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Strategic Management of Technology and Innovation

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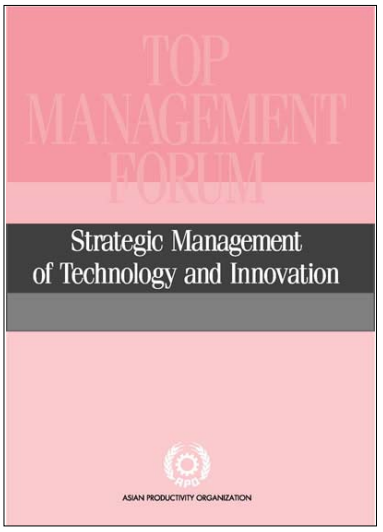
Report of the APO Top Management Forum on Strategic Management of Technology and Innovation



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TOP MANAGEMENT FORUM

Strategic Management of Technology and Innovation

ASIAN PRODUCTIVITY ORGANIZATION

Report of the APO Top Management Forum on Strategic Management of Technology and Innovation

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Foreword

In the global economy, companies must enhance their capacity for technology development and innovation, thereby, enabling the continuous creation of additional customer value. For that reason, many Japanese enterprises have introduced the management of technology to utilize the results of advances in technology in the most productive manner to offer more competitive products and services. The management of technology aims to maximize the cost-effectiveness of investments in technology development and ultimately contribute to enterprise value.

The APO Top Management Forum 2007 was organized in collaboration with the Japan Productivity Center for Socio-Economic Development (JPC-SED) and gathered 35 overseas participants from 18 APO member countries, as well as 20 local participants. The forum focused on the strategic management of technology. A wealth of information on the topic was offered by the distinguished speakers, and I would like to express my deep gratitude to them for sharing their knowledge and experience. Thanks to their insightful presentations, the participants had opportunities to examine the Japanese experience and best practices of the management of technology in enterprises, covering support from the government, creating leadership and an organizational culture, and human resources development to promote technology development and innovation. I hope that the participants will adapt the insights gained to enhance systems to manage technology and innovation in their own countries.

I also would like to express sincere gratitude to the Japanese government for financial support and to the JPC-SED for its assistance in organizing the forum.

This publication contains summaries of the presentations as well as a strategic paper on the management of technology and is intended to help the readers to review the topics covered in the APO Top Management Forum 2007. I hope that this volume is seen as useful to those involved in creating new concepts of how businesses can foster innovation to achieve sustainable growth in the Asia-Pacific region.

Shigeo Takenaka
Secretary-General

Tokyo
December 2007

Capturing the Value from Innovation — Introduction to Our Discussion at the Japan Research Center for Technology and Innovation Management

Dr. Kiyonori Sakakibara
Faculty of Policy Management
Keio University

New technology is a key factor for the success of both companies and nations. Through active investment in R&D, Japanese firms have succeeded in generating new technologies. However, capturing the value from these technologies is also important, and research suggests that the relative R&D performance of Japanese manufacturing firms has declined. While Japan is very active in R&D investment, capital investment has not followed. In addition, R&D investment has become less profitable.

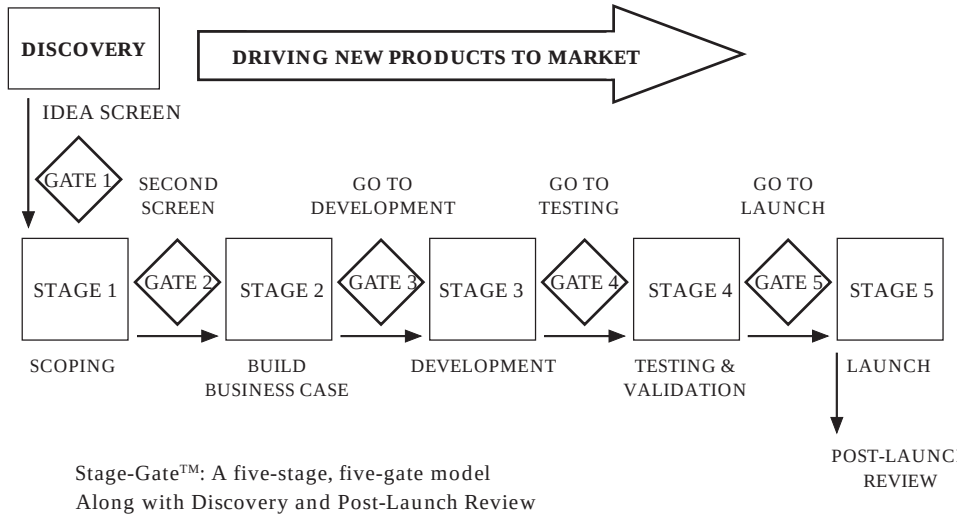
Why has R&D performance worsened in Japan? Some people say that there is overestimation of technological advantage, less consciousness of technological roadmaps, and continuous and spread investment in the same category of products. The result is that the business domain tends to be less focused. Another possible reason is inflexibility in project management. It is incremental and process-driven rather than target-driven; there is a reliance on continuous teamwork efforts. There is also hesitation in terminating R&D projects, which increases risk.

The challenge of Japan's technology strategy means that increased networking is now emphasized. There is currently limited alliance with universities and public research institutes. Rather, there is heavy reliance on internal R&D because large Japanese manufacturing companies have rich internal R&D resources. Compared to their US and European counterparts, Japanese companies are not very active in initiating international strategic technology alliances. While Japan's domestic companies are highly R&D-intensive in comparison with other OECD countries, most affiliates of foreign companies in Japan are not active in R&D in Japan. The implication is that Japan is isolated from the global knowledge network.

Another challenge of Japan's technology strategy is that it must be more target-driven. Currently there is no systematic development of a "technology platform" as the engine of growth, and there is weak vision and little strategic focus. The new product development textbook recommends the Stage-Gate system (see Figure 1). This management technique separates the innovation process into several stages, each stage consisting of a set of prescribed activities. The entrance to each stage is called a "gate." These gates control the process and serve as the go / stop checkpoint. By using the Stage-Gate system we can speed up the product development process and be more target-driven.

The third challenge of Japan's technology strategy is to capture more value from R&D. About 80% of Japanese patents are never commercialized. The ability to get returns from technological innovations varies between and within industries. I will take the example of Canon. Its business machines segment is quite profitable, with more than 20% returns on sales. After-sales support and consumable supplies are powerful sources of profit in this industry, and therefore the industry itself is profitable. Nonetheless, Canon consistently shows higher profitability than its domestic rivals. The important question is: why?

The Typical Stage-Gate™ Model — From Discovery to Launch



Source: Robert G.Cooper, "Winning at New Products", Third Edition, 2001, p.130.

Figure 1

In 1982, Canon developed the world's first all-in-one toner cartridge for copying machines, dramatically reducing the need for nationwide support and maintenance networks. The technology combined not only the consumables but also Canon's proprietary technologies, which meant that the company's intellectual property and its profitability were both embedded in the cartridge. In 1990, Canon launched a super-compact inkjet printer that combined the ink tank and the print head in a single disposable unit to make the body of the product inexpensive. However, this resulted in high running costs, earning Canon large profits from the disposable units. In 1993, Epson launched the MJ-500, which reduced running costs by separating the ink tank and print head, in contrast with Canon's strategy. In response, Canon adopted and patented designs that enabled then to flexibly shift added value between the printer body and the cartridge. The running costs for Canon printers therefore do not follow a consistent trend over time, bucking the general trend of consistently increasing running costs.

In conclusion, the case of Canon shows how variation in architecture design can determine a company's profit profile, so that it is able to meet the competitive conditions in its market while keeping its profitability robust. Implementing innovations is unquestionably important, but simply having strong technologies does not guarantee high profitability.

Questions and Answers

Question: What should be the balance between R&D costs and the profitability expectations for a company? Is there any benchmark for the percentage of company profits which should be earmarked as the R&D budget?

Dr. Sakakibara: You cannot really be sure what percentage of R&D expenditure is going to become profitable. Generally speaking, Japanese companies tend to invest a stable percentage of total sales as R&D expenditure. Japan's R&D expenditure as a share of total

sales is high, leading to a huge number of patents being accumulated, but profit from those technological potentials is comparatively low. Therefore there is no clear benchmark or indicator.

Question: Have you done any work in the area of initiating R&D efforts?

Dr. Sakakibara: My guess is that for many Asian companies, acquiring or generating technologies is itself an important subject for discussion. The simplest recommendation is that there is an ample technology pool in Japan you can utilize. But my point is that getting value from those technologies is not easy.

Question: Given the extreme competitiveness of the business atmosphere and the extremely protective nature of R&D from a company perspective, how has the Japanese business community been able to overcome the difficulties in networking?

Dr. Sakakibara: That is a very difficult task for Japanese companies. Generally, large Japanese firms have ample internal R&D resources that they want to utilize because they are confident that they have good people, technology, and facilities. Therefore, they are not so active in networking and utilizing global R&D resources. However, in many industries here, having an R&D base within the firms is not sufficient. Tying up with other countries, other firms, and other institutes is becoming more and more important.

Question: In Japan's experience, how long should one expect to wait for returns from R&D?

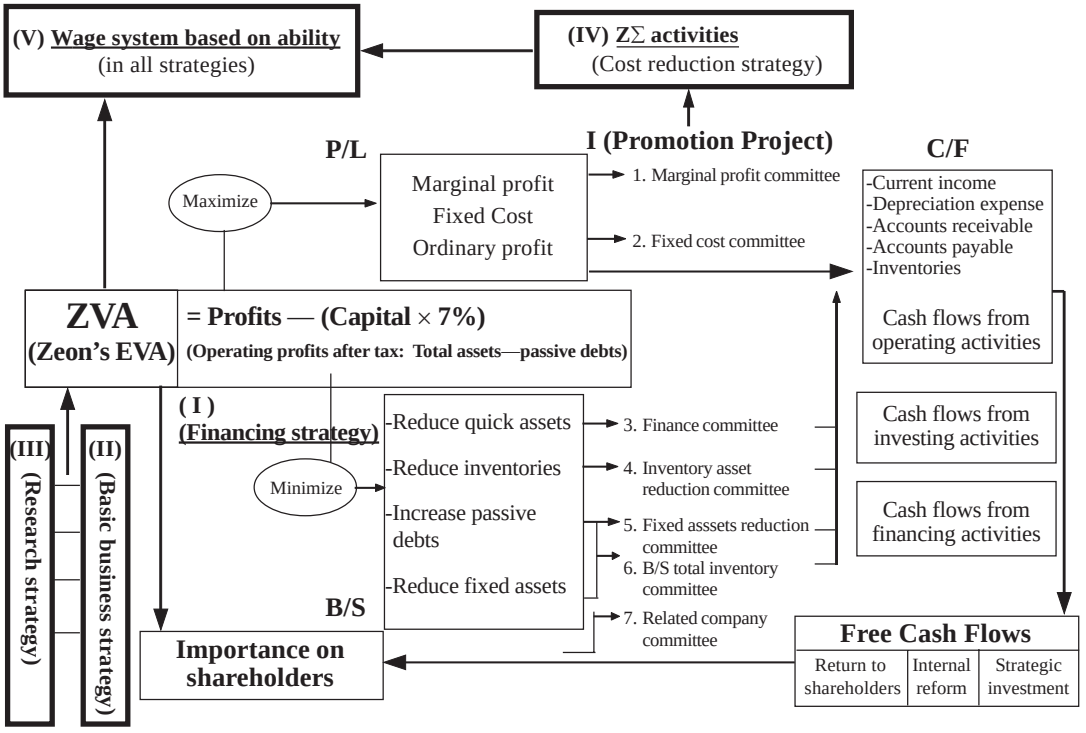
Dr. Sakakibara: Within individual private companies and industry categories there are different time frames for getting returns from R&D. I guess for a new product development, within two or three years. From the business division point of view, the time frame must be within a couple of years. But for large corporations the time frame is from five to seven years, and not more than 10 years.

Original and Without Compare: Zeon Management Strategy to Maximize Corporate Value

Katsuhiko Nakano
Chairman
Zeon Corporation

Zeon Corporation is a medium-scale chemical company with expanding operations in the specialty rubber and specialty high-performance businesses. At Zeon, we operate under the motto "Original and Without Compare." Basic management guidelines must clearly identify management philosophy and at the center of our basic management system is Zeon Value Added (ZVA). Our development is based on technologies that are original and without compare, and we operate under an original and unique Zeon management system.

ZVA is at the heart of our company's interactive process. It entails a financial strategy, basic business strategy, research strategy, z-sigma activities, and a wage system based on ability. All Zeon employees are provided a copy of our basic management system (see Figure 1) to allow them to understand the overall direction of the company, including the importance of reinvesting profits in new businesses.



PZ-2 (3-year) Plan

Source: Zeon

Figure 1. Zeon's Management System

Zeon has never had a voluntary retirement system. We instead promote efficiencies in our operations through "*kaizen*." The key to generating good employee suggestions and implementing them, as well swift advancements in R&D, is employee confidence that their jobs are secure and that top management places high importance on job security.

There are four basic tenets to Zeon's concept of technology management. First is that companies which cannot continue to create new products and new businesses will see a decline. This applies not only to R&D but also to business units. Second is R&D activities must foresee future needs and stay ahead of paradigm shifts in business development. Society is changing very dramatically and quickly, and as such, needs are also changing very dramatically. We have to stay ahead of the changes to come and to do so R&D activities are imperative. Also, when we receive verbal information from customers, it must be translated into data so that it can be connected to the technology R&D platform within the company. Third is verbal information must be converted into data and R&D activities must be linked to the company's technologies. Fourth is that it is too late when everybody agrees and the situation gains a clear perspective. We have to be ahead of our competitors and conduct our decision making in a top-down manner so as to act quickly. It is along these principles that we have planned and implemented R&D activities.

All products have a lifecycle, namely introduction, growth, maturity and decline. Each of these stages has its own strategies. The introduction stage involves launching new technologies one after another in a very proactive way. Key to this is a system of continuous innovation through which we base our R&D activities on the customer's perspective. The conventional approach to product introduction is a process of basic research, applied research, development, commercialization, and finally sales and distribution. At Zeon, however, the verbal information we have obtained from our customers tells us that a paradigm shift is on the horizon. As such, our approach to product introduction is guided by outstanding market insight and a synchronization of technological development and market development, or more specifically an interrelated process of steps consisting of market insight, concept / basic design, detailed design, production and redesign, and sales and distribution. During a product's growth stage, profits are obtained for innovative products but the difficulty facing companies is that innovative products are not found so frequently. Hence, it is important that business activities are maintained between the launch of innovative products. Finally, for the maturity stage, the aim should be market dominance. The biggest variable here is cost: where the cost is lower, there is survival, and where the cost is higher, products will lose to competitors.

Internally, both company leaders and researchers must be able to manage human resources. Yet, when it comes to management, there are many different conceptions. To achieve goals critical to the company's focus we need to promote the cooperation and participation of employees. Leaders must possess the ability to motivate employees. This is what I call the management.

Leaders must possess particular skills to excel in their role of an organization leader. These skills can be categorized three ways. First is to plan, act, and evaluate. In this respect, an organization leader needs to be able to foresee trends and make preparations toward them, have a vision of how things should be five years from now and strive toward that, and competently manage goals, tasks and evaluations at hand. Second is personal management and the education of junior staff. Here, the organization leader needs to focus on work that should be processed strategically, create time to educate junior staff and him / herself, support junior staff to complete assigned tasks and make decisions by assessing true causes. Third is leadership. For this skill, the organization leader needs to effectively communicate, motivate and have the ability to impress junior staff.

Overall, Zeon is striving to develop unique and original technologies without compare. In doing so, we need to focus on the product lifecycle and business strategies, advance customer-oriented R&D and foresee paradigm shifts based on verbal information and input by customers, promote decision-making with an aim to speed up processes and maintain the sustained drive of R&D personnel with a focus on synchronizing management and R&D strategies. In all of these ways, MOT is business management.

Questions and Answers

Question: In rewarding employees for their cost reductions, how do you distinguish between individual and group efforts? Is it not that individual enthusiasm goes down when the group is recognized instead? In addition, labor unions have been known for voicing their points of view through strikes and organized resistance. What is the background to Zeon's labor union converting its strike fund into a company equity fund?

Mr. Nakano: Concerning the first question, we look at achievements at the group level. While it is true that in a group, one person may have perhaps come up with a wonderful idea, that idea has been successfully supported and implemented by the entire group. Great improvement is reflected in a bonus to all the members of the group. As for the second question, Zeon has come to realize that for the labor union, job security is its most important requirement. The union also is not asking for higher wages to cause problems for top management. It just wants to the workers to have a share of the company's profits. Hence, our approach is to cooperate and collaborate with the union to expand the "pie" so that we all can have a bigger piece of it and ensure that job security is maintained. In doing so, we have built a trust-based relationship between the labor union and management.

Importance of Practical MOT Human Resources Development and Policy of METI

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Trade and Economic Cooperation Bureau
Ministry of Economy, Trade and Industry (METI)

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Planning for Industrial Technology
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Industrial Science and Technology Policy and Environment Bureau
Ministry of Economy, Trade and Industry (METI)

Let me begin with some of the problems that Japan faces today. After the economic bubble burst, domestic investment in plant and equipment dropped sharply. However, despite the economic recession, R&D spending has steadily increased. Although Japan is one of the most active countries in the world in terms of patent registration, the value-added has declined in recent years. In the electric machinery and automobiles industries, R&D investment has not led to high profitability. Compared with other advanced nations, Japan is experiencing rather slow growth in terms of total factor productivity. Business strategies, management of technology, and product planning capabilities are regarded as weak areas for Japanese companies. A large proportion of companies believe the conventional linear innovation model no longer works. To summarize the current situation, the environment surrounding technology innovation is changing. There are changes in the relationship between basic science and engineering and technology. And the advent of a knowledge society and knowledge networks has led to an era of open innovation.

Recognizing these challenges, our ministry began to construct the Innovation Super Highway Initiative last year. Innovation can be achieved when newly created goods and services from new technology bring about changes in economy and society. We recently formed a new economic growth strategy using two virtuous cycles centered on innovation. One virtuous cycle is the link between Japanese growth and the growth of Asian countries. The second is the link between innovations in different areas of Japan and creation of new demand. For cross-department or cross-sector policies, we believe five areas need to be promoted: people, goods, money, technology, and knowledge.

The three areas of science, technology, and business and manufacturing need to be well linked with each other. Between technology and business, public research organizations may play a very important role. The Innovation Super Highway Plan tries to create bi-directional flows between research and the market, upstream and downstream. Knowledge from different disciplines or industries must also be integrated in order to achieve innovation. In intellectual property creation, the integration of knowledge of different scientific domains is becoming even more important. Thus, the research areas which involve multiple domains are very important in making new innovations and breakthroughs. It is important that collaboration be offered from business to different disciplines.

Obstacles to collaboration between industry and academia must be removed by providing a better support system. University researchers who make great achievements in basic research need to collaborate more with private companies by finding new job opportunities in private firms. We believe that such academy-industry partnerships need to be further promoted. In order to survive, universities should also be taking initiatives. Universities, as creators of knowledge, should look at a variety of themes downstream. That is how R&D should be promoted on the university side.

Human resources for management of technology (MOT) are necessary, because such people are able to have a comprehensive view covering R&D, basic research, business activities, and academia. MOT human resources are necessary in various locations of business activities. Plant managers and heads of research departments are regarded as MOT human resources. These people will develop into CEOs, CTOs, or research fellows.

Both in terms of quantity and quality, human resources that can mediate between science, technology, and society are lacking, and there is a shortage of management of such human resources. Today, there can be a great deal of integration, resonance, and trade-off among technologies and sciences, so management has become quite complex, requiring a higher level of management skills.

For the past five years we have promoted the establishment of MOT programs, primarily at universities. Many universities and private education organizations are developing MOT human resources, and METI is offering support. In order to develop MOT human resources, we have to look at different business areas: overall management of business, commercialization, technology development, production, quality, and logistics. Each area requires different skills. We are first looking to increase the quantity of programs, and then we are going to focus on increasing the sophistication of contents. After five years of support, we have seen the appearance of many programs.

MOT education is mainly aimed at those who are already working in society, so they have to work while they try to complete their courses at night or on weekends. Because of their specific needs, we have to offer very efficient and friendly courses. Educational institutions need to verify the quality of the programs they offer. We are trying to establish criteria to evaluate the courses provided, and accreditation and certification are part of the support we wish to offer. Last year we prepared MOT education guidelines in order to have effective evaluation.

We looked at subjects provided by universities and prepared a matrix matching the desired MOT skills to subjects provided by the university courses. The matrix aims to make courses convenient to those who wish to participate, and helps universities to have an objective overview of the program they are providing. The matrix is also intended as a yardstick for businesses to evaluate those who wish to be recruited. It is important that businesses actively use MOT human resources. Also, there should be feedback through review by universities and industry collaborating together. That is what we have to do in the future.

Working for the Benefit of Society — Best Matching of Humans & Machines

Tsukasa Yamashita
Senior Managing Director
Omron Corporation

Omron's philosophy is "Let machines do what machines can do and humans should enjoy the activities in more creative field." In one word, "automation" is the value that has been ever-present in our minds as we have contributed to society since the foundation of Omron.

Globally, Omron strives to achieve *"Kyouso"* (collaborative innovation), whereby we work to create new and better things with other people and organizations. In this activity, we recognize the importance of "*Wa*" (harmony) with partners. With this in mind, there are two key points in conducting successful collaborative activities. The first is "open minded communication." For truly valuable output from collaboration, sharing values and visions with each other is important. The second is "finding the right partner." For the best achievement, partnering with the top people is strongly expected. In order to have the best association, we must be aware of the need to manage ourselves to raise ourselves technically and ideologically to communicate with the top people.

On the global scale, China is one country in which we are very much interested because of its huge market and many talented researchers. Today, the Chinese market is growing and changing and therefore its particular needs have still not been identified clearly. We think the needs in China should be found and developed by people in China. In order to undertake and promote innovation in China, we created the Omron R&D Collaborative Innovation Center in Shanghai. At this facility, we aim to present the space for collaborative activity. We hope that researchers in China will use this facility to meet with many other researchers including Omron's researchers and to conduct R&D collaboration with those people.

Research is the effort to create something that has not existed in the world before. As a company, the value of this research is shared with society only when its achievements are presented to society as a new beneficial product. Therefore, in companies, researchers are often given instructions on the research themes to be pursued. But, researchers need to have their own "will" and "strategy" to accomplish this task. Such "will" is the sense of what each researcher can accomplish and how to match the value of that accomplishment to societal needs. No matter how deeply the researchers pursue a technology, if this technology does not become a commercial product, the achievement does not have any value. And the "strategy" is how each researcher overcomes a lot of hurdles and obstacles in order to achieve the will. To facilitate the development of such a mindset among each and every researcher, as an example, we have poster sessions with many young engineers every month to discuss each researcher's "will" and "strategy" with their supervisors, colleagues, and researchers from different fields.

As a company working for the benefit of society, we contribute to society by creating values in respect to "automation." For this purpose, we have made many efforts to develop new technology based on the values of "fast" and "small" and to realize it by the core technology of "sensing & control." In this activity of making new things or values, the

researchers are asked to brush up their own "will" and "strategy." Researchers also are expected to have the mindset to lead their activities by themselves along with collaborative activity under the concept of "*Kyouso*" and "*Wa*."

Questions and Answers

Question: Regarding collaboration between different organizations and even different countries, what are the limitations that you have encountered in transferring technology, sharing information, etc.?

Mr. Yamashita: Since our emphasis is on collaboration over the long term, it is hard to expect a return in a very short period. Synthesizing and having meetings of the mind among researchers are things that we emphasize. Therefore, each researcher has to have his or her idea and there should be some synergy with other researchers. We try to recruit people who can share such ideas with as many people as possible. If this environment development is successful, I think there are always new research and business opportunities. And another comment is that in order to meet with good people, we have to improve ourselves. Through the enlightenment and the improving of ourselves, we will secure more opportunities to meet with good people.

Question: When you do joint research, who gets the patent?

Mr. Yamashita: If one side starts to assert its rights, there will be conflict between the parties. In order to resolve the conflict, we must have talks and consultations. The distribution of the patent right has to be discussed based on the contribution of each party.

Question: We are already struggling to harmonize corporate objectives and corporate social responsibility. How much should a corporation contribute toward the development of society as a part of its CSR activity?

Mr. Yamashita: Corporations in the past have focused too much on just making profit. Today, however, "*Wa*" (harmony) is necessary. We need to put forth efforts to satisfy everybody. If we can provide society with value, we should be able to obtain the equivalent return.

Question: There are a lot of global problems facing human society nowadays, such as avian influenza, HIV, and global warming. Is Omron engaged in R&D to address these societal problems?

Mr. Yamashita: We are aiming to contribute to society through our products such as many kinds of sensors and controllers. And we are currently aiming to put forth efforts on the domains of safety, security, environment, and health. Among these, energy is one of the main issues as a social problem. We consider that we may make certain contributions in the field of energy saving.

Effective Collaboration between Major Corporations & Venture Companies on Technology Development for Creating New Businesses

Dr. Noboru Maeda, Ph.D.
Professor
Graduate School for Creative Cities
Osaka City University

The famous Professor Drucker emphasized in his book, *Innovation and Entrepreneurship*, that entrepreneurship should be fostered not only by start-ups but also by large corporations. Ten years ago, Harvard University professor Clayton Christensen published a book called *The Innovator's Dilemma*, in which he emphasized that large corporations are not able to maintain an entrepreneurial attitude because they wish to have high sales volumes, so they focus primarily on operational innovation. MIT's Professor Weber says that in this age, many technologies should be combined to build new innovations, so start-ups and large corporations should work together with the aim of overcoming large corporations' lack of entrepreneurship. Methods of implementing such "Corporate Venturing" include investments, alliances, joint development, incubation and establishment support, mergers and acquisitions, and fostering in-house start-ups. Professor Weber says that in the coming decade corporate venturing is the key to Management of Technology (MOT).

I have found three key issues in Japan. The first issue is that as business is concentrated in Tokyo, competition does not occur. In my opinion Japan should focus on the development of regional power. Japan was good at industrial agglomeration, but the majority of those industries have moved to China already, so we should shift to developing regional clusters. Those clusters should be developed and networked, for which the entrepreneurship of R&D start-ups are the key.

The second issue is that in the last 10 to 20 years, Japan has been losing some industrial strength as large Japanese corporations continue to employ the old catch-up business model despite having already caught up with other leading industrialized countries. Japan needs to shift to a front-runner model. The business model in the United States is the Silicon Valley business model. By applying information technology, many high-tech start-ups are growing while at the same time large corporations are competing with those high-tech start-ups and conducting joint development. In the European Union there is a lot of cross-border interaction, including many mergers and acquisitions. I believe that in the coming decades, the United States and Europe will continue dynamic change and continue innovating.

The third issue is that in the past 20 to 30 years, Japan has had very few high-technology R&D-oriented start-ups, because in the catch-up age they were not needed so government policy did not encourage them. But 20 years ago, Japanese government and industry realized that start-ups were needed, and so tried to foster them, in particular high-technology start-ups. Many people said that start-ups are not viable in Japan because the Japanese culture emphasizes harmony, with everybody doing the same thing, and discourages failure. I object to that opinion because we had many successful start-ups after the war in the service industry. Internet start-ups have also been very successful in Japan. So Japan does have a culture that can foster start-ups.

In the United States and Europe many successful high-technology entrepreneurs are very highly-educated. In contrast, the majority of highly-educated persons in Japan work for large corporations or national laboratories, or as university professors. This is the reason why R&D start-ups are not being created in Japan. However, in the past 10 to 15 years very capable engineers have been quitting large corporations to begin start-ups, saying that the corporations did not wish to develop areas the engineers wished to develop. Those engineers are experienced in strategic collaboration with large corporations, have close relationships with university professors, and collaborate globally. Surprisingly, many are making a profit from the first year of operation. They have working experience in the United States and wish to make IPOs from a very early stage. These days, engineering students of famous universities and young engineers of large corporations wish to move to these start-ups. This is a totally new culture.

Large corporations are not good at disruptive innovation, but if they have a win-win relationship with start-ups, they can receive entrepreneurship from the start-ups. Those start-ups badly need the help of large corporations. Nobody will buy high technology-oriented products except the large corporations, so collaboration between the two is the key in Japan. Unfortunately, the majority of large corporations' executives are not interested in start-ups, thinking that their quality is low and they are unreliable and unstable.

I have developed what I call the "five-circle" business model (see Figure 1). But unless we develop high-tech start-ups, especially in IT-related areas, Japan's new strengths cannot be utilized in this five-circle business model.

To conclude, Japan is spending over 3% of its GDP on technology research, the highest percentage in the world, but we are not really getting the returns from those investments. I think this is because Japanese industry is losing entrepreneurship, especially in the large corporations. Unless large corporations recover entrepreneurship in partnership with high-tech start-ups, Japan will not grow any further.

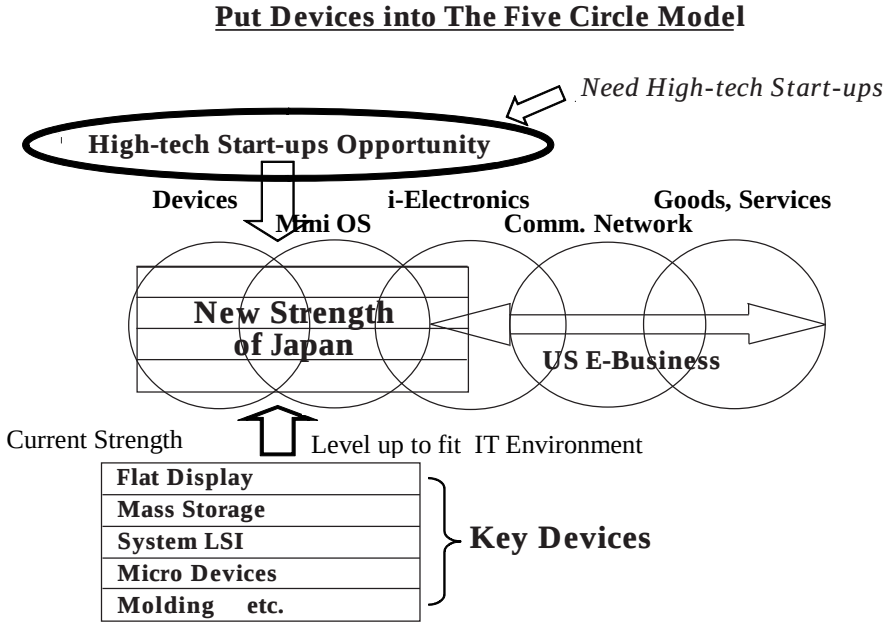

Figure 1

Questions and Answers

Question: Does Japanese economic policy match your opinion?

Dr. Maeda: In my opinion, Japan does not know what kind of business model to develop. I am emphasizing the importance of entrepreneurship, especially R&D-related entrepreneurship, but the Japanese government and large corporations are still not convinced. Having said that, I have noted that there is now some mobility. I often say to government that Japan will change even without any policy, and that government's job is to accelerate the speed of the change.

Question: What effective mechanisms can government use to foster the link-up between IT start-ups and large corporations?

Dr. Maeda: When Japan was at its peak in the 1980s, the US government and large corporations' management came to Japan to find out why Japan was so successful in manufacturing. They found Japan's success was because of the competition and collaboration between large corporations and start-ups. So the US government created a law called Small Business Innovation Research (SBR), requiring that 0.25% of government outsourcing money for R&D to be given to start-ups. In that way, the United States is developing start-ups very strategically. My opinion is that rather than just follow the American or European way, Japan should think strategically about how to foster start-ups.

Question: What difficulties and barriers face start-ups in Japan?

Dr. Maeda: In the past five years or so, many obstacles have been defined, and the government has produced many policies and incubation centers, and encouraged university collaboration, so there is a lot of activity. However, in Japan, start-ups and entrepreneurs are not respected at all. Unless we change this attitude, particularly in top management of large corporations, start-ups will not grow rapidly.

Effective Management of Technology Development

Dr. Atsushi Abe
Dean
Graduate School of Technology Management
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In the past, Japanese companies have engaged in a "catch-up" economic model, by taking existing product technologies and enhancing their yield, price, or quality. As Japan is shifting to be a technological front-runner, this catch-up model is no longer viable. However, due to its previous successes, it is difficult to move away from it. In addition, as global competition intensifies and the product cycle shrinks, agility and speed are becoming important in continuously creating new products and services. Companies are thus faced with hard decisions that bring about many unknown factors and high risks in deciding how to allocate resources for product commercialization. To address these issues, management of technology comes into play.

There are three important factors that a successful management of technology has to tackle. First, there is always a time lag between the development of a technology and the commercialization of a product or service borne out of that technology. Second, it is very hard to have insight into the future when making evaluations and planning. Third is the readiness and abilities of engineers to draft ideas and concepts and manage development.

A roadmap is an overall picture of all the activities a company should undertake in order to launch a certain product in a given time scale, usually done by a cross-functional team that gets together to brainstorm and develop the roadmap. Successful roadmapping allows a company to maximize the value of the company. However it is important to focus on the process of roadmapping rather than on the results. A roadmap aims to achieve local optimization, the value of which should maximize overall optimization. In order to implement local optimization, portfolio management and scenario planning must be combined effectively and human and monetary resources must be considered while creating a roadmap since they are limited but also important company priorities.

In creating a roadmap there are three factors that should be considered. First, clarifying the gap between the future vision and the present situation of the organization will help all members of the organization to work in a common direction to overcome this gap. Second, at each of the company, industry, and country levels, the direction and the framework related to interdisciplinary technological development can be shared, that lead to a more effective and efficient technological development activities. Finally, a roadmap is an effective tool for companies to facilitate organic coordination between technology and business. By creating a "common language," consensus among assisting teams within a company can be easily reached and in my understanding, the purpose of a technology strategy is to draw a specific story while the purpose of a roadmap is to form a specific solution to realize a specific story, such is the kind of staffing and financing required (see Figure 1).

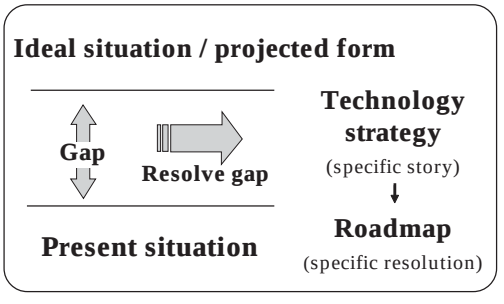

Figure 1. Procedures to Create a Roadmap

There are four types of products or technology roadmaps. First, product and technology roadmaps in specific fields. Second, roadmaps that consider alliance opportunities. Japanese companies can no longer rely on their own technology resources to be successful, so they have to form partnership alliances. Third, platform roadmaps allow engineers from different product groups to collaborate based upon a shared platform technology. Fourth, roadmaps that consider the needs of existing OEM customers.

The above types of roadmaps can be used in a number of situations. They are useful for getting a company-wide consensus, by providing a common language across the company. They also allow company executives to have a clear picture of the future of the company in a more comprehensive manner.

In as much as roadmaps offer advantages, we should not forget that roadmaps also have certain limitations. It is often the case where scientists and engineers take on the development of a technology for which the resulting products or the success of those products are still unknown. If a company only emphasizes efficiency of business creation, promising and new opportunities may be overlooked and consequently discarded at the point of approving a market roadmap. As many companies in Japan are now moving into the front-runners frontier, it is becoming particularly important to allow the seeds of new business and technology to grow.

Questions and Answers

Question: Globalization is widening competition and the product life cycle is becoming shorter. Research will probably not enjoy the luxury of having 10-years time to exploit the market before newer research takes over with newer products. In such a situation, what is the optimal product life cycle from the point of view of incurring huge R&D costs?

Dr. Abe: I would say five to 10 years is the appropriate time span. In my personal opinion, there should always be new technology replacing conventional technology.

Question: Are roadmaps suitable for small and medium-sized enterprises?

Dr. Abe: A roadmap provides a common language for communication. On the level of divisions or departments within large companies a very precise roadmap is not necessary if the people within a division know each other well. Similarly, if a company is very small perhaps a roadmap is not necessary, but if they have many supporting people, such as venture capitalists, a roadmap may be useful in communicating the vision and ideas to those people. It is not a question of how large a company is so much as how a roadmap should be used.

Question: As a company grows, more time is needed to make decisions. Considering a large company where there are many people, each having their own ideas, how can you reach a final decision without compromising the others?

Dr. Abe: In my personal opinion, final decisions should be made by a person with the authority to decide upon staffing, budgeting, and so on. But through discussions, opinions can be expressed and exchanged by other interested parties that can influence the final decision.

Denso R&D Management

Yoshifumi Kato
General Manager
Technology Planning Department
Denso Corporation

Denso is working hard to establish a presence in developing markets as well as to maintain its position in mature markets like Japan and the United States. Our aim is to be the top player in any market in which we operate. As of 2005, Denso had 25 products with a number one global market share and we are continually striving to increase our position.

Within Denso, we conduct R&D on both the corporate side and business-unit side. On the corporate side, we are working to enhance innovation while in our business units we are seeking to improve existing products through R&D. Nevertheless, it is important that there is cross-functional coordination between the two sides.

With respect to our basic philosophy and principles of R&D, even though Denso is an auto parts manufacturer, we try to take a broader perspective in our R&D. We make efforts to develop systems from a vehicle perspective and develop parts and subsystems from a systems perspective. This is one of the most important policies at Denso. A second philosophy or principle is that there is close cooperation with our clients, beginning from the early stage of development. Third is that for essential core technologies, we develop them internally regardless of the cost or effort.

As corporate R&D and business-unit R&D are separate, it is quite important that there be a shared vision between the two. For this reason, we have made a roadmap that acts as the basis for our products and technology strategy. The roadmap helps to define which business areas will produce what kinds of products and when. In creating the roadmap, it is quite important to make clear the orientation concerning R&D and to make wise resource allocation decisions.

The selection of R&D themes is quite important because it affects the very survival of the company. To decide the direction for important development, we have to maintain transparency. Hence, Denso's top management meets once a year to discuss strategies R&D direction. From there, the development advisory board or the development promotion committee and steering committees are in charge of daily activities concerning R&D management. The four major directions for Denso's R&D are environment, safety, comfort and convenience.

One of the biggest problems facing Denso is how to strengthen our engineering resources. Currently, our engineers are facing a heavy workload and human resources in engineering are becoming scarce. We have to satisfy the cost, development and speed requirements of our customers while at the same time systems are becoming increasingly complex and large scale. Failure to meet these challenges means that we will not be able to compete with our competitors.

In addressing specific measures and solutions, for human resources the first thing we can do is to enhance the capacity of our current engineers. As such, we are now improving our training programs for those engineers. To meet our demand for engineers, we strategically categorize the engineering tasks into two: tasks that must be done in-house and tasks that can be outsourced. A typical example of outsourced tasks is software coding. In the area of

tools and strategies, 3D CAD will be introduced, and we need to increase simulations to reduce our number of experiments. Development of algorithms should be conducted on a model basis and engine control adjustments have to be done to utilize engineer resources effectively. At Denso, we are putting a lot of priority on training. Denso engineers receive training and testing as they proceed through their different stages of development. For excellent performers, we provide specialized technology training.

Questions and Answers

Question: What is the basis for Denso's decision to locate research and development centers in specific localities worldwide?

Mr. Kato: Technical centers overseas are responsible for development or design, but not research. For technical centers in Asia, their mission is to satisfy the automotive car producers in local markets by providing necessary design activities. Although we do have some collaboration with universities in the United States and Europe, our Japan operations are mainly responsible for conducting research.

Question: For every success in R&D, there is said to be twice as many failures. What sort of failures has Denso experienced?

Mr. Kato: For any type of R&D, we have had more failures than successes. But those few successes have driven our business growth. When automakers communicate their needs to us, we are particularly successful in our R&D but for internally developed concepts, we have experienced many failures.

Question: What do you do to motivate R&D teams in cases of failure?

Mr. Kato: Even if R&D has failed in a particular project, the acquired knowledge can be utilized as basic research and eventually used in another way.

Question: How do you make sure that your young engineers continue to stay for a considerable period of time instead of leaving to join startups?

Mr. Kato: For Denso, fortunately our young engineers are staying for a fairly long period of time. Young people are interested in whether the company can give them an opportunity to develop their potential and to be at the frontline of technological advancement.

Question: From your own perspective, what are the key success factors in R&D management at Denso?

Mr. Kato: One of the most important aspects is the understanding and patience of top management. There is no guarantee that long-running projects will succeed and developing innovative technologies requires huge amounts of investment in money and effort.

Question: What kind of cooperation have you received from labor unions during processes of transition from one product to the next and during the stage of implementation?

Mr. Kato: At Denso, management-labor union relations are very good. The allocation of timing and training to learn new skills is coordinated in consultation. We collaborate with each other, because if one party fails, the other fails as well.

Question: How does Denso promote innovation when knowledge is passed from senior researchers to junior ones without any infusion of outside ideas?

Mr. Kato: When we conduct training at Denso, we generally produce the curriculum internally, but sometimes we ask university professors to hold training sessions, or we have discussions between university professors and our engineers. It really depends on the technology area concerned. If the training is about software, I believe Denso is quite advanced. But concerning ergonomics, we do need collaboration with universities in preparing the curriculum.

Reforming Japan's Innovation System

Dr. Atsushi Sunami
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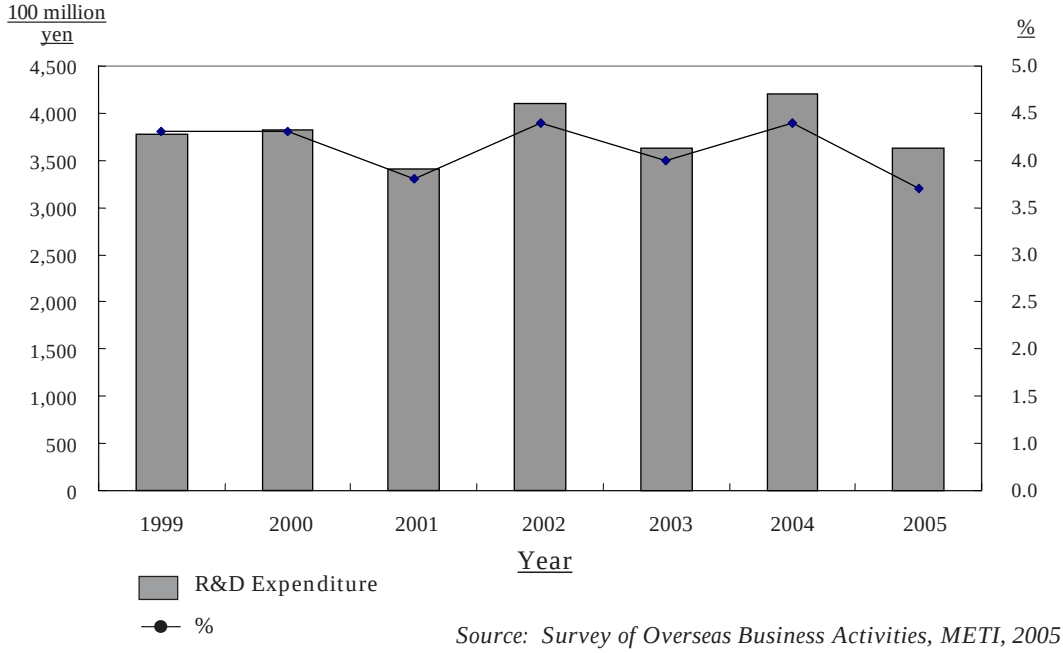
I will be discussing the development of R&D strategies for Japanese corporations, in an Asian context. To learn from the experiences of Japanese firms, it is best to talk to those people who are in the Japanese business community. This is because in contrast to the United States, there is a lack of case studies of Japanese companies. Especially in the area of R&D strategies, case studies are a rather new phenomenon.

We need a new dynamism to change the Japanese innovation system, which is essentially closed at present. Japan is still very behind in terms of globalization of R&D and incorporating the dynamics of Asia into Japanese R&D activities. Prime Minister Shinzo Abe is putting together a plan called Innovation 25, which is a road map for Japanese innovation looking toward the year 2025. The tone of the current Japanese cabinet's policy toward innovation is opening up.

The Japanese economy is just coming out of a 15-year recession. Industrial sectors have gradually started investing in R&D activities. However, Japan's overseas R&D share is still quite low (see Figure 1). Most Japanese R&D is still conducted in Japan. The only regions in which R&D activities are greatly increasing are in Asia, so Asia now looks very promising.



Source: Survey of Overseas Business Activities, METI, 2005

Figure 1. R&D Expenditures by Japanese Manufactures and the Share of Overseas R&D

Many Japanese firms are moving into China, which is understandable given the recent expansion of the Chinese economy. However, not many Japanese firms have set up subsidiaries in India, in contrast to US and some European companies. The few Japanese firms in India are concentrated in the auto industry rather than services.

China and to some extent Bangkok are the only places where there are R&D institutes for Japanese companies. They fall into four types of institutes. The first is R&D centers established in subsidiary companies. However, the required talent is not necessarily in the same place as the best conditions for manufacturing, so the location becomes difficult to select. The second is independent R&D centers. Again, the cultures, the employment systems, and so on are very different, so firms quickly run into difficulties. The third is for a company to use the same back office and divisions for the subsidiary, and then use that to share the different parts of R&D activities that are moving into somewhere like China or Bangkok. However, you have to have a large company that is able to do this kind of exchange of activities. Finally, many Japanese companies are setting up R&D centers in local universities or public research institutes.

Japanese firms recognize that they are facing a world of globalizing R&D. However, although they try to understand the theory of using the knowledge management cycle to search for sources of innovation all over the world that can be leveraged into new products, this is not really being put into practice. Most valuable knowledge is difficult to move; much of it is intangible knowledge. There is a lack of ability to share and put into effect intangible knowledge collected from different locations. This ability requires unique skills and experience, and Japanese firms are still new in this field.

Japan does not engage in very much outsourcing or hiring of foreign engineers. The demand for IT engineers is, of course, increasing. Most of the in-flow of highly-skilled labor comes from China, and Chinese students dominate those foreign students studying in Japan who subsequently stay and work for Japanese companies. However, despite the fact that many of those students acquire technology-based degrees, the majority of them work in back office support, doing translation and so forth. Almost half are employed by small and medium-sized firms. So although there are many foreign students now studying in Japan, they are not moving into the Japanese R&D workforce.

To conclude, a meta-national company transcends national modes of production and activities. I have laid out some of the difficulties in achieving that. I have not yet seen a Japanese company that can really claim to be a meta-national company.

Questions and Answers

Question: I read some articles on the Japanese policy on innovation and technology management and I came across a term, “phronesis.” Could you explain this term?

Dr. Sunami: Phronesis is the concept of a company leader who not only understands the technology road map, but has a philosophy, a higher sense about where to lead the company. These leaders or company founders have a vision not just of where the technology should go, but where the company should go in the globalized world. The question is how you pass this DNA from the founder to subsequent generations of leaders. That is the difficulty that Japanese firms face. The companies that are still successfully conducting creative activities are those which are able to pass down the DNA of the founders and visionary leaders of those companies.

Question: In India, not many young people are moving into the basic sciences, because professions like management and IT are much better paying and the payback period is shorter. Are you facing this kind of problem in Japan? If so, how are you addressing that?

Dr. Sunami: Many companies in Japan are facing that problem as well and there is a great deal of ongoing policy debate. Young talent is not necessarily moving into the traditional innovative sectors or R&D activities, but rather into more service-oriented fields or those fields that offer short-term returns. The problem that companies face is acquiring good talent from the Japanese talent pool. They are able to directly hire graduates from some of the leading Asian universities, and bring them to work in an environment of traditional Japanese R&D activities, to see whether they can work together and develop innovation activity talents. In other words, the source is outside of Japan but we try to have a traditional Japanese training process in manufacturing because one of the things that Japanese companies pay a lot of attention to is the manufacturing process. We will bring the young talent from Asia and see whether they can obtain that knowledge and hopefully return to their countries and help Japanese companies' activities in those subsidiary areas. That is the next phase that some companies are looking at.

Panasonic Global R&D Strategy

Yoshikuni Hirayama
Director
Overseas R&D Promotion Center
Matsushita Electric Industrial Co., Ltd.

Panasonic's brand slogan is "Ideas for life." The slogan is truly representative of our operations as we integrate all our R&D resources and technologies to realize customer satisfaction into the ideas for life. Like other big multinational companies, we have corporate R&D and business-company R&D. The role of each is slightly different. Corporate R&D focuses more long-term technologies while business-company R&D is geared toward more straightforward product development.

Panasonic faces various challenges in regard to R&D. To begin with, price competition is becoming much more severe these days. From an R&D perspective, we need to increase our development efficiency to keep up with this rapid change. As products move from analog to digital bases, the development that goes into products is becoming more advanced. In addition, we really must improve our R&D efficiency. Finally, we need to come up with a better way of creating new intellectual value or technologies.

To improve the efficiency of R&D and increase value, we are asking our operations to establish technology business plans for their areas of focus (see Figure 1). Company-wide, we have coherent R&D strategies that allow us to avoid unnecessary double investments as much as possible and we are prioritizing our investments into more important areas through the technology business plans. Many processes are being introduced based on our respective

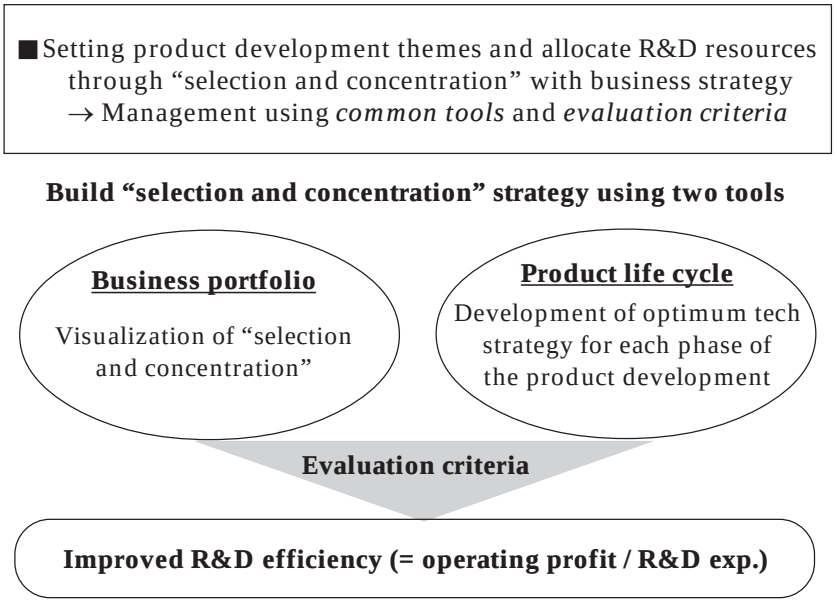


Figure 1. Technology Business Plan

phases of development and for advanced research areas we have introduced a process called Panasonic Risk Return Assessment of Innovative Technologies (PRRAIT), which is a tool to manage new innovation, particularly for new advanced technologies. For traditional R&D technology development, we introduced phase change management, which is Panasonic's version of a stage gate process. Moreover, we are using a process called Development Process Innovation Management (DPIM) to enhance our product development on the business-company side.

With respect to our technology business plans, we take two factors into consideration: the business portfolio and product lifecycle. The product lifecycle has many phases, namely product introduction, growth, maturation, and harvesting. The corporate R&D group tries to emphasize R&D in the early phases over the later phases so that we can harvest more value out of our investments later on.

The Panasonic Group has many technology areas in its business segments including televisions, DVDs, cameras, and automobile electronics components. We also are pooling these technologies to achieve much greater synergy between our products and to establish more efficient ways of development. We call this a value chain strategy.

Our strategy is based on globally optimized R&D systems. Traditionally at Panasonic we have had Japan R&D and overseas R&D. Yet, as much of our business portfolio extends outside Japan we really need to expand R&D globally to compete with competitors in the marketplace. We cannot really afford to have a two-tiered system of R&D in the form of Japan R&D versus overseas R&D. Instead, we should have more globally optimized R&D with Japan one component of that. This is the kind of approach we are now taking. Some R&D can be done better in Japan because the factory may be much closer, but some R&D can be better done in Asian countries or Europe for example. It really depends on the technology category. We are looking at what is best in the way of optimum location and optimum operation.

Panasonic has nine company R&D operations in seven countries: United Kingdom, Germany, United States, China, Taiwan, Singapore, and Malaysia. Our new business concept creation is conducted in Europe and North America while our super effective development is taking place in the ASEAN region and China.

The Asian region has so much potential in the way of R&D resources and we have actually set up a R&D hub operation in Singapore and Malaysia. Our expectations are high for a number of reasons such as high quality and low cost R&D resources, increasing R&D performance, the importance of an internationally competitive R&D environment, access to huge Asian markets, the opportunity to enhance our brand image and presence, and a good pool of highly skilled graduates.

Going forward, we see the key issues for Asian R&D growth to be communication ability in English and Japanese, high cost-performance and secure software development especially the efficiency of embedded software development, special corporate tax exemptions to encourage the setting up of headquarters, and inexpensive, good quality and secure infrastructure and safe office equipment.

Questions and Answers

Question: Starting R&D operations overseas is a big challenge for many Japanese companies. What is Panasonic's Key Performance Indicator especially in advanced R&D outside Japan and how can Japanese headquarters recognize and assess global R&D centers?

Mr. Hirayama: The assessment system I talked about, the PRRAIT, is primarily used for advanced research labs in Japan but we are also working closely with our R&D centers outside Japan. We primarily use outside resources, primarily universities, to conduct

advanced research. We would like to encourage more advanced research to be done in universities rather than doing everything in-house. The assessment system is very critical, but I think we are still trying to improve it.

Question: You emphasized that you would not want your R&D to fall into the hands of a competitor. So before investing, particularly before setting up an R&D facility, do you look at the infrastructure, namely legal aspects like protecting patents, before investing in a particular area?

Mr. Hirayama: Yes, that is very critical. In setting up an R&D operation, there are many typical areas we need to investigate such as intellectual property law and business law. We also look at the human resources side such as engineering skills, software skills, and the level of education and graduates. The legal background and human resources sides are the two most critical factors we investigate. As far as we are satisfied with those two factors, then I think the rest of the issues are not so difficult to overcome.

Chairman: It was a wonderful lesson in that we learned major companies like Panasonic are sandwiched between very difficult pressures like price competition and the need to spend R&D expenses more effectively. To achieve sustainable growth, you need to achieve and improve development efficiency and create added intellectual value.

The Importance of the Strategic Management of Technology and Innovation to APO Member Countries in the Current Asian Context and the Future

Dr. Atsushi Sunami
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INTRODUCTION

When Thomas Friedman's *The World is Flat* came out in 2005, it captured the minds of policy circles in Washington, D.C. Soon after, it quickly spread around the world because he so eloquently described today's globalized world as being "flat." Since then, one cannot begin the discussion of "innovation in the Asian context" without addressing the paradox of globalization. Innovation is certainly occurring globally. It is occurring in Silicon Valley, Shanghai, Bangalore, and Tel Aviv, and they are all connected. Business process outsourcing has transformed the US economy as well as places like Bangalore, India, or Dalian, China. The paradox of this global economy is that the more we witness the forces of globalization carried along by the constant introduction of new technology, especially in ITC, the more we realize that innovation is being localized in a few areas or "hot spots" around the globe. The development of the globalized "knowledge economy" is supported by local strength that nurtures the capacity for continued innovation and entrepreneurship in regional clusters.

How do the effects of globalization in the world of the knowledge economy enforce the emergence of "growth poles" or the disparities among different regions in their economic growth? Several factors highlight the importance of regional components in understanding the process of innovation such as 1) the importance of sharing tacit knowledge, 2) knowledge-based networks of industry, academia, and government, and 3) interactions between users and producers of technology. Furthermore, some recent studies have focused on the concentration of knowledge to understand why some cities are more actively innovative than others (Florida, 2002). What lies behind all of this is the emergence of global networks of knowledge and the importance of tapping into this globalized knowledge flow.

If one looks around the world today, it is self-evident that the differences in economic performance among different parts of the globe are widening. While the differences in productivity and economic wealth are growing, a few groups of economies, particularly in Asia, have narrowed the gap between the front-runners in both productivity and income. The challenge for Asia is to continue this catch-up process engaged in over the past five decades and spread it to the regions in Asia which were less fortunate than others in facing the new challenges posed by the era of global innovation.

Studies on leading regional clusters or hot spots in global innovation show how the institutions and management of innovation and their knowledge infrastructure are crucial at the initial stage of development. It is here that many Asian economies still need to concentrate their efforts by placing innovation at the heart of their economic development strategy. After the initial stage of development, factors such as global human resources or

talent pools, multinational R&D activities, and financial assistance in the form of venture capital begin to play important roles in moving toward self-sustainable growth. Places like Daedeok Valley in the Republic of Korea, Zhongguancun in the People's Republic of China, Hsinchu in the Republic of China, and Bangalore in India are all facing the need to tap into the web of global innovation networks. Thus, learning how to cope with these challenges ranging from managing innovation at the firm level to the creation of local innovation networks at the policy level is an important task for Asian economies to bring their productivity high enough to sustain their economic growth.

INNOVATION, CATCH-UP, AND ECONOMIC GROWTH

The development of the neoclassical growth theory supported by the introduction of new macroeconomic statistics and computing capability in the 1950s marked the beginning of the rise of interest in innovation studies (Fagerberg et al., 2005). However, the many who became interested in understanding the processes of technological progress or innovation gradually created this research area, because they all felt the limitations of the conceptual framework of the neoclassical model in capturing the sophisticated processes of learning and innovating or technological progress (Nelson and Winter, 1982). To distinguish the development of the standard economic growth theory from Solow to Romer, this group of scholars has often been referred to as "the Schumpeterian school" or "evolutionary economists." While the growing interest in innovation is a more recent phenomenon, many scholars took up the issues of productivity and income growth throughout the history of capitalism in the wake of the Industrial Revolution. Adam Smith and Alfred Marshal were among the leading scholars who grappled with questions of productivity and income growth. In particular, the long-term trend in the divergence of productivity and income growth across different economies has been one of the important questions for many social scientists.

As Fagerberg and Godinho acknowledged, there are two main related but distinctive research trends associated with the question of productivity growth. One is the idea of convergence; the other is catch-up. Fagerberg and Godinho made the following distinction: "'Catch-up' relates to the ability of a single country to narrow the gap in productivity and income vis-à-vis a leader country, while 'convergence' refers to a trend towards a reduction of the overall differences in productivity and income in the world as a whole" (Fagerberg, Nelson, and Mowery, 2005). Thus, the question that Asian economies need to address is why only some countries were able to narrow the gap with the front-runners while others fell behind. This is essentially the catch-up problem.

Earlier writers on catch-up tried to show how Germany was successful in catching up with the UK in the period prior to WWI. The works of Thorstein Veblen and Friederich List were among the first to point out the importance of institutions in the process of catch-up. Since then, there have been a number of studies with the central research focus on understanding the processes and institutions involved in technological progress. Consequently, given the present environment of the globalization of innovation, understanding the processes and institutions involved in catch-up should be an important question for the economic studies of development. Furthermore, much of today's policy debates in this area clearly depends on how well we understand the experiences of Germany, the USA, and then Japan, the Republic of Korea, and the Republic of China in successfully catching up with the technological and economic leaders of their time, then carefully reflecting on what is different about the present conditions for the People's Republic of China, India, and others to follow.

Catch-up requires gaining access to and mastering of the technologies and forms of economic and social organization used by the leading economies of that time. Thus, the acutual mechanisms of learning advanced technology need to be explored. However, one needs to take a broader view of what technologies are, defining the term covering the wide range of techniques that have been developed over the years, from sophisticated product designs, to procedures used in productive agriculture, to effective public health practices, to air traffic control systems, and to alternative energy supply systems. Consequently, in the process of catching up, many different kinds of capabilities must be acquired; hence, their acquisition may take different paths for each case of technological progress.

In many instances, it is not easy to learn what others already have done. Moreover, while the term "catching up" seems to mean more or less exact copying of the practices of the more technologically advanced economies, and efforts to develop often involve attempts in deliberate copying, what is achieved often diverges in a number of ways from those practices in the countries serving as the model. On the one hand, this divergence reflects that imitating the model perfectly is almost impossible, and that attempts to replicate at best barely come close in reality. On the other hand, it shows deliberate and often creative modifications to make those practices more adaptive to the local environment. The organizational, managerial, and institutional aspects of innovative practices often are the most difficult to replicate or reproduce for catching-up economies (Sunami, 2001).

Moses Abramowitz has been one of the key scholars eloquently illustrating how institutions determine successful catch-up level variables that are too aggregated to permit analysis of many of the relevant factors (Abramowitz, 1989). Following his work, there have been a few recent empirical studies showing how countries that are rapidly catching up have focused on the development of their higher education systems for engineering training and have developed indigenous research capabilities through these institutions. Furthermore, several studies examined firms in developing countries which have successfully caught up in specific industries. However, almost all of those studies concentrated on manufacturing, and few were concerned with agriculture or service industries. Successful economic development requires learning from abroad and modifying to adapt what is learned to the distinctively unique environment. Studies on the ways developing countries learn to improve their systems of public health and medical care and on how competence in resource and environmental management is acquired are becoming an important part of innovation research.

LOOKING BACK AT HISTORY

A careful review of the historical studies on catch-up tell us that, in the past, there were several common elements in all successful examples. First, a considerable international or cross-border flow of human talent, with a combination of not the usual brain drain but "brain circulation" between the country that is catching up and the front-runners and the technical advisors bringing know-how from the advanced economies to the followers in the process of technology diffusion (Saxenian, 2006). Thus, for instance, British textile manufacturing know-how was brought over to the new continent that would become the USA by British technicians. Sidney Pollard illustrated the flow of the British to northern Europe in the early 19th century, who came with the objective of setting up businesses on the new continent (Pollard, 1981). The development of Japanese industry in the late 19th and early 20th centuries, as well as the post-WWII catch-up period, was helped by technical advisors from abroad, as well as by Japanese returned after studying in the West. The Korean

and Taiwanese electronics industries were developed largely by students who had studied and often worked in the USA.

During the 20th century, firms came to play an increasing role in this learning and teaching process. The new Japanese automobile and electrical equipment firms established close interactions with their counterparts in the USA and Europe, which served in essence as their technical advisors. How Korean and Taiwanese firms developed their competence through working for US and Japanese electronics companies as original equipment manufacturers is well documented by a number of studies. Moreover, the different roles of multinational corporations and their overseas factories and R&D centers in the host countries catching up through technology diffusion have been one of the key topics of recent innovation studies.

Over the last quarter-century, an important part of the transnational mobility of human resources in the catch-up process has involved university students studying abroad in the relevant fields of engineering and applied science. University faculty in the successful developing countries have been based to a considerable degree on scholars who received their education abroad. While this development has been quite visible in recent years, one should be reminded that until WWII, a good fraction of the Americans taking advanced training in chemistry and various subfields of physics received their training in Europe. This transnational learning through the system of higher education played a significant role during the 20th century for the countries who were catching up. One can suspect that this university-based transnational learning will also play a major role for developing countries trying to improve their capabilities in resource management, and hence overall innovation management.

The next important aspect of countries that successfully caught up with the leaders during the 19th and 20th centuries was active government support for the catch-up process, involving various forms of protection and direct and indirect subsidies. The argument behind this policy debate has been the need of domestic firms for protection from advanced foreign competitors in the industries considered critical for the development. Alexander Hamilton's argument for infant industry protection in the early development phase of the USA was very similar to that put forth by Friederich List regarding Germany. The policies and institutions needed in continental Europe to enable catch-up with the UK are documented in Gershenkron's *Economic Backwardness in Historical Perspective* (1966). The same story also applies well to the case of Japan, and of the Republic of Korea and Republic of China. In many countries, such policies engendered not successful catch-up but a protected inefficient home industry. Furthermore, those policies obviously were problematic for firms and governments in the developed economies, especially when the supported industry began to penetrate the world market. While the case made after WWII for free trade was mostly concerned with eliminating protection and subsidies among the rich economies, increasingly international treaties have been used against import protection and subsidies in countries trying to catch up from far behind.

Finally, during the 19th and early 20th centuries, many developing countries operated with intellectual property rights regimes that did not seriously limit the ability of their firms to imitate technologies used in advanced countries. Like infant industry protection and subsidies, conflicts emerged when the firm that is catching up began to penetrate into world markets or even the home market of the rival firms holding the original patent rights. This is one of the major factors in bring about the international regime based on the treaty on Trade-Related Intellectual Property Rights. Strict enforcement of intellectual property rights by major advanced economies is affecting agricultural development and the public health

systems in developing countries, as well as manufacturing development. Patented seed varieties play an increasingly important role in modern agriculture. Also, patented pharmaceuticals are crucial in the treatment of a number of diseases that devastate poor countries.

FROM "JAPAN INC." TO "THE ASIAN MIRACLE"

Gershenkron (1966) illustrated that the role of the state, and hence both policies and institutions, was a crucial determining factor in Germany's success in catching up with the UK during the mid- and late 19th century. His claim has become the pillar of today's developmental state argument. However, other than those basically inclined to the study of economic history, few development economists have paid attention to the processes of catch-up per se, in large part because prevailing economic growth theory has seen the principal reason for low productivity and incomes as low levels of physical and human capital, as contrasted with inadequate access to or command over technologies and other practices used in high-income countries. Moreover, imitation of technologies and practices that are in use in advanced countries generally has been viewed as relatively easy, if the needed physical and human capital is available and there are no barriers such as intellectual property rights.

Japan has gone through many phases of catch-up. However, it was after the Meiji Restoration of 1868 that real efforts began to catch up with the West. There were two major catch-up periods: pre-WWII and post-WWII. It is the experience of postwar Japan which sparked many scholars of technological progress and catch-up to look into the role of institutions, government policy, and organizational structures, particularly in manufacturing, in Japan's success in taking over the lead in many key industries such as electronics and automobiles from the West. It is no coincidence that in the 1980s the effort to uncover the secret of Japan's success in catching up with the West in technology led to the birth of the study of what is referred to as national innovation systems today (Freeman, 1987). After the success of Japan, the Republic of Korea, and Republic of China, other "Asian Tigers" were considered to follow Japan by many. The notion of the "developmental state" has become the center of the debate in understanding "the Asian Miracle," such as in the study by the World Bank. Now, the newly emerging economies are the People's Republic of China and India.

TOWARD THE THEORY OF GROWTH OF THE FIRM

To understand the processes of innovation and catch-up, the capabilities in acquiring technological know-how involve significantly more than what scientists and engineers generally mean when they think about technology. While important aspects of these activities are structured or embodied in machinery or other physical artifacts, they also involve the modes of organizing, coordinating, and managing activities. In many instances, these latter capabilities are much more difficult to acquire and develop than the formal knowledge of engineering know-how.

Technologies are operated through organizations; thus, learning to master the organizational structures and the modes of management that are necessary for technological advance is an essential part of the catch-up process as well. In turn, firms and other organizations are dependent upon a nation's knowledge infrastructure such as education and training systems, labor and capital markets, competition and regulatory policies, resource and environmental management, and the ability of the government to provide a context for rapid sustainable economic development. Thus, building an institutional structure that is

capable of facilitating catch-up may be the most difficult part of economic development. Successfully managing innovation is clearly one of the most important aspects for the countries catching up and firms that are trying to grow in those economies. However, it is only recently that the concept of the management of technology, primarily developed in the USA, has been introduced in Japan and the rest of Asia following the decade-long recession in the 1990s in Japan and the Asian financial crisis. Those who saw the value in the management of technology considered it to be a way to rebuild the Japanese manufacturing industry.

NEW CONDITIONS FOR FUTURE PROSPECTS

The new global environment surrounding Asian economies today is very complex. Globalization and the rise of Brazil, Russia, India, and the People's Republic of China are partly based on a system heavily dependent on national systems of innovation based on natural resource endowments. The rising energy costs propelled by increasing demand for economic growth are a source of investment for innovation. Globalized venture capitalists are searching for new investment opportunities all over the world. The source of investment funds is spread over and interconnected throughout the world financial centers. Thus, it is very clear that the current and future development environment for countries trying to catch up is significantly different from what it has been. Various international regimes have changed the environment for catch-up in significant ways. Large corporations in advanced economies will press hard for access to markets and for operations all over the world. Therefore firms and governments in developing countries must develop new strategies to compete and survive in the global economy.

The new regulatory regimes have been put into place in a context in which both business and finance are operating on a more global scale. Foreign direct investment and globalized R&D have played a significant role in the catch-up processes of some successful countries and are likely to play an even greater role in the future. Technological alliances between firms in developing countries and their counterparts in developed countries that possess advanced know-how will also be a factor which cannot be ignored. Once again, managing innovation with a strategy matching the leading multinationals is absolutely crucial for any growing firm in the economies currently catching up.

Arguably, the scientific and technical communities in different economies also are now more connected than they used to be as leading technologies have increasingly become associated with fields of applied science or engineering from traditional fields of chemical and electrical engineering to modern fields of computer science, and biotechnology. In technologies that require a strong scientific base, advanced training in the field has become a prerequisite for the ability to acquire necessary know-how.

Succeeding in catch-up in the future likely will involve firms and sectors doing their own R&D to build up their capabilities earlier in the catch-up process than was typical in past cases of catch-up. This process in many instances will involve partnerships with foreign firms and foreign direct investment. The building of R&D capabilities in firms will require that the higher education system is capable of providing an adequate number of trained scientists and engineers. Thus, the role of universities and research institutions is a very important starting point for the catch-up story for many firms in developing economies. To be able to tap into and fully utilize the local knowledge infrastructure is certainly the necessary initial step to succeed in managing innovation strategically. Engaging in the strategic management of innovation for growing firms trying to catch up is a very complex but unavoidable path for the development of Asian economies today.

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Appendix 1

Top Management Forum: Strategic Management of Technology and Innovation
(26—28 February 2007, Kyoto, Japan)

List of Participants and Resource Speakers

Participants

Bangladesh	Mr. A.S.M. Rashidul Hai Chairman Bangladesh Chemical Industries Corporation (BCIC) BCIC Bhaban, 30-31, Dilkusha Commercial Area Dhaka
	Dr. Mohammad Ayub Miah Additional Secretary Ministry of Industries, Government of Bangladesh Shilpa Bhaban, Matijheel C / A Dhaka
Cambodia	Mr. Nguon Meng Tech Director General Cambodia Chamber of Commerce Villa 7B the Coner of Road 109 and 81 Sang Kat Boeung Raing Khan Daun Penh Phnom Penh
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	Dr. Cheng Ta Kuo Senior Director, R&D Division Epitech Technology Corp. No. 16 Dashun 9th Road, Southern Taiwan Science Park Sin-shih Township Tainan
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	Mr. Sikander Mohan Dewan Director General Standing Conference of Public Enterprises (SCOPE) "Scope Complex" Core-8, First Floor, 7, Lodi Road New Delhi
	Mr. Subhas Chandra Roy Deputy Secretary Department of Industrial Policy & Promotion Ministry of Commerce & Industry Udyog Bhavan New Delhi
Indonesia	Mr. Irawan Sumardi Investor Relation Senior Manager PI Indonesia Power Jalan Jenderal Gatot Subroto Kav 18 Jakarta
	Mr. Yusuf Hady General Manager PT. Nippon Indosari Corpindo Jl. Jababeka XII Blok W 40-41 Kawasan Industri Jababeka-Cikarang Bekasi, Jawa Barat
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	Mr. Pradeep Jung Pandey Chairperson, Industrial Promotion Committee Federation of Nepalese Chambers of Commerce & Industry Pachali Shahid Shukra FNCCI Milan Marg, Teku P.O. Box 269 Kathmandu
Pakistan	Mr. Pervaiz Iqbal Deputy General Manager Balancing Modernization Revamping (BMR) Directorate Pakistan Steel Mill, Ministry of Industries & Production Bin Qasim Karachi

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Singapore	Mr. Foo See Meng Senior Director, School of Engineering Ngee Ann Polytechnic 535 Clementi Road Singapore
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Sri Lanka	Mr. Sunil Gamini Wijesinha Chairman & Managing Director Dankotuwa Porcelain Ltd. Kurunegala Road Dankotuwa
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(Note: Designations at the time of the project implementation)

Top Management Forum: Strategic Management of Technology and Innovation
26—28 February 2007, Kyoto, Japan

Program and Itinerary

Monday, 26 February 2007

09:00-09:30	Opening Ceremony
10:00-11:15	Session I: "*Capturing the Value from Innovation — Introduction to our Discussion at the Japan Research Center for Technology and Innovation Management*" by Dr. Kiyonori Sakakibara, Faculty of Policy Management, Keio University (Comprehensive Program Director, TiM-Japan)
11:30-12:45	Session II: "*Original and Without Compare: Zeon Management Strategy to Maximize Corporate Value*" by Mr. Katsuhiko Nakano, Chairman, Zeon Corporation
14:15-15:00	Session III: "*Importance of Practical MOT Human Resources Development and Policy of METI*" by Mr. Hidehiko Yamachika, Director, Technical Cooperation Division, Trade and Economic Cooperation Bureau, METI and by Mr. Yoshito Goto, Senior Officer on Human Resource Development, Planning for Industrial Technology, Academia-Industry Cooperation Promotion Division, Industrial Science and Technology Policy and Environment Bureau, METI
15:15-16:30	Session IV: "*Working for the Benefit of Society — Best Matching of Humans & Machines*" by Mr. Tsukasa Yamashita, Senior Managing Director, Omron Corporation
16:45-18:00	Session V: "*Effective Collaboration between Major Corporations & Venture Companies on Technology Development for Creating New Businesses*" by Dr. Noboru Maeda, Ph.D. Professor, Graduate School for Creative Cities, Osaka City University (Chair Person of Study Team on Corporate Venturing in TiM-Japan)

Tuesday, 27 February 2007

9:30-10:45	Session VI: "*Effective Management of Technology Development*" by Dr. Atsushi Abe, Dean, Graduate School of Technology Management, Ritsumeikan University (Chair Person of Study Group on Product Development Management and Road-Mapping)

11:00-12:15	Session VII: *"Denso R&D Management"* by Mr. Yoshifumi Kato, Director, Technology Planning Dept., Denso Corporation
13:45-14:30	Session VIII: *"Reforming Japan's Innovation System"* by Dr. Atsushi Sunami, Associate Professor, National Graduate Institute for Policy Studies (Chair Person of Study Group on Asia R&D Strategy in Open Innovation Era)
14:45-16:00	Session IX: *"Panasonic Global R&D Strategy"* by Mr. Yoshikuni Hirayama, Director, Overseas R&D Promotion Center, Matsushita Electric Industrial Co., Ltd.
16:00-18:30	Session X: Group Discussion and Presentation on *"Application of Results Learnt to Each APO Member Countries"* Coordinated by Dr. Atsushi Sunami

Wednesday, 28 February 2007

10:00-12:00	Company Visit: Horiba, Ltd.
13:00-13:30	Closing Session

(The program has been revised from that distributed at the forum.)