Comparative Evaluation of Industrial Competitiveness of Japan, the United States, Europe and Asia: A New Framework of ‘Symbiotic Competitiveness’ for the 21st Century

AKIO KAMEOKA
The Graduate School of Knowledge Science, Japan Advanced Institute of Science and Technology

The concept of industrial competitiveness, which emerged in the United States during the 1980s, has now become a critical issue for many countries. An intensive comparative survey on the industrial competitiveness of Japan, the United States, Europe, and Asia, was carried out in 1999 and 2000, and it clearly revealed each country’s comparative strengths and weaknesses. The surveys cover 290 items of industrial technologies categorized in 14 fields, from materials, devices, and system engineering, to production technology and management technology. This survey implies that management of technology (MOT), namely innovation management, is a critical factor recovering and sustaining competitiveness. It should be noted that the paradigm shift of innovation management from the catch-up “incremental model” to the front-runner “radical model” requires completely different approaches. In this paper, a “cross-generational framework” for next generation innovation model is derived from the linear model to “market finding” Kline model, the to the third “market experiment abduction model” and finally to “market creation” interactive model. Furthermore, a new type of technologist, “technoproducers,” who come up with creative objectives and coordinate the practical program to achieve the objective is proposed. The linkage among industry, academia and government, and their higher integration are critical important. Finally, this paper introduces an important concept of “symbolic competitiveness,” a philosophical point of view that suggests a redefinition of the current concept of competitiveness for future world prosperity.

* The author would like to acknowledge those who gave valuable advice about conducting the survey including Dr. Hitoshi Inose, the chairman of the competitiveness committee, who introduced a new symbiotic concept of competitiveness; Dr. Teruo Yamanouchi, core leader, Mr. Shoichi Saba, chairman, and other members of the Japan Techno-Economics Society (JATES). Finally the author appreciates Dr. Meng Li and Mr. Gaku Ishii, graduate students of JAIST for their cooperation and assistance in this study.

Direct all correspondence to Akio Kameoka, Professor of the Graduate School of Knowledge Science, Japan Advanced Institute of Science and Technology, 1-1, Tatsunokuchi, Ishikawa 923-1292, Japan. Tel: 81-761-51-1720; Fax: 81-761-51-1774; E-mail: kameoka@jaist.ac.jp
I. INTRODUCTORY REVIEW OF COMPETITIVENESS

The concept of industrial competitiveness, which emerged in the United States during the 1980s, has now become a critical issue for many countries. In the United States, the President's Commission on Industrial Competitiveness began in 1983 to investigate the U.S.'s competitiveness and to advise the President. The first chairperson was John Young, then president of Hewlett-Packard Corporation. On January 15, 1985, the committee published its first report: *Global Competition: the New Reality*, which had a great impact on the U.S. industrial and technological policy. The Council on Competitiveness (COC), which was established in 1991, continued advising the government and industry on industrial competitiveness. In 1999 Report, COC evaluated the competitiveness of each industrialized country as shown in Table 1, and the report strongly warned that although the present data for the United States were favoring the U.S. companies, it was time for the United States to realize that if there were no changes in the national policies and investment in research and technology development, the country might lose its position as a country of innovation within the following ten years.

| Rank | 1980  | 1986  | 1993  | 1995  | 1999  | 2005  |
|------|-------|-------|-------|-------|-------|-------|
| 1    | Switzerland | Switzerland | Switzerland | U.S.  | Japan | Japan  |
| 2    | U.S.  | U.S.  | Japan | Switzerland | Switzerland | Finland |
| 3    | Germany | Japan | U.S.  | Japan | U.S.  | Switzerland |
| 4    | Japan | Germany | Germany | Sweden | Sweden | Denmark |
| 5    | Sweden | Sweden | Sweden | Germany | Germany | Sweden |
| 6    | Canada | Canada | Denmark | Finland | Finland | U.S.  |
| 7    | France | Finland | France | Denmark | Denmark | Germany |

*Source:* "The New Challenge to Americas Prosperity: Findings from the Innovation Index" by M. Porter and S. Stern in COC, 1999.

In Europe, studies on competitiveness following the United States began. Germany, France, and Great Britain evaluated their technologies in order to improve their competitiveness. *World Competitiveness Yearbook*, published annually by the International Institute for Management Development (IMD) in Switzerland, has a different viewpoint on international competitiveness, which focuses on the potential of national infrastructure as a whole.

The latest IMD yearbook, published in 2002, concluded that Japan is facing a major decline in its overall competitiveness. One aspect that the yearbook focused on in terms of ranking the countries was each country's overall competitiveness. This

---

1 See U.S. President's Commission on Industrial Competitiveness (1985); Reports of COC (1999) and (1994).
was based not only on technological competitiveness but also on the domestic economy, internationalization, government, finance, infrastructure, management, science and technology, and population. Another aspect is that its analysis covers an extremely wide range of criteria; the questionnaire collects both statistical data and opinion surveys, i.e., soft data that reflect the opinions of the executives of many different corporations. The respondents were mainly intellectuals like executive managers while this may or may not imply that the results are affected by economic fluctuations. A framework for evaluating competitiveness is introduced below.

**FIGURE 1. FRAMEWORK OF COMPETITIVENESS INDEXES**

![Diagram of Framework of Competitiveness Indexes]

Figure 1 shows a simple business model where industrial activities take place in a country in such a way that each company fosters its capability within the national infrastructure for better performance. The model shows the differences between the evaluations of each organization: While the IMD and World Economic Forum base their evaluations on the national infrastructure as it's competitive potential, the COC bases its evaluation on performance. The IMD's index is designed to measure the effectiveness of the national environment in terms of promoting foreign investment. In other words, it measures the level of attractiveness of the country with regard to drawing investment from foreign countries. On the other hand, the COC focuses on the actual performance. Thus, no matter how stable the country's infrastructure is, if firms are not active, the performance turns out to be not as good as expected. From this particular point of view, Japan's performance has not yet declined as much as the IMD's evaluation predicted. This will be made clear later in this paper. Nevertheless, if the infrastructure on which corporate activities are based deteriorates and the base potential decreases, the corporations in the country will eventually decide to move out their manufacturing bases overseas. As the hollowing out of manufacturing sectors continues, domestic corporate activities will eventually suffer. As this discussion suggests, evaluation methods should be carefully chosen to meet situations and purposes. We should always keep in mind the inconsistency of self-evaluation, the possibility of misjudging cause-and-effect relationship, the risk inherent in the use of a unified index, and the purpose of evaluation. We should also be careful about what level of competitiveness we are looking at: corporate competitiveness or the overall com-
comparitiveness of a whole nation.

It is necessary to clearly define what competitiveness means. In a project on "Framework Conditions for Industrial Competitiveness" conducted by the Organization for Economic and Co-operation and Development (OECD), a working definition of competitiveness was defined as "... the ability of companies, industries, regions, nations or supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis (OECD 1997)." According to Yoichi Hara and other scholars, "international competitiveness" should be regarded as the "competitiveness that a nation has," and "competitiveness enables business sections based in a country to keep the country's advantageous position in both the domestic and world markets continuously from this present over to the future."

II. EVALUATION OF JAPAN'S INDUSTRIAL COMPETITIVENESS

In order to identify Japan's strong and weak areas with regard to industrial technology, and to collect fundamental data necessary for providing political advice on establishing strategies, we conducted surveys from 1999 to 2000. Using the collected data, we compared Japan with the United States, Europe and other Asian countries in terms of both technological and global market level. First, the industrial technologies were segmented into 290 items under 14 fields, covering various professional technology fields that include materials, devices, software and system engineering, production technology and management of technology. The respondents were corporate executive managers, researchers in universities, and corporate consultants.2

Outline of the Survey

The questionnaire sheets were sent to the chief technology officers of the member firms of Japan Techno-Economics Society (JATES), who were able to deliver the sheets to the suitable technical planning and research and development (R&D) management staff in the corporate headquarters or technical management staff in different divisions. As the evaluation categories and questions were widely ranged, respondents were asked to respond to the questions on the areas or items strongly related to their responsibilities. They were also given opportunities to provide opinions on the area; beyond their expertise and other business areas of the companies they represented.

The questions covered every aspect of industrial technology from new materials, devices, systems, software, services and production systems to management technologies including human resources. In terms of major industrial technologies or products, we compared Japan's product competitiveness with that of the United States, Europe, and other Asian countries, both in the technological potential and the product market.

2 For the details, see Japan Research Institute, 2000; Japan Machinery Federation, 1999; and JATES, 1994.
### Table 2-1. Industrial Technologies (1/2)

| Item No. | Item Name |
|----------|-----------|
| 1. NMOI | High function metal |
| 2. NMOI | High function polymer |
| 3. NMOI | Surface thin layer technology |
| 4. NMOI | Electronic materials |
| 5. NMOI | High-tensile steel |
| 6. NMOI | Amorphous alloys |
| 7. NMOI | Superconducting materials |
| 8. NMOI | Fine conduction |
| 9. NMOI | Advanced plastics |
| 10. NMOI | High molecular sequence fiber |
| 11. NMOI | Engineering plastics |
| 12. NMOI | Computer materials |
| 13. NMOI | Nonlinear photonic materials |
| 14. NMOI | Insulating materials |
| 15. NMOI | Molecular functional materials |
| 16. NMOI | Superconducting advanced ceramic materials |
| 17. NMOI | New high-temperature superconductors |
| 18. NMOI | Hydrogen absorbing alloys |
| 19. NMOI | Materials of new fuel carbon system |
| 20. NMOI | Silicon chemical materials |
| 21. NMOI | Gallium arsenide alloy materials |
| 22. NMOI | Precise cutting |
| 23. NMOI | Advanced materials technology and use |

| Item No. | Item Name |
|----------|-----------|
| 24. NTOI | Gene conversion technology |
| 25. NTOI | Creation of high function elements |
| 26. NTOI | Base and core technologies for precision engineering |
| 27. NTOI | Building micro data bases |
| 28. NTOI | Seeds and systems of next gestation systems |
| 29. NTOI | High-speed, high-precision technology in micro nanoscopic range |
| 30. NTOI | Silicon semiconductor material in micro nanoscopic range |
| 31. NTOI | Optical and electronic technology |
| 32. NTOI | The process of nanoscopic and microscopic technology |
| 33. NTOI | Creation of bio-technological processes in micro nanoscopic range |
| 34. NTOI | Biocompatibility materials in micro nanoscopic range |
| 35. NTII | Human genome analysis enabling to 21st century |
| 36. NTII | Synthetic medicine and restaurant technology |
| 37. BT13 | Artificial bone (human) data technology in artificial materials |
| 38. BT13 | Joint in organismic determination (DNA) amp technology in artificial materials |
| 39. BT13 | Biocompatible material |
We also took the development processes, market conditions on entry, and market size and profitability for each item into account. The questionnaire was sophisticated enough to identify the critical technologies, which are the key to improving industrial competitiveness, and it was helpful in figuring out what factors brought the country the current level of competitiveness. The response sheets were designed to identify the leading corporations, universities, and research laboratories of each specialized technology. Tables 2-1 and Table 2-2 are the lists of the industrial technologies and products consisting of 290 items covering the 14 fields.3

Results of Survey and Analysis

There are two main scores for each country in JATES's survey; one is “level of technology”; and the other, “competitiveness in market.” Each score is determined by the average of all item scores in the respective fields.

FIGURE 2. COMPETITIVENESS EVALUATIONS AMONG JAPAN, THE UNITED STATES, EUROPE, AND ASIAN COUNTRIES

| Competitiveness in Level (Field Name) | Field (Mark) | U.S. | Europe | Asia |
|--------------------------------------|-------------|------|--------|------|
| 1: NM (New Material)                 | NM          | 0.4  | 0.8    | 1.6  |
| 2: BT (Biotechnology)                | BT          | -0.8 | -0.3   | -1.3 |
| 3: EM (Electronic/Optical Materials) | EM          | 0.2  | 0.6    | 1.6  |
| 4: ED (Electronics Device)           | ED          | 0.0  | 0.5    | 1.4  |
| 5: IT (Information Equipment/System) | IT          | 0.4  | 1.0    | 1.5  |
| 6: SW (Software/System)              | SW          | -0.8 | 0.0    | 0.9  |
| 7: CS (Communication System)         | CS          | -0.6 | 0.0    | 1.4  |
| 8: CE (Information Appliance)        | CE          | 1.2  | 1.4    | 1.7  |
| 9: EN (Energy)                       | EN          | 0.2  | 0.2    | 1.4  |
| 10: ME (Medical Engineering)         | ME          | -0.6 | -0.3   | -1.3 |
| 11: EV (Environment Engineering)     | EV          | 0.2  | 0.0    | 1.3  |
| 12: IF (Traffic/Construction/Infrastructure) | IF  | 0.5  | 0.5    | 1.6  |
| 13: PD (Production Engineering)      | PD          | 0.5  | 0.6    | 1.5  |
| 14: MG (Management/Human Resource, Etc.) | MG | -0.9 | -0.5   | 0.6  |

For the details of each report, see JATES Report, 1999; 2000; and Kameoka, 1999; Kameoka et al., 1999.
Comparative Evaluation of Industrial Competitiveness of Japan, the United States...

| Competitiveness in Market (Field Name) | Field (mark) | U.S. | Europe | Asia |
|---------------------------------------|-------------|------|--------|------|
|                                       | Present     | Future | Present | Future | Present | Future |
| 1: NM (New Material)                  | NM          | 0.3   | 0.3    | 0.6   | 0.6    | 1.4     | 1.3    |
| 2: BT (Biotechnology)                 | BT          | -0.8  | -0.7   | -0.3  | -0.2   | 1.1     | 1.1    |
| 3: EM (Electronic/Optical Materials)  | EM          | 0.4   | 0.4    | 0.7   | 0.6    | 1.4     | 1.2    |
| 4: ED (Electronics Device)            | ED          | 0.0   | 0.0    | 0.6   | 0.5    | 1.1     | 0.8    |
| 5: IT (Information Equipment/System)   | IT          | 0.4   | 0.3    | 1.0   | 0.9    | 1.2     | 0.9    |
| 6: SW (Software/System)               | SW          | -0.9  | -0.6   | -0.1  | 0.1    | 0.9     | 0.9    |
| 7: CS (Communication System)          | CS          | -0.8  | -0.6   | -0.1  | 0.0    | 1.2     | 1.1    |
| 8: CE (Information Appliance)         | CE          | 1.3   | 1.0    | 1.4   | 1.2    | 1.7     | 1.1    |
| 9: EN (Energy)                        | EN          | 0.0   | 0.1    | 0.1   | 0.1    | 1.2     | 1.0    |
| 10: ME (Medical Engineering)          | ME          | -0.7  | -0.4   | -0.5  | -0.2   | 1.2     | 1.3    |
| 11: EV (Environment Engineering)      | EV          | 0.1   | 0.2    | 0.0   | 0.2    | 1.2     | 1.1    |
| 12: IF (Traffic/Construction/Infrastructure) | IF     | 0.4   | 0.3    | 0.4   | 0.3    | 1.4     | 1.2    |
| 13: PD (Production Engineering)       | PD          | 0.4   | 0.4    | 0.5   | 0.4    | 1.3     | 1.1    |
| 14: MG (Management/Human Resource, Etc.) | MG      | -0.8  | -0.5   | -0.4  | -0.2   | 0.5     | 0.5    |

Source: JATES, 2000.

Figure 2 shows that the level of technological competitiveness of Japan is slightly lower than that of the United States, but the gap will be narrow in the future. Compared to the European countries, it has a modestly higher level in most of the cases. Japan has much higher score in every area than other Asian countries though the gap will likely to become narrow in the future. In the area of Consumer Electronics (CE), Japan holds an extremely strong position and is strong in Production Technology (PD) as well; in the field of New Materials (NM) and Electrical Devices (ED), Japan is relatively strong. In the field of Infrastructures (IF) such as traffic systems and environment, Japan is comparably strong and will improve performance in the near future. However, in Biotechnology (BI), Software Development (SW), Communication Systems (CS), and Medical Engineering (ME), Japan is relatively weak compared to the leading countries. Figure 3 shows the technological levels according to each country's strengths and weaknesses.

This survey introduced the field, which is categorized as "Management Technology and Human Resources (MG)," by taking up such new items as managerial methodologies and practical skills and techniques. It is worth pointing out that the survey shows the weakness of Japanese companies in management and human resources, which contrasted the prior survey results praising Japanese management systems. The result
of the global comparison shows that in this field, Japan scored lower than it did in any other fields. The items in which Japan keeps almost the same level as the United States and the European countries do are R&D commercialization (266), integration of R&D, product design and production (272), and technologist-training systems (280). However, in the items such as standardization (264), management of intellectual property (265), integrated project management (268), benchmarking (269), supply-chain management (270), knowledge creation (278), and systems for cooperation among the industrial, governmental, and academic sectors (273), Japan is considerably inferior to the United States. The field shows a much smaller gap between Japan and the rest of Asia. Moreover, Japan is behind in foreign language education (English, for instance). In terms of “venturing system (275),” which is one of the hottest current items, Japan’s potential is just about the same as that of other Asian countries.

**FIGURE 3. COMPETITIVENESS OF JAPANESE INDUSTRIAL TECHNOLOGIES**

| CE | IT | NM | PD | IF | EN | EM | ED | EV | BT | CS | ME | SW | MG |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 2.0 | 1.5 | 1.0 | 0.5 | 0.0 | -0.5 | -1.0 | -1.5 | -2.0 |

*Source: JATES 2000.*

It is obvious that in the critical items that determine competitiveness, such as “management of technology (MOT)” and “corporate strategy,” Japanese companies will have to face the problematic points. Accordingly, improvement of the quality of technology management should be seriously taken into account. The management of technology should be regarded as the most important factor as Japan seeks to recover world competitiveness.

Through the survey results, it can be conclude that the average potential level of Japan can best contribute to the future world economy by making the optimal combination of the complementary technologies. The problems lie in the lack of strategic goal setting and management system, as well as the underlying social structure that promotes new innovations. The country would be able to have more opportunities.
III. A CROSS-GENERATION FRAMEWORK: NEW INNOVATION PROCESS MODEL

How to generate a new innovation is the key factor in obtaining competitiveness. Stephen Kline proposed a chain-linked innovation model in 1985, which had a great impact on science and technology policy and corporate technology management, and challenged the traditional linear model of innovation, which had been accepted for many years (Kline 1985; Kline and Rosenberg 1986). The former is a technology-push model and the latter is a market-pull model.

A cross-generational synthetic framework, which is newly introduced here for better understanding of the innovation processes, suggests that the Kline model actually takes the place of the first linear model as the market grows mature. This framework is derived from the “market experiment” model in which new products or services can be detected only by having experiments in the real market. Further, it suggests a “market creation” model in which new products and services are created in the market by interactive synergy among consumers and producers. These future innovation models manifest a new type of technologist that I term “techno-producer,” who plays an important role as an innovator in a highly advanced techno-flow market that is designed for such a complex future innovation process.

Paradigm Shift of Innovation Management

The paradigm of the management of technology in Japan is on the brink of an overall shift. How to create an original product target to generate a radical innovation is now the central issue for technology management. This is completely different in nature from the conventional management for incremental process. It is critically important to establish a new management system that surpasses the conventional style by focusing on concept creation and rapid and dynamic decision-making to achieve agile management. The linkage between research and technology development (RTD) and the corporate business strategy, RTD networking and outsourcing is extremely crucial in establishing a new management system. Higher integration of industry, academia and government are also important.

Among others, strategic planning for creating new innovations is important for Japan as well as for the world economy. The main focus of this paper is on the innovation model of the next generation, which will work more effectively in the intensive IT-related-knowledge based industry and society.

Innovation process is complex and uncertain. There have been a lot of arguments for many years about whether to choose the technology-push “linear model” or the market-pull “chain-linked model.” Our primary concern in this paper is how to generate
new innovations in order to enhance industrial competitiveness and contribute to
the world economy. Our interest in the study is to determine what kind of innovation
model would become dominant in the future.

For this purpose, this paper proposes a cross-generational innovation model that
suggests a future direction, and a new type of technologist called a “techno-producer,”
whose main role is to set creative objectives and coordinate the practical programs
with technology-based innovator. The goal of the techno-producer should be to achieve
the innovative objectives in a “highly advanced techno-flow market” that should be
provided as a social infrastructure to enhance technological knowledge transfer based
on the market mechanism.

**Linear Model to Kline Model**

The “linear model” of innovation has been widely spread among scientists, engineers,
corporate management, and many other people in various countries. This model puts
the “research” activity ahead of the innovation process and the “development” process
comes after the “research” activity. Then, it leads to the “production” and finally to
the “marketing” process, as shown in Figure 4.

**Figure 4. Linear Model of Innovation**

Kline and Rosenberg (1986) proposed a new “chain-linked” innovation process
model against the conventional “linear model” accepted for many years. Innovation
is complex, uncertain, somewhat disorderly, and subject to changes of many sorts.
Innovation is also difficult to measure and demands close coordination of adequate
technical knowledge and excellent market judgment in order to satisfy economic, tech­
nological, and other types of constraints—all simultaneously. The process of innovation
must be viewed as a series of changes in a complex system not only of hardware,
but also of market environment, production facilities and knowledge, and the social
contexts of the innovation organization.

Figure 5 shows the “chain-linked model” that represents the central chain-of-innovation
stemming from “market finding.” The path begins with a product concept based on
the market finding. Then, the invention, analytic design, detailed design and test come
after the first step. It continues through production, redesign, distribution and marketing,
with feedback. The characteristics of this model are: first, the innovation process
is engineering and it is separated from the research process of knowledge creation
in the upper science layer; secondly, as the Kline model made clear, the starting
point of innovation is the market finding; thirdly, it provides the feedback for the
previous stages. The chain-link between the knowledge layer of research and the
innovation process layer is very important.
The Kline model clearly explains the LCD display industry case of Japan, one of the typical examples of success in recent innovation that showed the importance of “demand articulation” in adjusting technologies to the market demands, as shown in Figure 6.

**FIGURE 5. CHAIN-LINKED INNOVATION PROCESS MODEL**

**FIGURE 6. SPIRAL INNOVATION PROCESS OF LCD DISPLAY**

Fumio Kodama named it a “trickle-up innovation” that continues market-driven innovation with such a spiral advancement process (Kodama 1991).
Cross-Generational Interpretation of the Innovation Models

The technology-oriented linear model and the market-driven chain-linked model have been discussed among many researchers from dichotomous viewpoints. However, it could be interpreted as one generation taking over another as the market grows over time. Accordingly, the linear model is interpreted as the first-generation model in this generational framework, and the Kline model as the second-generation model. In the first generation, market needs are obvious to the researchers and engineers when finding the technologies necessary to the demand. However, as the market grows and becomes mature in the second generation, careful market experiments and observations are necessary to find market needs. In the third generation, market needs can no longer be grasped only by observation but also by placing products on the real market as a trial.

The market matures stepwise from the first generation, "linear model," in which the market is self-evident, to the second generation, "Kline model," in which the market is found by observation, then to the third generation, "experimental model," in which the market is explored by market experiments.

Accordingly, this framework no longer treats the linear model and the Kline chain-linked model as dichotomous or conflicting perspective, but it puts them in the generational stage of market advancement.

**Figure 7. A CROSS-GENERATIONAL INNOVATION PROCESS MODEL**

Next Generation Innovation Model: A Cross-Generational Viewpoint

The recent case studies of Japanese innovations, such as the ‘i-mode’ mobile phone, Sony’s PlayStation game, and their marketing strategies, provide good examples for the third experimental and fourth interactive models. These models comply with the recent marketing strategies using Internet websites to meet user’s demand and create a new interactive platform equipped with interactive chances and places ("Ba" in Japanese) (Nonaka et al. 2001).

This implies that for an innovator to lead the next generational innovation, it is necessary for a person to be capable of generating such concepts by “abduction,”
a new way of thinking. Figure 8 shows a generational innovation process model, which proceeds from the third-generation "abduction model" to the fourth-generation "interactive model," each of which requires a different type of innovation development management.

**Figure 8. Next-Generation Innovation Model**

In the third generation, market demands can no longer be determined only by observation but also by experimenting via placing some exploratory products in the market. As the market grows mature, its demands become weak and uncertain and it sometimes needs to be stimulated. In the fourth generation, new markets should be created. In other words, the market undergoes different stages from "self-evident market," to "market finding," to "market experiment," and finally to "market creation" stage. It is safe to say that the types of innovation processes also change according to the market maturity. Thus, in the next generational models, the linear model and Kline model are no longer dichotomous in terms of "technology-push" vs. "market-pull" models. Instead, the maturity level of the market characterizes them. In order for a company to lead innovation in the third or fourth generation process, it must be able to generate new product concepts. This requires a new type of technologist called "techno-producer" as an innovator, who leads the creative activities needed for the market experiments and creation.

**IV. Strategy for Next Generation Innovation System**

It is important for policy-makers and technology managers to have access to reliable databases, which that show the level of science and technology and industrial competitiveness that are crucial for the formulation of strategic frameworks. For industrial and economic restoration, strategic goals and implementation of the programs must be set up first to quickly reflect the industrial sector.

JATES, for example, recently tried to promote this whole process aggressively with close cooperation with different types of industries by funding the Industrial Science and Technology Competitiveness Committee that would start a systematic approach
to develop industrial strategies (Li, Ishii, and Kameoka 2001). The basic concept of the committee installation was a triangular structure composed of three partners: supervisors of experienced intellectuals, corporate executives with knowledge in practice, and young core workgroups of technology managers to develop strategic programs.

Time for Techno-Producers to Prevail

A techno-producer, who sets up the strategic and creative goals for creating new industries, acts like a composer or conductor in an orchestra in the sense that he needs not only to generate new concepts and construct strategies but also to lead the process of innovation. Techno-producers, shown in Figure 9, play two roles of setting creative goals and leading the activities to achieve the goals.

![Figure 9. Techno-producer](image)

Techno-producers are asked to play their parts inside their corporate structures as well as across corporate boundaries to promote cooperation among the industrial, governmental, and academic sectors. It is important for a country to develop an innovation platform on which producers create their strategic concepts and participate in sharing strategic goals as actively as possible. To facilitate the activities, a sophisticated infrastructure has to be built to enhance the flow of technological knowledge across organizational and national borders. In order to promote this type of new infrastructure and to enhance technology transfer based on the market mechanism, a “highly advanced techno-flow market” should be established.

Shaping social infrastructure for R&D including these elements is very important for Japan to prompt itself to build a science-and technology-based nation as prescribed by the basic science and technology law established in 1999. It provides an effective way to avoid its economic stagnation and contribute more to the world economy,
by refraining from homogeneous and excessive competition in both knowledge-intensive information industry and traditional manufacturing industry.

According to the recent survey on industrial competitiveness, Japan has a great technological potential to improve its competitiveness in its industries, and thus has more chances to grow its market if techno-producers create strategic objectives and present inspiring targets. Although there are some weaknesses in Japanese industrial technologies, the nation's overall potential is strong enough to make valuable contributions to the world economy and prosperity.

**Concept of Competitiveness for the 21 Century**

At the beginning of the 21st century, it is worth taking a look at what competitiveness is for and what it should be like from a philosophical viewpoint. What is competitiveness? Hiroshi Inose raised a significant point that explains the concept of competitiveness. He wrote:

The word ‘compete’ derives from a Latin word “*competere,*” The prefix “*com*” means “*together,*” and “*petere*” means “*pursue.*” Consequently, “*competere*” means to “*pursue together.*” However, what is to pursue? The answer is human ideals. When people pursue ideals, they help each other and strive for goals together. In correcting errors and weaknesses, and acknowledging each other’s insights and strengths, they see the true competitiveness. Thus, competitiveness should come from the power for self-discipline instead of the motivation imposed by commanding power, tricks, or fraud tactics, just because their purpose is to pursue human ideals (Inose et al. 2000).

He clarified an 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 the oriental *kyösei* thought would stimulate new thinking beyond the current western concept of competition (Kaku 1997). He said that Japan, from this time on, should always keep this new idea in mind and work to prompt people all over the world to understand this for their happiness in the 21st century (JATES 2000).

**V. CONCLUSION**

From the analysis based on the surveys, although there are some weaknesses in Japanese industrial technologies, Japan's overall potential is strong enough to make valuable contributions to the world economy. The results showed that the weaknesses were the lack of innovation management, which produces new concept products by linking available technologies, and the unawareness of the relationship between corporate
cultures and social environment that support the creative activities. These shortcomings could be remedied by improving the corporate knowledge of technology and innovation management. This becomes imperative because the basis of industrial competitiveness has started to shift from natural science and technology to humanities and new social infrastructure is needed to facilitate the flow of advanced technological knowledge.

The newly introduced framework of cross-generational innovation model is derived from the next generation innovation models; the “market experiment” model for the third innovation stage, and the “market creation” model for the fourth stage characterized by interactive platform. The next generational innovators are a new type of technologist, the so-called “techno-producers” who play a crucial role as concept creators, in a sophisticated national innovation system equipped with highly advanced technological knowledge.

Creating new industries by promoting innovations is critically important for a country to prosper. This paper provided a new approach to generate innovations, and introduced the basic concept of “symbiotic competition” with others to promote the world cooperation in the 21st century.

REFERENCES

Council on Competitiveness. 1994. Critical Technologies Updates 1994.
Council on Competitiveness. 1999. The New Challenge to America’s Prosperity: Finding from the Innovation Index.
Council on Competitiveness. 1999. Gaining New Ground: Technology Priorities for America’s Future.
Dentsu Institute for Human Studies (DIHS). 1999. World Competitiveness Report 1999 (in Japanese).
IMD. 2001. World Competitiveness Yearbook 2001.
Inose, Hiroshi, Akio Yamanouchi, and Akio Kameoka. 2000. “Japan’s Technological Competitiveness in Industrial Technology and Economy (in Japanese).” Technology and Economy: 451.
Japan Machinery Federation. 1999. Research on Strengthening the International Competitiveness of Japan’s Machine Industry (Part 2) Report on Factors of Competitiveness (in Japanese).
Japan Research Institute (JRI) and JATES. 2000. Research on the Evaluation of and Factors in Japan’s Industrial Competitiveness with Regard to Electrical Devices and Related Fields Part 2 (in Japanese). Tokyo: JATES.
Japan Techno-Economics Society. 1994. Made in Japan Guide to Reforming Japan’s Manufacturing Industry. Supervised by Hiroyuki Yoshikawa and edited by the Japan Committee on Industrial Performance (JCIP) (in Japanese). Tokyo: JATES.
Japan Techno-Economics Society. 1999. “Aiming to Develop Practical Strategic Programs Based on a Japanese Version of the Young Report (in Japanese).” Technology and Economy 339: 6257.
Japan Techno-Economics Society. 1999. Evaluation of Japan’s International Competitiveness.
in Industrial Technology (in Japanese). Tokyo: JATES.
Japan Techno-Economics Society. 2000. Trend of Japan's International Competitiveness in Industrial Technology (in Japanese). Tokyo: JATES.
Kaku, Ryuzaburo. 1997. “The Path of Kyosei.” Harvard Business Review, July-August: 55-63.
Kameoka, Akio, Gaku Ishii, Mayumi Sakai, Teruyuki Kimura, and Nobuaki Kayanuma. 2001. Comparative Evaluation of Industry/Technological Competitiveness in Japan, the USA, Europe and Asia - A New Framework of 'Symbiotic Competitiveness' for the 21 Century, PICMET 01, Portland, Oregon.
Kameoka, Akio, Moriharu Marumoto, Hajime Wakuta, and Masaharu Sakuta. 1999. “International Evaluation of Japan's Competitiveness in Industrial Technology: Definition, Methodology, Result, and Countermeasure.” Proceedings of the 14th Annual Meeting of Japan Society of Science Policy and Research Management (in Japanese), Tokyo, 179-184.
Kameoka, Akio. 1999. “Strengthen Japan's International Competitiveness in Industrial Scientific Technology in Japanese.” R&D Management, December: 1222.
Kameoka, Ito, Kobayashi. 2001. A Cross-Generation Framework for Deriving Next Generation Innovation Process Mode., IEEE IEMC2001 Proceedings 'Change Management and the New Industrial Revolution.' Albany, New York, USA, October 7-9, 2001.
Kameoka Akio. 2001. International Comparison of Japanese Competitiveness and Policies in Industrial Technology-A New Framework of 'Symbiotic Competitiveness' for the 21 Century. International Conference on 'Measuring and Evaluating R&D and Innovation in Knowledge Economy,' Taipei, Taiwan, August: 23-24.
Kline, Stephen J. 1985. “Innovation is Not a Linear Process.” Research Management, 24 (4): 36-45.
Kline, Stephen J. and Nathan Rosenberg. 1986. “An Overview of Innovation.” In The Positive Sum Strategy, ed. R. Landau and N. Rosenberg, Washington: National Academy Press.
Kodama, Fumio, and Kiminori Genba. 2000. Strategic Approach to Creating New Business and Industry: Case studies by Cycle Theory (in Japanese). Tokyo: Seisansei Shupansha.
Kodama, Fumio. 1991. Analyzing Japanese High Technologies: The Techno-paradigm Shift. New York: Printer.
Meng Li, Gaku Ishii, Akio Kameoka. 2001. A Framework on Industrial Competitiveness: An Alternative Perspective Blending Competition with Cooperation. PICMET'01, Portland, Oregon.
Miller, William L. and Langdon Morris. 1998. Fourth Generation R&D: Managing Knowledge, Technology, and Innovation. New York: John Willey & Sons.
Nonaka, Ikujiro, Dai Seno, Toshi Akutsu. 2001. Practicing Management by Knowledge (in Japanese). Tokyo: Hakuto Shobo.
OECD. 1997. Industrial Competitiveness: Benchmarking Business Environment in the Global Economy. Paris: Publishing service, OECD Publishing.
President's Commission on Industrial Competitiveness. 1985. Global Competition The New Reality. Washington, D.C.
Suzuki, Jun. 2001. “IT Industry and Technological Innovation Models (in Japanese).” The 30 Anniversary Symposium of IFTEC (Institute for Future Technology). Tokyo.