Published in *Technological Forecasting & Social Change*. DOI information: 10.1016/j.techfore.2010.08.005. In Press.

PERCEPTIONS OF DOMAIN EXPERTS ON IMPACT OF FORESIGHT ON POLICY-MAKING: THE CASE OF JAPAN

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Keywords: Delphi method, impact, foresight, policy making, perception, survey

Abstract

In this study, the perceptions of domain experts who participated in foresight activities on the impact on policy making are examined by conducting interviews and surveys on five previous foresights in Japan between 1996 and 2007. The purpose of the study is to examine how domain experts look at the practice of foresight in general, and perceive its overall impact on policy making in particular, in the setting of Japanese foresight conducted in the past 15 years. There are two tasks for doing that in this study: to know the views of scientists and engineers who participated in foresights on the impact of foresights they participated; and to know the effect of respondent's characteristics on their perceptions on impact.

There are two main findings of this study. First, the impact on policy making perceived by domain experts who participated in foresight activities in Japan is not very high. Second, there are different patterns of perception on the size of the impact on policy making depending on ages, organizations, member status during foresight, and science and technology areas, and habit of following the situation in general looking for any impacts after the foresight.

1 Introduction

An international group that analyzes methods for future technology analysis defines foresight as "a systematic process to identify future technology developments and their interactions with society and the environment for the purpose of guiding actions designed to produce a more desirable future"[1]. Foresight techniques are defined as methods for conducting foresight, or, methods aimed at "apprehending the longer-term future of science, technology, economy and/or society in order to identify strategic research and emerging technologies coupled with economic and social benefits" [2].

There are various kinds of evaluation studies on foresight activities such as studies on the accuracy and reliability of its products [3; 4] its deliberation process [5; 6], its networking effects [7], its productivity [8], its regional differences[9; 10; 11; 12], its role at funding agencies [13], and its impact on policy making.

Martin and Johnston explain the benefit of foresight process as follows [7]:

> In conclusion, experience with foresight in the countries reviewed here suggests that government, industry, research and educational organizations, professional societies, and community groups should all be encouraged to undertake, or to be involved in, foresight exercises. Such exercises develop a better informed forum and a participatory and transparent process for decision making on science and technology, allowing us to anticipate the potential consequences of current decisions. In short, technology foresight can enable us to shape the future so that it better meets our longer-term economic and social needs.

In this process, "disparate group of people (academics, industrial researchers from different sectors, policy makers, professional forecasters and scientific commentators)" are brought together and "a structure within which they can communicate directly or indirectly with each other" is made [14]. Communication is stimulated and partnerships are forged among researchers, and between researchers, research users, and research funders [7]. Consensus is achieved among experts on an uncertain subject [15]. A feeling of commitment to the results of foresight is generated, the ideas generated are turned in action, and they are likely to be self-fulfilling [14]. So the role of experts and their input into the process is very important for the success of foresight activities and selection of experts is important for conducting high quality foresight. The reliability of foresight depends on appropriate selection of experts [16]. Participation of well-respected experts is influential in persuading people that the foresight is taken seriously, and time and commitment are required from a range of experts to conduct foresight successfully as a participatory process [17]. Keenan and Miles explain that experts' work include the following [17]:

- Gathering relevant information and knowledge;
- Stimulating new insights and creative views and strategies for the future;

- Helping to build new networks;
- Diffusing the foresight process and results to much wider constituencies, and
- Identifying and acting on ways to maximize the overall impact of foresight in terms of follow-up action

There are three types of participants in foresight: experts in foresight methods and organization, experts in the domain(s) addressed by a particular exercise, and users of the outcome of the exercise [18]. The role of participants is important, and there are previous studies on foresight activities including their processes and products from the standpoint of experts in foresight methods and users of the outcomes such as government policy makers. In the explanation on generational development of foresight in the past, it is pointed out that “domain expertise becomes more significant” and experts have “never disappeared from the scene” [19]. But there are not many previous studies on foresight activities from the standpoint of domain experts who participated in foresights. One such study [20] found that “autonomy is still valued by researchers and there was considerable antagonism towards many of the policies that impinged on academics and were seen as an attack on them” based on analysis on UK foresight activities. But is this statement valid to another foresight, for example, conducted in another country?

In this study, the perceptions of domain experts in foresight activities, whose types are varied in terms of their science and technology areas or affiliated organization, on the impact of foresight on policy-making are examined by conducting interviews and surveys on participants in five previous foresights in Japan conducted between 1996 and 2007. Japan initiated its first foresight using Delphi method in 1972 and has been conducting foresight since then basically every 5 years [11]. In 2010, the ninth Delphi study was finished. The practice of foresight in Japan is conspicuous in terms of consistency of activities and involvement of a large number of scientists and engineers.

1.1 Purpose of the study

The purpose of this study is, as stated above, to examine how domain experts look at the practice of foresight in general, and perceive its overall impact on policy making in particular, in the setting of Japanese foresight conducted in the past 15 years. There are two tasks for doing that in this study. The first is to know the views of scientists and engineers on the impact of foresight activities they participated in Japan. What are their evaluations on impact? What kind of impact do they observe? On which actors and on which area of science do they perceive the impact as high, or low? Are there any differences among the foresight activities perceived in terms of the size of impact?

The second task is to know the relationship between the characteristics of the respondent and their perception on impact. There are various types of participation (committee member, Delphi respondents, workshop participants, scenario writers, and so on), and various types of participants (organization, scientist or engineer, science and technology area, age group, gender, distance from government, and so on). How are these differences in characteristics related to their perceptions on impact?

By analyzing those, lessons, perspectives or recommendations are gleaned which was not found by previous studies focusing on the views of method experts, and users of foresight.

1.2 Previous literature

In this section, previous literature on Japanese foresight is discussed. As stated above, foresight based on the Delphi method started nearly 40 years ago in Japan, and has continued since then. The foresights were evaluated by practitioners, academics, or users. One practitioner of Japanese foresight explains its advantages as follows [21]:

- The S & T community must periodically think seriously and in detail about the significant science and technology trends relative to important socio-economic priorities and obstacles;
- Participation of science experts outside of the government helps maintain information flow into the government and improves the ability to assess future demands on national infrastructure; and
- The Delphi provides a disciplined way to handle a broad range of topics, including new and/or cross-cutting areas of science

He also emphasizes the role of foresight in building consensus, arguing that foresight provides “language” to communicate among Japanese actors in science, technology, and society. The result of foresight is not only “sources of valuable general insight for policy makers and managers but also in some important cases have triggered action plans” [22]. He stresses that the strong interest in society in foresight was shown by the fact that around 3,000 copies of the report were distributed in case of the fifth survey and major aspects were introduced to the public by many newspapers and magazines [21].

Another practitioner in Japan also stresses that it is possible to collect wide range of S & T information periodically by conducting Delphi survey. The collected information is comparable across periods since the framework of survey is based on the framework used last time. From the result of Delphi survey in Japan, it is possible to read the direction of technological development and agenda for promotion of research and development. He pointed out that the significance of the Delphi surveys is not on whether the predictions on realization of technological development is correct or not, but rather on contribution to promotion of technological development by showing the future direction of research and development. He also emphasizes that the reliability of Delphi survey in Japan is enhanced by spending about one year for selection of experts and topics for the Delphi survey. Selection of technological experts and topics is important for conducing high quality Delphi survey. Only experts in each technology domain who have a broad and balanced view on long-term science and technology trend can select appropriate topics, and the participation of knowledgeable experts in Delphi survey makes the result of the survey reliable [16; 23].

The report of the National Institute of Science and Technology Policy (NISTEP), which is responsible for foresights in Japan since the 5th Delphi survey in 1990[1], argues that there is "concrete influences (of foresight) on Japan's research and development as well as technology developments in general" [24]. In addition, NISTEP conducts a mail-based survey of private firms that purchased the foresight report in 2000. The survey with 175 responses examined who purchased the report for what purposes, how they utilized the results, and what kinds of information they found useful. For about 75% of the respondents, the purpose of the usage of the report was to grasp the general trend of long-term science and technology development, and about 60% thinks that the survey is valuable when making research strategy of each firm [25].

Irvine and Martin are the first scholars to pay attention to Japanese foresight in the early 1980s. They emphasized that the main benefit is not the product of foresight but the process by which forecasts are generated. Benefits of Japanese foresight summarized by them are basically the same as the advantages stated above: [14; 26]

- They provide a mechanism to ensure that researchers in all sectors, along with policy-makers in government and industry, are periodically forced to think systematically about the longer-term future;
- The forecasts yield a general summary of what is happening, or likely to happen, across the entire range of R & D activities;
- By surveying comprehensively the intentions and visions (and thus indirectly the current strategic R & D activity) of the industrial research community, it provides a useful mechanism for synthesizing major research trends across science-based sectors; and
- The forecasts provide a useful mechanism for helping the government establish national priorities in allocating resources

Cuhls pointed out that foresight in Japan brings in elements to moderate or negotiate between the social interest groups and the results of foresight provide "the code to communicate between social actors in science, technology, and society." Earthquake research and solar cells are pointed out as two example of policy relevance of foresight in science and technology policy in Japan, since the fact that both topics were listed in topics for Delphi surveys contributed to the continuance of research in those areas [27]. Eto discusses that technology forecasting based on such consensus is considered in Japan to be reliable and the consensus promotes cooperation

[1] The Science and Technology Agency was responsible for conducting the 1st to 4th Delphi surveys. Since the 4th Delphi survey in 1986, the Institute for Future Technology has been responsible for the operation including panel discussion and survey itself.

and as a result the probability of success in research projects will be increased. According to him, the wider the Delphi consensus is, the more accurate the Delphi forecast [28].

As to evaluation on reliability and accuracy, each foresight, conducted every 4 to 5 years, analyzes the realization of results after 15 to 20 years. For example, in the 8th Delphi survey in 2004, the realization of the 1st (1971), the 2nd (1976), the 3rd (1981) and the 4th (1986) Delphi results was examined by panel members. They found that 69% of 616 topics in 1st Delphi, 68% of 641 topics in 2nd Delphi, 73% of 748 topics in the 3rd Delphi, and 66% of 933 topics in 4th Delphi survey were realized or realized partly. Considering the fact that over 60% of the Delphi topics are realized, it was pointed out that Delphi surveys have played the role of giving scientists and engineers in Japan the targets of R & D, and thus promoting their realization [23].

As mentioned above, foresight in Japan has been evaluated as highly effective by previous literature. It is a periodically conducted participatory process that covers broad areas of science and technology. It promotes communication and helps building consensus. The society and the industry in Japan are interested in the results, which have been found relatively accurate. It provides the government valuable information on science and technology. The government sets a priority based on the areas where the results of the Delphi survey show promising, and scientists and engineers make efforts around those areas.

But is this a real picture of what is going on? If this is real, to what extent? There are three questions. First, there are many participants in the Delphi survey including both panel members and respondents to Delphi survey as explained later. The Delphi survey sends a questionnaire twice in order to narrow the divergence of views. Does this guarantee that the consensus is reached? Originally the purpose of conducting the Delphi survey was to seek consensus, because consensus of expert opinion was hypothesized to be more accurate than an individual forecast by an expert. But Delphi is now seen as “no more or less than a systematic means of synthesizing the judgments of experts – the aggregate judgment representing a kind of composite expert composed, in the domain of interest, of the expertise of all participants” [29]. According to the Merriam-Webster’s online dictionary, the word “consensus” is defined as 1 a. general agreement, unanimity, b. the judgment arrived at by most of those concerned, or 2. group solidarity in sentiment and belief. In previous literature on Japanese Delphi surveys, the word “consensus” is used not only as “general agreement” and “judgment arrived at by most of those concerned” on future direction of technology development but also “group solidarity in sentiment and belief” so as to achieve the development of prioritized science and technology topics as a result of Delphi survey.

Second, as stated above, on what kind of information basis does the evaluation of Delphi studies in Japan in previous studies reach to such a positive picture? Practitioners’ analyses are mostly based on their own experiences, which are valuable but tend to be subjective or worse be biased towards being too positive to look good. Works by academics draw on the information gleaned through interviews with practitioners and users of the results of foresights including policymakers or industries. Third, previous studies on foresight gave us the impression of determinism, that is, the impression that the result of foresight more or less determines the allocation of funding, behavior of scientists and engineers, decisions made by government and firms, direction of science and technology development, and ultimately long-term prosperity of a society. But even if foresight provides valuable information and opportunities for networking, it is one of the information sources and one of networking opportunities. It is important to know the relative size of “behavioral additionality” [30] foresight bring about compared with other measures of informing science and technology policy.

Considering those, it is important to know how domain experts perceive the effect of the results of foresight activities on the direction of science and technology development in their domain. Previous literature focusing on Delphi in Japan does not provide an answer to this question fully.

Fig. 1 is a conceptual and simplified model on the impact of foresight on allocation of resources such as budget, S & T workforce and S & T accomplishment proposed by Eto [28]. The basic thinking is, as stated above, the foresight in Japan achieves consensus among domain experts, government policy makers, and industry on promising areas of R & D for a mid- to long-term. As a result of such consensus, the allocation of resources is concentrated in those promising areas, which facilitates the accomplishment of S & T goals that the results of foresight set as targets. So this figure represents the positive evaluation of Japanese foresight in previous studies as explained above.

Relevant to this study is that “consensus on important topics and accomplishment date”, “S & T resources” and “accomplishment of important topics” in the figure are consensus among domain experts, resources allocation towards domain experts, and accomplishment by domain experts. Therefore, domain experts who participated in foresights are in a good position to judge the degree to which the practice and results of foresight in Japan gave impact on the resource allocation, their research environment, and their accomplishment, as compared to other factors that may influence those. As stated above, practitioners of foresight is in a position to tend to have an incentive to tell outside observers that foresight provides valuable input to policymaking but participated domain experts do not have an incentive to say so to justify their participation. The model in this figure is not a model that this study intends to show or refute its validity, but a starting point to show to what degree the conceptual model in this figure is valid in describing the system for the production of S & T knowledge in Japan to domain expert’s mind.

[Insert Figure 1]

2 Methodology

2.1 Five foresights under study

Perceptions on the impact of foresight of scientists and engineers who participated in major foresight activities in Japan are measured. Activities include the 6th Delphi survey in 1995/1996, 7th Delphi survey in 1999/2000, 8th Delphi survey in 2003/2004, “Social Vision toward 2025” conducted by NISTEP in 2006/2007, and Science Council of Japan foresight in 2006/2007.

Table 1 compares these foresights. For example, in the 6th Delphi survey, one steering committee with 14 experts was set up, which decided on 14 technological areas (1.material/process, 2.electronics, 3.information technology, 4.life sciences, 5.space, 6.marine/earth sciences, 7.resources/energy, 8.environment, 9.agriculture, 10.production/machinery, 11.architecture/civil engineering, 12.communication technology, 13.transportation, and 14.health and medical sciences). For each technological area, a technology panel with about 5 to 10 members was set up and it decided on science and technological topics in each area, that are expected to be realized within 30 years. A questionnaire was prepared to determine the degree of importance of each topic, time frame for realization, Japan’s relative level on the topic compared to Europe, United States and Asia, necessary government measures for realization, and possible negative impact of topic, and so on. Panel members selected experts to whom the questionnaires could be sent [22]. The 6th Delphi survey covered 1,072 topics classified into 14 science and technology areas. The first questionnaire was sent to 4,868 experts in various science and technology fields, and 4,220 responses were received. The second questionnaire was sent to 4,196 experts, who had responded to the first questionnaire, and 3,586 responses were received [25; 31]. The basic format of the 7th and 8th Delphi surveys was the same as in the 6th survey, although technological areas or questions to be asked were updated and revised [32; 33].

Both Social Vision towards 2025 and Science Council of Japan foresight were prepared as input to the cabinet level deliberation on “Innovation 25” [34; 35; 36]. Those foresights did not conduct Delphi surveys and mainly was based on deliberation by panel members, although the former used the results of the recent Delphi surveys. Innovation 25 was a policy initiative initiated by then Prime Minister Abe and was intended as a long-term strategy initiative for the creation of innovation contributing to the growth with an eye on the year 2025. NISTEP and the Science Council of Japan prepared foresights separately. The Science Council of Japan is a special organization under the jurisdiction of the Prime Minister and consists of 210 members, most of them academics.

[Insert Table 1]

Fig. 2 depicts the major development of science and technology policy and foresight exercises. In 1995, Science and Technology Basic Law was enacted in Japan, and every five years, Science and Technology Basic Plan was prepared based on the law. The First Science and Technology Basic Plan was decided in July 1996. Reasoning based on sequences of events, because the second round of 6th Delphi survey was conducted in December 1996 [31], it was not possible for the 6th Delphi survey to have an impact on the 1st Basic Plan as this was formulated in July 1996. Likewise, as the second round of the 7th Delphi survey was conducted in December 2000 [32], it was difficult for the 7th Delphi survey to have much impact on the 2nd Basic Plan that was decided on March 2001. However, it was enough time for the 8th Delphi survey to have impact, because its results were obtained in fiscal year 2004 [33], and the third Basic Plan was decided in March 2006. It was possible for both kinds of foresights for “Innovation 25” to have an impact on the decision on the content of “Innovation 25”, and was intended to do so. According to NISTEP, there was a “moderate link between S & T policy and foresight” during the 1990s, and a “link between S & T policy and foresight” during the 2000s [37]. In 2001, the Council for Science and Technology Policy was established within the Cabinet Office in order to make the decision-making process more top-down and strengthen prioritization in government R & D funding [21].

[Insert Figure 2]

2.2 Interview

Interviews were conducted with key members of panel committees on Delphi surveys and innovation 25-related foresights. The selection of interviewees was not random. Interviewees were chosen by consulting with the person at the Institute for Future Technology who was responsible for the operation of the 6th, 7th, 8th and Social Vision 2025. The participants in the panel committees of the surveys who were involved in the deliberation process in terms of attendance and contributed to the discussion were selected. The requests for interviews were sent basically by e-mails. Interviews were conducted in July and August 2008 and the length of an interview is about 1 hour.

For each of the five foresights, the author of this article had interviews with two to three members (one for Science Council foresight). In addition, the results of interviews are used to complement and interpret findings from the survey of this study. In interviews, the following questions are asked:

- What was your role in foresight?
- Do you think that the result of foresight is utilized by policymakers or firms?
- Do you know any examples of impact of foresight on policy making?
- Do you think that the current level of impact of foresight is adequate?
- What do you think is necessary to increase the size of impact?

The design of the questionnaire of the survey for domain experts who participated in foresights was based on the qualitative information collected from interviews, which is explained next.

2.3 Survey

Panel members, survey respondents, and participants in workshops for the five foresights listed in Table 1 were asked about their perceptions on the impact of those foresight studies on policy making. Internet-based survey was conducted. E-mail addresses were collected by searching the web by participants' name and organization. I sent e-mails to participants, and they entered data online. The following is the list of questions:

- Q1. Type of organization at the time of foresight (private firm, university, government research institute, nonprofit organization, other)
- Q2. Age at the time of foresight (less than 40, 40 to 49, 50 to 59, more than 60)
- Q3. How involved in the foresight (member of steering committee, member of panel committee, respondent to Delphi survey)
- Q4. (For a member of panel committee) Area of panel committee (IT, life sciences, energy, …)
- Q5. (For respondents to Delphi survey) Science and technology area(s) (IT, life sciences, energy, …)[2]
- Q6. Perception on level of impact of the foresight to the following organization (Choose from 1 (weak) to 5 (strong)) (central government, regional government, public research institute, private firms, foreign government, individual researchers)
- Q7. Perception on level of impact of the foresight with regard to the following type of impact (effective background study for policy making, contribution to making of mid- to long-term policies, contribution to making of an annual policy, contribution to the decision on prioritization of R & D, contribution to the making of a new R & D program)
- Q8. Perception on the level of impact of the foresight with regard to the following policy areas (training of R & D personnel, strengthening relationship among

[2] For participants in the 6th Delphi survey, the following categories were used: 1.-6. (same as Q4), 7.Resources/energy, 8.Environment, 9.Agriculture, 10.Production/machinery, 11.City/architecture/civil engineering, 12.Communications, 13.Transportation, and 14.Health/medical/social welfare. Those are the names of S & T areas used for Delphi questionnaires. Those are divided into the 8 categories in the same way as in Q4 except for the following: 7.Resources/energy: Energy, and 8.Environment: Environment.

The following categories were used for the participants in the 7th Delphi: 1.-5. (same as Q4), 6.Maritime/earth, 7.Space, 8.Resources/energy, 9.Environment, 10.Materials/processes, 11.Manufacturing, 12.Distributions, 13.Business Administration, 14.City/architecture/civil engineering, 15.Transportation, and 16.Service. Those are matched as follows: 6.Maritime/earth: Frontier, 7.Space: Frontier, 8.Resources/energy: Energy, 9.Environment: Environment, 13.Business Administration: Manufacturing, 16.Service: Manufacturing. The rest is the same as Q4 for the 7th Delphi participants.

For the participants in the 8th Delphi, the Social Vision 2025 and the Science Council foresight study, Q5 used the same categories as Q4.

industry/universities/government, constructing R & D infrastructure, R & D investment, make better environment for private firms, deregulation, introduction of new regulation)

Q9. Perception on overall impact of the foresight

Q10. Whether the current level of impact of the foresight is adequate

Q11. (If you think that the current level of impact is inadequate) Reason why it was not possible to achieve the appropriate level of impact (timing of the foresight, problem in method, not enough efforts at the government to give impact, government not interested, private firms not interested, the general public not interested, others) (choose one plus open question)

Q12. Degree of following the situation in general to see if there has been any impacts of the foresight on government policies or other areas (not at all, not very often, neither, moderately often, and often)

Q13. How to increase the impact of foresights (open question)

Q14. Whether interested in receiving the report of this study on impact of foresight in Japan

For Q4, the list of panel committees shown in Table 2 is used for each of the foresights. Each panel committee is matched with one of the following 8 science and technology categories for analysis purpose: 1. ICT, 2. life sciences, 3. nano/material, 4. environment, 5. manufacturing, 6. infrastructure, 7. frontier technology, and 8. energy.

[Insert Table 2]

If participants did not respond after three weeks, a reminder was sent by e-mail. The survey results are summarized first followed by statistical analysis of the data.

3 Result

3.1 Interview results

Overall, the majority of observations by members of the foresights are that the impact of those studies is not very high, and is different from the picture that a consensus on long-term R & D target is made, results of foresights influence the resource allocation, and foresight guarantee the nurturing of the S & T strengths. Most think that government has problems in utilizing the results for policy making. Some think that there is a limitation in Delphi methodology, which does not produce concrete proposals or measures for policy making, although they provide general direction. As to the two foresights related to “Innovation 25”, all interviewees think that the results were used by the report of “Innovation 25.” Other comments are as follows:

- Results of Delphi may be useful for understanding the big picture. But it would be a rare case where Delphi results were converted into a specific policy initiative. [member of the 6th Delphi]
- The purpose of conducting Delphi survey is not clear. The survey starts without thinking much about how to use the results. [member of the 6th Delphi]
- The quality of the Delphi study is good, but the problem is how to present the results to government or the public. [member of the 6th Delphi survey]
- Japanese policy does not change by the results of Delphi survey. There is a system to authorize various reports like Delphi, but no system to utilize them for policy making. [member of the 7th Delphi]
- Delphi survey should be conducted by or in close cooperation with organizations that make a strategy. In the current system the results are not utilized very well. [member of the 7th Delphi]
- The results of Delphi were not used by government and realized as policy. In Japan, studies like Delphi is just shelved and not utilized very much. I am very discouraged after participating in the Delphi study. [participants of the 7th Delphi survey]
- In the Delphi survey the emphasis is on when topics will be realized and not on what the process of realization of topics would be like. It is not clear in Delphi how the technology is converted into social benefits. Without such information, it would be difficult to use the results for policy making. [member of the 8th Delphi]
- Delphi results suggest only the general direction of future science and technology. The general information does not contribute much to policy choices, which is usually made drawing on very specific and quantitative information. [member of the 8th Delphi]
- In the field I participated, there was no impact of Delphi on the 3rd Science and Technology Basic Plan. [member of the 8th Delphi]
- The impact of the 8th Delphi on the 3rd basic plan is not large. There are many studies by government ministries, such as the Ministry of Education, the Ministry of Economy, Trade and Industry, or the Ministry of Agriculture. Those studies are much more detailed than Delphi and tailored to policy questions more specifically. Delphi is a dictionary-like document, and does not lead to policy directly [member of the 8th Delphi].
- In foresight on “Social Visions towards 2025,” we had a very clear goal to have impact on “Innovation 25.” [member of Social Visions towards 2025 foresight]
- I do not think that results of the Delphi survey, which is based on mail-based survey, is not very trustworthy. I think that study by experts on a narrower area, for example, by using technology roadmapping method, is more trustworthy. [member of Social Visions towards 2025 foresight]
- The results of foresight by the Science Council of Japan were used for “Innovation 25” [member of Science Council of Japan foresight].

Although those comments are interesting, they are more or less subjective observations collected from a limited number of interviews I conducted. So in order to examine the average and distribution of subjective observations among domain experts who participated in the foresights, I conducted a survey and explain the result in the next section.

3.2 Survey results

Table 3 shows the response rate of the survey, which is calculated as the ratio of responses to the number of e-mail addresses working to which a questionnaire was sent.

[Insert Table 3]

3.2.1 Description of survey results

3.2.1.1. Characteristics of respondents (Q1 and Q2)

Table 4 shows that 60%, 61% and 43% of respondents to this survey who participated in the 6th, 7th and 8th Delphi surveys respectively belonged to universities, and 19%, 28%, and 31% of respondents respectively belonged to private firms at the time of the Delphi survey. Table 5 shows that 37%, 42% and 45% of respondents to 6th, 7th, and 8th Delphi surveys respectively belonged to universities, and 36%, 31% and 27% of respondents belonged to private firms at the time of the Delphi survey. The proportion of researchers at universities is higher for the foresight by the Science Council of Japan, which is an organization mainly for university professors. Regarding age distribution at the time of the foresights, less than 20% of the respondents to this survey were less than 40 years old and about 10% of respondents were more than 60 years old. Respondents for the Science Council of Japan foresight were older than those of Delphi surveys.

A comparison of Table 4 and Table 5 shows respondents belonging to universities are larger in this survey than in Delphi surveys. This is because e-mail addresses of university professors are easier to locate on the web than those of employees at private firms and government research institutes. As to age structure, respondents in the 40-49 age bracket is larger compared to 50-59 age bracket, especially for participants in the 6th Delphi survey. This is because part of the participants over 50 years old at the time of the survey (1996) are now retired and their e-mail addresses could not be obtained.

[Insert Table 4 and Table 5]

3.2.1.2. Impact (organization, policy tools, and policy areas) (Q6 –Q8)

In Table 6, Table 7 and Table 8, respondents' perceptions on the size of impact of the foresights on various aspects of policy making are shown. The score in the figures are calculated using the formula:

Score = {(No. of Weak) x 1+(No. of Moderately weak)x 2+(No. of Neither weak nor strong)x3+(No. of Moderately strong)x4+(No. of Strong)x5}/ (No. of Respondents)

Therefore, a score less than 3 signifies that the extent of impact is weak, and a score greater than 3 signifies the extent of impact is strong. Table 6 shows the extent of impact with regard to the type of organizations affected; the majority of the scores for all of the choices are less than 3 and the extent of impact is perceived to be weak. Among those choices, the score for the impacts toward central government and public research institutes are relatively higher, but still less than 3 or slightly above 3. What is interesting is that the score for individual researcher is about the same as central government and public research institutes. Table 7 shows the perceived extent of impact with regard to policy tools; the score for all categories is less than 3 or slightly above 3, but among those, scores for "cooperation among firms, universities and government" and "R & D funding" are relatively higher. In Table 8, the scores for "contribution to decision on R & D priorities" and "contributions to mid- to long-term policymaking" are higher than for other categories and are more than 3.

In those tables, the scores for Social Vision toward 2025 foresight are higher for most of the categories than those for the Delphi surveys, and the scores for the Science Council of Japan foresight are lower for most categories than those for the Delphi surveys.

[Insert Table 6, Table 7 and Table 8]

3.2.1.3. Overall perception on level of impact and its causes (Q9-Q11)

Overall extent of impact is perceived to be not very strong (Table 9). For example, more than 40% of participants in the 6th Delphi survey think that the level is moderately weak or weak, and 45% think it is "neither strong nor weak." Eleven percent perceives the level to be moderately strong or strong. In addition, the level of impact is perceived to be insufficient by almost 80% of respondents (Table 10). Table 11 shows that respondents think that the low level of impact of foresights in Japan is caused by low level of efforts by the government to make an impact on policy and the low level of interest of the general public in the results of the foresights. About 50-60% of respondents chose those as the causes. Although the proportion of respondents who think that the cause is the methodology used for the foresights is less than 5%, up to 30% of respondents perceive that the results of foresight are not clear.

Fig. 3 compares the distribution of the size of overall impact in five foresights in the survey. The score (average of impact) gradually increases in Delphi surveys, and the score of "Social Vision towards 2025" is higher than Delphi surveys. However, these differences are statistically not significant as the 95% confidence intervals of the average are not small enough compared to the differences.

[Insert Table 9, Table 10, and Table 11]

[Insert Figure 3]

3.2.2 Statistical analysis

The effect of various factors on the size of perception of "impact" is analyzed by logistic regression analysis. Independent variables in the regression, that is, factors that affect the dependent variable (=impact), include the following:

- Type of foresight (6th, 7th, and 8th Delphi; Social vision toward 2025, and Science Council of Japan foresight)
- Occupation (university, firms, government, and nonprofit)
- Age (-39, 40-49, 50-59, and 60+)
- Manner of involvement in foresight (member of a panel committee or not)
- Science and technology areas (ICT, life sciences, nano/material, environment; manufacturing, social infrastructure, frontier (space or marine sciences), and energy), and
- Degree of following if there has been an impact of the foresight on government policies or other areas (not at all, not very often, neither, moderately often, and often).

The variables are chosen based on Fig.1, since 1) different foresights have different levels of impact, 2) different domain experts observe different levels of impact, and 3) different levels of involvement in foresight and different levels of interest in impact of foresight on policy affect the perception. In addition to the analysis on the effects of those factors on 1) the extent of perceived impact, an analysis is made of the effects of those factors on 2) the perception on whether the extent of impact is adequate or not. As there are five answer categories to evaluate "impact" in the survey (weak, moderately weak, neither weak nor strong, moderately strong, and strong), "logistic regression with ordered category (ordered logistic regression)" [38] (pp.911-912), [39] (pp.241-244) is used for the first analysis. As the variable on whether the extent of impact is adequate or not is dichotomous (yes or no), logistic regression analysis is used for the second analysis instead of ordered logistic regression.

The characteristics of independent variables used in this analysis are examined (Table 12). All independent variables for this analysis except for the 6th variable above are dichotomous (0 or 1). Table 12 shows the number of each dichotomous variable that takes the value 0 or 1 in each of the five foresights and in total (pooled data). For example, the number of the variable "university," which shows occupation of respondents, equal to 1 (yes) is 310 out of 561 respondents in total, and 67 out of 111 respondents from the 6th Delphi survey. As to the kinds of foresights, the majority of respondents are participants in the three Delphi surveys, and respondents of participants in the "Social Vision toward 2025" and Science Council of Japan foresight are relatively small. As to science and technology areas, all eight areas are represented in the respondents, although there are no respondents in some of the areas in "Social Vision toward 2025" foresight as the result of small number of committees (six) in this foresight (see Table 2). The eight science and technology areas are areas used in the second and third Science and Technology Basic Plans. Information and communication technology (ICT), life sciences, nano/material, and environment are designated as "primary prioritized areas" and manufacturing, infrastructure, frontier technology, and energy are designated as "secondary prioritized areas" [40]. As there are more than eight science and technology areas used in Delphi surveys, areas in Delphi surveys are matched with those eight science and technology areas.

Table 13 shows the distributions of two above-mentioned dependent variables, which will be discussed in the regression analysis.

[Insert Table 12 and Table 13]

Table 14 shows the result of statistical analysis on the effect of various factors (foresight, organization, age, member status, science and technology area, and the degree of following the situation) on a) the perception on impact, and b) perception on whether the level of impact is adequate. Pooled data including the data on respondents who participated in the 6th Delphi survey, 7th Delphi survey, 8th Delphi survey, Social vision towards 2025, and Science Council of Japan foresight was used for the analysis.

3.2.2.1 Impact

Ordered logistic regression is used for this dependent variable. Ordered logistic regression estimates a score, S, as a linear function of independent variables. For example, when a respondent participated in the 8th Delphi (base group in foresight category) and he was a university professor (base group in occupation category) in his forties and not a panel member, and follow if there has been any impacts neither often nor not at all, and his academic background is nano/material area, the score is calculated as:

$$S = 0+0-0.52+1.01+1.88 \times 0.5=2.46$$

Because this is between cut point 2 and cut point 3, it is most likely that the respondent's perceived impact is "neither weak nor strong." When the score moves higher, it becomes more likely that respondent's selection moves to a stronger level of impact. Significant variables are firms (+ (meaning sign is positive compared with a base group, or university in this category)), non-profit (+), age less than 40 (-), age 40-49 (-), life science (+), nano/material (+), and degree of following (+), which shows the following:

- Survey respondents at private firms or at nonprofit organizations perceived a larger impact of foresight they participated than respondents at universities (base group), controlling for other factors.
- Survey respondents in their twenties, thirties, and forties perceived a lower level of impact than respondents in their fifties (base group). In other words, younger respondents saw less impact, controlling for other factors.
- Survey respondents in life science or nano/material perceived a larger level of impact than respondents in other science and technology areas, controlling for other factors. It is understandable that participants in primary prioritized science and technology areas in the Science and Technology Basic Plan perceived more impact than in other areas. In the second basic Plan, science and technology fields are prioritized, and in the third Basic Plan, topics within science and technology fields are prioritized in more detail.
- Survey respondents who follow more if there have been impacts perceived more level of impact.

However, the effects of those factors are not very strong because the sizes of coefficients are smaller than the size of score between the cut points. In other words, it is difficult to accumulate a score to go beyond the cut points 3 and 4.

3.2.2.2. Is impact adequate?

As the answer is dichotomous (yes or no) in the question, logistic regression is used. If the coefficient is positive, it means that the increase of the independent variable increases the odds of choosing the answer "yes" over "no." Full model does not fit the data. Instead, only age-related variables and member variable are used. Likelihood chi squared is 9.65, and is statistically significant with 95% confidence. Significant variables are age 40-49 (+), and member (-), which shows the following:

- Survey respondents who are a member of the foresights are more likely to perceive that the current level of impact is inadequate than non-member, controlling for other factors. It is understandable that members of foresights who are more committed to foresight expect more impact from it and set a higher standard for adequateness of impact.

[Insert Table 14]

3.2.3 Perception and reality

There may be critical argument that the domain experts' responses to the survey are based just on their perception, which may not fully reflect upon the reality on the foresights' past impact on policy making. After all, domain experts are experts on their S & T domains, and not experts on policymaking, although they are in an R & D environment directly or indirectly influenced by policy decisions on resource allocation. Perception is defined as the "process by which people select, organize, interpret, retrieve, and respond to information from the world around them" [41]. Or, perception is defined as the "process of organizing and interpreting sensations into meaningful experiences" and "the result of psychological processes in which meaning, context, judgment, past experiences, and memories are invoked" [42]. So expert's past experiences or memories affect more or less which information they select or respond, or how to interpret them, and if such effects are too strong to cloud the real picture, his judgment or perception of the reality is called biased or prejudiced. Perception is a "dynamic conflict between the attempts of an outer world to impose an actuality on us and our efforts to transform this actuality into a self-centered perspective [43]."

In order to look at the degree of "perceptionness" of the responses to this survey, that is, the degree of effects of an "outer world" on the process of cognition, two factors, that is, the degree to which the respondent follow if there has been any impacts and whether the respondent is a panel member or not, are examined. It is expected that "attempts of an outer world to impose an actuality" is stronger if a respondent follows the situation around them more often, and is a panel member. So there should be a trend in the responses related to those two factors.

The results of statistical analysis shown in Table 14 show the following. First, the effect of "panel member or not (variable name: "member") on their perception on overall impact is not statistically significant, but the effect of "member" on the degree that they feel the effect is adequate is statistically significant and negative. That is, being a panel member does not affect their perception on the size of overall impact of foresight on policymaking but respondents who was a panel member tend to perceive that such size of impact is not adequate enough. Second, the effect of how often they follow if there have been impacts (variable name: "follow") on their perception on the size of impact is statistically significant and positive. That is, more often they follow, larger their perception on the size becomes.

Next, the data is examined in terms of the two variables, "member" and "follow" in more detail. Table 15 shows the mean and 95% confidence interval of the mean for each category of responses in terms of question on 1) panel member or not, and 2) how often you follow the news related to impact. In general, when comparing answer categories to the question on "follow," the mean for the panel members is higher than mean for the non-members, and mean for respondents who follow the situation more often tends to be higher. For example, when comparing the mean for the respondents who are panel members and who follow the situation "very often" and the mean for respondents who are not panel members and who do "not at all" follow the situation, the former is higher and the difference is statistically significant. In addition, the mean for the respondents who are not panel members and "do not all" follow the situation is lower than the mean for the respondents who are not panel members and who do follow the situation "not very often" "neither" or "often" and the differences are statistically significant. However, for other pairs, the difference is not statistically significant. In other words, 95% confidence intervals of the mean tend to be overlapping because Ns for some categories are not very high.

[Insert Table 15]

From those data, the influence of "attempts of an outer world to impose an actuality on us" is seen to a certain degree and a certain degree of "perceptionness" is seen in the responses. In other words, more information from outside on the impact of foresight on policymaking, that is, being a panel member or following more often, affects their perception on the size so as to make it larger. So the size of impact of foresight on policymaking in the responses to this survey is biased downwards to a degree when comparing it with "reality."

What is the size of the degree of bias downwards? The mean response from the respondents who are panel members and who follow the situation "very often" is 3.14, in other words, near to the category "the size of impact is neither strong nor weak." On the other hand, the mean response from the respondents who are not panel members and who do not at all follow the situation is 2.07, in other words, near to the category "the size is moderately weak." So even if there is a certain degree of bias, and assuming that respondents in the former category is more bias-free and the respondents in the latter category is more biased, getting rid of all the bias is not enough for moving the perceived size of impact higher up to the level of "strong" or "very strong."

Having said that, it is important to acknowledge that there is a case where perceived reality is more important than the reality itself. For example, when the role of disorder is examined for knowing the process of the social differentiation of urban areas and neighbourhood change, you find that perceived disorder plays a vital role, since "it is not a disorder but people's assessment of the seriousness of disorders that matters [44]." In the case of technology foresight, how is perception on the impact on policy-making more important than the reality or as important as the reality? There would be two possibilities. First, participation rate of scientists and engineers in foresight, or response rate to Delphi surveys and attendance of panel members would be enhanced if they perceive that their activities are important for policy-making. Second, quality of information provided by scientists and engineers who participated in foresight, or efforts and time allocated for contributing to the product of foresight would be enhanced if they perceive their activities are important for policy making. Although the corroboration of those points, or hypotheses, is beyond the scope of this study, and the relationship of various factors that could affect the participation rate or quality of participation is clearly very complex, after all, the "most important resource input (for foresight) is voluntary contribution of participants" [30], and motivation other than pecuniary one for them is important for increasing frequency and quality of their participation.

4 Conclusion and policy implications

4.1 Key findings

There are two main findings of this study. First, among the domain experts who participated in foresight in Japan, the level of perception on its impact on policy making is found to be not very high, based on the results of interviews and surveys conducted on the five foresights in Japan. In addition, the majority think that the current level of impact is inadequate. Although this finding seems to be different from previous literature about foresights in Japan, which tends to interpret the role of foresight more or less as critical information basis for S & T policy and technological development in Japan as shown in Figure 1, it is necessary to be cautious in interpreting the results as representing the "reality" on the impact of foresight on policy making in Japan because this is based on experts' perceptions or views on it. However, at least the results reflect the general situation on the role of foresight for policy making in Japan and the perception, which may not be fully mirror the reality, has the significance for itself for the conduct of foresight in terms of motivation of domain experts for participating in foresights.

Second, it is found that there are different patterns of perception on impact on policy making (including adequate or not) by ages, organizations, member status, and science and technology areas. Experts in prioritized science and technology areas naturally perceive more impact. Panel members expect more impact and are less satisfied. Experts working for private firms think that the impact is larger than university professors, but may have different (or lower) expectations from the result of foresight.

Generalizability of the finding across foresight in general is not proved in this study that analyzed only foresights conducted in Japan between 1996 and 2007. So the following is the speculative conjecture. Two general questions can be asked from the findings of this study.

1) Does the level of domain experts' perception on impact of foresight on policy tends to be lower than methods experts or users?

2) If so, does that come from the fact that domain experts have different perspectives on the impact of foresight on policy from methods experts or users?

Considering the finding from this study that domain experts' perceptions are not very high in spite of the fact that previous research shows the high impact of Japanese foresight on policy, it is probable that there is more or less gap between the perception between domain experts and, methods experts and users. As to the second question, one study that examined the impact of policy evaluation research on policy in the field of public health pointed out that "We found that evaluation research is used by decisionmakers but not in the clear-cut and organization-shaking ways that social scientists sometimes believe research should be used" and "The problem ... may well lie more in many social scientists' overly grand expectations about their own importance to policy decisions than in the intransigence of federal bureaucrats." Then the authors concluded that "what is typically characterized as underutilization or nonutilization of evaluation research can be attributed in substantial degree to a definition of utilization that is too narrow and fails to take into consideration the nature of actual decision-making processes in most programs"[45].

This may be a probable explanation that is also valid to the domain experts' perception on foresight. However, even if this explanation is valid for explaining the gap in perceptions, that does not lead to the conclusion that it is ok to leave domain experts to continue to have that negative perception after participating in foresight. Finally, going back to the Japanese foresight case, even if domain experts in Japan have "overly grand expectations," it is still unexpected that they have on average the perception that the impact of foresight in Japan on policy is not very high, considering the very positive picture on the various kinds of good effects of Japanese foresight depicted in the previous literature.

4.2 Limitation of the study

There are three sources of limitations of this study. First, response rates are not very high, which may lead to inaccuracy or bias of estimates. In addition, respondents may not be representative in this e-mail-based survey, especially for older foresight activities, although the similarity of the data on respondents and original participants of foresights was checked. Second, there is the limitation of memory of participants. Do participants remember what they did or heard more than 10 years ago? Although it is important to stimulate the memory of participants on foresights in a survey, it certainly decreases the response rate if too much is demanded, for example, by asking participants to read the foresight they contributed to produce. Third, the fact that this study analyzes "perception" of domain experts is the limitation of this study if one would like to measure the impact of foresight on policy making from the viewpoint closer to the policy making process and not through the more or less subjective eyes of domain experts. Perception of domain experts may not be the reality in all instances.

4.3 Policy implication

One implication of the study is that the impact is perceived differently among domain experts who participated in foresight. If it is necessary to discuss the impact of foresight during the evaluation stage of foresight activities, it is better to collect observations and views of domain experts in various organizations, science and technology areas, member status, or age groups.

Another policy implication is that more feed-back information to domain experts on how the results will be used and were used would be necessary, to maintain their motivation in participation. Scientists and engineers are interested in knowing how they could make a difference in policy making by providing their expertise. Provision for more feed-back information would improve the involvement of participants and increase the quality of foresight.

Acknowledgement: This study was partly funded by the Watanabe Memorial Foundation for the Advancement of Technology. The author appreciates the helpful comments of two reviewers, and financial support from the European Commission for presenting a part of this study at a conference at the Institute for Prospective Technological Studies.

References

1. **Technology Futures Analysis Methods Working Group.** Technology futures analysis: Toward integration of the field and new methods. Technology Forecasting and Social Change. 71, pp.287-303. 2004.

2. **Martin, B.R.** Foresight in science and technology. Technology Analysis and Strategic Management 7, 139‐168. 1995.

3. **Woudenberg, Fred.** An evaluation of Delphi. Technological Forecasting and Social Change 40, pp. 131‐150. 1991.

4. **Rowe, Gene; Wright, George; Bolger, and Fergus.** The Delphi technique as a forecasting tool: issues and analysis. International Journal of Forecasting. Vol.15, Issue 4, pp. 353-375. 1999.

5. **Cuhls, Kerstin.** Futur ‐ foresight for priority-setting in Germany. International Journal of Foresight and Innovation Policy. Vol. 1, No.3/4. Pp.183‐194. 2004.

6. **Cuhls, Kerstin, and Luke Georghiou.** Evaluating a participative foresight process: ‘Futur - the German research dialogue.’ Research Evaluation. Vol. 13, No.3, 1 December 2004. Pp.143-153. 2004.

7. **Martin, Ben R. and Ron Johnston.** Technology Foresight for Wiring Up the National Innovation System ‐ Experiences in Britain, Australia, and New Zealand. Technological Forecasting and Social Change, Volume 60, Number 1, January 1999, pp. 37-54. 1999.

8. **Rask, Mikko.** Foresight ‐ balancing between increasing variety and productive convergence. Technological Forecasting and Social Change. 75 (2008) 1157-1175. 2008.

9. **Blind, Knut, Kerstin Cuhls and Harolf Grupp.** Current Foresight Activities in Central Europe. Technological Forecasting and Social Change. 60, Pp.15-35. 1999.

10. **Shin, Taeyoung.** Using Delphi for a Long-Range Technology Forecasting, and Assessing Directions of Future R & D Activities: The Korean Exercise. Technology Forecasting and Social Change. 58. Pp.125-154. 1998.

11. **Grupp, Hariolf, and Harold A. Linstone.** National Technology Foresight Activities Around the Globe: Resurrection and New Paradigms. Technological Foresight and Social Change. 60. Pp.85-94. 1999.

12. **Héraud, Jean-Alain, and Kerstin Cuhls.** Current Foresight Activities in France, Spain, and Italy. Technological Forecasting and Social Change. 60. Pp.55-70. 1999.

13. **Anderson, Joe.** Foresight analysis in research funding agencies: A UK experiment. Higher Education. 28: Pp.39-54. 1994.

14. **Irvine, J. and B.R. Martin.** Foresight in Science: Picking the Winners. London/Dover : Frances Pinter, 1984.

15. **Munier, Francis and Patrick Ronde.** The role of knowledge codification in the emergence of consensus under uncertainty: empirical analysis and policy implications, Research Policy, 330 (2001), 1537-1551. 2001.

16. **Kondo, Satoru.** R & D Senryaku Ritsuan No Tameno "Gijutsu Yosoku" Katsuyo Guidebook (Guidebook on technological forecasting for making R & D strategy) (in Japanese). Tokyo : Urban Produce, 1993.

17. **Keenan, Michael and Ian Miles.** Scoping and Planning Foresight in The Handbook of Technology Foresight edited by Luke Georghiou et al, pp.342-375. Cheltenham : Edward Elgar Publishing, 2008.

18. **Miles, Ian et al.** New Frontiers: Emerging Foresight. In The Handbook of Technology Foresight: Concepts and Practice. pp.400-417. Cheltenham : Edward Elgar Publishing, 2008.

19. −. The Many Faces of Foresight. in The Handbook of Technology Foresight: Concepts and Practice. Edited by Georghiou, Luke et al. Northampton: Edward Elgar Publishing. 2008.

20. **Hanney, Steve, Mary Henkel and Dagmar von Walden Laing.** Making and implementing foresight policy to engage the academic community: health and life scientists' involvement in, and response to, development of the UK's technology foresight programme. Research Policy 30 (2001) 1203‐1219. 2001.

21. **Kuwahara, Terutaka, Kerstin Cuhls and Luke Georghiou.** “Foresight in Japan” in The Handbook of Technology Foresight: Concepts and Practice, edited by Luke Georghio et al. Cheltenham : Edward Elgar Publishing, 2008.

22. **Kuwahara, Terutaka.** Technology Forecasting Activities in Japan. Technological Forecasting and Social Change, 60, 5-14. 1999.

23. **Kondo, Satoru.** Method and Application of Technological Forecasting: Centering around the Delphi Method [in Japanese], Japan Society for Science Policy and Research Management, Vol.7 Issue 1, 1992, pp.20-25. 1992.

24. **National Institute of Science and Technology Policy.** Outlook for Japanese and German Future Technology - Comparing Japanese and German Technology Forecast Surveys-. NISTEP report material No.33. March 1994. 1994.

25. −. The Results of the User Survey on "The 6th Technology Forecast Survey." NISTEP report material No.69. March 2000. 2000 .

26. **Vos, Cornelis M. and Cor L. Balfoort.** Strategic conferencing: A new approach in science policy, Research Policy, 18, pp. 51-57. 1989.

27. **Cuhls, Kerstin.** Technikvorausschau in Japan. Physica-Springer, Heidelberg. 1998.

28. **Eto, Hajime.** Obstacles to the acceptance of technology foresight for decision makers. International Journal of Foresight and Innovation Policy. Issue: Vol.1, No. 3-4. Pp. 232 – 242. 2004.

29. **Gordon, Theodore Jay.** The Delphi Method, Futures Research Methodology, AC/UNU Millennium Project. 1994.

30. **Georghiou, Luke and Michael Keenan.** Evaluation and Impact of Foresight. In The Handbook of Technology Foresight: Concepts and Practice. Edited by Georghiou, Luke et al. Edward Elgar Publishing. 2008. 2008.

31. **National Institute of Science and Technology Policy.** The Sixth Technology Forecast Survey- Future Technology in Japan Toward The Year 2025 -. NISTEP Report No. 52. June 1997. URL: www.nistep.go.jp/achiev/ftx/eng/rep052e/idx052e.html. 1997 .

32. −. The Seventh Technology Foresight: Future Technology in Japan toward the Year 2030. NISTEP Report No.71. July 2001. URL: www.nistep.go.jp/achiev/ftx/eng/rep071e/idx071e.html. 2001.

33. −. The Eighth Technology Foresight: Future Technology in Japan toward the Year 2035. NISTEP Report No.97. May 2005. URL: www.nistep.go.jp/achiev/ftx/jpn/rep097j/idx097j.html (in Japanese). 2005.

34. −. Social vision towards 2025: scenario discussion based on S & T foresight. NISTEP Report No.101. May 2007. URL: www.nistep.go.jp/achiev/ftx/jpn/rep101j/idx101j.html (in Japanese). 2007 .

35. **Science Council of Japan.** The Future Society Envisioned by the Science Community. Committee for the Investigation of Innovation Promotion. January 25, 2007. URL: www.scj.go.jp/ja/info/kohyo/pdf/kohyo-20-t32e.pdf. 2007.

36. **Government of Japan.** Long-term Strategic Guidelines “Innovation 25” (Unofficial Translation). June 1, 2007. URL: www.kantei.go.jp/foreign/innovation/innovation_final.pdf. 2007.

37. **Kuwahara, Terutaka.** A New Multi-Methodology Foresight for Prioritization in the Next National S&T Basic Plan; presented at KISTEP-WREN Workshop on “National Models for Public R&D Evaluation: In Search of Best Practices and Collaborative Opportunities” May 31, 2005,. 2005.

38. **Green, William H.** Econometric Analysis. Third Edition. New Jersey : Prentice Hall, 1997.

39. **Hamilton, Lawrence.** Statistics with STATA 5. Duxbury Publishing. 1998.

40. **Council for Science and Technology Policy.** Outline for the 3rd Science &Technology Basic Plan (FY2006-2010), Dec. 27, 2005. URL: www8.cao.go.jp/cstp/english/basic/3rd-BasicPlan_outline.pdf. 2005.

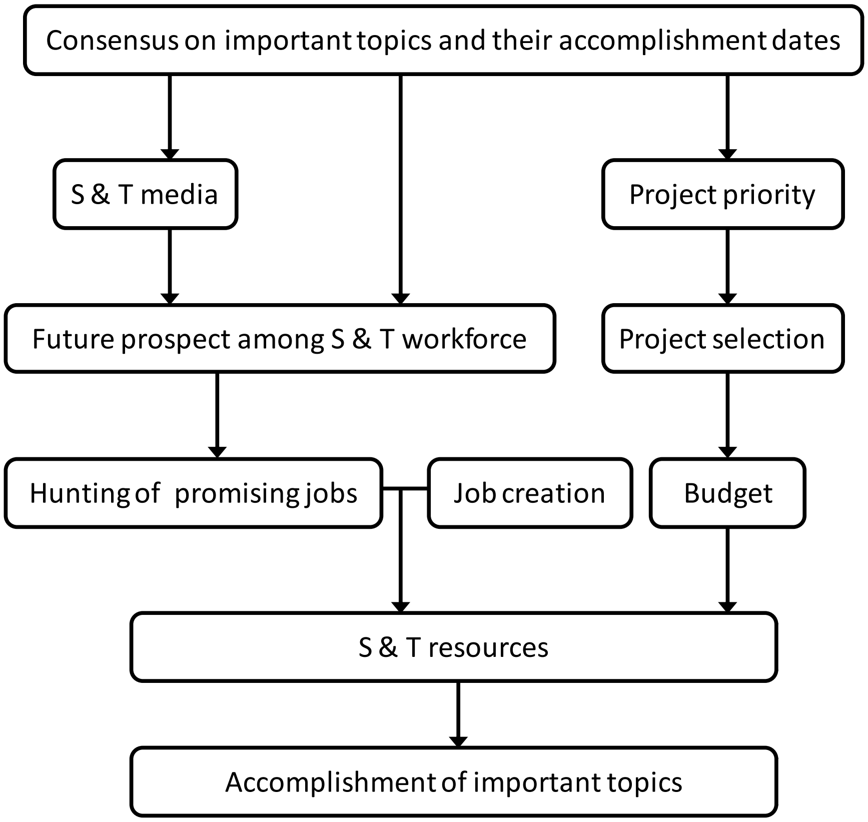
41. **Schermerhorn, John R., Jr.; James Hunt and Richard N. Osborn.** Organizational behavior, Eighth Edition. New York : John Wiley & Sons, 2003.

42. **Schiffmann, H. R.** Sensation and Perception: An Integrated Approach, 3rd edition. New York : Wiley, 1990.

43. **Rummel, R.J.** Understanding Conflict and War Volume 1: The Dynamic Psychological Field. Beverly Hills, CA : Sage, 1975.

44. **Wikström, Per-Olof H. .** “Questions of Perception and Reality.” British Journal of Sociology. 2009 Vol.60, Issue 1. 2009.

45. **Patton, Michael Q. et al.** "In Search of Impact: An Analysis of the Utilization of Federal Health Evaluation Research" in Using Social Research in Public Policy Making. pp.141-163. Lexington, Massachusetts : Lexington Books, 1977.



Source: Figure 2 (Effects of Delphi consensus on accomplishment) in Eto, Hajime (2004). “Obstacles to the acceptance of technology foresight for decision makers.” International Journal of Foresight and Innovation Policy. Issue: Vol.1, No. 3-4. Pp. 232 – 242 is revised.

Figure 1: Conceptual model on impact of technology foresight in Japan on science and technology accomplishment

Table 1: List of foresight analyzed in this study

	Survey period	No. of technical areas	No. of topics	Forecasted period	Members of panel groups	No. of responses
6th Delphi survey	1995-1996	14	1072	30 years to 2025	129 (1 steering committee, 13 panels)	3586
7th Delphi survey	1999-2000	16	1065	30 years to 2030	173 (1 steering committee, 17 panels)	3106
8th Delphi survey	2003-2004	13	858	30 years to 2035	190 (1 steering committee, 13 panels)	2239
Social vision towards 2025	2006-2007	6	-	20 years to 2025	93 (1 steering committee, 6 panels)	-
Science Council of Japan foresight	2006-2007	-	-	20 years to 2025	20 (1 committee)	-

Note: Numbers of responses to the 2nd round of the Delphi survey are shown.

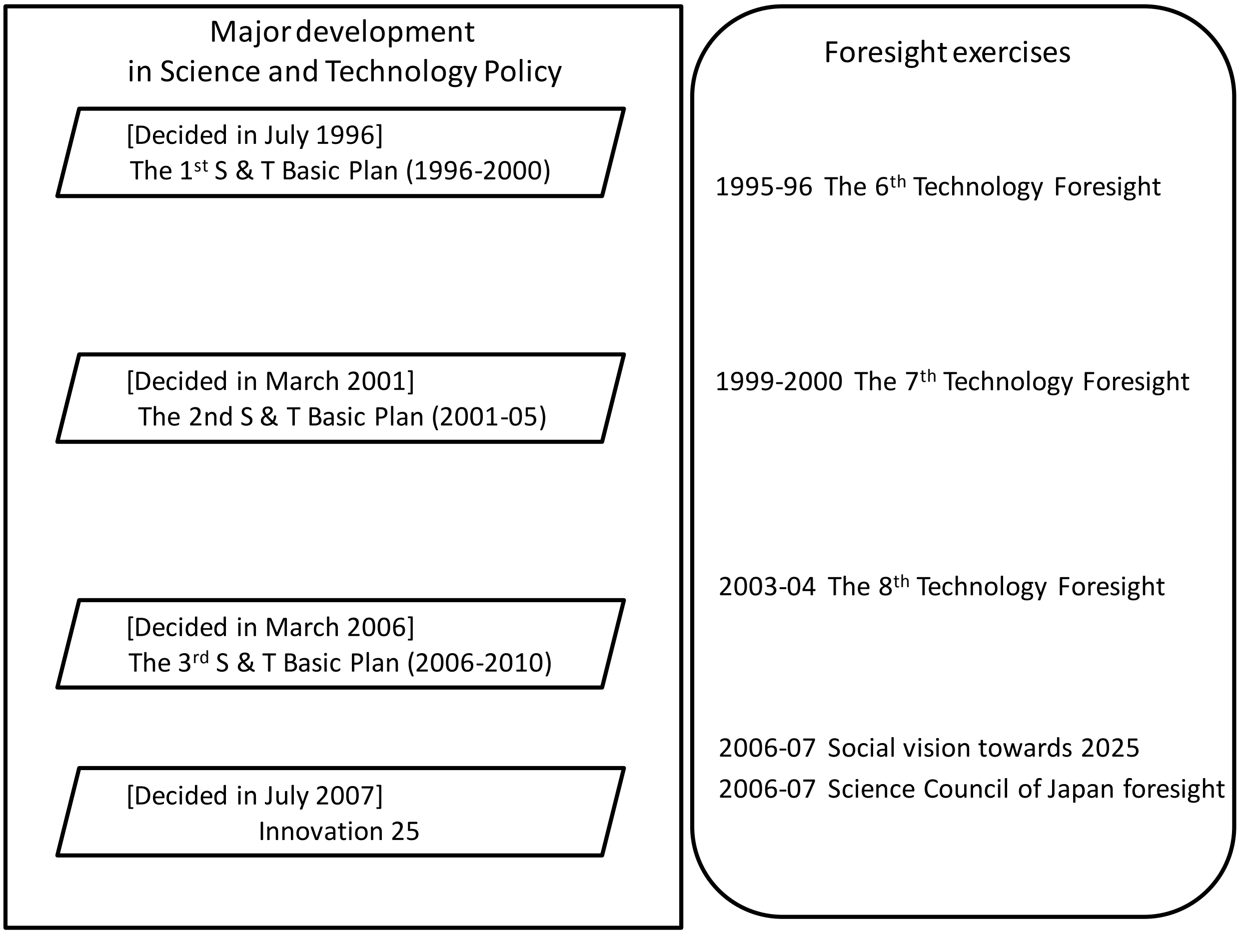


Figure 2: Foresight and major development of science and technology policy in Japan

Table 2: Panel committees set up in each foresight

	Panel committees		8 categories for analysis
6th Delphi survey	1. Materials/Process	→	3. Nano/Materials
	2. Electronics	→	1. ICT
	3. Information technology	→	1. ICT
	4. Life sciences	→	2. Life sciences
	5. Space technologies	→	7. Frontier technologies
	6. Marine/Earth	→	7. Frontier technologies
	7. Resources/Energy/Environment	→	8. Energy, 4. environment
	8. Agriculture	→	2. Life sciences
	9. Production/Machine	→	5. Manufacturing
	10. City/Architecture/Civil engineering	→	6. Infrastructure
	11. Communications	→	1. ICT
	12. Transportation	→	6. Infrastructure
	13. Health/Medical/Social welfare	→	2. Life sciences
7th Delphi survey	1. Information and communication	→	1. ICT
	2. Electronics	→	1. ICT
	3. Life sciences	→	2. Life sciences
	4. Health/Medical	→	2. Life sciences
	5. Agriculture/Food	→	2. Life sciences
	6. Marine/Earth/Space	→	7. Frontier technologies
	7. Resources/Energy/Environment	→	8. Energy, 4. environment
	8. Materials/Process	→	3. Nano/Materials
	9. Manufacturing	→	5. Manufacturing
	10. Distributions	→	5. Manufacturing
	11. Business administration	→	5. Manufacturing
	12. City/Architecture/Civil engineering	→	6. Infrastructure
	13. Transportation	→	6. Infrastructure
	14. Service	→	- (no response)
	15. New society/Economic system	→	- (no response)
	16. Declining birthrate/Aging society	→	- (1 response)
	17. Safety	→	- (no response)
8th Delphi survey	1. Information and communication	→	1. ICT
	2. Electronics	→	1. ICT
	3. Life sciences	→	2. Life sciences
	4. Health/Medical/Social welfare	→	2. Life sciences
	5. Agriculture/Food	→	2. Life sciences
	6. Frontier	→	7. Frontier technologies
	7. Energy/Resources	→	8. Energy
	8. Environment	→	4. Environment
	9. Nanotechnology/Materials	→	3. Nano/Materials
	10. Manufacturing	→	5. Manufacturing
	11. Industry infrastructure	→	5. Manufacturing
	12. Social infrastructure	→	6. Infrastructure
	13. Social technology	→	6. Infrastructure
Social Vision 2025	1. Health during entire life	→	2. Life sciences
	2. Information environment as infrastructure for daily-living	→	1. ICT
	3. Support for people by advancement of brain sciences	→	2. Life sciences, 1. ICT
	4. Safe and sustainable city	→	6. Infrastructure
	5. Satisfying life: selection of jobs, child rearing, diversification of senior life	→	- (2 responses)
	6. Resolution of global environment problems by living together with the world	→	4. Environment
Science Council	1. Information and communication	→	1. ICT
	2. Electronics	→	1. ICT

foresight	3. Life sciences	→	2. Life sciences
	4. Health/Medical/Social welfare	→	2. Life sciences
	5. Agriculture/Food	→	2. Life sciences
	6. Frontier	→	7. Frontier technologies
	7. Energy/Resources	→	8. Energy
	8. Environment	→	4. Environment
	9. Nanotechnology/Materials	→	3. Nano/Materials
	10. Manufacturing	→	5. Manufacturing
	11. Industry infrastructure	→	5. Manufacturing
	12. Social infrastructure	→	6. Infrastructure
	13. Social technology	→	6. Infrastructure
	14. Social science	→	- (3 responses)
	15. Humanities	→	- (2 responses)
	16. Others	→	- (no response)

Note: In the 7th Delphi survey, there were no responses in “14. Service,” “15. New society/economic system” and “17. Safety.” The 16th category (Declining birth rate/Aging society) was not matched with the 8 S & T categories, since this is a category for examining the needs for science and technology in general. The number of responses for each of those panels was shown in the parenthesis. For the same reason, the 5th category in the Social Vision 2025, and the 14th, 15th and 16th categories in Science Council foresight were not matched.

Table 3: Number of responses and response rate of the survey

	No. of participants (Delphi, etc.)	No. of e-mails sent	No. of e-mails working	No. of Responses	Response rate (%)
6th Delphi	3586	895	695	112	16
7th Delphi	3106	2723	1562	209	13
8th Delphi	2239	1022	693	197	28
Social vision towards 2025	228	228	225	43	19
Science Council of Japan foresight	294	119	101	16	16

Table 4: Characteristics of respondents to this survey (organization at the time of participation in foresight)

		6th Delphi (n=111) (%)	7th Delphi (n=203) (%)	8th Delphi (n=189) (%)	Social vision 2025 (n=42) (%)	Science council 2025 (n=16) (%)
Organization	University	60	61	43	52	88
	Private firm	19	28	31	19	6
	Government	13	4	18	10	6
	Not for profit	7	6	4	10	0
	Others	1	1	4	10	0
Age	-39	15	11	16	22	0
	40-49	49	40	34	24	25
	50-59	25	37	40	37	44
	60+	10	11	11	17	31

Note: For age, n=202 for the 7th Delphi, n=190 for the 8th Delphi, and n=41 for social vision 2025.

Source: Survey conducted by the author

Table 5: Characteristics of respondents to the Delphi survey (organization at the time of participation in foresight)

		6th Delphi (%)	7th Delphi (%)	8th Delphi (%)
Organization	University	37	42	45
	Private firm	36	31	27
	Government	15	14	19
	Not for profit	10	10	4
Age	-39	9	10	11
	40-49	36	31	33
	50-59	41	44	40
	60+	14	16	14

Source: National Institute of Science and Technology Policy [31; 32; 33]

Table 6: Foresight's Impact on organizations

	6th Delphi (n=111)	7th Delphi (n=200)	8th Delphi (n=188)	Social vision 2025 (n=41)	Science Council 2025 (n=16)
Central government	3.0	3.1	3.1	3.5	2.2
Local government	2.0	2.0	2.1	2.2	1.8
Public research institute	2.9	3.0	3.2	3.2	2.7
Private firms	2.7	2.7	2.5	2.7	2.3
Foreign government	2.2	1.9	1.9	2.0	2.0
Individual researchers	2.6	2.7	2.7	2.8	2.7

Source: Survey conducted by the author

Table 7: Impact on policy tools

	6th Delphi (n=111)	7th Delphi (n=200)	8th Delphi (n=188)	Social vision 2025 (n=41)	Science Council 2025 (n=16)
Education/training of research personnel	2.6	2.7	2.7	2.9	2.6
Cooperation among firms, universities, and government	2.9	2.9	3.0	3.1	2.9
R & D infrastructure	3.0	2.9	2.9	3.1	2.3
R & D funding	2.9	3.0	3.0	3.0	2.3
Environment for private firms	2.5	2.5	2.5	2.2	2.4
Deregulation	2.6	2.4	2.7	2.6	2.3
Introduction of new regulation	2.7	2.5	2.8	2.7	2.5

Source: Survey conducted by the author

Table 8: Foresight's impact (types of influences)

	6th Delphi (n=111)	7th Delphi (n=198)	8th Delphi (n=188)	Social vision 2025 (n=41)	Science Council 2025 (n=16)
Effective background research for policy making	3.0	3.0	3.0	3.4	2.7
Contribution to mid-to-long-term policymaking	2.9	3.1	3.2	3.1	2.7
Contribution to annual policymaking	2.5	2.6	2.6	2.9	2.1
Contribution to decision on research priorities	3.2	3.2	3.3	3.3	2.7
Contribution to new research program	3.0	3.1	3.0	3.3	2.9

Source: Survey conducted by the author

Table 9: Overall level of impact

	6th Delphi (n=109) (%)	7th Delphi (n=200) (%)	8th Delphi (n=188) (%)	Social vision 2025 (n=41) (%)	Science Council 2025 (n=15) (%)
Strong	1	0	1	0	7
Moderately strong	10	15	18	24	20
Neither weak nor strong	45	39	44	39	13
Moderately weak	21	36	26	27	40
Weak	22	10	11	10	20

Source: Survey conducted by the author

Table 10: Is overall level of impact adequate?

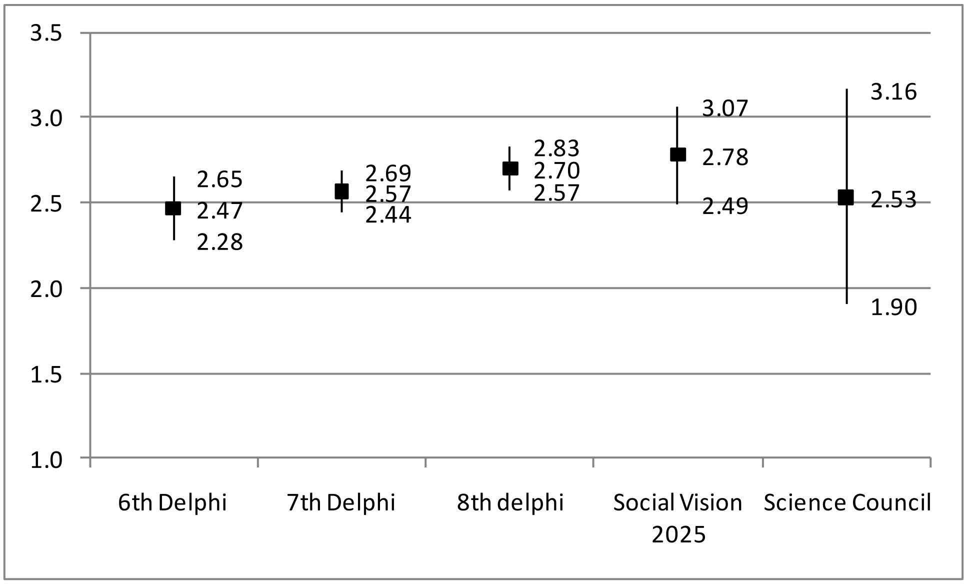
	6th Delphi (n=104) (%)	7th Delphi (n=200) (%)	8th Delphi (n=185) (%)	Social vision 2025 (n=41) (%)	Science Council 2025 (n=16) (%)
Adequate	19	19	23	17	7
Not adequate	81	81	77	83	93

Source: Survey conducted by the author

Table 11: Reasons for low level impact

	6th Delphi (n=98) (%)	7th Delphi (n=170) (%)	8th Delphi (n=156) (%)	Social vision 2025 (n=33) (%)	Science Council 2025 (n=14) (%)
Timing of study	0	2	1	3	0
Methodology of study	7	4	4	9	21
Unclear results of study	23	30	30	24	14
Not enough effort at government to increase impact	51	53	49	48	36
Government not interested in result of study	31	33	32	33	57
Firms not interested in result of study	28	41	31	33	21
The public not interested in result of study	57	59	61	61	29
Other reason	7	8	10	9	21

Source: Survey conducted by the author



Note: Marker shows the mean and line shows the 95% confidence interval of the mean, which is calculated as mean plus minus 1.96 x standard error of the mean.

Source: Survey conducted by the author

Figure 3: Comparison of the mean of perceived size of impact in 5 foresights (average and 95% confidence interval)

Table 12: Distribution of independent variables (dichotomous - 1: yes, 0: No)

Variable \ Foresight		Total (pooled data)		6th Delphi		7th Delphi		8th Delphi		Social vision 2025		Science Council of Japan	
		0	1	0	1	0	1	0	1	0	1	0	1
Foresight -related variables	Delphi 6	463	111	0	111	208	0	196	0	43	0	16	0
	Delphi 7	366	208	111	0	0	208	196	0	43	0	16	0
	Delphi 8	378	196	111	0	208	0	0	196	43	0	16	0
	Social vision	531	43	111	0	208	0	196	0	0	43	16	0
	Science Council	558	16	111	0	208	0	196	0	43	0	0	16
Occupation (organization)	University	251	310	44	67	78	125	107	82	20	22	2	14
	Firms	418	143	90	21	147	56	132	57	34	8	15	1
	Gov	500	61	97	14	195	8	155	34	38	4	15	1
	Not for profit	530	31	103	8	191	12	182	7	38	4	16	0
Age	-39	479	80	94	17	178	24	159	30	32	9	16	0
	40-49	347	212	57	54	121	81	126	63	31	10	12	4
	50-59	359	200	82	29	127	75	115	74	26	15	9	7
	60-	492	67	100	11	180	22	167	22	34	7	11	5
Member	Member	498	61	102	9	179	23	184	5	18	23	15	1
S & T areas	ICT	417	143	78	33	151	50	154	35	24	19	10	6
	Life sciences	399	161	85	26	156	45	125	64	23	20	10	6
	Nano/material	491	69	93	18	177	24	165	24	43	0	13	3
	Environment	437	123	87	24	156	45	147	42	35	8	12	4
	Manufacturing	499	61	106	5	169	32	168	21	43	0	13	3
	Infrastructure	468	92	97	14	167	34	156	33	35	8	13	3
	Frontier tech	489	71	86	25	173	28	174	15	43	0	13	3
	Energy	470	90	93	18	166	35	156	33	43	0	12	4
Follow the situation	Not at all	482	72	89	22	177	23	164	23	39	2	13	2
	Not very often	339	215	76	35	121	79	112	75	16	25	14	1
	Neither	401	153	76	35	141	59	142	45	32	9	10	5
	Moderately often	455	99	94	17	164	36	147	40	41	0	9	6
	Often	539	15	109	2	197	3	183	4	36	5	14	1

Note: The table shows the number of each dichotomous variable takes the value 0 (no) or 1 (yes) in each of the five foresights and in total (pooled data).

Table 13: Distribution of dependent variables

Variable	Foresight	Total (pooled data)	6th Delphi	7th Delphi	8th Delphi	Social vision 2025	Science Council Japan
Impact	Weak	74 (13.4%)	24	22	21	4	3
	Moderately weak	162 (29.3%)	23	72	50	11	6
	Neither	227 (41.1%)	50	77	82	16	2
	Moderately strong	87 (15.7%)	11	29	34	10	3
	Strong	3 (0.5%)	1	0	1	0	1
Impact adequate	Yes	111 (20.4%)	20	40	43	7	1
	No	433 (79.6%)	84	160	142	34	13

Note: The table shows the number of each dependent variable takes each of the answer categories in total (pooled data) and in each of the five foresights

Table 14: Effect of respondent's characteristics on perception on impact (pooled data)

Predictors	Impact	Impact adequate?
6th Delphi	-0.321	
7th Delphi	-0.266	
Social Vision towards 2025	0.175	
Science Council of Japan foresight	-0.896	
Firms	0.601***	
Government	-0.103	
Not for profit	0.761**	
Age -40	-0.520**	0.158
Age 40-49	-0.324*	0.528**
Age 60+	-0.212	0.402
Member	0.153	-0.901**
IT	0.085	
Life science	0.551***	
Nano/material	1.01***	
Environment	-0.066	
Manufacturing	0.138	
Frontier	0.068	
Infrastructure	0.341	
Energy	-0.106	
Follow the situation	1.88***	
Cut point 1 (weak⇒moderately weak)	-1.13	
Cut point 2（⇒neither weak nor strong）	0.564	
Cut point 3（⇒moderately strong）	2.690	
Cut point 4（⇒strong）	6.41	
Number of observation	552	544
likelihood ratio chi squared	77.39*** (dof=20)	9.65** (dof=4)
Hosmer-Lemeshow chi squared	-	0.17
Prob>Hosmer-Lemeshow chi squared	-	0.982

Note: Asterisks indicate significance at 10% (*), 5% (**), 1% (***). Results of "impact" show coefficients of logistic regression with ordered category which affect the response according to cut points. "follow" variables take the value 0 (not at all), 0.25 (not very often), 0.5 (neither), 0.75 (moderately often), or1 (often).

Table 15: perception on size of impact, divided by 1) panel member of not (row), and 2) how often to follow the situation looking for any impact (column)

		Not at all	Not very often	Neither	Often	Very often	Total
Panel member	N	2	27	14	9	7	59
	Mean	2.50	2.67	2.93	2.56	3.14	2.76
	95% confidence interval of mean	1.52-3.48	2.34-3.00	2.61-3.25	1.75-3.36	2.35-3.93	2.53-2.99
Non-panel member	N	69	188	139	89	8	493
	Mean	2.07	2.48	2.83	2.83	2.50	2.59
	95% confidence interval of mean	1.83-2.31	2.36-2.60	2.70-2.97	2.65-3.02	1.33-3.67	2.51-2.67

Note: The “mean” is calculated by taking average of “Weak” (=1), “Moderately weak” (=2), “Neither weak nor strong” (=3), “Moderately strong” (=4) and “Strong” (=5). 95% confidence interval of mean is calculated by mean plus minus 1.96 x standard error of the mean.

Source: Survey conducted by the author