The Technology of Japan

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It is probably safe to say that most readers of this feature are familiar with the significance of U.S. science and technology. Often overlooked, however, is the key role played by the next most technologically innovative nation—Japan. From automobiles to video game consoles to invisibility cloaks,[1] advances developed in Japan have impressed the world for centuries[2] and affect our lives in countless ways.

These innovations do not just pop out of thin air. Examining the mechanisms by which they arise can provide valuable context for their development, along with a glimpse at an alternative way of doing things that can lend additional perspective to technological enterprises in the U.S.

This report surveys the state of contemporary Japanese technology. The first section provides a general background, including the regulatory environment surrounding technology systems, to give a sense of their underlying assets and constraints. The second section focuses on the role of scientific innovation and the extent to which intellectual property protections foster or hinder it. The third section examines the influence of the defense industry, which affects scientific research to varying degrees in every nation. The fourth section considers the relation of other countries, especially the U.S., to the Japanese system via international technology transfers. Each section is accompanied by a brief case study to provide an applied example.

Not MIT, But MITI

Japan is one of the wealthiest nations with a large capital stock, an economy second in size only to the U.S., and a GDP per capita in excess of $25,000. This provides an ample financial foundation for technological enterprise. Although the economic slowdown of the past decade has tightened budgets, Japanese annual research funding still amounts to an impressive 100 billion yen, or over $1 billion (Figure 1).

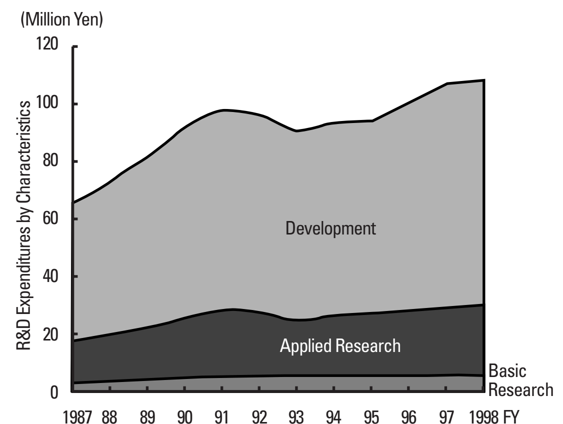

Figure 1. Japanese research and development expenditures since 1987.
Source: the National Institute of Science and Technology Policy (NISTEP) Report No. 66, "Science and Technology Indicators: 2000, A Systematic Analysis of Science and Technology Activities in Japan," Science and Technology Indicator Project Team, Japan Science and Technology Agency; and the Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"

Japanese policymakers have recognized that a crucial factor in maintaining this economic strength is advancing technology, which they view as "a strategic asset, not a commodity."[3] They have sought to encourage technology at the highest levels of government by means of a cabinet agency that balances energy and environmental interests[4] and coordinates industrial research. The Ministry of International Technology and Industry (MITI), established in 1949 and renamed METI three years ago,[5] has played an active role in ensuring that both applied research (creating a commercial application from existing knowledge) and basic research (seeking to create new knowledge) are conducted efficiently. Basic research is often underrepresented since competitors can take advantage of it as well.[6] Large research projects sensitive to economies of scale, such as supercomputers, have benefited tremendously from supportive measures such as special low-interest loans from Japan's national bank.[7]

There is a longstanding question, however, as to whether MITI's frequent "heavy-handed government intervention" has assisted or interfered with technological progress.[8] As one analyst said, "In a nutshell, Japan's institutions have not provided adequate governance structures for global and nonincremental technological changes that require a combination of decentralized autonomy in the search for innovative solutions and highly centralized project management in vast technology development programs." In other words, MITI should accommodate

Figure 2. Silicon wafer processing equipment.
Source: Renesas Eastern Japan Semiconductor, Inc.

decentralized, as well as state-sponsored, research initiatives.[9] Politics have also intruded, leading MITI to single out a few firms for research favoritism, potentially increasing the chances of failure by not distributing the risk over a broader spectrum.[10]

One should not assume that MITI is some sort of all-powerful behemoth—in fact, there is a "problem of authority in science and technology being dispersed in competing state agencies and organizations."[11] For example, MITI's rivals, including the Ministry of Finance, could potentially exacerbate any overregulation problem if each competing organization issued additional mandates to gain more organizational clout.

MITI's intrusiveness has traditionally been justified by the necessity for Japan to take drastic measures to catch up to the rest of the world technologically—"[p]rior to the mid-1970s, MITI's research programs displayed classic traits of an industry follower in a catch-up mode."[12] However, once Japan caught up with and, in many areas, surpassed its erstwhile leaders in the 1980s, MITI's intervention lingered for far longer than many considered necessary. To the extent that it may have adversely affected the scientific subculture, it could even have played a role in the economic slump thereafter.[13]

A representative case is the semiconductor industry.

Support and Semiconductors

It was formerly thought that possible MITI excesses were causing Japan to lag behind the U.S. in applied research, but an exhaustive study of the semiconductor industry (Figure 2) failed to show significantly higher costs due to poorer manufacturing techniques.[14]

Japan's former deficiency in semiconductor technology led MITI to organize an effort to reduce the gap: "Japan began attempting to promote the semiconductor industry through subsidized and government-encouraged collaborative research, especially the famous very large scale integration program."[15] This project arranged for disparate firms to work together for maximum efficiency by not duplicating each others' efforts, provided heavy protection from competition from outside firms, and took advantage of "the openness of the U.S. semiconductor industry to foreign investment" to introduce exogenous sources of technology.[16] As a result, Japan reached a level equivalent to or beyond that of the U.S. By 1987, the U.S. Department of Defense found that Japan held the lead in twelve of 24 major categories of semiconductor technology, with a 50% share of the world market, up from 30% a decade earlier.[17]

Since then, however, the Japanese edge in semiconductors has declined, raising questions concerning the appropriateness of continued MITI involvement. This involvement has accordingly fallen off: "Japanese semiconductor makers [are] able to achieve, even at best, a 20% profit rate on their sales," while the industry standard is around 35%.[18] Furthermore, "Japan's R&D projects display a decline in the government's interventionist capabilities as the country's computer and semiconductor industry dramatically moves from industry follower to technological pioneer."[19] Only time may tell if this step will lead to a rebound in the semiconductor industry.

Patent Mischief

By gathering multiple groups in the semiconductor field and encouraging cooperation, MITI temporarily hastened progress by reducing the inefficiencies inherent in redundant research. Yet in the long run, this strategy proved to reduce innovation. Because each firm's breakthroughs were instantly accessible to its competitors, the incentives to create additional such breakthroughs diminished, harming the enterprise in the long term.

The problem of protecting innovation is not new, and has long been resolved via patents and other intellectual property protections that give the inventor of a new scientific process exclusive rights to use or license it for a fixed period of time. There is an inherent tradeoff in any patent system between the short-term gains due to wide availability of technology and the long-term gains due to innovation that accrue from strong intellectual property rights; the longer the time period, the more long-term innovation, but also the more short-term inefficiency. To a much greater extent than the U.S. and most other industrialized countries, Japan has systematically favored the former objective, preferring to avoid the short-term inefficiencies of each firm reinventing the wheel. The Japan Patent Office openly cautions against people or firms "needlessly spend[ing] resources in order to invent the same thing" as a product already developed.[20] Japanese patents are cited more on average than U.S. patents, suggesting that the weaker patents were unable to make it through the system in the first place.[21]

While the Japanese government theoretically needs permission from a firm to distribute its technology to avoid violating its private property rights, in practice MITI is sufficiently powerful, and the government-industry connections are so close, that the firm would be hard-pressed to avoid giving at least conditional approval:[22] "[i]ndustries are valued for the knowledge they generate as much as the products they produce."[23] MITI wants to take full advantage of that knowledge, although the fact that Japan no longer needs to play catch-up has led to a partial reassessment of this strategy.

A DRAM of Innovation

The role of intellectual property protection in fostering innovation may be illustrated through the case of Dynamic Random Access Memory integrated circuits, or DRAMs (Figure 3). Firms producing DRAMs face high start-up costs, rendering the pooling of resources beneficial, a fact that did not go unnoticed by MITI: "Facilitated by initial guidance from MITI, large Japanese corporations pooled some resources for joint pre-commercial research projects, simultaneously made strenuous efforts to acquire advantages over their

competitors through proprietary research, and eventually succeeded in controlling the bulk of the international DRAM market."[24] Other regulatory agencies went further still: "In the 1970s and early 1980s, government-owned Nippon Telegraph and Telephone (NTT) transferred device designs and production technology of 64K and 256K DRAMs to other Japanese firms, allowing them access to the knowledge at little cost."[25]

These distributionary policies helped Japanese firms equal the United States in competitiveness, but at the cost of degrading long-term innovation. An observer noted in 1991 that "[a]s the complexity of further improvements in semiconductors accelerates, it is questionable, however, whether past patterns of innovation with relatively little direct state subsidies will be a guide to future success in this technology area."[26] As in the case of semiconductors, the Japanese edge in DRAMs has declined over the past decade, fulfilling the prediction.

Defense Technology

As we have seen, most Japanese scientific research is initiated by private industry, which is generally sufficient to cover the full spectrum of required commercial research. But what about the defense sector? The defense industry plays an important role in scientific research for almost every country, for the simple reasons that (a) security is a major national priority, and accordingly, (b) the military is flush with cash. For Japan, (a) is true to a lesser extent; its post-World War II pacifism has meant that economic growth takes priority over the military. Accordingly, (b) breaks down as well; Japan's Self-Defense Forces have a budget capped at a mere one percent of GDP, far below that of other industrialized nations.

While most countries explicitly use the abundant resources of their militaries to fund private research and rely upon private industry to bolster their defense needs, in Japan, this process is subtler. Japan's defense industrial strategy is tactfully expressed in the following excerpt from a document:[27] "(1) To maintain Japan's industrial base as a key factor in national security; (2) To acquire equipment from Japan's domestic R&D and production efforts; (3) To use civil industries; (4) To have R&D and production plans follow long-term perspective; (5) To introduce the "Principle of Competition" into defense production."[28] Hardly a ringing endorsement.

The relatively low stature of the defense industry is reflected in research funding allocation. In the U.S., about 55% of all scientific research goes to military purposes, and civilian technology is often "spun-off" of defense technology; in Japan, that figure is in the single digits, and defense technology is often "spun-on" civilian technology.[29] Even ostensibly defense-related research contracts are not necessarily awarded on the basis of providing the strongest military equipment, for "defense technology is valued as much for its ability to elevate the fundamental capacities of the economy than as a means for actually producing military hardware."[30] Responsibility for maintaining research funding is divided between MITI, the Ministry of Finance, and the Japan Defense Agency. One of MITI's main tools in this regard is the negotiation of co-production arrangements, apportioning contracts to both Japanese and American firms.

Figure 3. The first mass-produced 90nm 512 Mb DRAM. Source: Samsung.

The main tool MITI lacks is arms exports. The World War II peace settlement forbids Japan from exporting arms, a policy wholeheartedly endorsed by U.S. and European firms seeking to avoid competition. Japan has partially circumvented the ban via the export of dual-use (both civilian and military) products such as the BK-117 helicopter, and its arms exports are slowly growing.[31] Japan has also encouraged "all manufacturing companies [to become] involved in defense manufacturing" to minimize the inevitable negative balance of payments in the defense sector.[32]

Despite intermittent moves towards autonomy, "[t]he Japanese defense industry is still too embedded within its larger civilian industrial network to be able to stand on its own. Vertical expansion is not possible. Therefore, horizontal extension through cooperation with American arms makers represents Japan's most efficient route to acquire technology for possible civilian and military applications and market expansion."[33] This situation is unlikely to change, as "Japanese industry has continued to be reluctant to commit itself to arms manufacturing. No major Japanese weapons manufacturer is dependent on arms contracts for more than 10 percent of its sales."[34] Unlike the specialized private defense contractors found in plentiful supply in the U.S. and elsewhere, "the Japanese defense industry is not characterized by large independent companies, similar to General Dynamics, Northrup [Grumman], and Lockheed [Martin], that operate primarily on defense contracts. Japanese companies exhibit the reverse structure: large civilian enterprises that rely primarily on market forces but which have defense firms appended to them."[35] Accordingly, within each firm, defense is only a minor priority compared to more profitable civilian enterprises.

An appropriate case study is the ill-fated FS-X which is not an '80s alternative-rock band, but a futuristic fighter.

The FS-X

The FS-X (Figure 4), originally conceived as a replacement for an obsolete jet fighter, was to be the first major all-Japanese defense program. A May 1985 study commissioned by the Japan Defense Agency found that domestic firms were capable of full production of the aircraft except for the engines, which would be subcontracted to a U.S. firm.[36] The project was launched, but the passage of time revealed gradually increasing levels of U.S. involvement.

Not wishing to see Japan gain too much defense autonomy for geo-strategic reasons, but also not wishing to appear too heavy-handed, the U.S. exerted pressure on Japanese policymakers to place a greater emphasis on engines and other systems in which domestic firms were

Figure 4. An artist's conception of the unbuilt FS-X.
Source: GlobalSecurity.org.

relatively inefficient. The Japanese firms, due in part to their overwhelming orientation towards civilian purposes and the lack of any historical precedent of an all-Japan defense effort, could not keep pace. Escalating projected cost overruns (Japan could have simply purchased F-18s for a mere 4 billion yen apiece[37]) soon led Japan to give up and in 1987 agree to a traditional co-production arrangement with the U.S. firm General Dynamics based upon modifications to the F-16.

This backtracking was not all bad news for Japan. The terms of the co-production arrangement were quite favorable, as the U.S. was desperate to end the FS-X project and its accompanying move towards Japanese defense technological autonomy. The lengths to which the U.S. was willing to go to avoid such a scenario—including the acceptance of only 40 percent of the $1.2 billion estimated for development expenditures[38] and one-sided technology transfers to Japan—have in fact led various U.S. interests to complain of one-sidedness. The FS-X or any similar program, therefore, is unlikely to resurface.

Technology Transfer

Thus far this report has focused primarily on internal mechanisms. But the plight of the FS-X illustrates that other countries, especially the U.S., play a key role in Japan's technology landscape. As seen above, Japan has a large net import of technology from the U.S., and while "there are very few countries with which Japan enjoys a technology trade surplus,"[39] among them are several of Japan's extensive contacts in Europe and East Asia.

There is a net technology transfer out of Japan and into China, Thailand, Indonesia, and the United Kingdom,[40] which in part reflects Japan's willingness to "serve as a 'tutor' who transfers industrial knowledge to the comparatively advantaged industries of the developing countries."[41] For example, "[South Korea] looked to Japan as a model for organizing science and technology, specifically to Tsukuba Science City, where Japanese planners had brought together a number of national laboratories and research institutes in the conviction that close geographic proximity would encourage intellectual synergy."[42]

Nevertheless, the U.S. looms largest. Technology transfer between these two nations is immense, accounting for over 15% of overall Japanese R&D expenditures. As mentioned above, defense technology flows westward across the Pacific Ocean, while civilian technology in the automobile, video game consoles, and (perhaps) invisibility-cloak sectors flow eastward. Acquiring existing U.S. technology frees up resources that then permit "the subsequent application of domestic R&D resources towards improving upon the quality of existing products,"[43] R&D expenditures which "have generally promoted Japan's trade advantage."[44] Clearly this trade in knowledge, as with trade in material goods, is a win-win situation.

At times, however, petty bilateral disputes have led many to lose sight of this larger picture. Japanese scientific research is less open than its counterpart in the U.S., making it more difficult for U.S. firms to obtain Japanese technology than vice-versa: "[I]t is sometimes argued that international spillovers are one-sided: Japanese firms can learn from U.S. firms, but U.S. firms are unable to learn from Japanese firms. Throughout the 1960s and 1970s, Japan acquired a substantial amount of U.S. technology from license agreements with major U.S. firms that were prevented from investing directly in Japan. Some believe that a one-way flow of technology continues today because of the openness of U.S. society and the lack of investment restrictions."[45] This problem is exacerbated by the large differential in foreign direct investment. Japanese equity investments in the U.S. "presumably give Japanese investors direct, first-hand access to state of the art technology," while the relative impermeability of Japan to U.S. investment has created no countervailing influence.[46] Thus, U.S. calls have gone out, especially in the 1980s, to restrict Japanese investment as well as technology transfer.

Many of the worst tensions caused by this issue were alleviated when "the two governments reached agreement and signed a memorandum of understanding on

Figure 5. Industrial milling equipment similar to that involved in the Toshiba scandal.
Source: Separator Engineering, Ltd.

November 29, 1988...[a]ny technology 'essentially derived' by the Japanese from U.S. technology was to be available to U.S. firms free of charge, while non-derived technology would be licensed to interested U.S. firms, for a fee, under the terms of a U.S.-Japan defense technology transfer agreement signed in 1983."[47] This agreement favored Japan economically, while maintaining U.S. dominance in areas of defense technology. In other words, there would be no more FS-X's.

Toshiba: Not Just Cool Laptops

Despite the closure of the FS-X project, elements of mutual distrust have remained. Fears of sharing sensitive technology are only heightened when matters of national security are involved, which an incident from the late 1980s seemed to confirm.

The Japanese industrial giant Toshiba (now mainly known for its extensive line of consumer electronics products) had been cooperating with U.S. defense firms to construct submarines. This endeavor naturally required Toshiba to be privy to the relevant naval technology. Yet somehow Toshiba was unable to safeguard certain computerized submarine propeller milling machines (Figure 5) designed to smooth the propellers' surfaces, thus making the subs quieter and harder to detect. The technology ultimately fell into the clutches of the Soviet Union.

With the Cold War still raging, the security breach set off a furor. U.S. firms, already disgruntled over the perceived one-way technology transfer, viewed it as yet one more reason not to deal with the Japanese. Prior to the incident, there had been "some government financial support, but...quite modest" for this particular machine tool sector, but soon the sums became still more modest as the Japanese government yielded to pressure.[48] Toshiba discontinued production of the offending milling machines. There never was an elegant resolution to the crisis, which illustrates that even a highly successful and extensive bilateral technology transfer regime can be subject to sudden unexpected disruption. The demise of the U.S.S.R. has alleviated this particular problem, although China and various rogue nations remain concerns.[49]

Discussion

In summary, we have seen that Japanese technological capabilities are first-rate, on par with those of the U.S. They differ in the following respects: the Japanese system is more heavily regulated by MITI; favors short-term efficiency at the expense of long-term innovation; focuses more on civilian applications to improve the economy, rather than military applications to improve security; and is a net recipient of technology transfers, as opposed to a net exporter.

For Japan, these findings allow for a great deal of flexibility with respect to domestic security but very little with respect to international security. Since the defense sector plays a relatively small role in the Japanese scientific research system, technological enterprise would largely proceed unhindered without it. Accordingly, should Japan wish to cut the Self-Defense Forces, its research programs would not be significantly impacted; on the other hand, should it wish to improve them, the scientific infrastructure could provide sufficient accommodation.

One thing Japan cannot afford to do, however, is terminate or scale back its technological relationship with the U.S. While Japan's historic economic reliance on the U.S. is waning due to the growth of China and other developing Asian states, its technological dependence shows no such signs to any significant degree. Although it is unlikely that the U.S. would (or could) shut off technology exports, this fact alone seems to indicate that the strong Japan-U.S. alliance will endure for the foreseeable future. For the U.S., it is a matter of strategic interest; for Japan, one of economic and technological necessity.

References

1. Robin McKie, "Japanese boffins spawn almost invisible man," *The Guardian*, 13 June 2004.
2. Francis L. Hawks, *Narrative of the Expedition of an American Squadron to the China Seas and Japan* (Washington, DC, 1856)
3. Eric Heginbotham and Richard J. Samuels, "Mercantile Realism and Japanese Foreign Policy," *International Security*, Vol. 22, No. 4 (Spring 1998), p. 197.
4. Peter C. Evans, "Japan's Green Aid Plan: The Limits of State-Led Technology Transfer," *Asian Survey*, Vol. 39, No. 6 (November/December 1999), pp. 837-838.
5. To avoid confusion, METI shall be referred to as MITI.
6. Chalmers Johnson, *MITI and the Japanese Miracle: The Growth of Industrial Policy, 1925-1975*. Stanford, CA: Stanford University Press, 1983.
7. Marie Anchordoguy, "Japanese-American Trade Conflict and Supercomputers," *Political Science Quarterly*, Vol. 109, No. 1 (Spring 1994), p. 41.
8. Glenn R. Fong, "Follower at the Frontier: International Competition and Japanese Industrial Policy," International Studies Quarterly, Vol. 42, No. 2 (June 1998), p. 340.
9. Herbert Kitschelt, "Industrial Governance Structures, Innovation Strategies, and the Case of Japan: Sectoral or Cross-National Comparative Analysis?", International Organization, Vol. 45, No. 4 (Autumn 1991), p. 485.
10. Fong, "Follower at the Frontier: International Competition and Japanese Industrial Policy," p. 362.
11. Gregory P. Corning, "U.S.-Japan Security Cooperation in the 1990s: The Promise of High-Tech Defense," *Asian Survey,* Vol. 29, No. 3 (March 1989), p. 283.
12. Fong, "Follower at the Frontier: International Competition and Japanese Industrial Policy," p. 340.
13. *The Economist*, April 8, 1989, p. 72.
14. Douglas A. Irwin and Peter J. Klenow, "Learning-by-Doing Spillovers in the Semiconductor Industry," T*he Journal of Political Economy*, Vol. 102, No. 6 (December 1994), p. 1203.
15. Paul R. Krugman, Carlos F. Diaz-Alejandro, and Robert Z. Lawrence, "The U.S. Response to Foreign

Industrial Targeting," *Brookings Papers on Economic Activity*, Vol. 1984, No. 1 (1984), p. 121.

16. National Research Council. *U.S.-Japan Strategic Alliances in the Semiconductor Industry: Technology Transfer, Competition, and Public Policy.* Washington: National Academy Press, 1992, p. 51.
17. Defense Science Board Task Force on Semiconductor Dependency, *Defense Semiconductor Dependency.* Washington, DC: Office of the Under Secretary of Defense for Acquisition, February 1987. See also Glenn R. Fong, "Follower at the Frontier: International Competition and Japanese Industrial Policy," p. 343.
18. Fukuda Hidetaka, "Seven Questions and Comments for Japan's Semiconductor Industry," Research Institute of Economy, Trade, and Industry, 29 January 2002.
19. Fong, "Follower at the Frontier: International Competition and Japanese Industrial Policy," p. 339.
20. Japan Patent Office, http://www.jpo.go.jp/
21. National Science Foundation, "Asia's New High Tech Competitors: Technological Importance of Asian Patents," http://www.nsf.gov/sbe/srs/s4495/conten1b.htm.
22. Evans, "Japan's Green Aid Plan: The Limits of State-Led Technology Transfer," p. 839.
23. Peter J. Katzenstein and Nobuo Okawara, "Japan's National Security: Structures, Norms, and Policies," *International Security*, Vol. 17, No. 4 (Spring 1993), p. 99; from David Friedman and Richard J. Samuels, *How to Succeed without Really Flying: The Japanese Aircraft Industry and Japan's Technology Ideology*, Cambridge, MA: Japan Program, Center for International Studies, MIT, 1992, p. 55.
24. Kitschelt, "Industrial Governance Structures, Innovation Strategies, and the Case of Japan: Sectoral or Cross-National Comparative Analysis?", pp. 485-486; see also R. Fong, "State Strength, Industry Structure, and Industrial Policy: American and Japanese Experiences in Microelectronics," *Comparative Politics* 22 (April 1990), pp. 273-99.
25. Irwin and Klenow, "Learning-by-Doing Spillovers in the Semiconductor Industry," p. 1205.
26. Kitschelt, "Industrial Governance Structures, Innovation Strategies, and the Case of Japan: Sectoral or Cross-National Comparative Analysis?", pp. 485-486; see also R. Fong, "State Strength, Industry Structure, and Industrial Policy: American and Japanese Experiences in Microelectronics," pp. 273-99.
27. Jacques S. Gansler, "Needed: A U.S. Defense Industrial Strategy," International Security, Vol. 12, No. 2 (Autumn 1987), pp. 61-62.
28. Japan Defense Agency, "Basic Policy for Development and Production of Defense Equipment," July 1970; published in *Defense and Foreign Affairs*, July 1983, p. 25.
29. Richard J. Samuels, *Rich Nation, Strong Army: National Security and the Technological Transformation of Japan.* Ithaca, NY: Cornell University Press, 1996.
30. Friedman and Samuels, *How to Succeed without Really Flying: The Japanese Aircraft Industry and Japan's Technology Ideology*, pp. 4-5.
31. Corning, "U.S.-Japan Security Cooperation in the 1990s: The Promise of High-Tech Defense," p. 284.
32. Malcolm McIntosh, *Japan Re-armed.* London: Frances Pinter, 1986, p. 52.
33. Andrew K. Hanami, "The Emerging Military-Industrial Relationship in Japan and the U.S. Connection," *Asian Survey*, Vol. 33, No. 6 (June 1993), p. 609.
34. Thomas U. Berger, "From Sword to Chrysanthemum: Japan's Culture of Anti-militarism," *International Security*, Vol. 17, No. 4 (Spring 1993), p. 127.
35. Hanami, "The Emerging Military-Industrial Relationship in Japan and the U.S. Connection," pp. 600-601.
36. Masaru Kohno, "Japanese Defense Policy Making: The FSX Selection, 1985-1987," *Asian Survey*, Vol. 29, No. 5 (May 1989), p. 459.
37. Ibid., pp. 460, 468.
38. Michael Mastanduno, "Do Relative Gains Matter? America's Response to Japanese Industrial Policy," International Security, Vol. 16, No. 1 (Summer 1991), p. 86.
39. Eric Heginbotham and Richard J. Samuels, "Mercantile Realism and Japanese Foreign Policy," *International Security*, Vol. 22, No. 4 (Spring 1998), p. 197.
40. Ibid.
41. Terutomo Ozawa, "International Investment and Industrial Structure: New Theoretical Implications from the Japanese Experience," *Oxford Economic Papers*, New Series, Vol. 31, No. 1 (March 1979), p. 80.
42. Sheridan Tatsuno, *The Technolopis Strategy: Japan, High-Technology, and the Control of the Twenty-first Century* (New York: Prentice-Hall, 1986); Kim Dong-Won and Stuart W. Leslie, "Winning Markets or Winning Nobel Prizes? KAIST and the Challenges of Late Industrialization," Osiris, 2nd Series, Vol. 13 (1998), p. 178.
43. David B. Audretsch and Hideki Yamawaki, "R & D Rivalry, Industrial Policy, and U.S.-Japanese Trade," *The Review of Economics and Statistics*, Vol. 70, No. 3 (August 1988), p. 447.
44. Ibid., p. 438.
45. Irwin and Klenow, "Learning-by-Doing Spillovers in the Semiconductor Industry," pp. 1205-1206.
46. National Research Council, *U.S.-Japan Strategic Alliances in the Semiconductor Industry: Technology Transfer, Competition, and Public Policy,* p. 51.
47. Mastanduno, "Do Relative Gains Matter? America's Response to Japanese Industrial Policy," p. 86.
48. Krugman, Diaz-Alejandro, and Lawrence, "The U.S. Response to Foreign Industrial Targeting," p. 121.
49. *Japan Today*, "Japanese precision device found in Libyan nuke plant," 9 September 2004.