

Competitiveness in High-Tech Fields and Nanotechnology

Naoki IKEZAWA

Nomura Research Institute

Competitiveness in High-Tech Fields and Nanotechnology

Naoki IKEZAWA

- I Declining Competitiveness in the 1990s
 - 1 Shift Towards the Basics Began in the 1980s
 - 2 Changing Competitiveness in the High-Tech Field
 - 3 Innovation Not Leading to Value Creation
- II Touchstone of Competitiveness: Nanotechnology
 - 1 Nanotechnology and Business Opportunities
 - 2 Responding to the Hollowing-Out of Core Competencies Through Nanotechnology
 - 3 Nanotechnology as Competitiveness
 - 4 A Paradigm Change and Nanotechnology
 - 5 Nanotechnology as a Touchstone

During the so-called “lost decade” of the 1990s, Japan’s competitiveness sharply declined in such representative high-tech areas as semiconductors and liquid crystal applications, accelerating a hollowing-out of core technologies. Despite various measures taken in recent years to remedy this situation, there is still a long ways to go before we will see any fruitful results in terms of industrial competitiveness. Accordingly, the realization of a new paradigm towards the acquisition of competitiveness is required among both companies and the government. This means the establishment of new business models in the case of companies, and a thorough overhaul of the vertically divided administrative structure in the case of the government.

One of the touchstones in dealing with these issues is the case involving nanotechnology. As a follow-up to the December 2001 edition of NRI Papers entitled “Nanotechnology: Encounters of Atoms, Bits and Genomes,” this essay takes a closer look at the business opportunities that nanotechnology would create, and explores how progress in nanotechnology would contribute to the current measures aimed at halting the hollowing-out process and strengthening Japan’s competitiveness in these vital areas.

I Declining Competitiveness in the 1990s

1 Shift Towards the Basics Began in the 1980s

(1) Criticizing Japan's alleged free ride in basic research

Japan began to rapidly improve its technological competitiveness in the 1970s and started to pose a major threat to leading companies in the United States and Europe, which had long been the targets of Japan's efforts to catch up. Indeed, the exact situation that Japan is facing, i.e., declining competitiveness and the hollowing-out of domestic industries, was taking place in Europe and, particularly, in the United States.

The domestic measures mounted in the United States to reverse these trends included a strengthening of research and development investment in such leading-edge fields as information and biotechnology, where the prospects for industrialization were unclear at the time. Such measures also included the vitalization of universities and the implementation of various steps to link the results of academic research to industry.

In terms of external measures, a survey organization known as the Japanese Technology Evaluation Center (JTEC) was established in 1983 and exclusively charged with monitoring developments and analyzing the background of Japan's efforts to improve its competitiveness. This represented the classic approach of "knowing one's enemy and learning what should be learned."

At the same time, the developing trade friction between Japan and the United States over television sets and semiconductors led to an increase in criticism since the 1970s about what the United States saw as Japan's industrial development policies. In other words, the United States regarded Japan's policies as using the full efforts of the nation to support selected industries, or so-called "targeting policies," and increased its criticism by using the term "Japan Inc."

This criticism became especially acrimonious over the issue of basic research, with many Western observers claiming that Japan was taking a "free ride in basic technology." As the results of basic research are seen as the public domain of the world at large, it is a widely accepted notion that every nation should make appropriate contributions to its formation. Accordingly, the crux of the argument was that Japan was enjoying industrial success by utilizing the results of basic research (acquired from the United States and Europe), but was doing little to fulfill its international responsibilities with respect to creating basic research results.

(2) Shift towards basic research by both the government and private sector companies

While some doubt still remains over the validity of such criticism, there was a shift by both the government and

private sector companies in Japan towards carrying out more basic research. The government moves included the steps taken in 1981 to inaugurate the Technology Research and Development Program for Next-Generation Industrial Infrastructures to replace the Development Program for Large-Scale Industrial Technology (known as the "large projects"), which had led to major successes in catching up with leading Western companies in the computer industry since its establishment in 1996. This new program was set up with the aim of further improving originality and creativity by regarding the former large projects category as representative of efforts to catch up in technological terms. Since then, the weight of basic research has been increased under projects led by the Ministry of International Trade and Industry.

Another move taken in 1981 was the establishment of the Exploratory Research for Advanced Technology (ERATO) by the Science and Technology Agency. As evidenced by the fact that projects under this program took on the names of individual researchers, the emphasis has been placed on the ideas of the inventors and researchers involved rather than their ultimate purposes and applications. This has served to strongly orient the program towards the basics.

This national policy of focusing on basic research has had a major positive impact in terms of enhancing the infrastructural technology that supports the basics in various areas of industry. As will be discussed later with respect to nanotechnology, for example, many related themes were taken up under the programs inaugurated by the Ministry of International Trade and Industry and the Science and Technology Agency in 1981, some of which have yielded excellent results in the process.

(3) Two problems in the shift towards basic research

From the viewpoint of industrial competitiveness, however, this shift towards basic research has raised two problems. The first relates to what many see as an excessive emphasis on basic over applied research in many areas. This has led to a significant cutback in the number of large-scale research and development projects that entail shared final objectives (e.g., high-performance mainframe computers, large-capacity memory systems, and superhigh-density LSI applications).

Moreover, this trend of shifting towards the basics has not been limited to government efforts only. Similarly, private sector companies have seemingly responded en masse to the nation's shift towards basic research—a phenomenon that is perhaps best symbolized by the number of basic research laboratories established by major Japanese companies. Like the boom in setting up central laboratories that occurred in the high growth era of the 1960s, a similar rush to open laboratories devoted to basic research started to take place. For example, Hitachi, Ltd. established a basic research laboratory under its central laboratories in 1985.

While one would assume that the relative importance of basic vs. applied research is not a matter to be determined by the proximity of commercially feasible applications, some companies were so caught in this basic research boom that they tended to neglect research and development activities in fields that were only steps away from practical realization. As a result, efforts to strengthen competitiveness in typical high-tech products such as semiconductors, magnetic memories, optical communications, and liquid crystal displays (LCDs) were neglected.

The second problem in the shift towards the basics by the government and the private sector was the climate of pushing forward almost blindly without fully digesting the essence of basic research or adopting a methodology for its promotion. In short, a mindset began to take hold that saw the success of basic research as “wholly dependent on the skills of those conducting such research.” This scenario essentially discouraged any effort to evaluate the progress of research during the process itself on the grounds that everything should await the final stage once the researchers had been selected and their skills identified.

For example, the Technology Research and Development Program for Next-Generation Industrial Infrastructures adopted an implementation period of ten years for each theme. The program divided this period into two phases, with an evaluation at the end of the first phase to determine the appropriateness of continuing the research. As it turned out, however, this evaluation system had never worked effectively when it was first adopted.

Consequently, the situation became one in which there were many small, independent basic research themes, which offered creativity but had little objective review from the outside. As a result, the system led to the establishment of a plethora of what were essentially isolated outposts spread across an extensive field of basic research. While some of them housed excellent researchers, predominance among the various independent entities could only be maintained by competition. Yet a structure that consisted of scattered outposts is simply not effective from the standpoint of industrialization and business development, in which the combined strength of many researchers and entities determines success or failure.

As described above, these two problems created a tendency to avoid competition in the main high-tech arenas of industrial and corporate competitiveness. And because competitiveness is fostered through competition, Japan’s competitiveness in various high-tech fields inevitably started declining after the 1980s as a result of these trends.

(4) The matter of Japan’s hubris

In addition to the shift towards the basics, another factor that should be cited as part of the background to this declining competitiveness was the blatant hubris on the

part of Japan. In essence, regardless of how fierce the criticism from overseas became, the pendulum would not have swung so far away from applied research and towards basic research if this sense of arrogance had not been so pronounced.

Indicative of the self-congratulatory tenor of the times, many of those associated with the production lines turning out semiconductor LSI devices echoed a shared belief that the “research and development divisions were useless and not really necessary, as future developments in silicon LSI applications were secure as long as the manufacturing division keeps doing what it should do.” There were actually some companies in which the business division handled all silicon-related matters including research and development, with laboratories relegated to carrying out research related to compound semiconductors. Those spouting such comments at the time could not even imagine that LSI production would be shifted to Korea, Taiwan and even to China only ten short years later.

2 Changing Competitiveness in the High-Tech Field

It is important to note that this declining competitiveness in the high-tech field involved not only a shrinking market share, but also the acceleration of a more ominous hollowing-out of Japan’s technological capabilities in these areas. Let us examine this in greater detail by looking first at the semiconductor field (Table 1) with respect to the decline in market share. By 1990, Japanese companies had essentially established a dominant position in the DRAM (dynamic random access memory) chips that make up the general-purpose memories of semiconductors as of 1990. However, Korean companies such as Samsung began eating into this lead as the decade progressed. Even Intel, the company that had developed the DRAM chip, had been forced to withdraw from this field under the early onslaught of Japanese companies. Following this withdrawal, however, Intel shifted its focus to the microprocessor field and has roared back to reassert its overwhelming competitiveness in this market as indicated in Table 1.

Indeed, despite the fact that Japanese companies had long been warned of the need to shift from DRAM production, steps to reduce their reliance on DRAM technology made only very slow progress. While the reasons for these delays were multifold, one of the factors was a shortage of effective R&D and technological development that could support such a shift. And despite the fact that various national projects related to semiconductor technology were implemented even during the 1990s, it is obvious from the results noted above that these projects have not been as effective as they should have been.

Turning next to the accelerating hollowing-out of Japan’s technological capabilities, let’s look at the

Table 1. Changes in Semiconductor Sales Rankings

Rank	1990	1992	1994	1996	1998	2000	2001
1	NEC	Intel	Intel	Intel	Intel	Intel	Intel
2	Toshiba	NEC	NEC	NEC	NEC	Samsung	ST Micro
3	Hitachi	Toshiba	Toshiba	Motorola	Motorola	TI	Toshiba
4	Motorola	Motorola	Motorola	Hitachi	Toshiba	Toshiba	Samsung
5	Intel	Hitachi	Hitachi	Toshiba	TI	NEC	TI
6	Fujitsu	TI	TI	TI	Samsung	Motorola	NEC
7	TI	Fujitsu	Samsung	Samsung	Hitachi	ST Micro	Motorola
8	Mitsubishi	Mitsubishi	Fujitsu	Fujitsu	Philips	Hitachi	Hitachi
9	Philips	Philips	Mitsubishi	Mitsubishi	ST Micro	Infineon	Infineon
10	Matsushita	Matsushita	Philips	SGS-Thomson	Fujitsu	Hynix	Philips

Notes: (1) □ = Japanese companies; ■ = US companies; ■ = European companies and ■ = Korean companies; (2) ST Micro = ST Microelectronics; TI = Texas Instruments; Infineon = Infineon Technologies; Hynix = Hynix Semiconductors.
Source: Compiled on the basis of various materials.

Table 2. Changing Share of Production Capacity in Active LCDs by Major Area

	1994	1995	1996	1997	1998	1999	2000	2001
Japan	91	90	91	87	74	69	55	50
North America	3	2	2	1	1	1	0	0
Europe	2	1	2	1	1	0	0	0
Asia	5	6	6	11	25	30	44	49
World Total	100	100	100	100	100	100	100	100

Note: LCD = Liquid crystal displays.

Source: Compiled on the basis of various materials.

situation with respect to active LCDs, which are most representative of display technology (see Table 2). As manufacturing output in the Asian region includes LCD production under capital alliances and technology transfers involving Japanese companies, the results presented in Table 2 cannot be directly linked to any conclusions concerning a decline of competitiveness among Japanese companies. However, the continuing hollowing-out of Japan's technological base is clearly indicated.

While the government provided effective support to the semiconductor field from the initial stages as discussed previously, work in the area of liquid crystal displays has not received any such government support—mainly because Japan's technological standards were considered to be high enough at the advent of LCDs. This meant that a high market share (for example, 91% in 1994) was garnered purely on the basis of the competitive strengths marshaled by the private sector. Unlike the case with semiconductors, moreover, one of the features that distinguish the LCD field is the rapidity of product turnabouts. In contrast to an adherence on DRAMs in the semiconductor field, efforts to develop new products are being made on a continuous basis in the liquid crystal market in order to maintain competitiveness.

As a matter of fact, this difference essentially overviews the advantages and disadvantages of industrial support by the government. Yet the hollowing-out of Japan's technological base is steadily moving forward even in the liquid crystal displays, a field that has been developed under the initiatives taken by the private sector.

3 Innovation Not Leading to Value Creation

(1) A strengthening of functional competitiveness is needed

In the case of the United States, which experienced the same decline in competitiveness and the hollowing-out process a few years ahead of Japan, various measures to strengthen competitiveness were compiled in a 1985 study known as the Young Report.¹ The suggestions included in this report apply equally to Japan's current situation as well.

The Young Report defined competitiveness as “the extent to which a nation can produce goods and services that can compete in the international market, and at the same time, the extent to which the real income of the people of such a nation can be maintained or increased.” In other words, competitiveness means the ability to

expand national wealth. In the case of companies, competitiveness means the ability to earn profits.

Such competitiveness can be divided into price competitiveness and functional competitiveness. It is possible to acquire and expand national wealth and profits under either scenario. However, functional competitiveness is required in the current case in Japan, which is the same thing that was required in the United States during the period when the Young Report was being put together. That functional competitiveness comes from the superior functions and performance of the nation's products and services. Accordingly, the road to strengthening competitiveness will basically be realized through innovation. In short, it is necessary to build competitiveness through creating value from the "new knowledge" that is the result of innovation.

(2) Inefficient research and development investments

In relation to the promotion of innovations in Japan, important measures were implemented in and after 2000, namely: (1) the establishment of the Council for Science and Technology Policy (January 2001), and (2) the implementation of two Science and Technology Basic Plans.

Previously, there had been a strong tendency towards formulating the country's basic science and technology strategy by just gathering all the individual strategies being advanced by each ministry and agency under a vertically divided administrative structure. Through the activities of the Council for Science and Technology Policy, however, an effort has been to formulate a comprehensive science and technology strategy on more of a top-down basis that is focused more on the nation's

core vision. This approach should be seen as one that is closer to what a national strategy should be.

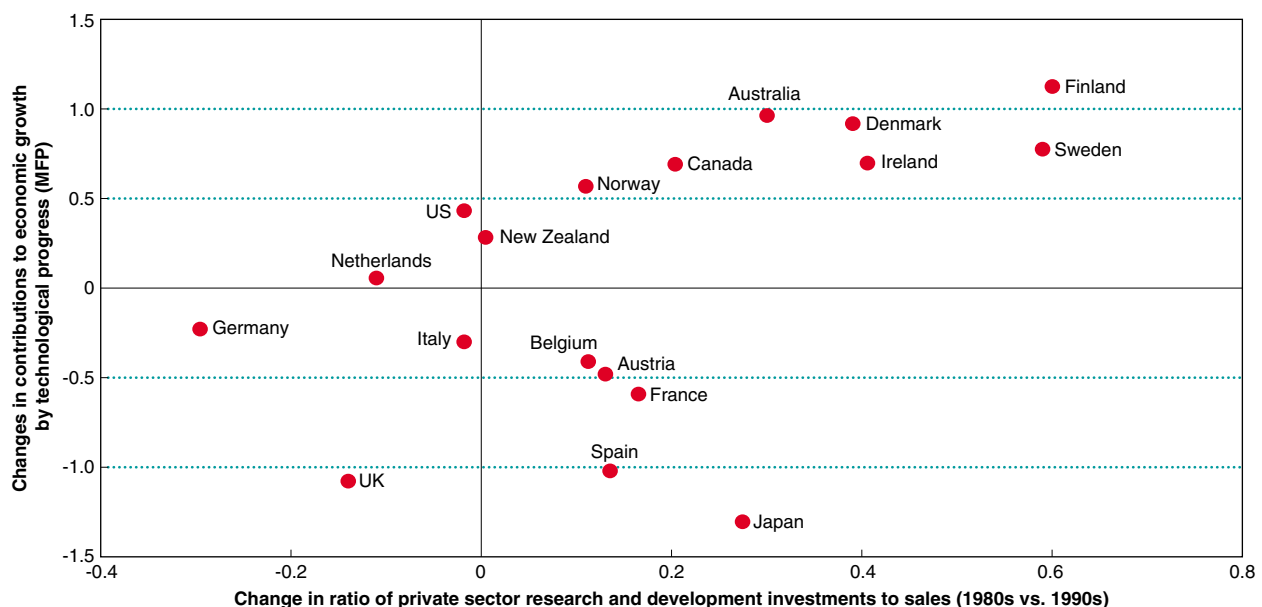
The biggest problem is that these measures have not resulted in strengthening industrial competitiveness in spite of their concentration on science and technology and the implementation of the Science and Technology Basic Plans (first phase: ¥17 trillion; second phase: ¥24 trillion). Although new knowledge has been increased, no progress has been made in value creation. The sad reality is that Japan's research and development investments have been inefficient from the standpoint of promoting competitiveness.

Similar inefficiencies can also be pointed out with respect to the private sector as well. Figure 1, for example, shows the results of a survey by the OECD (Organization for Economic Cooperation and Development).² The MFP (Multi Factor Productivity) in Figure 1 corresponds to other factors when the factors of economic growth are broken down into three parameters, i.e., capital, labor and other factors.

In the broadest terms, MFP includes the results of technological development, structural reforms, etc., and is generally used as an index that highlights innovations. MFP has such a meaning in the analyses related to Figure 1 as well. While TFP (Total Factor Productivity) is sometimes used as an index for the effect of innovations, the concept is basically the same and the results of the measurements correspond in each case.

Although research and development investments made by private sector companies in Japan in the 1990s increased in comparison to those in the 1980s, a negative MFP was recorded and Japan ranked lowest among the countries surveyed as shown in Figure 1. While

Figure 1. Private Sector Research and Development Investments and Economic Growth (1980s vs. 1990s)



Note: MFP = Multi Factor Productivity.

Source: Organization for Economic Cooperation and Development (OECD).

research and development investments must have promoted innovations and produced new knowledge, the net result did not lead to value creation and can be interpreted as not contributing to economic growth.

(3) The pendulum swings back from basic to applied research

It is assumed that the situation shown in Figure 1 can be attributed to the excessive shift towards the basics since the 1980s, even when the methodology remained unclear. If this assumption is correct, we can conclude that private sector companies at the very least need to correct this overemphasis on the basics.

In point of fact, the government has also begun to embark on measures that recognize the need for a change in course. For instance, the policies announced by the Ministry of Economy, Trade and Industry for 2003 include a vitalization program for the economy known as Focus 21 that is directly geared towards promoting commercialization.

Essentially, this program is designed to select projects from among four major fields (such as the life sciences and information and communications) that appear to be nearing the practical application stage within a relatively short period, and to allocate concentrated budgets towards their timely fruition. Similar to the approach taken for large-scale projects in the past, this program explicitly recognizes the definitive and conclusive goal of technological development, and identifies the development issues involved to reach such a point.

Current plans call for a budget of some ¥50 billion to be allocated to this program. This funding is earmarked towards activities that represent a full 180-degree reversal from the course pursued in the shift towards the basics in the 1980s, suggesting that the pendulum has started swinging back from the focus on basic research and is now moving towards applied research.

II Touchstone of Competitiveness: Nanotechnology

1 Nanotechnology and Business Opportunities

Under the Focus 21 program that gives a priority to issues directly related to practical applications as the target of investment, the areas for which investments totaling some ¥13 billion are planned relate to the nanotechnology and material fields. Further, the results that can be targeted under Focus 21 because definitive and conclusive goals have become clear are also emerging from the area of nanotechnology, which was strengthened during the shift towards the basics in the 1980s. While it can be said that Japan's shift towards basic research came in response to criticism from the United

States, we now find some 20 years later that the themes offering the greatest potential for business development in a short period of time are also being generated from the nanotechnology-related materials science frontiers that benefited from such a shift.

The direct benefits brought about by nanotechnology are those related to materials. When these materials are used for a wide variety of applications and devices as well as new equipment technologies, a wide range of new functions and performance can be realized. This extremely broad scope of applications is a major feature of nanotechnology. The ripple effects of such technologies are extensive, and a wealth of diversified business opportunities are also emerging from work in nanotechnology.³ In terms of likely market scale, trial calculations that have examined the far-reaching effects and the projected number of business opportunities put the potential at some ¥20 trillion to ¥30 trillion by 2010. Most experts in this area have no trouble accepting these projections.

With respect to the electronics field, pro forma data have estimated an especially large market scale for new displays, secondary batteries, magnetic recording devices, and devices that can replace the current DRAM applications. In terms of biotechnology, a large market scale is forecast for DDS (drug delivery systems) in which a drug can be targeted for delivery to just the affected tissues within the body by a microcapsule made by nanotechnology. Indeed, there are especially high expectations for a promising market in this field by Japanese companies that have advanced strengths in polymer chemistry.

Furthermore, in relation to existing materials in areas such as steel and glass, for example, expectations are also high that functions and performance can be substantially improved by applying nanotechnology. Accordingly, a number of business opportunities and a large market scale are also projected for these areas as well.

2 Responding to the Hollowing-Out of Core Competencies Through Nanotechnology

Nanotechnology can function as an effective countermeasure for the rapidly accelerating hollowing-out of core competencies by providing many business opportunities to companies in Japan's manufacturing base. As seen from the example of liquid crystal technologies mentioned earlier, this hollowing-out is being rapidly accelerated in various high-tech fields in Japan as more and more of Japan's technologies are being overtaken by other countries. The most effective measure to respond to such incursions is the promotion of innovations, which depends on creating new knowledge faster than the speed at which the hollowing-out is taking place. Moreover, what is required is to create knowledge at the level that does not easily lend itself to reverse engineering and copying, and to incorporate

such knowledge into products. While the previously mentioned Young Report attracted considerable attention for setting out strategies concerning intellectual property rights, the creation of intellectual properties requiring such protection is the first thing to do before establishing protective strategies.

If efforts are not made to promote innovations, other countries will gradually overtake Japan's existing industrial prowess and the hollowing-out in the manufacturing industry will continue without stopping as Japan's industrial and technological competitiveness flows steadily abroad. The development of nanotechnology, which has an enormous reservoir of latent innovation opportunities, is the most effective means to bring this hollowing-out process under control in the future.

3 Nanotechnology as Competitiveness

In addition to its potential in creating a number of business opportunities as well as its effect as a countermeasure to the hollowing-out process, another important element offered by nanotechnology is that it helps generate a strong competitiveness among companies and industries in Japan.

It is clear that the strongest technology is the source of competitiveness between companies as well as between nations, as little competitiveness can be generated by technology that is just average at best. Among the various technologies that are recognized as cutting-edge, the main focus invariably goes to aerospace technology, advanced medical technology, and nuclear fusion technology in the energy field. In view of the overwhelming predominance of the United States in these areas, however, it is difficult to see any promising technologies that can generate competitiveness in these fields.

But even when there is not enough strength to become competitive in some areas, this does not necessarily mean that the need for such technologies should be ignored or played down. Rather, it is vitally important for Japan, which needs to acquire national wealth in high-tech fields, to develop and foster technologies that can fully demonstrate their strength in the international market, and the representative candidate for this purpose is nanotechnology.

As noted before, nanotechnology in Japan proffers a strong factor for competitiveness on its own, as basic research provides the seeds for development and applied research nurtures these buds into applications that can be highly competitive.

4 A Paradigm Change and Nanotechnology

The establishment of a new paradigm as overviewed below is required in order for companies and industries in Japan to take full advantage of the features offered by nanotechnology. Both research and development as

well as business development efforts in the area of nanotechnology are being implemented all over the world. These activities are being energetically pursued in the United States, where the boom originated, as well as in Europe and countries in East Asia such as Korea, Taiwan and China. Accordingly, the first step of vital importance is to move quickly to gain effective business results from research in nanotechnology. With respect to nurturing the seeds for business development, an approach that focuses on actively utilizing outside resources and quickly realizing business creation is required. This means it is necessary to overcome the restrictive "self-developed technology" principle that has long been a debilitating paradigm in the world of technology.

What is additionally required on the part of private sector companies is a flexible attitude regarding value creation based on technology. In the past, various processes such as basic research, applied research, product development and business development were generally necessary before value was created from technology. In order to sustain active developments in the world of nanotechnology, however, it is important to consider that value creation from technology is possible at all stages of development, e.g., from the embryonic stages of basic research through the needs of the future as well. In particular, it is necessary to actively create value at early development stages where value creation did not take place in the past.

An approach that considers value creation only after the completion of research cannot meet the need for quick responses as noted above, and will lead to lost opportunities in the face of rapid changes in terms of the market prices of such technology. This is especially true in the case of high-tech fields such as nanotechnology, in which existing parameters quickly become obsolete, prices rapidly change with the passage of time, and the worth of even the most promising developments gradually declines in value. This makes it especially important to see fundamental changes in both the business models and guiding paradigms in relation to value creation based on technology.

Corresponding to the need to triumph over the self-developed technology principle among private sector companies, it is also necessary for the government to overcome the vertically divided administrative structure on its part. In other words, it is not effective to try to classify the far-ranging scope and myriad applications of nanotechnology in accordance with conventional technology classifications such as semiconductor technology and biotechnology. Rather, it is necessary to change the status of ministries and agencies that are pegged to such classifications.

Nanotechnology includes technologies that have already been put into practical use as seen in cutting-edge semiconductor devices, as well as themes that are projected to take another 20 years or more before a

market emerges. Because of these characteristics, nanotechnology offers a number of directions that will require the best use of the respective features provided by research organizations in industry, academia and government. Moreover, abundant opportunities can also be found in areas where the respective results of industry, academia and government can be mutually utilized.

Accordingly, nanotechnology will provide a venue where opportunities for diversified linkages among industry, academia and government can be found. In order to make the best use of such opportunities, of course, all three must work to establish a new paradigm that enables effective linkages.⁴

5 Nanotechnology as a Touchstone

The successful implementation of business development and industrialization in terms of nanotechnology will mean that the necessary paradigm change has also been implemented. And the effect of this paradigm change will similarly cover a broad array of fields beyond nanotechnology alone.

For example, what has been pointed out as a background factor behind the decline of competitiveness in the semiconductor field—as well as one of the causes for delays in product conversion—is the harmful effects of the self-developed technology principle.

There have also been cases in which restricting procurement to affiliated companies rather than going outside for needed equipment has caused a loss in competitiveness, or even led companies to shelve promising ideas by stubbornly sticking to business development within one's own company. Moreover, the negative effects of the vertically divided administrative structure have been cited on many occasions, and the need for linkages among industry, academia and government has long been pointed out.

As stated before, the pendulum that swung largely from applications to basics in the 1980s has now begun to swing in the opposite direction, and both the government and the private sector have started focusing on applied research. Because of the positive effects that business developments originating in universities has had on vitalizing industry, for example, technology licensing organizations (TLOs) have newly been established in many universities, where the focus is inevitably placed on achieving business results in a short time.

Connecting the research results at universities to industrialization and business development itself is a require-

ment of the times when there is a need to strengthen competitiveness and respond to the pernicious effects of the hollowing-out process. These developments should be most welcome. At the same time, however, universities must guard against the natural tendency of succumbing to the attention and flattery stemming from their newfound status by neglecting research and development on themes that are considered far removed from industry and business. Basic research cannot be neglected for the reason that it takes time before industrialization and business development. Accordingly, the return swing of the pendulum could become a problem if it is excessive.

What Japan now needs is not only the means of finding and fostering businesses and industries that are strongly competitive; what is also required is the establishment of mechanisms that continue to generate such businesses and industries in the future as well. These needs embrace the establishment of systems that enable the formulation of technological strategies with a wide-ranging perspective, the promotion of effective applications of intellectual and human resources, and the maintenance of competitiveness while responding to the hollowing-out process and the constant efforts by other countries to catch up with and eventually overcome Japan's strengths in technology.

The type of exercise that will establish a paradigm that enables the continuation of strong competitiveness by avoiding an excessive shift towards either basic or applied research under these circumstances is no more than the promotion of business development and industrialization related to nanotechnology. In sum, nanotechnology is the touchstone that spells out the fortunes of Japan's manufacturing industry in terms of competitiveness in the first half of the 21st century.

-
- (1) "U.S. Competitiveness Policy Since the Young Report and Its Implications for the Hollowing-Out of Japan's Manufacturing Industry," Development Bank of Japan, December 2001.
 - (2) Science, Technology and Industry Outlook, special Edition, OECD, 2001.
 - (3) Naoki Ikezawa, "Nanotechnology: Encounters of Atoms, Bits and Genomes," *Knowledge Creation and Integration*, December 2001.
 - (4) Naoki Ikezawa, *Nanotechnology to Japan's Rescue*, Kodansha, 2002.
-

Naoki IKEZAWA is senior chief industrial researcher and consultant at NRI. His specialties include R&D management.

As a leading think-tank and system integrator in Japan, Nomura Research Institute is opening new perspectives for the social paradigm by creating intellectual property for the benefit of all industries. NRI's services cover both public and private sectors around the world through knowledge creation and integration in the three creative spheres; "Research and Consulting," "Knowledge Solutions" and "Systems Solutions."

The world economy is facing thorough structural changes led by the dramatic growth of IT industries and the rapid expansion of worldwide Internet usage—the challenges of which require new concepts and improvement of current systems. NRI devotes all the efforts to equipping the clients with business strategies for success by providing the best in knowledge resources and solutions.

NRI Papers present selected works of NRI's 3,000 professionals through its worldwide research network. The mission of *NRI Papers* is to contribute new ideas and insights into business management and future policy planning that are indispensable for overcoming the obstacles to the structural changes in our society.

All copyrights to *NRI Papers* are reserved by NRI. No part of this publication may be reproduced in any form without the prior written consent of NRI.

Inquiries to: Corporate Communications Department
Nomura Research Institute, Ltd.
E-mail: nri-papers@nri.co.jp
FAX: +81-3-5255-9312