenda (for budgets, general support, public recommendation, discussions, and the like) — but a degree of idealistic thinking regarding contributing to the progress of the country was and is always included.

When European innovation researchers began to take an interest in Japanese approaches in the early 1990s through studies such as that of Irvine and Martin (1984), as well as the later links with Germany (BMFT 1993, 1994; Cuhls and Kuwahara 1994; Cuhls et al. 1998; Cuhls 1998), Japan not only influenced Western practice but also began an interactive relationship that saw concepts and details of technique flowing in both directions. The result of the mutual observation was mutual exchanges and mutual influence. But the Japanese side was close to policy-making very early in the development: The changes in Japan at the beginning of this century have been characterized by two major linked ones more broadly: one being a much closer engagement with policymaking, and the other an expansion of the toolbox and the broader concept so as to be able to deliver on this. With science policy on a stable course for the years until 2011, this was regarded as fruitful. However we can perceive new changes, and now, after the 10th Foresight has been completed, the discussion is open as to whether Foresight will be continued hereafter or instead has reached its ultimate limits. The occasion for this new discussion was the criticism voiced during an evaluation performance in 2014/15, in which it became obvious that the Foresight program, while acknowledged as a very important concept, is not well known among policymakers anymore. Whereas the Delphi surveys from their 4th iteration onward were published in the form of books, tables, even manga (and also in a publicly understandable form), the activities since the 8th Foresight have more and more been directed toward the government — especially the CSTP and the new Innovation 25 strategy (see CSTP 2006; Cuhls and Wieczorek 2010). In these, the Delphi results were used to formulate innovation stories of the future. They were regarded as being very simplistic, linear, and overoptimistic, but nevertheless well known. The problem is rather that the link to the original source, the Delphi survey, has become more and more forgotten. However in 2010 it was not questioned if Foresight should go on, because it was the Delphi surveys that kept earthquake prediction and prevention permanently on the agenda in Japan — even during times of lower seismic activity (see Cuhls 1998).

Coming back to the research question presented at the outset, the official reasons why Foresight is regarded as being at a crossroads are the following: One is the ready availability of information via the internet and an information overflow, instead of deficit. In the Japanese Foresight study this is called "Collapse of Information Asymmetry." In the past any information regarding science and technology was held primarily by the government and academia; as such, information asymmetry was so high that great significance could be found in providing Foresight results and roadmaps. Due to the acceleration of ICT use, however, this asymmetry has collapsed, allowing the public to possess sophisticated information, to assess that of everybody involved, and to ensure data retrievability. Consequently, some policymakers find no meaning in solely organizing their own surveys and publishing the results of Foresight when there are only a few readers and related perceptions and uses are limited. Even if Foresight is mainly performed directly for policymakers, it cannot be brought to their attention anymore.

Yet – and here Foresight can be regarded as forward-looking science and technology studies – more than just assessment is necessary. Communication with different stakeholders — in some cases even the participation of "citizens," beyond science and technology experts — are necessary to gain support for making future assumptions real and for developing technologies into marketable products. Even new processes are necessary. This goes far beyond the "acceptance" debate; it is proactive, collaborative, and requires a new means of policymaking.

The second development is a growing uncertainty or "Expansion of Uncertainty Factors." Most technological developments have reached their limits, or have already met the required level of overt demand. This trend is now taking technological development in uncertain multiple directions, but not in one unambiguous one. Therefore Horizon Scanning (in the sense of needing to understand subtle social and/or technological changes, and also to estimate what impacts these will have on our future) has increased in importance (moving toward new awareness, rather than consensus) — forward-looking science and technology studies are at the forefront here. In fact, Foresight and Horizon Scanning are directly linked (see Cuhls 2015); in most countries Horizon Scanning is always part of Foresight. In Japanese Foresight, the identification of hot areas or bibliometric approaches have always been forms of Horizon Scanning.

The third development of note is the shift to innovation: Owing to it, the trends of both science and technology and their policy have moved from a passive concept (such-and-such a technology will be needed because so-and-so society will emerge after X number of years) toward a more active one (such-and-such a technology must be developed to create so-and-so society). Thus, exploring business potential will result in the concentration of investment and human resources, accelerating the research and development process (moving toward opportunities, rather than a roadmap). This is linked to an increased need for securing competitive edges. In the past both scientific pursuits and the early stages in a technology's development were recognized as precompetitive fields, and thus were premised on information sharing. However in science-type industries such as drug discovery, even in scientific fields or during the early stage of a technology's development, a strategic nature is needed in Foresight itself because the findings may have a great impact on competitive edges (moving toward strategies, rather than a road map). In other countries like France or Germany, there are thus approaches like Foresight for Strategies (being for example one of the business areas of the Fraunhofer ISI) or Strategic Foresight (Coates et al. 2010; Godet 2007). These focus on the application of Foresight results for strategy building. Experiences with policy implementation of Foresight are also reported (see Cuhls and Jaspers 2004; Meissner et al. 2013).

Thus Foresight is indeed still relevant, even in science and technology itself — in the science and technology policy of the government, in industry, or in research organizations, where new programs and budgets have to be decided upon. Of course, there is a lot of uncertainty. Yet scientific projects have plans (which have an application, a start, and an end), and it can be estimated when they will end and if they will be successful. The more application-oriented the technology is, the more difficult the estimation — as it is not only science and technology that is responsible for the success of an innovation or new product on the market. Here, more and more demand, "acceptance," even values and ethical issues are at the forefront; even more factors besides have to be considered when estimating success or realization times (see Figure 3 above). This is a "classic" task of science and technology studies; when talking about Japan, a more detailed understanding of culture, values, and society are required.

Therefore Foresight, in the past, was mainly performed for "technology," having a rather predictive character in Japan. Nowadays the Foresight horizon moves more and more toward people's and society's needs — which are unpredictable of course, and even difficult to imagine. As such experiments with new tools, imagination, intuition, "Mental time traveling", and participative approaches are ongoing (see for example the FTA conference 2014 in Brussels; also, Cuhls and Daheim 2016). They go beyond the consensual nature of Delphi surveys, the short and limited Delphi theses — with their desire to be an element in the Foresight that highlights subjective and normative future visions for wide areas of basic science, technology, and societal impacts.

To sum up, the expectations of policymakers, the community, and the Japanese public for Foresight are high — should it even continue at all. A combination with other Horizon Scanning activities (see for example Cuhls et al. 2015) is intended in the country, and the cooperation with academic societies/a strategy planning hub will lead to the complete eventual construction of a Foresight/strategy platform (see Ogasawara 2015, or the NISTEP presentation by Yokoo 2015). This is similar to what is happening in other countries, and helps contribute to creating "science, technology, and innovation" policies. Forward-looking science and technology studies will have their part to play in it.

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