Available online at www.sciencedirect.com
SCIENCE DIRECT®
Technological Forecasting & Social Change
71 (2004) 579–598
Technological Forecasting and Social Change

A challenge of integrating technology foresight and assessment in industrial strategy development and policymaking

Akio Kameoka[a,b,*], Yoshiko Yokoo[b], Terutaka Kuwahara[b]

[a]*Japan Advanced Institute of Science and Technology (JAIST), Tatsunokuchi, Ishikawa 923-1292, Japan*
[b]*National Institute of Science and Technology Policy (NISTEP), 1-3-2, Kasumigaseki, Chiyoda-ku, Tokyo 100-0013, Japan*

Received 14 August 2002; received in revised form 27 November 2002; accepted 2 December 2002

Abstract

Appropriate demand articulation of emerging technologies to social needs are vital to the economic and social productivity, and it is essential to grasp the future trends of social needs and technology advancement to promote the strategic technology policy. Japan embarked on technology foresight in the early 1970s and has since been conducting a regular Delphi survey approximately every 5 years. To explore a new intelligent methodology for integrating technological seeds and social needs by articulating future demands, this paper reviews the following two cases: the Delphi-scenario writing (DSW) method, which is applied in 1977 for the home/office small facsimile, and the method of general assessment applied in 1972 for *informationalization*, which focused on the rapidly advancing information society, with a matrix scoring and policy-simulation method. Those new approaches were proved to be a powerful methodology to integrate the technology forecasting and assessment for comprehensive understanding of the emerging technologies and their social impacts in the form of integrated technology road mapping, which supports the integrated strategic planning methodology for enhancing the future innovation system.

Keywords: Delphi-scenario writing method; General assessment method; Demand articulation; Informationalization

* Corresponding author. Japan Advanced Institute of Science and Technology (JAIST), Tatsunokuchi, Ishikawa 923-1292, Japan.
E-mail addresses: kameoka@jaist.ac.jp (A. Kameoka), yokoo@nistep.go.jp (Y. Yokoo), kuwahara@nistep.go.jp (T. Kuwahara).
URLs: http://www.jaist.ac.jp, http://www.nistep.go.jp.

0040-1625/$ – see front matter © 2002 Elsevier Inc. All rights reserved.
doi:10.1016/S0040-1625(02)00397-9

1. Introduction

Appropriate demand articulations[1] of emerging technologies to social needs are vital to economic and social productivity, which seeks the continuous improvement in the progress of humanity [1]. In December 1995, *The Science and Technology Basic Law of Japan* was enacted, and, in 2001, the *Second Science and Technology Basic Plan* was approved by the Cabinet, whereby the government adopted a clear political stance of setting priorities on science and technology under the new science and technology administrative structure composed of the Council for Science and Technology Policy (CSTP), Ministry of Education, Culture, Sports, Science and Technology (MEXT), and other ministries. For these organizations, it is essential to grasp the future trends of social needs and the technology to promote the strategic technology development and economic policy formulation.

2. Technology foresight in Japan

MEXT embarked on technology foresight in the early 1970s and has since been conducting a regular survey approximately every 5 years. Each survey aims at forecasting long-term trends in various fields of science and technology for the next 30 years by adopting the Delphi method throughout the survey [2–5]. The number of technological fields and topics have increased as shown in Table 1, covering all science and technology fields in the major surveys and experts.

2.1. Methodological approach

Prior to a survey, a steering committee is formed with subcommittees set up around it. The leader of each subcommittee is a member of the steering committee. The members of the steering committee and the subcommittees are appointed by National Institute of Science and Technology Policy (NISTEP), which implements the surveys after consultation with expert groups and the appropriate ministries/agencies. More than 100 experts are involved in the design of a survey and the analysis of the results. These experts hold responsible and influential positions in their institutes, universities, and companies. Furthermore, more than 3000 experts participate as respondents. The results are provided to the related ministries/agencies, and they are also widely used in industry. The major aspects are made open to many newspaper and magazines in response to the strong requirement.

2.2. The survey results

The seventh survey (latest), which started in 1999 and adopted a new approach of including social dimensions, reflected the social needs on technology development by experts

[1] This concept was first introduced by Fumio Kodama by saying "In developing new policies to meet this needs, the most important element is the process of 'demand articulation.' Through this process, the need for a specific technology manifests itself and the R&D efforts is targeted toward developing and perfecting it."

Table 1
The history of MEXT's technology foresight

Number	Survey year	Fields	Topics	Foresight period	Experts
1	1970–1971	5	644	1971–2000	2482
2	1976	7	656	1976–2005	1316
3	1981–1982	13	800	1981–2010	1727
4	1986	17	1071	1986–2015	2007
5	1991	16	1149	1991–2020	2385
6	1996	14	1072	1996–2025	3586
7	2000	16	1065	2001–2030	3106

in humanities and social sciences. The results were released in 2001. As shown in Fig. 1, the social needs approach panels predicted the social trends and presented those needs to the technology panels as a reference for determining the technology forecasting topics consisted of 1065 items covering 16 technological fields from information and communications, electronics, life science, to services as shown in Table 2. The 14 technology panels determined the survey topics, and the respondents were asked to evaluate the topics in terms of their importance, time of realization, leading countries or areas, etc.

Fig. 2 shows the survey results, which revealed the priority of Japanese, consisting of the following six technology fields: (1) information technology (information, communications, electronics, etc.), (2) life science (life science, medical care, food, etc.), (3) earth science and environment technology (environment, resource, energy, ocean, earth, space, etc.), (4) material technology (substance, material, process technology, etc.), (5) manufacturing and management technology (manufacturing, distribution, business, etc.), and (6) social infrastructure technology (city, traffic, social service, etc.).

As for important fields in the "coming 10 years," the three fields of "earth science and environment technology," "information technology," and "life science" were especially valued, and this inclination was similar to the expert groups. The important fields "after

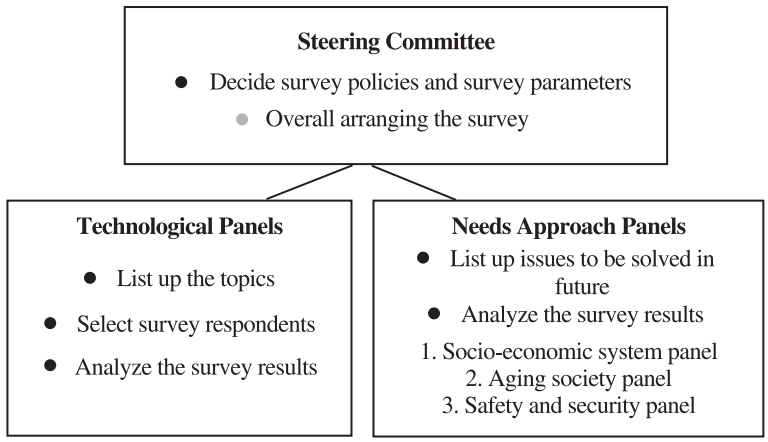

Fig. 1. Implementation structure–needs approach.

Table 2
Survey technology fields

Survey fields	*Examples of topics*
1. Information and communications (96 topics)	Widespread use of portable terminals
2. Electronics (69 topics)	capable of voice communication
3. Life science (88 topics)	from anywhere in the world
4. Health and medical care (94 topics)	Practical use of effective methods
5. Agriculture, forestry, fisheries, and food (79 topics)	against cancer metastasis
6. Marine science and earth science (65 topics)	
7. Space (40 topics)	*Questions to the topics*
8. Resources and energy (78 topics)	Degree of importance
9. Environment (40 topics)	Expected effect
10. Materials and processes (103 topics)	Forecasted realization time
11. Manufacturing (52 topics)	Current leading countries
12. Distribution (40 topics)	Effective measures that the
13. Business and management (38 topics)	government should adopt
14. Urbanization and construction (73 topics)	Potential problems
15. Transportation (60 topics)	
16. Services (50 topics)	
Total (1065 topics)	

2010" were the two fields of "earth science and environment technology" and "life science," with values higher than those in the "coming 10 years." The configuration of the importance/realization time, which takes the average of the importance and realization time of the topics classified by field, was calculated and plotted in Fig. 3. The upper right side of the figure indicates that the importance is higher but takes time to realize, and the bottom left side indicates that the importance is rather lower but can be realized within a short period.

2.3. The next eighth foresight program

The next eighth foresight program starting in 2003 intends to provide basic information for formulating the third basic plan. We need to further develop the foresight methodologies and analytical techniques in order to utilize them more effectively for establishing science and technology strategies. In order to explore an intelligent methodology for integrating technological seeds and social needs by articulating future demands with the rapidly advancing technologies, the following two practical cases were reviewed.

3. Case studies of integrating technology forecasting and assessment

3.1. Case 1: integrated strategy development using the Delphi-scenario writing method (DSW)

This case study reviews the DSW method, which consists of eight steps as shown in Fig. 4. This method was first applied in 1977 for the innovation strategy development

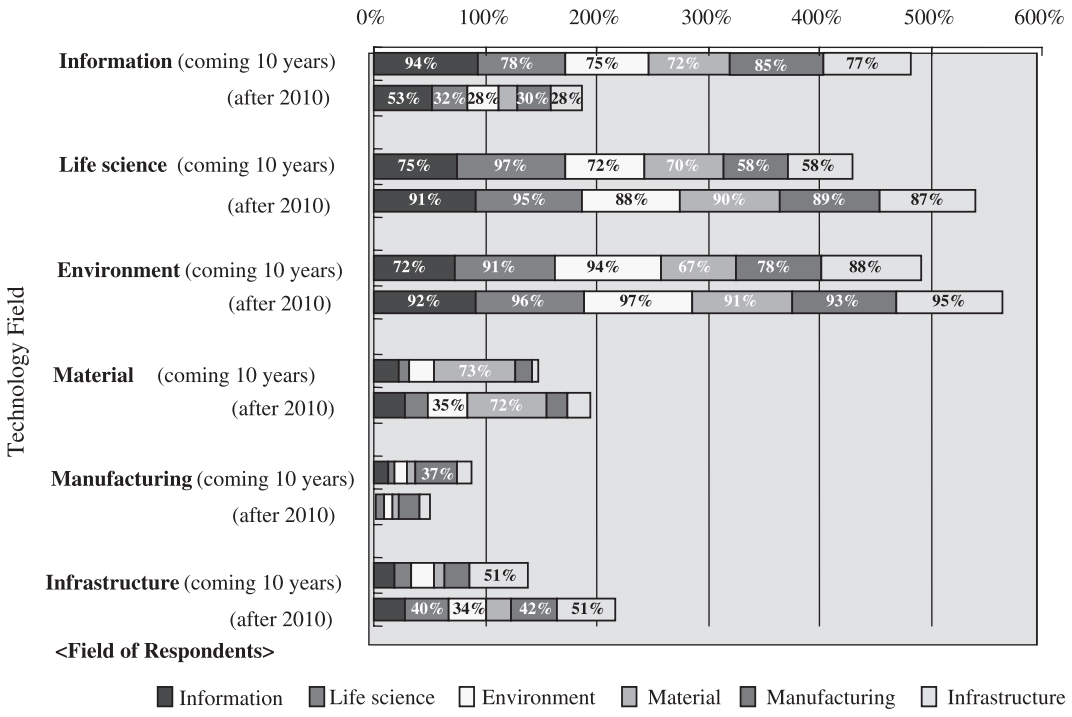

Fig. 2. Important fields (coming 10 years, after 2010).

of the home/office use small facsimile, which was one of the typical successful innovations that originated in Japan and then spread worldwide in the last decade. The actual process of the facsimile innovation was well described in the scenario. Consequently, it can be concluded that the DSW method provides a practical methodology for long-range strategy development and integrated technology road mapping [5–8].

3.1.1. Introduction

In the 1970s, Japan had a problem of how to promote office automation due to the use of many Chinese characters, which are very hard for most people to type and hinder their computerization. One of the solutions was found in the facsimile technology, which directly transfers handwritten documents through the telephone line. The author developed a strategy to promote the small home-use facsimile innovation by applying a new approach that would be called the "Delphi-scenario writing" (DSW) method. Presently, facsimile machines have been successfully introduced into most Japanese small offices and homes, while also being accepted worldwide. This paper follows the actual facsimile innovation process for the past 25 years and reviews the DSW method, which was first used in Toshiba in 1977 for developing the facsimile innovation strategy.

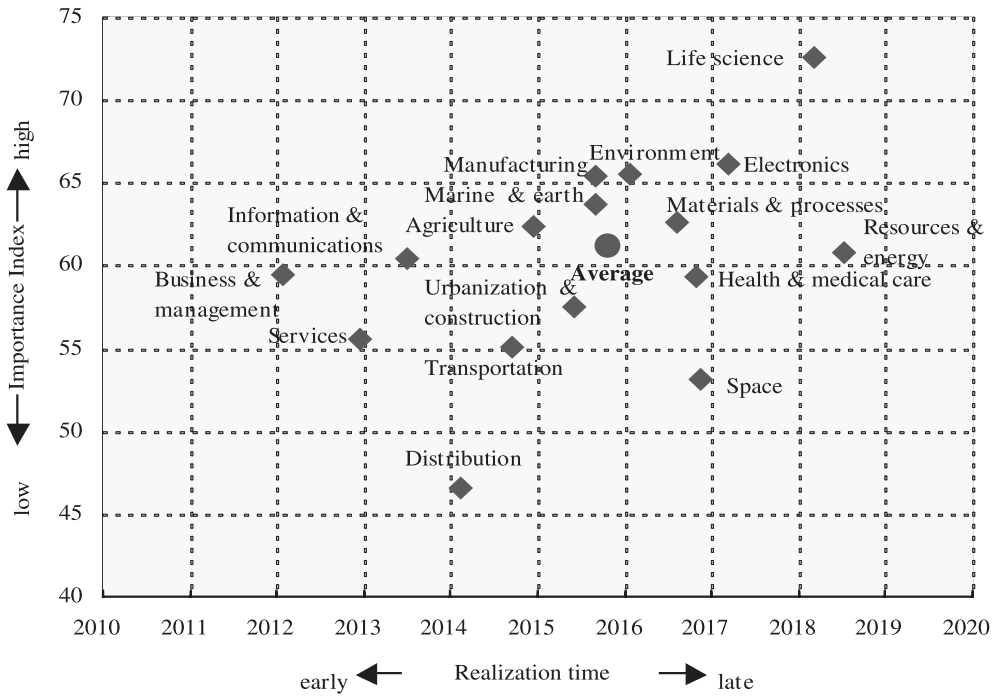

Fig. 3. Importance index vs. realization time.

3.1.2. DSW method

In every action, forecasting comes first. The Delphi method is a well-known intuitive method. The DSW method is an integrated method that provides a systematic approach to developing a strategic scenario for promoting the innovation process. The advantage of the Delphi forecast resides in its simplicity and easy to use process.

As shown in Fig. 4, the DSW method consists of eight steps. The first three steps (from object analysis to Delphi forecasting) provide a Delphi needs/time chart, which shows the preliminary information of the technology and the future services. Then, the next two steps (from morphology analysis to foresight scenario writing) clarify the interrelationship between the forecasted items and this provides a flow chart scenario that leads to the next two steps of strategy development from strategic program scenario writing to integrated strategy development. The final step, the strategy implementation, provides a practical program to promote the innovation and the expected results, for example, the projected penetration curve of the product life cycle.

The authors first applied the DSW method in 1977 (25 years ago) to develop an innovation strategy for the small office and home-use facsimile, which was promoted intensively in Japan to overcome the language difficulties resulting from the use of many Chinese characters, at least about 4000, in daily-use written documents. The problem Japan encountered in computerized office automation in the 1970s was how to handle the Chinese

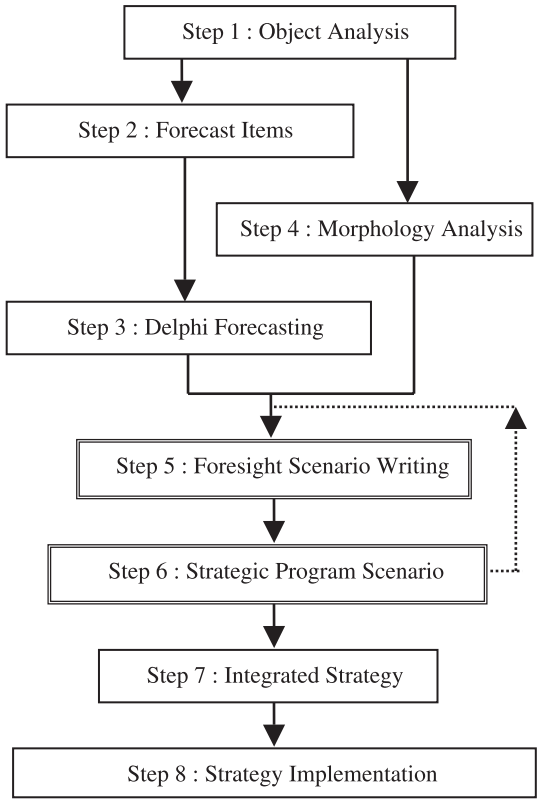

Fig. 4. Procedures of DSW.

characters when transferring handwritten Japanese documents through the telephone line, because the traditional Japanese typewriter required extensive training and was provided to professional typists only.

The process we adopted in the strategy development for the small facsimile is first briefly reviewed according to the above eight steps. For Step 1, the facsimile technology and services including its competing media such as the telephone, letter mail, telegram, television, newspaper, and others were analyzed in detail. In Step 2, the 49 services expected to be provided in the future were picked up, and then in Step 3, Delphi forecasting was carried out using work force members and some other external members by scoring the importance of the needs and time to start the services. Fig. 5 shows the needs/time flow chart. In the morphology analysis in Step 4, the 49 services were classified into 4 main categories and 13 medium groups using the KJ (Kawakita Jiro) method, a new finding of the two-dimensional portfolio matrix shown in Table 3, which consists of objectives (business vs. living) and means (communication vs. information). This matrix suggested that it is difficult to cross over from the upper left business communication (BC) domain to the right living communication (LC) domain, and it is necessary to pass through the business (BI) and living information services (LI) domains (see below).

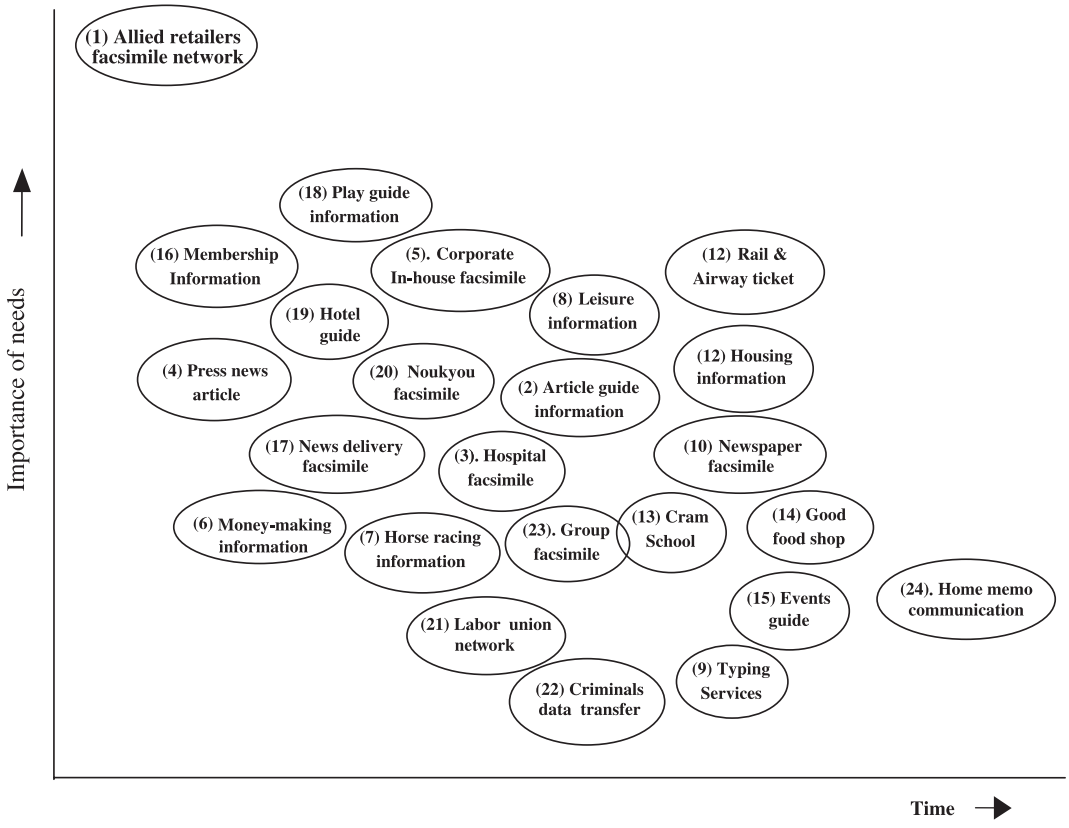

Fig. 5. Needs/time chart of small facsimile services forecasted by the Delphi method.

Step 5, or foresight scenario writing, is a process to integrate the results of Steps 3 and 4 and to generate a DSW flow chart, as shown in Fig. 6, which describes the facsimile service innovation process in the four domains [9].

3.1.3. Small facsimile innovation scenario

In 1977, the foresight scenario of the small facsimile was developed by the above-mentioned DSW method to promote the innovation. This outlines the processes in the following four categories: (a) BC, (b) BI, (c) LI, and (d) LC. Those innovation scenarios introduced new factors to enhance the process; for example, the facsimile CM and DM or the public FAX information and communication service terminals similar to public phones. Those new factors to induce the development could be found in writing the scenarios that require logical thinking by making clear the relations between the forecast items. This approach of finding new related factors is one of the critical advantages of this method. The second advantage is found in the easy processes of the scenario writing that do not require hard thinking by putting the Delphi forecasting in the prestage.

Table 3
Portfolio matrix of small facsimiles

		Objective	
		Business	*Living*
Function	*Communication*	**Business Communication Service (BC)**	**Living Communication Service (LC)**
	Information	**Business Information Service (BI)**	**Living Information Service (LI)**

3.1.4. Enhanced diffusion scenario

The next step in this approach was to find accelerating key factors to promote the penetration to home applications. The first factor was to spread usiness use facsimiles that could be promoted by the following five factors:

1) expanding cooperates in-house business facsimile systems that need to be connected to outside home-use facsimiles,
2) increase of information services to individual professional users in business offices that have common interests with the individuals at home,
3) information processing systems that support outsourcing of office works, for example, conference management and typewriting services,
4) whole–retail sale facsimile networks that extend to independent business offices,
5) information services directed to whole–retail sales and independent offices.

The next suggested target was to directly promote the diffusion of the home facsimiles, intending to increase the added values for the individual subscribers at home or to reduce the costs for the services. The items derived from the scenario were as follows:

1) integrated information services that provide the coordination of the whole services,
2) introduction of commercialism for reducing the costs,
3) simple charge-collecting system for the information and service providers,
4) promotion of experience by demonstration and open-system introduction to restaurants, coffee shops, and refreshing spots of such kind,
5) shift from the office-use to home-use in a small business office and a retailer's shop,
6) addition of new functions, for example, a copying function, a game function, and TV interfaces that could be provided with little modification,
7) new lifestyle campaign that provides the know-how of using the new facsimile machine.

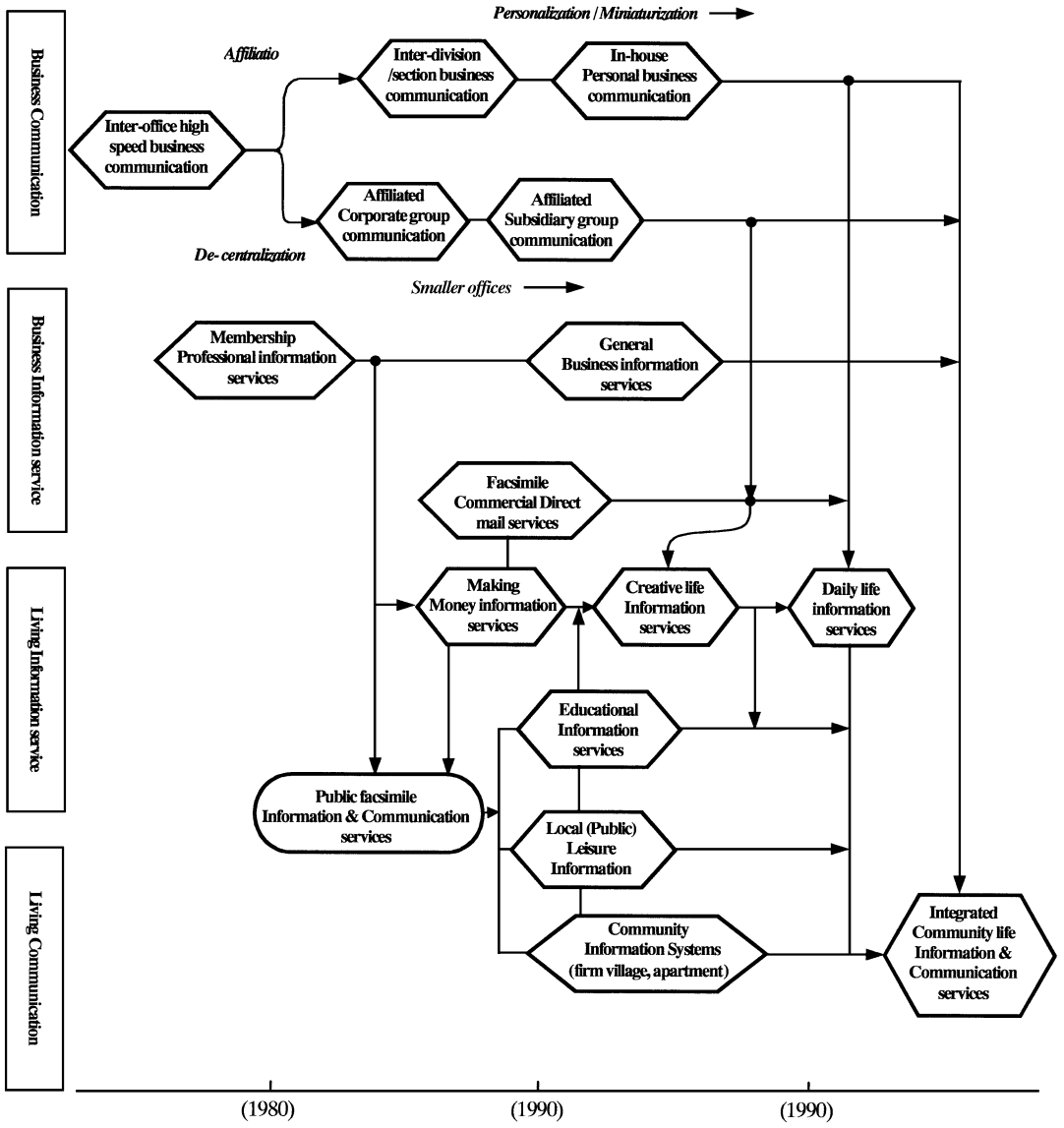

Fig. 6. A DSW flow chart of small facsimile innovation (Foresight in 1977 by Akio Kameoka in Toshiba).

The above mentioned countermeasures were integrated so as to attain higher performance by picking up the following six items: establishment of total information center, business office facsimile promotion, retailer/independent business office facsimile network, public facsimile distribution, community facsimile networks, and further cost reductions with improved functional performance.

3.1.5. Overview

Almost 25 years have passed since the foresight work force started in 1977. The facsimile innovation had been promoted by the Nippon Telegraph and Telephone Public Corporation in cooperation with the Japanese industry for about 30 years, which successfully achieved the original innovation in Japan and then its spread throughout the world. Fig. 7 shows the penetration curves projected in 1977 and the actual penetration curve. The predicted innovation scenario was characterized by the simple four portfolio categories, which suggested that the way to move directly to the LC domain from the BC domain was difficult

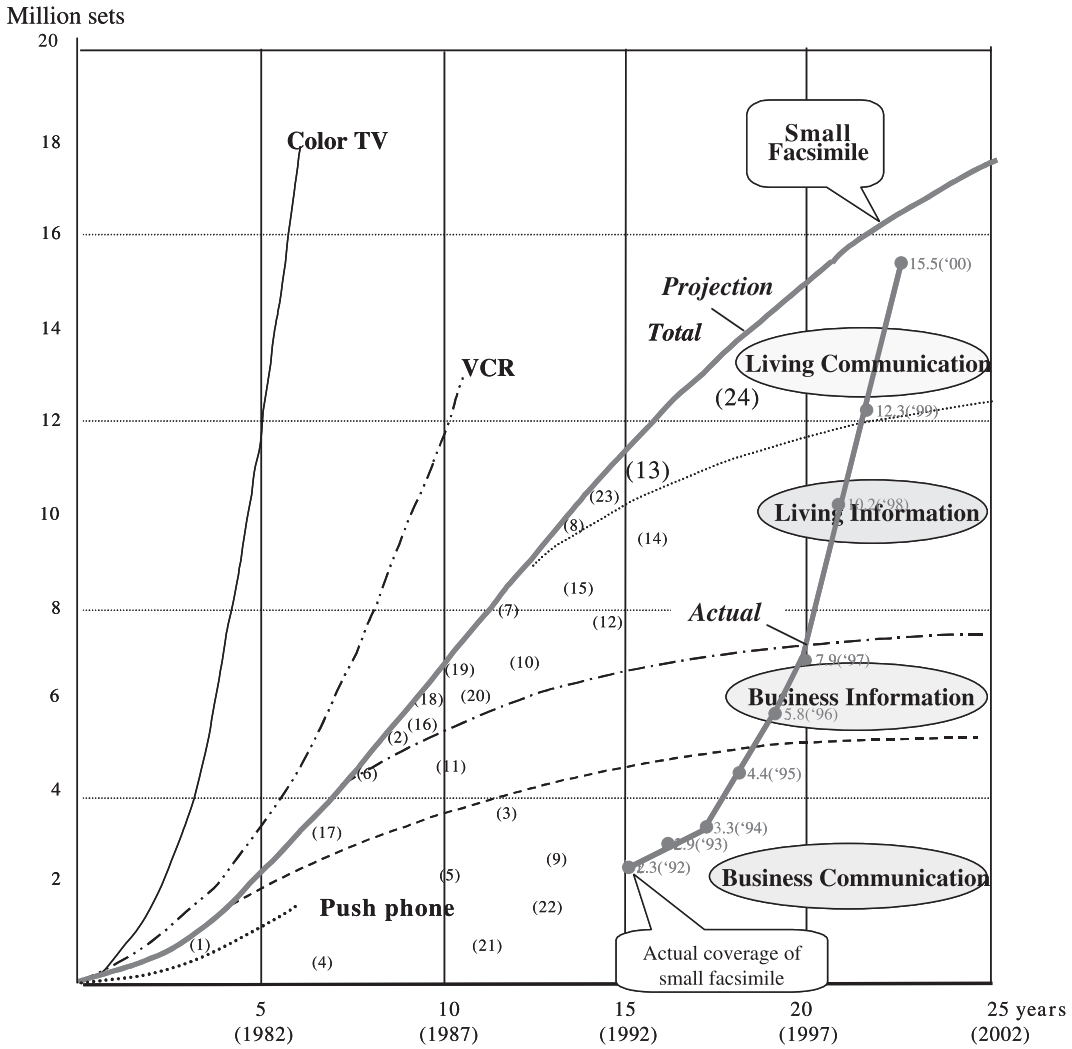

Fig. 7. Penetration curve of small facsimile in Japan: projection in 1977 and actual.

due to the network externality, and it was suggested that it was the lead to the information services, BI and LI domains, that increased the number. It can be concluded that this insight was generally appropriate. The actual penetration curve, however, was slow in starting up than the first prediction, as shown in Fig. 7. This could be interpreted that the network externality was underestimated. Another thing that differed from the first foresight was that the facsimile innovation had spread worldwide much more rapidly than expected. This was a good lesson to learn from this case study.

3.1.6. Implications of Case 1

The review of the small facsimile innovation process in Japan for the past 25 years and the DSW method applied in 1977 (a quarter century ago) to develop the innovation strategy leads to the conclusion that an adequate quality foresight of the future is possible, and the method that the DSW provides supports the strategy development. This method provides a basis for more integrated and comprehensive strategy developments.

3.2. Case 2: a general assessment of informationalization[2] in Japan

Since the early 1970s, technology assessment has been applied to various fields with the range of assessments expanding from advanced technologies to social developments. This case focuses on the rapidly advancing Japanese society in the 1970s toward the information society, or postindustrial society. This trend was often called "Joho-ka" or *informationalization*. The procedure characteristic to this survey was the matrix scoring assessment of various trends, actually 36 macrophenomena, by a number of evaluation categories consisting of 36 values of individuals, organizations, society, and mankind. The 36×36-matrix assessment provided scored data, which made it possible to perform some numerical policy simulations by putting priorities on the selected values under various assumptions. This policy simulation suggests a new approach to understanding such a complex social system and provides a new methodology for strategy development and policymaking [10–14].

3.2.1. Procedure of "general assessment"

The informationalization trends include various complex social changes promoted by the new information technologies as shown by the sketch in Fig. 7. To attain the above purpose of general assessment, the 11-step procedure was employed. The fundamental procedure was the matrix scoring assessment applied to plural macrophenomena of informationalization, evaluated by expert panelists in terms of the multiple categories of individual and group values. Then, a comprehensive policy simulation was attempted to achieve greater clarification as an aid to the generation of an improved policy.

[2] The term *informationalization* means the increasing informational activities and various social trends towards the information society.

3.2.2. Matrix scoring (36 macrophenomena of informationalization by 36 evaluation category of values)

In order to clarify the complex assessment object, 36 macrophenomenal social and technological trends were extracted as in Table 4. As often mentioned, the information society is capable of sustaining and indeed nurturing the coexistence of pluralistic value systems. In this context, 36 evaluation categories of individual and group values were prepared as shown in Table 5. As for the matrix assessment, the categorical scales from 1 to 5 for both impacts and trends were indicated. Twenty-four expert panelists gave scores to both the positive and negative impacts of each phenomenon. The positive and negative impacts, as well as the aggregated total positive impact, were scored.

Consequently, the impacts analysis of the 36 macrophenomena has revealed the following six significant features:

(1) change from mass information to mini-information,
(2) informationalization exerts an increasing impact on the life of an individual,
(3) informationalization exerts an increasing impact on social development,
(4) increasing anxiety associated with the negative impacts,
(5) perceptions of the magnitude of impact differs from individual to individual in accordance with his or her values,
(6) macrophenomena are closely interrelated and comprehensive problem solving is required.

3.2.3. Methodology of "policy simulation"

The approach adopted consisted of promoting the positive impacts, while simultaneously attempting to eliminate the negative impacts or to reduce the negative impacts to such a level that would be susceptible to assimilation into society or to the ameliorative influence of society. In order to analyze the informationalization using the previous matrix evaluation results and to explore a comprehensive informational policy, a simple quantitative model of "policy simulation" was applied as an analysis-by-synthesis method. The basic concept of the model was designed to promote macrophenomenal items, which have positive impacts on priority values for a certain policy, and to restrict items having smaller or negative impacts on those values. If priority is ascribed to a certain value, its political weighting coefficients upon each macrophenomenon are given to promote positive impact items and restrict negative impact items on that value. The expected impacts induced by the above policy can be aggregated. When priority is ascribed to more than two values, the political weighting coefficients can be calculated in the same manner by replacing it simply with added impact scores of the corresponding two or more priority values. This simulation model holds under the following assumptions:

(1) each macrophenomenon and each evaluation category of values is independent (although they appear to be interdependent),
(2) macrophenomena can be promoted or restricted by policy,
(3) linear addition of matrix scores is acceptable,
(4) all values are of equal importance.

Table 4
Macrophenomena of informationalization

A. Change of information
Contents:
1. Increase of new information
2. Increase of information via mass communication media
3. Increase of information via minicommunication media
4. Increase of sensuous information
5. Increase of logical information
6. Increase of advertising information
7. Increase of entertainment information
8. Increase of administrative information

Forms:
9. Increase of fragmentary information
10. Increase of unconsumable information
11. Increase of similar information

Qualities:
12. Increase of information that becomes trite rapidly

B. Change of subject
Informational activities:
13. Commercialization of information and knowledge
14. Increase of informational troubles
15. Increase of indirect experiences
16. Increase of accumulated information and knowledge
17. Increase of forecasting and planning information

Consciousness:
18. Diversification of values
19. Increase of judgment and selection
20. Enhancement of fight-consciousness of information
21. Enhancement of education consciousness

Social structure:
22. Development of intellectual industry
23. Growth of emotional industry
24. Activation of informational activities in enterprise administration
25. Substitution of transformation by communication

C. Change of informational circulation transmission
26. Widening or dissemination of information transmission
27. Improvement and diversification of communication technology
28. Spread of duplication techniques
29. Increase of man–machine communication
30. Increase of information systems on various kinds of social activities
31. Increase of information systems on social control
32. Increase of information internationally circulated
33. Spread of mobile communication

Processing:
34. Improvement of information processing

Recording:
35. Central control of recorded information

Table 5
Evaluation categories of values

A. Individual
1. Health and longer life
2. Safety and stability
3. Convenient life
4. Economic sufficiency
5. Privacy protection
6. Equality
7. Freedom
8. Leisure
9. Cultural life (activity)
10. Self-development
11. Creation
12. Social intercourse
13. Social activity
14. Social status and credit
15. Creed (religion, ism, morality)
16. Beauty

B. Organization
17. Economic activity
18. Self-preservation and extension
19. Harmony with society

C. Region
20. Regional development
21. Environmental development
22. Community activity
23. Tradition (local culture)
24. Decentralization
25. Cooperation among local public bodies

D. Nation
26. National defense and security
27. Public peace
28. Rationalization of administration
29. Democratization of administration
30. National welfare
31. Economic growth
32. Saving resources
33. International cooperation

E. Mankind
34. World peace
35. Welfare for mankind
36. Existence of mankind

3.2.4. Experiments by "policy simulation"

Some examples of policy simulations were carried out. In Example 1, the priority value was ascribed to *privacy protection*; in Example 2, to *rationalization of administration*; and in Example 3, to both *privacy protection* and *rationalization of administration* simultaneously. In Example 4, priority value was ascribed to six items: *safety and stability*, *privacy protection*, *self-development (knowledge, education, ability)*, *creation (art, learning, invention, work)*, *tradition (regional culture)*, and *saving of resources*.

The weighting coefficient was set rather high so as to reveal the characteristics of each macrophenomenon and evaluation category. A coefficient exceeding 1.0 means promotion, and one below 1.0 means restriction of the phenomenon. Conclusively, the four simulations indicated such experiments could be of significant help in understanding the complex interrelationship between the phenomena and values and also to finding a better policy. Although several methodological problems remain, the proposed policy-simulation method constituted a significant methodological advance.

3.2.5. Methodological discussion of the "general assessment"

The technology assessment on such a complex social and technological trends of "informationalization," whose assessment object was very difficult to grasp, was the first case of research. This general assessment study attempted several new approaches as follows:

(1) clarifying a comprehensive concept of informationalization,
(2) pluralistic description of the assessment object as the macrophenomena,
(3) multiple evaluation categories of values,
(4) multidimensional matrix scoring evaluation of both positive and negative impacts by expert panelists,
(5) an approach to general countermeasures with a method of policy simulation from the angle of analysis by synthesis.

The method proposed to grasp the object of assessment by pluralistic or multidimensional description and to carry out a quantitative matrix evaluation from the multiple evaluation categories of values. Finally, the procedure introduced a method of "policy simulation" based on the scored matrix data, which proved to be a powerful method to develop comprehensive countermeasures.

3.2.6. Improvement of the method of general assessment

The method of general assessment adopted in the primary study was discussed from a quantitative methodological point of view. First, it was noticed that it would be better to monitor the scoring characteristics of the panelists and disregard any scoring patterns found highly idiosyncratic in nature.

Secondly, as described above, the policy simulation model assumed, for simplicity, that each macrophenomenon and each evaluation category of values was independent and linear addition of matrix scores was acceptable. For a more precise numerical analysis of the matrix

scores, such a statistical method of multidimensional scaling (MDS) or multivariate analyses would be effective.

3.2.7. Implications of Case 2

The technology assessment applied to the "informationalization" in Japan almost 30 years ago was reviewed, primarily, from a methodological point of view. The assessment procedures were well designed to cover such complex social change by plural phenomenal descriptions associated with their forecast of trends and impacts on the multiple values. In the last 15 years, Japan has advanced very rapidly into an information society, as well as the United States and other countries. Most of the 36 macrophenomena predicted in the assessment have advanced and mainly cover recent new trends. However, there were some other drastic changes that were not clearly forecasted 15 years ago. One was office automation, especially the introduction of Japanese word processors, which radically changed the work style in Japanese offices. Another was the advancement of telecommunications, through the recent telecommunication networks, whose progress was accelerated due to deregulation. The quantitative analyses and the results obtained by the method of policy simulation proved to have contributed to a far better understanding of the complex social systems and have helped develop a comprehensive policy. For more precise analyses, a method of multidimensional analysis was tried to improve the procedure of general assessment.

Fortunately, at least in the past decade, the advancement of informationalization did not cause much negative impact as far as the pollution or environmental problems brought about in the process of industrialization. Today, however, in spite of rapid globalization advancing with the latest communication and information network technologies, informational security and informational troubles such as those associated with intellectual property protection and excessive centralization of information in, for example, the Tokyo metropolitan area are coming to the forefront. Thus, it could be stated that now is a good time to conduct further investigations on the widely expanding international informationalization from a global and comprehensive perspective for world prosperity.

4. Perspectives for integrated technology forecast and technology assessment (TF/TA)

The 2001 seventh foresight program of Japan showed a new direction towards a needs-oriented approach by putting more emphasis on the integration of socioeconomic needs into the foresight procedures and this direction would be continuously pursued in the next program. The above two case studies suggest some constructive ideas for exploring a new integrative methodology to solve the problem in the future. First, the DSW method helps strategy planners with an easier take off in scenario writing and deep understanding of the interrelations between the forecast items and social factors. Second, the general assessment method, equipped with the numerical simulation process, provides a synthetic policy development and its evaluation system. A comprehensive understanding and dynamic response to the rapidly advancing technologies and multifunctional social structure could be empowered by integrated TF/TA-

based strategy development, and it will contribute to high-quality management and governance in the coming knowledge-based global network society.

4.1. Role of advanced countries in science and technology

Japan, as with many other countries, is facing globalization and intense economic competition from abroad, but also is aging at an unprecedented pace. People are deeply concerned that Japan is heading towards a crisis, where the hollowing-out of industry, the lack of society's vitality, and the worsening living standard are highly evident. Moreover, the future existence of humans as a whole is confronted by global environmental issues, food shortages, and energy and resource depletion. In dealing with these problems, science and technology is expected to play an increasingly larger role. We have to strongly advance efforts in these fields. Top priorities are to radically improve the environment so as to upgrade the RTD (Research-Technology Development) abilities of industrial, academic, and governmental organizations, to formulate and carry out policies to make the best use of such environments, and to facilitate the use of all achievements by the public, society, and economy.

As for the administrative aspect, the Japanese government reformed its system in 2000, combining the 22 ministries and agencies into 12. The Science and Technology Agency and the Ministry of Education, Sports and Culture were merged into a single, new ministry. The Council for Science and Technology was reformed into a new council, which is responsible not only for science and technology but also for humanities. Japan needs to further develop its forecasting survey and analysis methodology in order to utilize them more effectively for establishing science and technology strategies to match the social and individual requirements of the future society.

4.2. Paradigm shift of "competitiveness" for the 21st century—towards cooperative competitiveness

Now, at the beginning of the 21st century, we would like to take a close look at what competitiveness is for and what it should be like from a philosophical point of view. What is competitiveness? The late Hiroshi Inose implied a significant point that explained the concept of competitiveness. He said, "The word 'compete' derives from the Latin word 'competere.' The prefix 'com' means 'together,' and 'petere' means 'pursue.' Consequently, 'competere' means to 'pursue together.' But, to pursue what? The answer is human ideals. When people pursue ideals, they help each other and strive together. In correcting each error and compensating for each other's weakness, and in acknowledging each other's insight and strength, they see true competitiveness. Competitiveness, thus, should come from the power of self-discipline and not from the motivating force to be superior by commanding power, tricks or fraud tactics, because their purpose is to pursue human ideals." He explained the new idea of "comprehensive competitiveness" by integrating the human and social sciences and the natural sciences, and proposed that this new concept of competitiveness based on oriental thought would help us more beyond the current western concept of competition. He said that Japan, from this moment on, should always keep this

new idea in mind and work to make this understood by people all over the world for their happiness in the 21st century.

5. Conclusions

In the abovementioned context, "technology foresight" includes forecasting of emerging technologies and their assessment and communication among the product providers, consumers, and stakeholders. The future-oriented technology analyses are complicated in its practice, which includes technology forecasting, technology foresight, technology intelligence, technology road mapping, and technology assessment. Consequently, those approaches should be integrated to achieve comprehensive understanding of the emerging technologies and their social impacts. Such an integrated strategic planning methodology should be explored to proceed a complex innovation system.

References

[1] F. Kodama, Analyzing Japanese High Technologies—The Technical Paradigm Shift, Printer Publishers, London, 1991, pp. 3–8.
[2] The Seventh Technology Foresight—Future Technology in Japan Towards the Year 2030, NISTEP Report No. 71, National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology, Japan, July 2001, Volume 2, pp. 821–825.
[3] T. Kuwahara, Technol. Forecast. Soc. Change 60 (1999) 5–14.
[4] T. Kuwahara, Technology foresight in Japan—the potential and implications of the Delphi approach, Proceedings of the International Conference on Technology Foresight, Report Material No. 77, March 2001.
[5] I. Karube, Integration of socio-economic needs into technology foresight, Proceedings of the International Conference on Technology Foresight, Report Material No. 77, March 2001.
[6] A. Kameoka, Y. Morikawa, Y. Sata, Technology forecasting: review of the 'Delphi-scenario writing method'—from the case of application to the small facsimile innovation strategy development in 1977, 25 years ago, Proc. Annu. Conf. Sci. Policy Res. Manage. Jpn. 1B13 (1999) 173–178 (in Japanese).
[7] A. Kameoka, Y. Morikawa, A forecast of a business product development process and the innovation strategy planning by a 'Delphi-scenario writing' method, 8th Technol. Forecast. Sympos., Proc. (1979) 19–24.
[8] An Effective Use of Facsimiles—The Innovation Process and Its Strategy Development, proposed by Mr. Mistuning, chief technology officer, to the Image Telecommunication Subcommittee, Telecommunication Technology Committee, Nippon Telegraph and Telephone Public Corporation.
[9] A. Kameoka, Y. Suzuki, Integrated strategy development by Delphi-scenario writing method—a review of home facsimile innovation and its strategy development in the 1970s, IEEE Engineering Management Society, IEMC 2002, Cambridge, UK, August 18–20, 2002.
[10] J.-F. Coats, Technology assessment, Futurist 5 (6) (1971).
[11] M.V. Jones, A Technology Assessment Methodology—Some Basic Propositions, MRT60099, 1, Mitre, Washington, 1971.
[12] A. Kameoka, An Application of Multidimensional Scaling Method to Technology Assessment, U.S. "Japan Seminar," Theory, Method and Application of Multidimensional Scaling and Related Techniques, University of California, San Diego, 1975, pp. 20–24.
[13] A. Kameoka, General Assessment of Informationalization Towards Future Informational Society, East–West Communication's 1976, Advanced Summer Seminar, East–West Center, Honolulu, June 5–16, 1976.

[14] A. Kameoka, A general assessment of informationalization in Japan, J. Sci. Policy Res. Manage. 3 (3) (1988) 274–289.

Akio Kameoka Professor, Graduate School of Knowledge Science, Japan Advanced Institute of Science and Technology (JAIST), Affiliate Fellow of NISTEP (1989–), Visiting Professor of the Graduate Research Institute of Policy Studies (2000–), Lecturer of "Innovation management" (1988–) and Visiting Professor of the University of Air (2001–), IEEE Engineering Management Society, Japan Chapter Chair.

B.S. Engineering, Ehime University (1963), Ph.D. Literature, Keio University (1974)

Joined Toshiba R&D Center (1963), Visiting Senior Researcher, Institute for Future Technology (1972), Senior Manager of Planning Group in Toshiba R&D Center (1984) and Corporate Planning Division (1986), Senior Fellow (1994) of Toshiba R&D Center, Senior Executive Director of the Japan Techno-Economics Society (1999).

Specialties: Industrial Competitiveness Strategy, Management of Technology (MOT), and Innovation Management.

Yoshiko Yokoo Researcher, National Institute of Science and Technology Policy (NISTEP), Ministry of Education, Culture, Sports, Science and Technology, Japan.

B.S. (1983), M.S. (1985) Ochanomizu University

Joined National Institute of Resources, Science and Technology Agency (1985).

Specialties: Science and Technology policy, Technology foresight.

Terutaka Kuwahara Director, Science and Technology Foresight Center, National Institute of Science and Technology Policy (NISTEP), Ministry of Education, Culture, Sports, Science and Technology, Japan. Visiting Professor of the Graduate Research Institute of Policy Studies (2001–), Planning Director for Research and Analysis, Council for Science and Technology Policy, Cabinet Office.

B.S. (1975), M.S. (1977) Computer Science, University of Tokyo. Joined Science and Technology Agency (1977), Head of the Technology Forecast Research Team at NISTEP, Science and Technology Agency (1993).

Specialties: Science and Technology policy, Technology foresight and assessment.