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New Strategies for New Challenges: Corporate Innovation in the United States and Japan

Report of the U.S.-Japan Task Force on Corporate Innovation

A Joint Project of the National Research Council Committee on Japan and the Japan Society for the Promotion of Science Committee 149

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OVERVIEW

Innovation, "*the process by which firms master and get into practice product designs and manufacturing processes that are new to them*," is vital for companies wishing to remain competitive in today's rapidly changing high technology industries.[1] American and Japanese firms are among the world's most technologically innovative and competitive. However, the changing dynamics of global competition are forcing them to rethink their technological innovation strategies. The choices they make will have great impact on their futures as companies as well as on the livelihoods of their employees and the communities in which they operate.

In order to understand the ways in which Japanese and American companies are changing their technological innovation strategies and practices, the Committee on Japan of the National Research Council and the Committee on Advanced Technology and the International Environment (Committee 149) of the Japan Society for the Promotion of Science (JSPS) organized a bilateral task force composed of leading representatives from industry and academia to assess developments in corporate innovation strategies and report on their findings for the benefit of government policymakers and corporate strategists alike. The task force explored the institutional division of innovation in both countries: the structure and performance of technology-based industries, the role of the government in the support of science and technology, and the role of universities in the science and technology system. The task force was particularly interested in exploring the points on which the two systems are converging, — i.e., becoming more similar in strategy and practice—and where they continue to be distinct and different.

Much more basic work would need to be done in a comprehensive assessment of U.S. and Japanese innovation. Therefore, the task force decided to identify a set of issues whose further elucidation should be helpful in guiding public policy in both nations. These issues include the role of external sourcing of innovation; transnational activity and globalization, the organization and performance of R&D, and the role of consortia, joint ventures and other joint activities.

The findings of the task force fall into two broad categories: some relate to emerging trends and issues which can be discerned either empirically or intuitively; others relate to the need for better analytical concepts and tools to develop a clearer understanding of the dynamics of innovation. The task force reached consensus on several major findings.

Major Areas of U.S.-Japan Convergence and Continued Disparity *There is both evidence of convergence in innovation strategies and practices between U.S. and Japanese corporations and also of sustained differences. Furthermore, there is great diversity within each system.*

In conducting this study, the task force used the concept of *convergence*—the idea that U.S. and Japanese corporations are beginning to function more like each other than they once did—as a lens with which to focus and clarify the complex and often confusing array of adaptations in corporate technological innovation strategies. This approach naturally led to searching-out similarities and differences in corporate innovation practices as they are currently evolving and

[1] Richard R. Nelson, *National Innovation Systems: A Comparative Analysis* (New York: Oxford University Press, 1993), p. 4.

also to a comparison of current practices with past paradigms of U.S. and Japanese corporate innovation systems. The picture which emerged is mixed. The Joint Task Force agrees that there is strong evidence that U.S.-Japan *problem convergence*, or increasing similarity in the problems to be addressed by corporate innovation in the two countries, is occurring.[2] However, there is a variety of views among committee members over whether U.S. and Japan-based companies are becoming more similar in their strategies and approaches to the problems of intensifying global competition. Some practices appear to be growing more similar, such as the use of external sources of innovation and the relationships of original equipment manufacturers with suppliers and customers. Other practices are still quite different, such as those of human resources utilization and development. The value of the approach taken by the task force lies not only in identifying areas of growing similarity, but in highlighting national and industry-level differences in corporate approaches to innovation. It is undoubtedly true that convergence is occurring in some areas. It is also undoubtedly true that major differences in underlying beliefs, motives, and institutional relationships which shape each nation's innovation strategies continue to exist. Following are specific points of convergence and continued differentiation:

Growing Similarities and Evidence for Convergence

Original equipment manufacturer (OEM)-supplier relations: U.S. firms are relying on a smaller number of trusted suppliers while Japanese suppliers are beginning to expand business with firms outside their traditional business groups. Drivers of this phenomenon include increasing global competitition and the search for cost reduction and quality. In the case of Japanese OEMs, the successful experience of transplant companies (which in many respects have been forced to use non-group suppliers), and yen appreciation have fueled an accelerated search for non-Japanese based suppliers to keep costs competitive.

Inventiveness: Companies in each country are focused on attaining innovation-related capabilities associated with firms in the other nation. For example, Japanese firms are putting greater emphasis on inventiveness, while U.S. firms are focusing more on being responsive to market needs, improving existing products, shortening product cycles, and improving manufacturing processes and quality.

Core competence: Firms in both countries are focusing their resources in the quest for greater efficiency and lower cost. Many lower priority activities are being outsourced. Some refer to this process as a strategy for placing priority on "core competencies"—the attributes of a firm that it believes are the primary source of competitive advantage. However, there is no consensus among Japanese and U.S. practitioners either on the meaning of core competence or on the extent to which it is an effective general strategy.

Role of government: The role of government with respect to innovation and competition is in flux in both the United States and Japan. In the United States, prior to the U.S. mid-term elections of November 1994, the federal government was moving toward expanded support for the development and diffusion of precompetitive commercial technology. However, due to the change in leadership and philosophy in the U.S. Congress, this tendency has shifted somewhat. The expansion of civilian technology programs has been frozen. While support for basic research has been largely maintained across relevant agencies, the outlook for continued long-term growth

[2] Box 3-1 explains the definition of *convergence* used by the Joint Task Force, as well as alternative formulations.

in entitlement spending has negative implications for discretionary programs, including science and technology.

In Japan, the government is said to be reducing industrial intervention. At the same time, it is increasing subsidies for research and development and continues to play a coordinating role in setting industrial policy. Also, a number of policy changes undertaken after the active portion of the Joint Task Force activity was completed reveal renewed determination on the part of the Japanese government to strengthen basic science. These changes include increased support for educational infrastructure in the supplemental budgets of recent years, as well as new and expanded programs of support for academic research by agencies other than the Ministry of Education, Science, and Culture (Mombusho), such as the Science and Technology Agency (STA) and the Ministry of International Trade and Industry (MITI). In 1995, Japan passed a new Science and Technology Basic Law, and released its Science and Technology Basic Plan in July 1996. Two key elements of these initiatives are increased public support for science and technology, and systemic changes aimed at improving the environment for creative basic research.[3]

Continuing Fundamental Differences and Evidence Against Convergence

Defense-related R&D spending: Despite a long-term decline in the share of U.S. R&D efforts devoted to defense, defense will continue to play a major role in U.S. research and innovation, while Japan's defense R&D, although growing rapidly, continues to be relatively limited.

Role of universities: Universities in the United States play a much greater role as performers of research and as partners with industry than do universities in Japan.

Industry/government division of responsibility: Notwithstanding recent changes in Japanese policy outlined above, industry continues to be the predominant source of research and development funding in Japan, whereas in the United States research and development funding is more evenly split between industry and government.

Labor-market practices: The Japanese labor market is characterized by long term employment, whereas the U.S. labor market is characterized by job mobility. These attributes lead to significant differences in corporate employee development practices.

Supplier networks: U.S. supplier networks are comparatively more accessible to newcomers than Japanese supplier networks, which are characterized by long-term business ties, often reinforced by ownership linkages. Japan's vertical *keiretsu* are adapting to new challenges, as described below, with indications that they will become more open, particularly as Japanese firms continue to globalize. Still, U.S.-Japan differences are likely to continue, especially with regards to innovation and production networks inside Japan.

Component sourcing: Japanese subsidiaries abroad continue to be more dependent on imports from the home country than do American subsidiaries abroad.

Financial environment for innovation: In Japan, *cross share-holding* and traditional horizontal business groups (horizontal *keiretsu*) composed of major banks and manufacturers

[3] Motivations and context for the Basic Law and Basic Plan are covered in "Constructing a New Global Partnership: Science and Technology as in Investment for the Future," address by Minister of State for Science and Technology Hidenao Nakagawa at the National Academy of Sciences, August 8, 1996.

help insure long-term financial stability. In the United States, *venture capital* is a driving force for innovation and competitiveness.

Emerging Trends

Greater reliance on external sources of innovation*In the view of the task force, external sourcing of technology and innovation— that is, the acquisition of technology and innovation from sources outside one's own firm—is the most important development in global technology management.*

External sourcing is taking place through what is traditionally referred to as the process of *outsourcing*—the practice by which OEMs solicit increasingly sophisticated technological components from suppliers—and through newly emerging forms of technological partnerships and alliances with other firms. American firms are becoming more like Japanese firms which have long sourced technology and innovation from outside. At the same time, the traditionally strong vertical alliances between Japanese OEMs and suppliers are changing as suppliers develop diagonal relationships with firms outside the group. The burgeoning *integration* of U.S. and Japanese corporations is a major factor in innovation sourcing. As corporations adapt to the imperatives of global financial markets, the complexities of high technology products and processes, and the high costs of innovation, they are entering into many forms of alliances, consortia, and joint ventures in which technology sharing, based on complementary assets, is a major factor. Some recent U.S.-Japan alliances would have been unthinkable a few years ago. For example, in the semiconductor industry U.S. and Japanese companies have concluded agreements to engage in joint production in the United States.

Shifts in corporate R&D strategies and organizations

As large U.S. corporations restructure to achieve efficiency and competitiveness, their internal basic research is diminishing, whereas some Japanese companies are beginning to enhance their research organizations and investments.

Even though U.S. firms continue increase linkages to universities and other external performers of basic research, some observers worry that if U.S. firms fail to continue internal research in leading edge fields, their attempts to rely on universities and other institutions may fail for lack of the ability to identify and absorb the help they need. Japanese corporations, on the other hand, seem to be protecting their internal basic research even as their overall expenditures on R&D have diminished over the past several years.

Role of consortia to set de facto standards

The emergence of business consortia to set de facto technology standards is a major development which will have far-reaching impact on industrial competitiveness and innovation.

The formal standards process is often too slow and too open to meet all the needs of firms, especially in information industries, to find a path to open systems that is consistent with business objectives. However, the growing number of business consortia composed of multinationals based in the United States, Japan and other countries that set *de facto* technology standards, while solving commercial needs, has raised antitrust concerns because these standards are often proprietary. This is likely to be an important issue in future multilateral trade negotiations. More attention needs to be devoted to this issue as well as to the proper role of national governments.

Need for more data on U.S., Japanese and global trends in corporate innovation

Much more systematic data collection and analysis is needed in order to make it possible to identify and understand the significant trends in corporate innovation practices.

In particular, lack of data to measure the extent of sourcing of innovation, and international trends in particular, is perhaps the most serious impediment to understanding the relationships of trans-national outsourcing of innovation on industrial dynamics and on international relations.

Need to continue scholarly work on models and frameworks for innovation

Continued work on new frameworks of analysis of systems of innovation is needed in order to better understand the discrepancies between the changes that are truly occurring in corporate and government policies and those that are merely being advocated.

Changes taking place today in the structure of high technology industries, the methods being used to optimize the technological components of competitiveness, and the importance of trans-national as well as domestic relationships among firms, are occurring so rapidly that the models underlying many government policies and attitudes toward U.S.-Japan relations in science and technology may be outdated. There is a continuing need for private sector input into policy decisions that affect the environment for innovation.

The concept of *national systems of innovation* is being challenged by the increasingly global nature of markets and production networks. Various approaches have been suggested in order to better understand the emerging dynamics and characteristics of global innovation. Each approach attempts to illuminate a part of this complex issue. For example, *market pull vs. technology-push* have long been employed as alternative analytical descriptors of different behaviors and stimuli for innovation. The concept of *demand articulation*, a two step process for working from market data to the development of products, explains innovation through an integration of supply and demand rather than from either the traditional supply or demand aspect alone. *Innovation mediated production*, which recognizes that information is at the core of new industrial innovation, is premised on understanding the increasingly central role of knowledge in the process of value creation. It is used to comprehend the emerging patterns in the globalization of innovation. Each of these conceptual frameworks represents an attempt to capture and explainthe essentials of real-world behavior and serve as a rough guide for innovation strategy.

Also needed are more realistic categories to measure and compare U.S. and Japanese technology resources and assets. The *corporate technology stock model,* which calls for accounting for R&D as an investment rather than as an expense, is one possible way of placing financial value on R&D activities which would lend itself to cross-national comparisons.

The task force learned that American firms have done much to address problems of competitiveness by adapting lessons learned from Japanese competitors. Japanese firms are also changing, but less is known about the extent of these changes.

RECOMMENDATIONS

Despite the existence of a large volume of literature on innovation, systematic collection of basic data is the greatest need for accurate analysis of developments in innovation. *The task force recommends that government departments concerned with data collection and technology policy, such as the U.S. National Science Foundation (NSF), the Bureau of the Census, the Bureau of Economic Analysis of the Department of Commerce, and the Science and Technology Agency (STA) and Management and Coordination Agency in Japan, increase their efforts to collect meaningful data on innovation. Multinational agencies such as the Organization for Economic Cooperation and Development (OECD), the United Nations, and the Asia Pacific Economic Cooperation forum also have important roles to play.* Efforts in this area are already underway in agencies such as NSF and STA. However, without real encouragement from the private sector, such efforts may fall subject to budget constraints. This would be regrettable given the importance of innovation to economic performance. As the scope of interests covered by the subject of innovation is so broad and complex, many different kinds of data and analysis are needed. Specific areas for further work are included in the last chapter of this study.

1
Introduction

The objective of the U.S.-Japan Corporate Innovation Task Force was to assess current trends in the state of technology-based innovation in U.S. and Japanese industry as well as government policies in order to enable U.S.-Japan relations in science and technology to reflect a more realistic understanding of innovation dynamics. The task force hopes this effort will lead to higher productivity and more effective commercialization of public and private R&D.

American and Japanese firms are among the world's most innovative, and both nations recognize the importance of science and technology in innovation. Annually, the United States and Japan account for nearly three-fourths of world investment in R&D and 40 percent of patents.[4] They also support large contingents of scientific and engineering manpower. An understanding of the similarities and differences in the U.S. and Japanese innovation systems and how U.S. and Japanese corporations are adapting to meet the challenges of changing global markets is necessary for informed policymaking and corporate strategy-building.

The idea of forming a joint task force to study corporate innovation developments was initiated in a meeting in July 1991 between leaders of the National Academy of Sciences and Engineering with Japanese counterparts in the Committee on Advanced Technology and the International Environment under the Japan Society for the Promotion of Sciences. The actual formation of the U.S. and Japanese study teams occurred in 1994. Meeting separately in early 1994, the two groups began the process of identifying the most important issues and planning for a joint workshop in the fall. Previous collaboration by the cochairs which resulted in a jointly-authored report provided a valuable base for the current study. [5] The cochairs met several times during the intervening months to discuss the progress of the two teams and to refine plans for the workshop. In September 1994, a two-day workshop was held in Japan at which the U.S. and Japanese teams reviewed key issues (see agenda in Appendix). This report presents the results of the joint task force effort.

In conducting this assessment, the task force encountered the fact that much of the data and analysis needed to understand significant trends in corporate innovation practices are currently unavailable. However, the task force believes that a number of significant trends can be discerned and observations made to guide policy formation and corporate decision-making. Rather than attempting a comprehensive assessment, the task force identified a set of issues whose further elucidation should be helpful in guiding public policy in both nations. These issues

[4] Percentages of world R&D investments were calculated using figures provided for the United States, Japan, Germany, France and the United Kingdom in constant 1987 dollars using OECD purchasing power parity exchange rates in National Science Foundation, *Science and Technology Pocket Data Book, 1994*, NSF 94-323 (Arlington, VA, 1994), Figure 30, p. 41. Percentages of world patents were calculated from figures provided by National Science Board, *Science and Engineering Indicators-1993,* Washington, D.C.: U.S. Government Printing Office, 1993, (NSB 93-1), Appendix Table 6-12, p. 455, and Appendix Table 6-21, p. 465.

[5] Lewis M. Branscomb and Fumio Kodama, *Japanese Innovation Strategy: Technical Support for Business Visions* (Cambridge, Mass.: Harvard University Center for Science and International Affairs, Occasional Paper No. 10, 1993). For an extended version of this monograph in Japanese, see Lewis M. Branscomb and Fumio Kodama, *Nihon no haiteku gijutsu senryaku (Japan's High Technology Strategy),* (Tokyo: NTT Publishing Co., 1995).

include the organization and performance of R&D, the role of external sourcing of innovation, transnational activity and globalization, and the role of consortia, joint ventures and other joint activities.

The task force also explored changes in the institutional division of innovation in both countries: the structure and performance of technology-based industries, the role of the government in the support of science and technology, and the role of universities in the science and technology system. The task force was particularly interested in understanding the points on which the two systems are converging, and where there continue to be sustained national differences.

Chapter 2 outlines the major factual and perceptual factors which have informed our understanding of the U.S. and Japanese innovation systems in the past, including a review of strengths and weaknesses of the two systems and national and firm level differences. Chapter 3 discusses emerging trends and issues with special focus on evidence for and against convergence. Chapter 4 addresses the growing role of external relationships in corporate technology policy and innovation strategy, and the increasingly multilateral nature of U.S.-Japan technology relationships including the importance of industrial standard-setting. Chapter 5 discusses the need for a new theoretical framework to analyze and compare the U.S. and Japanese corporate innovation systems, and Chapter 6 suggests areas where further work is needed.

2
Past Perceptions of U.S. and Japanese Innovation Systems

Many observers have compared the U.S. and Japanese corporate innovation systems in order to better understand their inherent strengths and weaknesses and to ascertain which elements might be borrowed or adapted as a means of improving competitive performance. Some experts have focused on particular aspects such as R&D; others have focused on distinctive institutional and organizational features; while yet others have produced broad overviews encompassing historical as well as current developments.[1] A summary of past perceptions of the U.S. and Japanese corporate innovation systems will be useful in evaluating ongoing changes.

In general, observers have concluded that in the spectrum of attributes and capabilities comprising innovation, the United States is strongest in inventiveness, and Japan is strongest in manufacturing and customer feedback to enhance product quality. More specifically, as described by Lynn and others, the strengths and weaknesses of the Japanese system, in contrast to the U.S. system, are as follows: (1) an alleged unique ability to exploit technical knowledge developed in other countries; (2) speed in commercializing technology; (3) strength at incremental process and product innovation; (4) weakness at making breakthroughs and generally in basic research; and (5) emphasis on manufacturing process and customer feedback.[2]

NATIONAL LEVEL DIFFERENCES

Underlying the strategies toward innovation in each country are fundamental national level differences which influence corporate innovation choices. These fundamental differences include:

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[1]The list of innovation characteristics for this report was compiled from National Research Council, *Learning the R&D System: Industrial R&D in Japan and the United States* (Washington, D.C.: National Academy Press) 1990; Leonard Lynn, "Japan's System of Innovation: A Framework for Theory Guided Research," in *Research in International Business and International Relations*, Volume 6, pp. 161-187 (JAI Press, Inc., 1994) pp. 162-163; and Committee on Science, Engineering, and Public Policy (COSEPUP), *The Government Role in Civilian Technology: Building a New Alliance* (Washington, D.C.: National Academy Press, 1992), pp. 31-39. Broader treatments may be found in David C. Mowery and Nathan Rosenberg, "The U.S. National Innovation System," in Nelson, op. cit., pp. 29-75; and Hiroyuki Odagiri and Akira Goto, "The Japanese System of Innovation: Past, Present, and Future," also in Nelson, pp. 76-114.

[2] Points 1-4 are from Lynn, op. cit., p. 163. See also National Academy of Engineering, *Mastering a New Role* (Washington, D.C.: National Academy Press, 1993), especially Chapter 3: "Strengths and Weaknesses of the U.S. Technology Enterprise," pp. 61-90, and Richard Florida and Martin Kenney, *The Breakthrough Illusion* (N.Y.: Basic Books, 1990).

- a higher share of GNP for nondefense R&D in Japan (3 percent) than in the United States (1.9 percent)[3]
- the higher percentage of total national R&D funded by industry in Japan than in the United States (73 percent in Japan [1991] vs. 46 percent in the United States [1990])[4]
- venture capital as a driving force for innovation and competitiveness in the United States
- the prominent role of U.S. universities as performers of research, especially basic research (most of which is funded from federal sources), and strong linkages between university research and private industry[5]
- the prominent role of the Japanese government in establishing industrial and technology policies, disseminating information about technological needs and opportunities, assisting technology adoption, and otherwise working with Japanese corporations[6] an aggressive system of Japanese trade associations, trading companies, and other intermediaries that distribute technological information[7]
- the increasing focus of U.S. firms on partnering

FIRM LEVEL DIFFERENCES

Different historical backgrounds and industrial structures make it inevitable that Japanese and U.S. corporations approach technology and innovation from different perspectives. Experts have noted the following firm-level characteristics and differences:[8]

Organization and Geography of R&D: Japanese firms have tended to locate their divisional laboratories within or beside production facilities whether in Japan or in off-shore production sites, and maintain more of their technology development at the plant level, particularly incremental process or product improvements. However, Japanese corporations, like their U.S. counterparts, typically locate their basic research laboratories at some remove from their factory sites. The geographic, organizational and social distance between basic research and manufacturing is likely to increase as the pressures for globalization increase.[9] In the United

[3] Between 1970 and 1991, the nondefense share of Japan's R&D rose from 1.7% to 3% of GNP, whereas the nondefense share of U.S. R&D moved only slightly from 1.7% to 1.9%. Source: National Science Board, op. cit., Appendix Table 4-36, p. 376.

[4] The percent of R&D funded by Japanese industry rose steadily throughout the 1980s reaching 73% in 1991. In the United States, between 1986 and 1990, industry's share of total R&D remained fairly stable at approximately 46%. Source: National Science Board, op. cit., tables 4-37 and 4-38, pp. 377-378.

[5] See COSEPUP, op. cit., p. 31, and Cohen, Florida and Goe, *University-Industry Research Centers* etc. For a different viewpoint which stresses the reliance of Japanese corporations on research in Japanese universities, see D. Hicks et al, "Japanese Corporations, scientific research, and globalization," *Research Policy*, June 1994, pp. 375-384.

[6] See National Academy of Sciences, Ibid., and Lynn, op. cit., p. 162.

[7] Lynn, Ibid. Richard Florida is of the opinion that the role of trade associations is critical and if anything more important, and less well-understood than MITI, as they frequently motivate and add the content to MITI decisions. He has likened the Japanese system as, in a way, a logical extension of Herbert Hoover's notion of "*voluntary associationalism.*" (From a personal communication)

[8] See National Research Council, op. cit., pp. 6-13 and Branscomb and Kodama, op. cit., pp. 2-5.

[9] See Richard Florida and Martin Kenney, "The Organization and Geography of Japanese R&D: Results of a Survey of Japanese Electronics and Biotechnology Firms," *Research Policy* 23 (1994), pp. 305-323.

States, the location and relative emphasis of R&D vary greatly from firm to firm, but there is a general movement toward the Japanese model.

Long-term and Short-term Perspectives: Japanese corporate research seems to be more persistent and to take a longer-term perspective in speculative areas. R&D organizations in Japanese corporations allocate percentages of their budgets to "seed" research that is intended to encourage individual researchers to look into potentially promising areas that may or may not be tied to the company's short- and medium-term strategic plans.

R&D's Role in Setting Corporate Business Plans: Differences in the degree of integration between research and business divisions in Japanese and U.S. corporations influence the role that R&D organizations play in carrying out fundamental business plans. Over the past two decades, Japanese firms have increasingly made their R&D organizations the centers of diversification efforts. While some leading U.S. industrial corporations have looked to acquisitions to diversify their businesses and technologies, Japanese firms seem to be more successful at internally sourced diversification, perhaps because acquisitions are much more difficult to accomplish in Japan.

Human Resources Utilization and Development: Many differences between Japanese and U.S. corporate organization cluster around human resource development and the careers of researchers:

- Japanese corporations hire relatively few PhDs considering them to be over-specialized and lacking commitment to corporate business goals. American corporations have been more willing to trade off these drawbacks for the PhDs' greater capacity to do independent and creative research.
- Many Japanese corporations move R&D personnel into production divisions to follow their projects through the chain of production and into the market. In the United States, however, firms have drawn sharper lines among personnel in R&D, production, and manufacturing, permitting less crossover among these functional areas. The result may be to hamper intrafirm technology transfer.
- In Japan, midcareer researchers rarely move from one large company to another, whereas in the United States the practice is quite common (check Ed Roberts data). For the Japanese corporation this means that all the investment which the corporation pours into the person—the education, experience, sabbaticals at U.S. and European universities, the contact network, the knowledge, etc.—stays with the corporation. This in turn creates substantial incentives for the company to continue to invest in that person (asset) because the person (asset) is secure and relatively riskless. It is more risky for a U.S. corporation to make the same calculation given the high probability that the person will leave.
- Survey research indicates that technology strategy is more tightly integrated into overall corporate strategy by the top managements of Japanese companies than those of U.S. companies.[10]
- U.S. industrial R&D organizations assign great importance to new product innovation versus the higher Japanese reliance on acquiring and enhancing externally

[10]Edward B. Roberts, *Strategic Management of Technology: Global Benchmarking (Initial Report)* (Cambridge, Massachusetts: Sloan School of Management, MIT, 1993), p 2, and Branscomb and Kodama, op. cit.

generated technology and on incremental innovation. In addition, Japanese firms are often considerably faster at carrying out innovations based on external technology than are American firms.[11]

[11]See Edwin Mansfield, "Industrial Innovation in Japan and the United States," *Science*, Vol. 241, September 30, 1988, pp. 1769-1774.

3

Are the U.S. and Japanese Innovation Systems Converging? Evidence For and Against

How are the innovation strategies of Japanese and U.S. corporations changing, and to what extent are they becoming more alike as they adjust to new and unprecedented global market conditions? The attempt to answer such questions involves a discussion of the concept of "*convergence*"— the belief that globalizing market and financial conditions tend to force similar responses from globally competing companies, irrespective of their national origins, whereas heretofore the strategies of companies based in different countries were shaped significantly by national differences in circumstances and needs.

Some observers believe that the attention being paid to innovation in both countries, brought on by emergent trends in science, engineering and management, is resulting in a growing similarity in approaches to industrial innovation in the two countries. According to this formulation, this similarity appears as the problems addressed by corporate innovation in the two countries converge toward each other under the influence of these emergent trends. As evidence, they point to the fact that Americans are adopting many Japanese practices, including fewer suppliers with stronger relationships, just-in-time production, and heightened attention to quality control through process control; and Japanese firms are adopting U.S. practices by expanding their relationships with universities and urging greater investments by government in fundamental research.[1]

Some observers argue that Japan and the United States have both entered a new era in relationships in which we face each other more as equals economically and technologically than in the past.[2] With improvement in the cost and quality of many U.S. products in industries that had been hurt—and stimulated to improve—by Japanese competition, a number of sectors, such as semiconductors and automobiles, have seen increased market shares in the last two or three years.[3] It can be postulated that, if the innovation systems of both countries were to converge on a more common model, relationships might be expected to exhibit less friction, especially in trade relations.

Although it is often asserted that U.S. and Japanese industry and government are converging and changing drastically, the extent to which it is happening is unclear. At the national level, U.S. defense R&D continues to be central, and Japanese industry still funds a much greater percentage of R&D than does U.S. industry.[4] The following sections include a review of how

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[1]Branscomb and Kodama, op. cit., p. 2.

[2]For a comprehensive discussion of Japan's technological capabilities see Thomas S. Arrison, et al, eds., *Japan's Growing Technological Capability: Implications for the U.S. Economy* (Washington, D.C.: National Academy Press, 1992).

[3]The strong yen has helped this effect, but it is not solely responsible.

[4]Despite the end of the Cold War, defense R&D in 1995 still consumes over 54% of the federal R&D budget. See Office of Management and Budget, *Budget of the United States Government, Analytical Perspectives, Fiscal*

Japanese and American universities, industry and government are adapting to changing global conditions and a discussion whether conclusions can be reached about the extent of convergence. Box 3-1 describes the Joint Task Force's approach to convergence.

Changes in Industry

In Japan, some increase has occurred in the budget allocated to universities, and progress is being made in the reorganization of Japanese universities around graduate programs.[5] However, the percentage of R&D expenditures devoted to basic research in Japan has remained fairly flat since the mid 1980s (Figure 3-1) despite the greater policy emphasis put on basic research.[6] In fact, basic research in Japan historically has dropped from 22 percent of total R&D in the early 1970s to its current level of around 12 percent.[7] In contrast, basic research in the United States since the mid 1980s has climbed from 13 percent to 16 percent of total R&D.[8] With the passage of the Science and Technology Basic Law in 1995, adoption of the Science and Technology Basic Plan in July 1996, and other recent policy changes to encourage venture business interactions with academia and wider agency support for academic research, the Japanese government is renewing and extending efforts to strengthen its basic research base. Two key elements of these initiatives are increased public support for science and technology, and systemic changes aimed at improving the environment for creative basic research.[9] (Info on venture capital interactions with academia from Japanese group).

Japanese industry has become famous for placing high value on the importance of R&D as a critical element in developing future products. Consequently, Japanese industry has traditionally treated R&D as a long-term investment. Therefore, recent signs of a tapering off, if not a reversal, in the growth of R&D in Japanese industry have been a cause of some worry among policymakers in Japan. In Japan Fiscal Year (JFY) 1992, R&D spending by Japanese industry dropped 1.9% , the first decline since record-keeping began in 1953. In JFY 1993, total Japanese R&D dropped 1.4%, a first-ever decline in total R&D spending, due primarily to a 5.3% decline

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(Washington, D.C.: U.S. Government Printing Office, 1994, Table 9-1. However, this is down considerably from the nearly 70% at the height of the Cold War.

[5]In the JFY 1994 budget, funds for science promotion programs of the Ministry of Education grew at a rate greater than for other activities of the Ministry. Grants-in-Aid for Scientific Research grew 12% to 82.4 billion yen, and improvement of educational and research facilities and equipment at universities grew 16% to 126.3 billion yen. Source: Japan Society for the Promotion of Science-Washington Liaison Office, *Science Promotion*, Vol. 1, No. 1, June 1994, pp. 1-2.

[6]Source: Michael Borrus, from a presentation on "The Context of Industrial R&D Activities in the United States and Japan," bilateral meeting of the U.S.-Japan Joint Task Force on Corporate Innovation Strategies, Makuhari, Japan, September 11-13, 1994. Basic research in Japan decreased from 14.1% of total R&D in 1982 to 12.6% in 1990 and rose to 13.5% in 1992. Source: Management and Coordination Agency (of Japan), *Report on the Survey of Research and Development-1993* (Tokyo: Japan Statistics Society, 1994) Table 5, p. 31.

[7] Source: Isamu Miyazaki, "The State of the Economy and Structural Reform," a paper presented at a meeting of the National Research Council's Committee on Japan and Committee 149 of the Japan Society for the Promotion of Science, Makuhari, Japan, November 8, 1994, p.3.

[8] National Science Board, *Science and Engineering Indicators 1993* (Washington, D.C.: U.S. Government Printing Office, 1993), p. 94.

[9] Motivations and context for the Basic Law and Basic Plan are covered in "Constructing a New Global Partnership: Science and Technology as in Investment for the Future," address by Minister of State for Science and Technology Hidenao Nakagawa at the National Academy of Sciences, August 8, 1996.

BOX 3-1: Defining "Convergence"

Amid the changing strategies for corporate innovation on which the Joint Task Force has focused, it is clear that certain aspects of U.S. and Japanese corporate innovation have grown more similar to each other while others have remained distinct. Just what can be said about the aggregate trend of these changes and the resulting implications is less obvious. For this reason, the question covered in this chapter--whether or not U.S. and Japanese companies are moving toward similar approaches to innovation--is a central issue in the report. In order to address this question, the Joint Task Force employed the concept of convergence as a tool with which to elucidate the complex and often confusing array of adaptatations occurring in corporate innovation strategies. Such a framework enables the strategies to be analyzed in light of the innovation process itself. Therefore, the Joint Task Force on Innovation thought it would be useful to clarify its own definition, and relate its approach to other debates over U.S.-Japan convergence.

One usage of convergence which is distinct from the usage of the Joint Task Force is one which we call *productivity convergence*. This an aspect of growth theory that concerns the striking postwar convergence between industrial nations in terms of productivity, per capita income and other indicators. Productivity convergence research attempts to understand the mechanisms that have enabled the convergence to occur and is thus positive (empirical) in nature. Its focus is on the catch-up process of lagging nations rather than on new strategies for corporate innovation.[1]

Another usage, which we call *policy convergence*, addresses the desire for a common ideology as a way for industrial nations to overcome the challenges of globalization. In theory, as the ideologies of nations converge, national policies, particularly economic policies, can be brought in line with each other through negotiated agreements so as to allow smooth transnational interactions. Implementation may be problematic, however, particularly when proponents of convergence adhere too rigidly to a specific model. In the case of the United States and Japan, some proponents of convergence have assumed that Japan should fit into the set of constructs used to analyze U.S. phenomena. It may make more sense to build upon the individual constructs of each country to form a set applicable to both the United States

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[1]Moses Abramovitz, "Catching Up, Forging Ahead, and Falling Behind," *Journal of Economic History*, vol. 46, no. 2, 1986, pp. 386-406; Richard R. Nelson and Gavin Wright, "The Rise and Fall of American Technological Leadership: The Postwar Era in Historical Perspective," *Journal of Economic Literature*, vol. XXX, December 1992, pp. 1931-1964; "Economic Growth," *The Economist*, vol. 339, no. 7967, May 25, 1996.

and Japan. As Eileen M. Doherty observes, "Historically, U.S. trade policy has been based on a belief that market economies can, and should, converge. Consequently, trade talks have centered on the need to remove trade barriers. More recently, (beginning primarily with the Uruguay Round), negotiations have focused on ways to harmonize trade-related rules (such as intellectual property rules and trade-related investment measures) and domestic regulatory structures."[2]

Advancement of one-sided convergence concepts has elicited strong criticism, such as this one by Chalmers Johnson: "The idea of Japanese-American convergence is a Western intellectual conceit with roots in the Allied Occupation of Japan after World War II and in the United States' shift from an alliance with China to an alliance with Japan as the basis of its Cold War strategy in East Asia."[3] In the view of the Joint Task Force, policy convergence is an attempt to change the nature of corporate innovation rather than a result of the changing nature of corporate innovation. Biased implemenation of it may create rather than resolve problems associated with globalization. The Joint Task Force wants to make it clear that it is not advancing an analogous one-sided concept of convergence in the area of corporate innovation.

In this report, the Joint Task Force would like to advance the concept of *problem convergence* as an outgrowth of the process of innovation itself. Rather than being based on the experience or ideology of one or another single country, it is based on two factors common to all players. The first factor is the driving force of technological innovation in today's businesses (companies on the cutting edge must increasingly respond to similar market conditions in similar ways). The second factor is the growing inter-penetration of various players into each other's markets due to the process of globalization (markets themselves are merging). Rather than implying that the United States and Japan will converge to a similar, normal way of business, the idea is that the problems addressed by corporate innovation throughout the world have more in common than they once did. In such an environment, "The great national differences

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[2]Eileen M. Doherty, "Introduction," in Eileen M. Doherty, ed., *Japanese Investment in Asia: International Production Strategies in a Rapidly Changing World*, (Berkeley, Calif.: Asia Foundation and the Berkeley Roundtable on the International Economy, 1995) p. 22.

[3]Chalmers Johnson, *Japan: Who Governs? The Rise of the Developmental State* (New York: W.W. Norton and Company, 1995), p. 70.

that used to matter are no longer national."[4]

As the problems faced by companies become more similar, the innovation systems of the two countries converge toward each other as they approach a new innovation model relevant to all players. While the specific structures for innovation naturally differ among industrial nations, such trends may lead to a stronger level of functional equivalence among the structures. In this way, increased similarity of the problems addressed by corporate innovation in the two countries tends to increase the similarity of the two countries' innovation approaches, but does not necessarily imply that the approaches will become the same. For the United States and Japan, the implication is that although the two innovation systems are still very different, they are now less different than they were.

Among the Joint Task Force membership, there is a range of views regarding the specifics of U.S.-Japan problem convergence in corporate innovation and its implications. There is consensus among all task force members that some degree of U.S.-Japan problem convergence in the area of corporate innovation is occurring. Most of the Japanese members along with several U.S. members would go further to argue that the approaches utilized by companies in the two countries are also converging. They emphasize the evidence for U.S.-Japan convergence, and believe that companies based in both countries are converging toward a new model, driven by globalization.[5] In contrast, several of the U.S. members point to evidence that U.S. and Japanese companies continue to develop distinct approaches, even where they face similar problems, and these approaches are shaped by their previous organizational and technological development. Although a project of this type could not hope to confirm one or the other view, the Joint Task Force does agree that the issue itself is and will continue to be critical.

Distinguishing between the various convergence concepts is crucial to this project. For the innovation-based approach of the task force, convergence does not carry the baggage of implying shared core beliefs and attitudes, which has proved to be a stumbling block for policy convergence. And while its positive rather than normative approach has similarities to productivity

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[4]Richard R. Nelson, "U.S. Technological Leadership: Where Did It Come from and Where Did it Go?" *Research Policy*, vol. 19, 1990, p. 130.

[5]For an example where the policy convergence perspective led policymakers astray while real convergence occurred in innovation strategies, see Gerald Hane, "The Real Lessons of Japanese Research Consortia," *Issues in Science and Technology*, Winter 1993-94, pp. 56-62.

convergence, problem convergence's focus on the implications for innovation strategy makes it more suitable for the forward-looking task at hand.

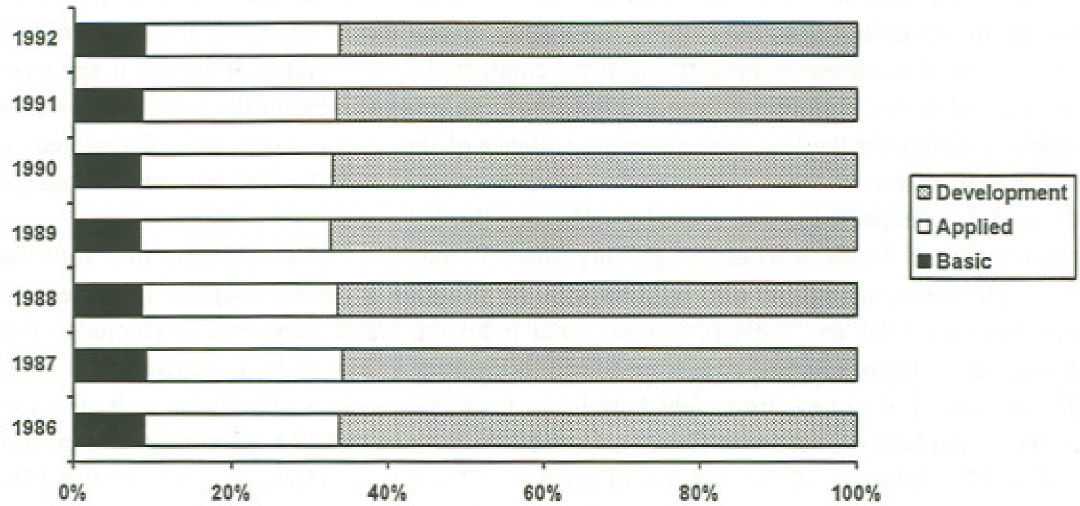

FIGURE 3-1 Japanese R&D Spending, by character of work. SOURCE: Japan Management and Coordination Agency.

in R&D spending by Japanese industry[10]. Fujitsu saved $450 million by cutting its 1994 R&D from 13 percent of sales to 12 percent,[11] and the electric power industry in Japan has reduced itsR&D by 4.2 percent.[12] As yet, however, there is little evidence that Japanese industry has given up its commitment to developing innovation driven technologies. In fact, according to a recent survey of Japanese manufacturing firms conducted by the Nikkei Shimbun, it appears that a turn around in the Japanese economy is leading to an improvement in the basic R&D stance of Japanese industry for the first time since the collapse of the "bubble economy." Fiscal year 1995 total R&D investment rose 3.75% over the previous year. This is the first increase in four years, and spending is expected to rise again by 4.1% in 1996.[13]

In the United States, forecasts of gloomy trends in industrial R&D spending first appeared in 1991.[14] However, the figures also indicate that the situation is rather complex. In current dollar terms, between 1991 and 1994 (estimate), total industrial R&D performance (includes federal sources and company sources) rose from $116.9 billions to $123.8 billions. However, in constant 1987 dollars, it declined from $99.4 billions to $98.2 billions. Omitting federal support, industry's own funding rose significantly, from $90.6 billions to $99.8 billions in current dollars and from $77 billions to $79.1 billions in constant 1987 dollars. However, in 1995 this gloomy picture began to moderate as many industries reported plans to increase spending and hire new graduates (get more recent numbers from IRI, which show even stronger gains). Many industries also reported a high level of attention to R&D by top management and a strong commitment to cooperative research in terms of grants to universities and increases in alliances and joint ventures. At the same time, less of the research being done is "directed basic research."

In some respects, U.S. and Japanese companies appear to be adopting more similar approaches to technology strategy and management as they restructure themselves in response to new global economic conditions. U.S. firms are relying more on trusted suppliers for innovations, while Japanese suppliers are beginning to expand business with firms outside their normal business groups. Technological parity seems to have been reached in many high tech industries between the U.S. and Japan; and the rate of change of relative technical capability has slowed as U.S. firms in several industries have recovered some of the market share lost to Japan in the 1980s.[15]

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[10] Source: Statistics Bureau, Management and Coordination Agency, as cited in John Choy, "Japanese Research Budgets Reel from Recession," *Japan Economic Institute Report NO. 16B*, April 28, 1995, p. 3.

[11]

[12] See "Fujitsu bucks slow economy, posts profit," *Electronic Engineering Times*, Dec. 12, 1994 n827, p.25(1), and "Den-ryoku Gyo-kai Kenkyu Kaihatsu Hi Hajime no Sakugen," (Electric power industry's first reduction in research and development), *Nihon Keizai Shimbun*, May 5, 1995, p. 7.

[13] *Nihon Keizai Shimbun*, August 3, 1996, p. 10.

[14] Information in this paragraph was obtained from Industrial Research Institute, *Annual R&D Trends Forecast.* (Washington, D.C.: Industrial Research Institute, November, 1994).

[15] Use of the term *technological parity* to compare the United States and Japan raises questions as to what is meant by *technology*. Indeed, many would agree that the United States generally has the most advanced technology in most fields. Here the task force refers to technology as a means to commercial ends. Therefore, it includes both the technical knowledge and the tools, skills and management structure-plus imbedded knowledge-that permit innovations to be accomplished. The best evidence for technological standing is to look at the sophistication and competitiveness of products. They are not the technology, but rather the products of technology.

Centralization and Decentralization of Research and Product Development

In the United States, domestic industrial research and product development are being decentralized, development more rapidly than research. In Japan, domestic industrial research is becoming more centralized, and development is staying about the same.[16] The U.S. trend toward decentralization of research is opposite to that of most countries, including Japan.[17] Regarding Japan's pattern of research centralization, some have suggested that it is a result of the process of playing "catch up" in regard to research after years of neglect and also that it perhaps is due to a greater sensitivity to the corporate strategic nature of research (see Figure 3-2: Trends in R&D Centralization/Decentralization).[18]

Joint Initiatives in Manufacturing and Product Development

Furthermore, in a major break with past practices, major Japanese electronics firms have begun to enter into joint manufacturing opportunities with major competitors to manufacture overseas. For example, Hitachi and Texas Instruments have teamed up to build a factory in Richardson, Texas to manufacture 16 Mb DRAMs and, by the year 2000, 64 Mb DRAMs.[19] A similarly tradition-breaking development was the agreement by Hitachi to buy IBM's S/390 mainframe CMOS, Power, and PowerPC microprocessors for Hitachi computers. This is the first time IBM has sold these microprocessors to other companies; and it is evidence of the difficulty which Hitachi had with its own microprocessor development strategy.[20] Similarly, Toshiba, in a departure from its previous policy of keeping the manufacture of semiconductors inside Japan, has licensed its 0.5 micron CMOS chips to Singapore's Chartered Semiconductor Manufacturing Ltd. due in part to the cheaper costs of production in Singapore.[21]

Capital Markets

A major difference between Japan and the United States is that the United States has well-developed venture capital markets which provide an institutionalized system of capital for small, entrepreneurial high-tech enterprises.[22] Japan does not yet have a system to compare with this, although recent developments in Japan, such as changes in stock market regulations allowing firms to list intellectual assets and attempts to develop a venture market, indicate a desire to develop venture capital as a factor in Japanese financing. The cost of capital is frequently mentioned as one of the principal factors influencing differences in the behavior of U.S. and Japanese companies.[23] Many believe that the gap in interest rates which was highly advantageous

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[16]Roberts, op. cit., pp. 8-9.

[17]Ibid., p. 8.

[18]Ibid., pp. 8-9.

[19]Loring Wirbal and Yoshiko Hara, "Hitachi, TI plan U.S. DRAM fab," *Electronic Engineering Times*, August 8, 1994, n809, p. 1.

[20]Yoshiko Hara, "Hitachi turns to IBM, eyes PowerPC," *Electronic Engineering Times*, May 2, 1994, n795, p. 14.

[21]David Lammars, "Toshiba in chartered CMOS pact," *Electronic Engineering Times*, Nov. 7, 1994, n822, p. 1.

[22] See Richard Florida and Martin Kenney, "The Breakthrough Illusion," and idem., "Venture Capital-Financed Innovation and Technological Change in the USA," *Research Policy* 17, (1988), pp. 119-137.

[23]Discussions of cost of capital and cost of funds containing frequent comparisons of the United States and Japan can be found in National Research Council, *Investing for Productivity and Prosperity* (Washington, D.C.: National Academy Press, 1994); Thomas R. Howell et al, *Creating Advantage: Semiconductors and Government Industrial*

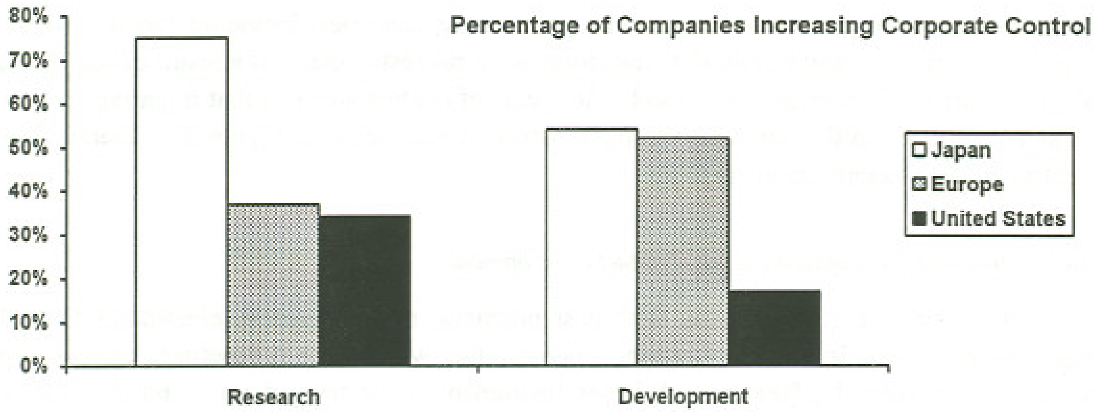

FIGURE 3-2 Trends in R&D centralization/decentralization. SOURCE: Edward B. Roberts, "Benchmarking the Strategic Management of Technology," *Research-Technology Management,* January-February 1995, p. 52.

to Japanese companies has largely disappeared after the collapse of Japan's bubble economy and therefore that environments for corporate management are converging. However, this is challenged by some experts who contend that the cost of capital in Japan has again receded to very low levels and is currently around 2 percent, making it still cheaper than in the United States.[24] Still others argue more fundamentally that the cost of capital is neither a compelling nor useful explanation of the success of Japanese industry compared to U.S. industry.[25]

Corporate Innovation Management

In the area of corporate innovation strategy, there are indications that firms in the two countries are converging in their approaches to management. Many U.S. companies are beginning to focus their R&D efforts on being more responsive to market needs, improving existing products and shortening product cycles. For example, the trend in GE research and development over the past twenty years has been away from "field of dreams" research motivated primarily by intellectual curiosity, to market-oriented R&D. This is exemplified by the teaming with customers at GE's Research and Development Center, especially with GE's own businesses, on multi-generational product developments and also by the fact that GE businesses in 1994 accounted for roughly 50 percent of the funding for corporate R&D, whereas in 1986 they accounted for less than a quarter.[26]

Focus on Improving Productivity

Intense competition has driven corporate managements in both nations to heightened efforts to increase productivity, match R&D to market needs, shorten product cycles, and seek to identify and optimize each firm's competitive advantage. The resulting constraints on investment call for a strict reprioritization of resources. Some firms are explicitly seeking to identify and buttress their *core competence* so that their businesses will exhibit those attributes that set them apart from their competitors. *Core competence* refers to the root strengths of the corporation which give rise to its core products, business units, and end products. Core competence is the collective learning in the organization, especially how to coordinate diverse production skills and integrate multiple streams of technologies. Therefore, it is neither synonymous with technological capability per se nor with particular end-products, but rather with the ability to integrate technology and production skills and to be flexible in terms of end products. Examples of core competence strategy include NEC's concentration on communications and computing technology, 3M's capability in adhesives and overall new product development, Xerox's

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Policy in the 1990s, (Semiconductor Industry Association, 1992), especially Chapter III C. "Capital," pp. 181-200; and National Academy of Engineering, *Time Horizons and Technology Investments* (Washington, D.C.: National Academy Press, 1992), especially Chapter 4 "Time Horizons and Cost of Capital," pp. 43-58, and Appendix A: Joseph Morone and Albert Paulson, "Cost of Capital-The Managerial Perspective," pp. 79-104.

[24](Obtain reference to Ken Courtis from Mike Borrus)

[25]See W. Carl Kester and Timothy A. Luehrman, "The Myth of Japan's Low-Cost Capital," *Harvard Business Review*, May-June 1992, pp. 130-138.

[26] Source: Marvin Garfinkel, "The GE R&D Center: Structure and Strategy," from presentation made at the meeting of the United States-Japan Joint Task Force on Corporate Innovation, Makuhari, Japan, September 11-13, 1994.

capability in developing and manufacturing machinery to move paper, and Sony's focus on miniaturization in new product innovation.[27]

Role of Knowledge

The role of knowledge in value creation is becoming increasingly important and is giving rise to new ways of looking at the relationship between physical and intellectual capabilities as exemplified in the theory of *innovation-mediated production* discussed later in Chapter 5.[28] It is also causing companies to look more closely at the kinds of knowledge actually being applied at various levels within the company. For example, companies are becoming increasingly aware of the importance of *tacit knowledge*—largely unspoken, unwritten, and often unrecognized knowledge and skills necessary to get the job done—as exemplified by Xerox's focus on *communities of practice,* a term which refers to slowly evolved often unstructured networks of people who get things done within the company.[29] These *communities of practice*, can be said to embody *core competence*, and rest on unique qualities of organizational behavior and *tacit knowledge*.

Priority Setting

While firms are pursuing more productive approaches to innovation through prioritization and focus on critical capabilities, and often use the same phrases to describe it, it is not clear that each is addressing core competence issues in the same way. Indeed, case studies suggest that such technology strategies will depend on the business model adopted by each firm.[30] Therefore, it is uncertain how truly these concepts are influencing the way firms invest in and outsource R&D.

When prioritization on core competencies leads to a narrowing scope of investment, which it surely does when overall expenditures are sharply reduced, it follows that requirements for innovations no longer addressed within the core investments must be outsourced. Other firms that are not reducing their overall level of expenditure and investment may also be deliberately reducing the scope of R&D in order to assure a strongly competitive technological position in their core technologies. Others may be focusing resources more sharply on diversification to meet competitive challenges from outside their historic competitor group. All of these strategies may lead to increased outsourcing of innovation.

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[27]See C.K. Prahalad and Gary Hamel, "The Core Competence of the Corporation," *Harvard Business Review*, May-June 1990, pp. 79-91. Several of the examples cited here were discussed in the article, while others are drawn from task force discussions.

[28] See pp xx. See also Peter F. Drucker, *Post-Capitalist Society*. (New York: Harper Business, 1994), and Ikujiro Nonaka and Hirotaka Takeuchi, *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation.* (New York: Oxford University Press, 1995)

[29] Source: Robert Spinrad, ""Communities of Practice," presentation made at the meeting of the United States-Japan Joint Task Force on Corporate Innovation, Makuhari, Japan, September 11-13, 1994.

[30]See Branscomb and Kodama, op. cit., pp. 38-53 for a discussion of the business models employed by a number of leading Japanese firms.

Globalization of Innovation

The globalization of innovation has grown substantially over the past decade or so. And, while companies continue to do the lion's share of their research and development at home, they are rapidly expanding their global innovation efforts. Research indicates that roughly 15 percent of all U.S. patents are granted to foreign inventors.[31] It has also been found that the number of cross-national patents (that is, patents granted to inventors in two or more countries), while relatively small, is growing at a rapid rate. Furthermore, the United States is at the cutting edge of the shift toward global innovation. U.S. corporations spend roughly 15 percent of their total R&D expenditures on offshore facilities, and more than 12 percent of all U.S. industrial R&D expenditures are provided by foreign-affiliated laboratories operating within the United States. While Japanese companies are rapidly increasing their offshore R&D spending in the United States, Europe and Asia, Japan itself has had a relatively low level of foreign-owned R&D facilities. There are indications that foreign-owned corporate R&D activity in Japan is increasing.[32]

Driven by yen appreciation as well as by globalizing markets, Japanese firms are diversifying their manufacturing abroad and are becoming increasingly multinational in production as well as in sales. For example, Aiwa transferred 78 percent of its production to Singapore and other overseas units, mostly in Asia; and Sony plans to raise its overseas production ratio to 45 percent.[33] Direct investment overseas by Japanese corporations rose 5.5 percent in fiscal 1993 to $36 billion due to the shift to offshore production. Also, in 1993, the number of Japanese cars made in the United States surpassed the number of Japanese cars shipped from Japan to the United States.[34]

Some studies show that although economic activity has been globalizing, the globalization of R&D activity has not progressed as much as have other corporate activities such as manufacturing. Corporate R&D activity is still primarily home based (see Table 3-1).[35] This implies a need to look at the globalization of R&D activity in terms of "economy of scope" rather than economy of scale. Doing research overseas rather than in one central location may enable firms to achieve economies of scope by allowing R&D in more fields and by placing laboratories near customers and sources of technology for those customers. In this context, the trade metaphor might not be appropriate.

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[31] See Pari Patel and Keith Pavitt, "Large Firms in the Production of the World's Technology: An Important Case of Non-Globalization," *International Business Studies* 1, 1991.

[32] Although a number of U.S. companies have long maintained R&D facilities in Japan. See Donald Dalton and Manuel Serapio, *Globalizing Industrial Research and Development* (Washington, D.C.: U.S. Department of Commerce, 1995).

[33] Source: "Overseas Shift of Production Key to Bullish Results," *Journal of Japanese Trade and Industry* No. 4, 1994, p. 6.

[34] Source: Tohru Hirose, "Hollowing out: Can new growth replace Japan's pruned Industries?," *Nikkei Weekly*, January 16, 1995, p. 8.

[35] "Unlike other principal activities of MNEs [multinational enterprises], research and technology development tends to be concentrated in the country of national origin," and "...the available evidence suggests that ...[Japanese and European corporations] conduct similar if not smaller percentages of their R&D overseas than do U.S. firms." U.S. Congress, Office of Technology Assessment, *Multinationals and the U.S. Technology Base*, OTA-ITE-612 (Washington, DC: U.S. Government Printing Office, September 1994), p. 2. See also Edward B. Roberts, op. cit., p. 11, Figure 14: Internal Sources are Still Primary for Both Research and Development [includes U.S. and Japanese companies]; and D. Hicks et al, op. cit.

TABLE 3-1 Sources of Technology (rank-ordered in importance)

For Research Work	For Development Work
Internal R&D within division	Joint ventures/alliances
Sponsored university research	Central corporate research
Recruiting students	Incorporating supplier technology
University liaison programs	Licensing
Consultants/contract R&D	Acquisition of external technologies
Continuing education	Acquisition of products
Joint ventures/alliances	Consultants/contract R&D

SOURCE: Edward B. Roberts, "Benchmarking the Strategic Management of Technology" *Research-Technology Management)*, January-February 1995, p. 55.

Major Japanese electronics, automotive and biotechnology companies have moved rapidly in the past ten years to globalize their research and development capabilities in concert with the globalization of their economic activities.[36] According to a recent report, Japanese corporate R&D facilities in the United States increased from slightly over 20 in 1985 to approximately 225 in 1994.[37] This trend in some ways resembles the globalization of R&D followed by U.S.-based companies such as IBM and Xerox.

However, the data also indicate that whereas the number of Japanese R&D facilities abroad is high compared to the U.S. R&D facilities of companies based in other countries (Figure 3-3), their expenditures per facility are much lower (Figure 3-4). Although Japanese companies operate about one-third of foreign-affiliated R&D facilities in the United States, they account for a little over a tenth of total R&D spending by foreign companies. What this means is unclear. Some have contended that Japan's foreign R&D facilities are primarily listening posts to grab technology and talent. Others, however, have pointed out that Japan's foreign R&D is primarily in industries such as electronics and automobiles in which Japan is a technological leader and that the net flow of technology is likely toward the host country.[38] The disparity between the number of Japanese-owned U.S. R&D facilities and their spending levels compared with other foreign owners may be due to the relatively shorter history of the Japanese facilities or strategic differences in terms of a closer linkage to production of the non-Japanese foreign-owned R&D facilities. Indeed, the most recent statistics indicate that Japanese-owned R&D is trending toward higher spending per facility.[39]

Issues Raised by Globalization

Globalization of the world economy and corporate technology development raises important policy questions for the United States and Japan, which have been widely debated in recent years.[40] On one side are those who believe that governments should embrace, not restrict cooperative technology development with foreign companies and governments and on the other those who believe that policies of openness that ignore reciprocity concerns are ideologically driven and ignore the enduring importance of national interest.[41]

The former emphasize the strong trend toward global technological and economic integration, the global spread of innovative activity, and growing technological cooperation

[36]See Richard Florida and Martin Kenney, "The Globalization of Japanese Innovation: The Economic Geography of Japanese R&D in the United States" *Economic Geography* (October 1994), 70,4: 344-69. See also Dalton and Serapio, op. cit. Japanese corporations spent $1.8 billion on U.S.-based R&D in 1993 up from $307 million in 1987.

[37]Dalton and Serapio, op. cit. One committee member cautioned that surveys may tend to overcount the number of facilities.

[38]For a discussion of these various viewpoints see Florida, ibid., pp. 8-9

[39] Dalton and Serapio, op. cit.

[40] For contrasting views of this issue, see Richard Florida, "Technology Policy for a Global Economy," *Issues in Science and Technology*. Spring 1995, pp. 49-56; and the reply by Alan Tonelson, "The Perils of Techno-Globalism," *Issues in Science and Technology*. Summer 1995. pp. 31-38. These issues are the central themes in Sylvia Ostry and Richard R. Nelson, *Techno-Nationalism and Techno-Globalism: Conflict and Cooperation*. Washington, D.C.: The Brookings Institution, 1995).

[41] The terms *techno-globalist* and *techno-nationalist* are frequently used to describe these two positions and their adherents. While these terms are handy and have their usefulness in debate, they also tend to push complex issues and viewpoints into opposing ideological camps rendering subsequent discussion more polemical than enlightening. Therefore, the task force has chosen not to employ such terms.

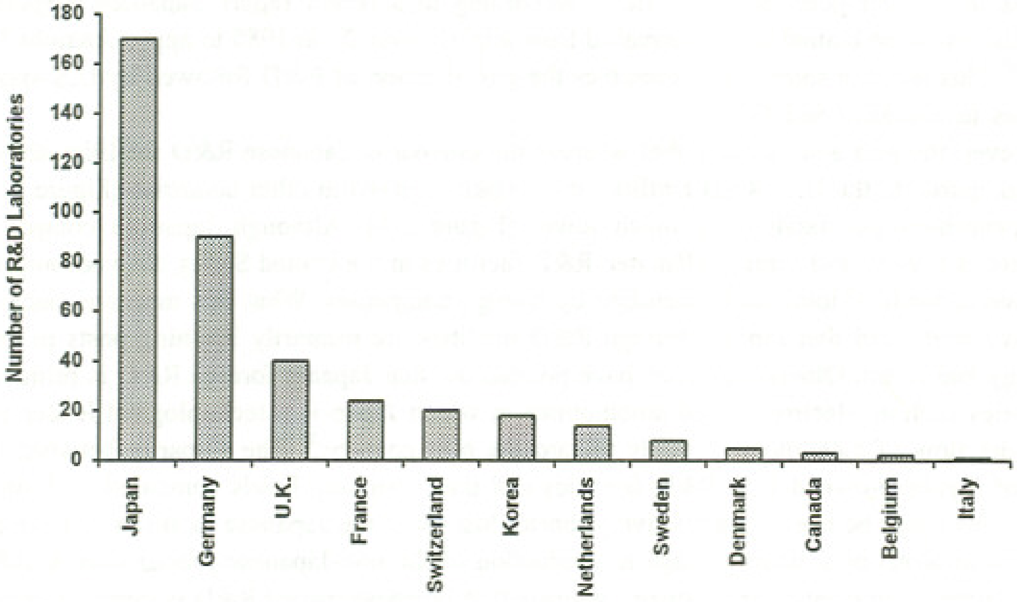

FIGURE 3-3 Number of foreign-affiliated R&D facilities in the United States by country of origin. SOURCE: Richard Florida, International R&D Affiliate Database, Center for Economic Development, Carnegie Mellon University, April 1994.

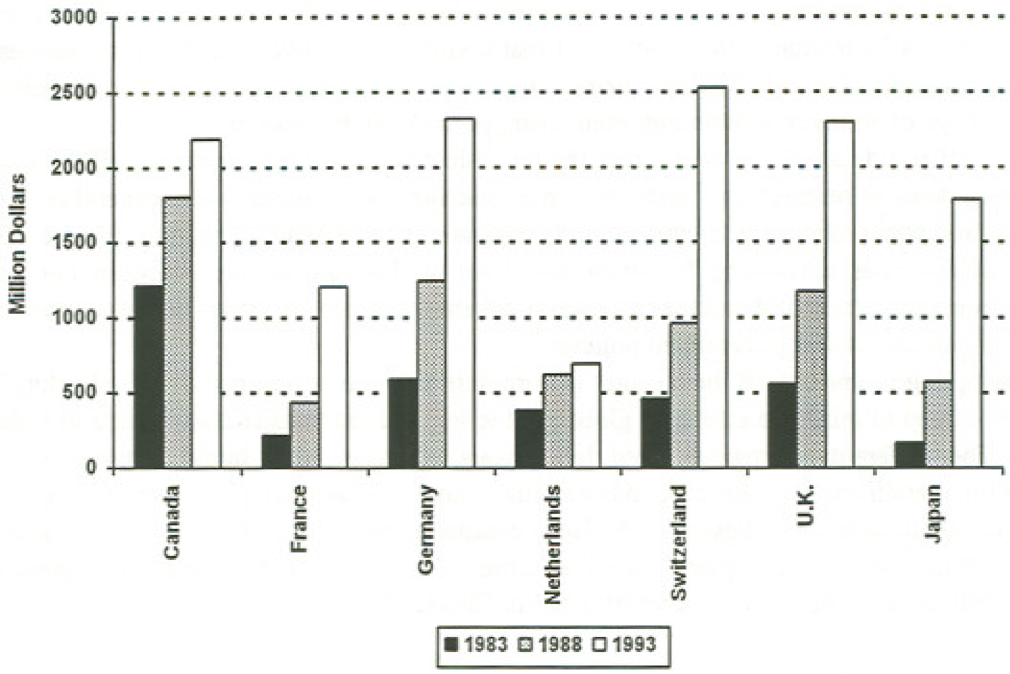

FIGURE 3-4 Foreign R&D expenditures in the United States by county, 1980-1990. NOTE: Includes foreign direct investments of nonbank U.S. affiliates with 10 percent or more foreign ownership. Excludes expenditures for R&D conducted for others under contract. SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, *Foreign Direct Investment in the United States*, as presented in National Science Foundation, *Science and Engineering Indicators 1996*.

among private firms. They believe that restrictive measures threaten to cut off a critical source of innovation, productivity improvement, and economic growth, namely the influx of manufacturing and technological investments from abroad. They point out that the total value of goods and services resulting from foreign investment has reached $6 trillion, whereas the same figure for trade is $4 trillion, with one-third of that taking place between affiliates of businesses located in different countries.[42] Consequently, they view restrictive approaches as potentially dangerous ways of addressing these important changes in the global economy.[43]

On the other side are those who stress the possible risks faced by countries with relatively accessible systems of research and innovation in interacting with systems where capability is less accessible, and who point out that national and corporate interests may sometimes diverge. They believe that doctrines advocating free trade and open markets are neither practiced nor taken seriously in most of the world and that as long as different systems of capitalism exist, countries will need to pursue activist government policies.[44]

In attempting to understand the changes in corporate innovation outlined in this chapter, it is important to keep in mind the effects of global partnering and the transnational nature of today's markets. The different approaches used by various alliances have broad implications for corporate innovation strategy. Because many alliances are multinational groupings of companies, comparative analyses must go beyond U.S.-Japan comparisons. In light of these trends, it may be less useful than it was in years past to think in terms of distinct U.S. and Japanese approaches. Corporate alliances are discussed in greater detail in Chapter 4.

Divergence in Industrial Structure

Although not addressed by the task force, one of the most interesting and intriguing developments in industrial structure in the past ten years is the extraordinary rise in the proportion of U.S. industrial R&D performed by nonmanufacturing industries (e.g., computer services, software, multimedia), now at 24% of total industry-performed R&D, whereas in Japan (and Germany) it has remained flat at less than 4%.[45] (See Table 3-2) The innovation implications of this change in industrial structure are likely to be far-reaching.

Changes in Government's Role

Both in Japan and in the United States, decentralization of government responsibilities is a driving force, at least at the level of policy discussion.

Much of the discussion on the changing role of government in Japan has focused on the Ministry of International Trade and Industry (MITI) which is said to be reducing the level of its industrial intervention.[46] At the same time, the central government in Japan continues to play a

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[42] Source: Florida, ibid., p. 50.

[43] Ibid.

[44] Tonelson, op. cit.

[45] Source: National Science Foundation, *Research and Development in Industry: 1992,* NSF 95-324 (Arlington, VA, 1995). This issue is likely to be addressed in depth in a forthcoming study of the National Research Council's Committee on Japan.

[46] Michiyuki Uenohara has pointed out that although the Japanese government (MITI) protected the infant computer industry in the early stages, since the 1970s it has not provided a substantial amount of subsidies. Source: Michiyuki Uenohara, "Relevance of Government-Sponsored Corporate R&D Projects to Large Japanese

TABLE 3-2 Comparison of Growth in Nonmanufacturing R&D to Total R&D Performance in U.S., Japanese, and German Industry

	Nonmanufacturing		Total		Growth in Services	Nonmanufacturing as a Percentage of Enterprise	
	1982	1992	1982	1992		1982	1992
United States (million $)	2,472	30,103	58,650	121,314	1,218%	4.2%	24.8%
Japan (million ¥)	145,400	372,065	4,039,020	9,560,685	256%	3.6%	3.9%
Germany (million DM)	834	1,513	28,620	50,434	181%	2.9%	2.9%

SOURCE: OECD, DSTI (STAN/ANBERD), 1994.

different and more direct role with respect to industrial and technology policy than it does in the United States. MITI still performs a coordinating role with respect to industrial policy where market mechanisms alone appear insufficient. For example, with 70 percent financing from MITI ($42.5 million at 100 yen/dollar), NEC, Matsushita, Sony, Ascii, Toshiba, Fujitsu, and Hitachi, through the Japan Key Technology Center, have agreed to jointly develop the system technologies central to multimedia, including standards needed for new products.[47] MITI has also established a committee to examine the current problems facing Japan in the development of science and technology and to report on how to improve government policies in that area. The committee is drawn from two existing committees: the Industrial Structure Council and the Industrial Technology Council. MITI formed this committee due to concerns that Japan lacks the policies, programs, and resources to compete effectively in advanced research and the resulting technology of the future.[48] Furthermore, in addition to MITI, there are other government agencies which influence the actions of the private sector. In this regard, some observers have pointed out that the Ministry of Finance (MOF), referred to as "the Ministry of Ministries," deserves more study in that it ultimately controls the purse strings of all the other ministries, including MITI. This is summed up in the familiar phrase "MITI proposes, and the MOF disposes."[49]

In the United States, any description of government policy is greatly complicated by differences in philosophy over the appropriate federal government role in national research and development activities, differences which have sharpened in recent years with the end of the Cold War and increased pressure to balance the federal budget. For example, in the aftermath of the November 1994 elections, federal programs supporting the development and diffusion of generic or precompetitive commercial technology have come under attack. A number of federal initiatives in this area were launched during the Reagan and Bush administrations, and funding support grew rapidly in the first few years of the Clinton administration. To some, this restraint or scaling back of federal civilian technology programs signalled a return to the traditional U.S. policy of caution in economic intervention and S&T policies that emphasize the support of basic science and mission-oriented technological developments in defense and public health.[50] One of the main differences between the currently emerging policy and that of the past is that there is no longer a consensus on the role of government in such areas as energy and space, and even in

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Corporations," a presentation at the bilateral meeting of the U.S.-Japan Corporate Innovation Task Force, Makuhari, Japan, September 11-13, 1994. See also Branscomb and Kodama, op. cit., p. 4. On the other hand, the Japanese government has provided loans at very low rates to encourage new technologies and business alliances through such avenues as the Japan Key Technology Center which is funded through dividends derived from government-owned shares in Nippon Telegraph and Telephone Company (NTT) funneled through the Ministries of Posts and Telecommunications and International Trade and Industry. These funds, which are substantial, are not included in Japanese government budget figures. Also, the Japanese government has provided in-kind services to industry. For example, for years NTT designed the prototypes that later became the products of Hitachi, Fujitsu, and others.

[47] See *Nihon Keizai Shimbun* (American Edition), "Kan-min Kyodo Kaihatsu e Shinkaisha," (New company for public-private joint development), January 14, 1995, p. 1.

[48] Source: U.S. Embassy, Tokyo, cable date 4/24/95, "Research Development Plan," Subject: "MITI Advisory Group to Report on Ways to Improve Japan's Research and Technology Policies." (update to cite actual report).

[49] See Eamonn Fingleton, "Japan's Invisible Leviathan," *Foreign Affairs*, Volume 74, No. 2 , March/April 1995, pp. 69-85.

[50] The Clinton Administration's policy of encouraging greater government-industry cooperation and its intention to devote considerably more federal resources to pre-competitive projects of commercial relevance was first announced in William J. Clinton and Albert Gore, *Technology for America's Economic Growth, A New Direction to Build Economic Strength*, February 22, 1993.

defense the long-term trend has been toward shrinking budgets despite recent relative increases. For some time, experts have noted a decline in commercial spin-offs from government mission-oriented R&D, particularly in defense.[51] Consequently, there is no longer any theoretical or financial basis to expect much technological spin-off from the government to the private sector.

In conclusion, it is clear that in responding to global developments, U.S. and Japanese companies are adopting and adapting each other's approaches. To that extent, it can be said that they are converging in their approaches. However, some movement toward convergence in approaches does not mean that the U.S. and Japanese environments for innovation are the same, and problem convergence itself is not premised on U.S. and Japanese top managements or policymakers sharing the same core beliefs. As long as differences remain in the basic relationships between manufacturers and suppliers in Japan and the United States, in their respective business networks abroad, and in the structure of their R&D systems, areas of convergence should be considered in balance with continuing differences in formulating innovation strategy. Therefore, the caution expressed in a 1990 National Research Council report is still valid today:

It is highly unlikely, given vastly different historical backgrounds and the different industrial bases which Japan and the United States are building, that there will soon be a homogenization of the patterns of R&D within industrial firms in the two countries. But in an age of increasing competition both in technology development and market position, firms on both sides of the Pacific are finding it necessary to learn from each other's strengths.[52]

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[51] John A. Alic, Lewis M. Branscomb, Harvey Brooks, Ashton B. Carter, and Gerald L. Epstein, *Beyond Spinoff: Military and Commercial Technologies in a Changing World* (Cambridge, Mass.: Harvard University Press, 1992).

[52] National Research Council, *Learning the R&D System: Industrial R&D in Japan and the United States*, op. cit., p. 13.

4

External Relationships in Corporate Technology Policy and Innovation Strategy

The trend toward increasing reliance on external relationships in corporate technology policy and innovation strategy in both the United States and Japan is widespread, and has both domestic and international aspects. It is driven by the globalization of markets, the high cost of keeping abreast of new technologies, and the complexity of high technology products and systems which force companies to focus their resources on the most important corporate assets. Companies must therefore rely more and more on capabilities outside the firm. Some hope this will result in mutual sourcing and symbiotic competition worldwide.

The trend toward greater reliance on external relationships takes at least three forms: 1) outsourcing for technology accompanied by deemphasis on vertical integration, 2) alliances and precompetitive consortia with suppliers of technology in order to get faster access to a broad base of innovation, and 3) voluntary associations of firms for the purpose of agreeing on *de facto* standards through which architectures and interfaces are agreed on to foster market growth through the stimulation of interoperability. The latter relationships are prominent in software and other areas of information technology. The following section includes a discussion of outsourcing, alliances and precompetitive consortia, and consortia for *de facto* standardization. Figure 4-1 is an attempt to characterize these relationships in terms of the exclusivity of the relationship and OEM vs. supplier control.

EXTERNAL SOURCING OF TECHNOLOGY AND INNOVATION

Greater reliance on external sourcing, the search for and acquisition of technology and innovation from sources outside one's own firm, is, in the judgment of the task force, the most important trend in global technology management. The practice of acquiring technology and innovation from outside the firm, a long-standing operational practice in Japan, is growing (see Figure 4-2). Some experts suggest that outsourcing is the key to corporate innovation strategy in both countries.[1] At the same time, the nature of external relationships is changing as the level of dependence on outside affiliations for critical technology increases. In general, the level of supplier control increases in proportion to the sophistication of the technology provided to the original equipment manufacturer (OEM), and consequently the level of OEM control decreases. Another way of looking at it is that as the level of technology controlled by suppliers increases, OEMs must enter into more equal relationships with them. Therefore partnering between OEMs and suppliers is becoming more frequent.

External sourcing of technology and innovation generally occurs within two types of institutional relationships. One is the relationship between OEMs and suppliers. *Outsourcing*

[1]Tsuneo Nakahara, "Strategic Mutual Outsourcing between the U.S. and Japan for Innovation and Technology Transfer in the Post Cold-War Age," paper delivered at the meeting of the U.S.-Japan Joint Task Force on Corporate Innovation, Makuhari, Japan, September 11-13, 1994.

	Relationship	Trend	Model	Examples	
High	Supplier produces engineered parts	Supplier given greater responsibility for engineering and product development	Japanese keiretsu	Many supplier relationships in U.S. auto industry are moving in this direction	
OEM control, exclusivity	Supplier provides critical subsystems, components, equipment,	Supplier increasing scope for value-added; expands range of OEM relationships	Demand articulation	Nippon Denso Johnson Controls Sharp Nikon	Supplier control, commonality
	Supplier provides fundamental capability, standard	Supplier establishes proprietary, open system	DOS	Microsoft Lotus Sony	*High*

FIGURE 4-1 Typology and trends in corporate alliances and the outsourcing of innovation. SOURCE: National Research Council Task Force on Corporate Innovation in the United States and Japan.

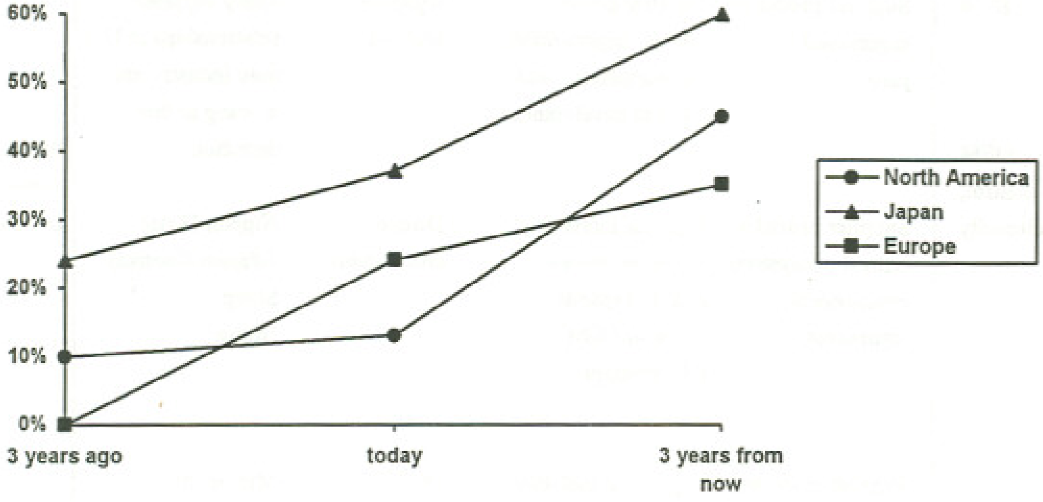

FIGURE 4-2 Percentage of companies with high reliance on external sources for technology. SOURCE: Edward B. Roberts, "Benchmarking the Strategic Management of Technology," *Research-Technology Management,* January-February 1995, p. 55.

is the term usually applied to this type of relationship. The other is the formation of strategic technology partnerships between corporations, usually for a limited time and purpose. The terms *alliance* and *consortium* are commonly used to describe this form of relationship. External sourcing as used in this report includes both types of relationships. It also encompasses a broad range of activities from a growing reliance on suppliers for increasingly independent and sophisticated engineering and design work to encouraging suppliers and universities to conduct research and development which can be integrated into the corporate innovation process.

VERTICAL AND DIAGONAL RELATIONSHIPS IN OUTSOURCING

The relationships of trust between suppliers and OEMs and the benefits to technological innovation that such relationships can bring are characteristic of many of the Japanese vertical alliant business groups (vertical *keiretsu*). U.S. firms have been adopting aspects of the Japanese vertical *keiretsu* model by reducing the number of suppliers, giving those suppliers more scope to innovate (sometimes by providing functional specifications), and increasing the level of technological cooperation between original equipment manufacturer and supplier.

Japanese OEMs have enjoyed more or less exclusive vertical relationships with their suppliers, and conducted research and development jointly with commitment by the OEM to buy and by the supplier to produce. Now more Japanese suppliers appear to be expanding to diagonal relationships, diversifying their research, and expanding markets, leading to higher levels of outsourcing in the Japanese economy. (is there any objective or anecdotal evidence that the Japanese group can provide for this trend?)

Japan's vertical *keiretsu* are an interesting model for U.S. firms. While some may wonder whether U.S. firms may make the mistake of mimicking old *keiretsu*, after Japan has moved to "diagonal" relationships across vertical alliance boundaries, others have pointed out that some American corporations, such as Chrysler and Eaton, apparently have successfully adapted Japanese supplier relationships to their own circumstances.[2] Driving this trend is increasing global competition across industries which pushes companies to develop and produce higher quality, competitively priced products quickly for demanding end users. At the same time, it should also be noted that although some U.S. companies have emulated Japan's vertical *keiretsu*, few or none have emulated the horizontal alliant business groups composed of major manufacturers, large banks, and trading companies, which are also referred to by the term *keiretsu*. Horizontal *keiretsu* remain a dominant and distinguishing feature of Japanese business which is not mirrored in the U.S. system.

Rising foreign direct investment by manufacturing firms has also encouraged sourcing beyond the immediate group as companies search for high quality, low cost suppliers to support their production operations around the world. Also contributing is the fact that suppliers are required to have significant capacity to conduct R&D and to innovate alongside end-users. For example, Johnson Controls, a large U.S. automotive components supplier, has become the lead supplier of seat subassemblies to Toyota's global assembly operations

[2]See Rajan R. Kamath and Jeffrey K. Liker, "A Second Look at Japanese Product Development," *Harvard Business Review*, November-December, 1994, pp. 168-169.

providing seats to Toyota assembly plants in Georgetown (Kentucky), Fremont (California), Ontario (Canada), and Cardiff (Wales).

Diversification vs. New Firm Creation in Relation to Outsourcing Innovation

As outsourcing becomes more prevalent, the capabilities of external sources of technology becomes an important issue. Large Japanese firms are often said to be adept at internal diversification using both foreign and domestic assets.[3] Yet the effectiveness of this strategy has been brought into question. In the United States, diversification takes place primarily through the creation of new firms and secondarily through mergers and acquisitions. The former method is important for new emerging technologies (biotech, computer hardware, software) but not for later stage growth or stable fields. The advantages of diversification through acquisition are that it is faster and requires less R&D resources. However, only acquisitions in closely related businesses have a good track record, and they are the basis for only modest degrees of diversification. Unrelated acquisitions have high failure rates. Internal diversification through R&D has less initial risk, is more flexible, and provides broader business scope.[4] In addition, it is typical for large Japanese electronics firms to sell to the OEM component market while also consuming their component output in their vertically integrated businesses, which can facilitate diversification in electronic components and end products.

The advantages and disadvantages of various routes to business growth through innovation can be seen in recent U.S. and Japanese examples. Several of the leading Japanese integrated electronics companies have successfully launched liquid crystal display (LCD) manufacturing in recent years on the foundation of their existing business and technological bases (diversification through internal R&D). Other attempts by large Japanese manufacturers during the late 1980s and early 1990s to diversify into high technology fields far removed from their original businesses through acquisitions have yielded fewer examples of success.

In the United States, the investment community and business pressures have an important influence on strategic decisions to enter new businesses, as opposed to Japan, where company management has been more free to formulate and pursue long-term strategies without external pressures. The U.S. investment climate is currently not favorable to firms that stray far from their core businesses through acquisitions or internal R&D programs. Indeed, the current climate has encouraged some large companies to consolidate to achieve critical mass in fields as diverse as defense and entertainment. Similar pressures have encouraged other U.S. firms to divest or spinoff noncore businesses (successful or not), a phenomenon which is very rare in Japan. One problem that arises in acquisition is that talented individuals in the acquired company often do not fit into the new corporate environment, and are thus lost in the acquisition process.

New firm creation is another vehicle to commercialize new technologies. Clearly, this mechanism has been and continues to be very important in the United States. In the post World War II period, a number of strong Japanese companies were founded and achieved rapid growth, although in recent years examples of Japanese high technology start-ups that have achieved outstanding success are relatively rare. Recent Japanese policy changes and

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[3]For examples of the diversification strategies of several major Japanese companies, see Branscomb and Kodama, op. cit., pp. 38-53.

[4]Ibid., p. 46.

pronouncements have been aimed at encouraging new firm creation in high technology industries. Nevertheless, it appears that the Japanese innovation system's relative strength in new technology commercialization by existing firms and the relative strength of new firms in the U.S. system is one continuing difference between the two countries that is likely to persist for the foreseeable the future.

Lack of Data to Measure the Extent of Foreign Sourcing of Innovation

Although a number of studies have provided substantial insights into foreign sourcing of innovation, lack of data in this area is perhaps the most serious impediment to understanding trends and emerging issues. [5] Business surveys, such as the Bureau of the Census' survey of manufacturers and the National Science Foundation's survey of industrial R&D, contain valuable aggregate data on U.S. industrial sectors. However, more is needed not only to make it possible to quantify the extent to which outsourcing relationships are being created across national boundaries, but also to determine whether the relationships are in the form of off-shore laboratories, joint ventures, alliances, or agreements with suppliers and subcontractors. Some of this data has been collected by NSF in a pilot study of 1,000 U.S. companies, but even less is known about non-U.S. companies.[6]

NSF reports that between 1982 and 1992, total company-financed R&D performed outside the United States by U.S. companies and their foreign subsidiaries tripled from roughly $3 billion to almost $10 billion (reported in current dollars).[7] Proportionally, it grew from 7.7 percent of total company-financed R&D to 10.3 percent. The greatest increases were in chemicals and allied products, machinery, transportation equipment, professional and scientific instruments, and nonmanufacturing industries. The most notable area of relatively poor growth was in electrical equipment, which includes radio and TV receiving equipment, communication equipment, electronic components, and others electrical equipment (see Table 4-1).

Several questions are raised by this trend toward increased outsourcing of R&D. What are the barriers on each side to successful use of outsourcing? For example, can the needed relationships of trust be consistent with diagonal business relationships in Japan? Will concern about changes in U.S. firm management, personnel turnover, and the frequency of mergers and acquisitions inhibit these relationships in the United States? One idea that was discussed by the Joint Task Force is the possibility that U.S. and Japanese OEMs might work together to raise

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[5] See Florida, op. cit., and Roberts, op. cit.

[6] NSF, through the Bureau of the Census, conducted a pilot survey of 1,000 U.S. companies to provide measures of activities surrounding the development of new products and processes. The survey, entitled the Manufacturers' Innovation Survey, requested information in several main areas including innovation activities, sources of information for innovation, objectives of innovation, acquisition/transfer of technology, R&D activity, factors hampering innovation, costs of innovation, and impact of innovation activities. The survey specifically asked for information on channels used to provide access to new technology and cooperative agreements for R&D with clients, suppliers, joint ventures, universities, etc. NSF currently is compiling the data, some of which will appear in the forthcoming *Science Indicators-1995*. Further information can be obtained from the Division of Science Resources Studies. For other countries, including Japan and Germany, OECD provides data of R&D performance by industry including aggregate numbers for "total services" (i.e., non-manufacturing industries R&D performance). See OECD, *DSTI (STAN)ANBERD)*, 1994, Appendix Tables 6-4 (U.S.), 6-5 (Japan), and 6-6 (Germany).

[7] Source: National Science Foundation, *Research and Development in Industry: 1992*, Table A-9.

TABLE 4-1 Company-financed R&D Performed Outside the United States by U.S. Domestic Companies and Their Foreign Subsidiaries, by selected industry, 1982-1992

Industry	SIC Code	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Total		3,094	3,269	3,633	3,650	4,624	5,226	6,208	6,706	7,952	9,147	9,981
Food, kindred, and tobacco products[a]	20,21	64	63	70	75	69	37	27	42	41	66	68
Chemicals and allied products	28	682	729	786	843	1,071	1,243	1,548	1,532	2,007	2,401	2,683
Industrial and other chemicals	281-82,284-89	319	368	385	444	579	625	855	609	720	1,009	1,042
Drugs and medicines	283	363	361	401	399	492	618	693	923	1,287	1,392	1,641
Petroleum refining and extraction	13,29	133	103	101	47	40	47	59	47	76	107	119
Stone, clay, and glass products	32	10	19	60	[b]	[b]	[b]	[b]	[b]	59	38	41
Primay metals	33	9	10	9	[b]	[b]	18	23	24	26	20	20
Fabricated metal products	34	25	23	21	21	26	40	[b]	[b]	95	86	98
Machinery	35	494	577	740	689	951	1,233	1,326	1,432	1,451	1,476	1,450
Electrical equipment	36	467	482	537	591	[c]	432	591	573	770	651	554
Radio and TV receiving equipment	365	[d]	[d]	[b]	[b]	[b]	0	[b]	[b]	[b]	2	[b]
Communication equipment	366			[b]	[b]	[b]	189	290	199	174	151	180
Electronic components	367	38	[d]	92	117	150	204	246	160	185	164	169
Other electrical equipment	361-64,369	43	38	30	24	25	39	[b]	[b]	[b]	334	[b]
Transportation	37	843	880	907	1,025	[b]	[b]	1,750	1,916	2,055	2,402	[b]
Motor vehicles and other transportation equipment	371,373-75,379	[d]	[d]	[b]	[b]	[b]	[b]	1,477	1,501	1,901	2,166	[b]
Aircraft and missiles	372,376	[d]	[d]	[b]	[b]	182	237	273	415	154	236	406
Professional and scientific instruments	38	237	[d]	263	169	212	317	404	474	611	656	700
Other manufacturing industries[a]	22-27,30-31,39	123	92	131	125	141	138	178	269	344	467	[b]
Nonmanufacturing industries	07-10,12-17,40-42 44-49,50-59,60-65,67,71,73 75-76,78-79,80-81,83-84,87,89	7	10	8	18	27	64	146	256	415	778	860

[a]Until 1984, tobacco products (SIC 21) was included with "Other manufacturing industries." [b]Data withheld to avoid disclosing operations of individual companies. [c]Data withheld to because of imputation of more than 50 percent. [d]Data not separately available, but are included in total. NOTE: Data are reported in current U.S. dollars. SOURCE: National Science Foundation, *Research and Development in Industry: 1992*, NSF 95-324 (Arlington, VA: 1995).

the innovative capabilities of suppliers in developing and rapidly industrializing countries.[8] This sort of "mutual outsourcing" would probably be more straightforward to implement in cases where U.S. and Japanese companies have existing joint venture or alliance relationships aimed at Asian markets or Asian procurement.

Impact of External Sourcing of Innovation on Sources of Basic Industrial Research

Since the mid 1980s, industry supported basic research has remained fairly stable in the United States (see Figure 4-3). However, some have argued that restructuring of corporate R&D of the type undertaken by IBM, General Electric, and other firms which have downsized central labs and refocused work on nearer term business needs will result in inadequate funding of long-range, industry-sponsored, basic research in the global economy. Others have argued that increased focus and efficiency in U.S. corporate R&D is a fundamentally healthy response to competitive pressure. Japanese firms are seen as most dependent on external sources for basic research, and this reliance appears to be continuing despite the basic research boom which began in the late 1980s. Firms that outsource increasing fractions of their innovation needs are likely to do so at the expense of their fundamental industrial research, as the scope of the latter is narrowed. This increased reliance on other institutions (universities and other public research institutions) may well result in an overall reduction in long range research investments, or it may create a clearer demand for such research.

Some experts predict that the U.S. corporate central lab will increasingly play a scanning and mediating role, quickly linking the firm's business needs to internal and external sources of necessary technology. In this formulation, the central lab will put relatively less emphasis on internal research and relatively more on managing rapidly evolving innovation networks comprised of partnerships and alliances of various forms.[9] It is also possible that firms will fail to maintain a critical mass of internal capability needed to identify and absorb the help they need. It will be important to track this trend, since the small and medium enterprises and universities to which innovation is outsourced may be innovative but may prove unable to contribute to basic industrial research. However, this also differs from industry to industry. For example, small U.S. start-up firms have played a major role in commercializing basic knowledge in biotechnology and computer software. In some industries and technical fields, industry-university partnerships, sometimes with government participation and support, appear to be effective in leveraging research efforts.

ALLIANCES AND PRECOMPETITIVE CONSORTIA

Since the early 1980s the number of corporate alliances has been growing rapidly (Figure 3-8) The number of international multi-firm alliances grew from 86 in 1973-76 to 988 in 1985-88 (substitute newer info from new Indicators).[10] Such alliances have many purposes including

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[8] Remarks by Tsuneo Nakahara at the meeting of the U.S.-Japan Joint Task Force on Innovation, Makuhari, Japan, September 11-13, 1994.

[9] Richard S. Rosenbloom and William J. Spencer, eds., *Engines of Innovation: U.S. Industrial Research at the End of an Era* (Cambridge, Mass.: Harvard Business School Press, 1996).

[10] See National Science Board, op. cit. p. 123. The database from which these figures were taken, the Maastricht Economic Research Institute on Innovation and Technology's Cooperative Agreements and

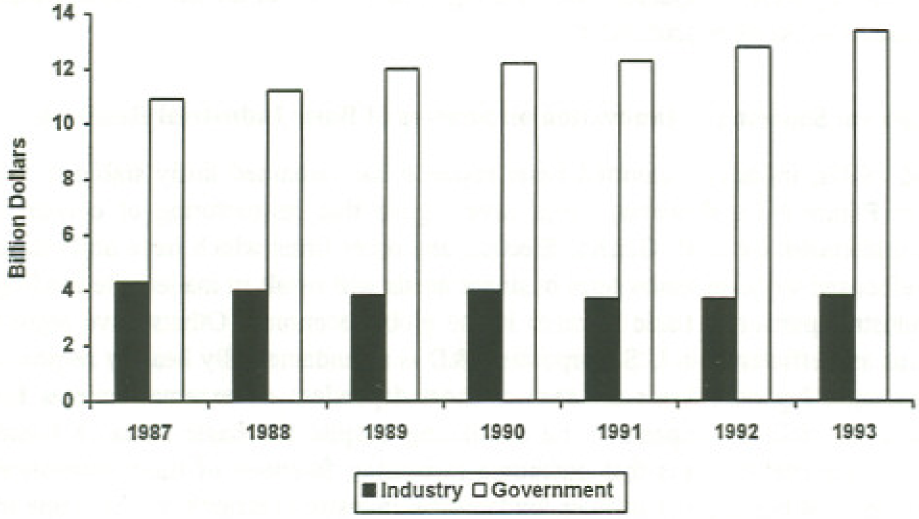
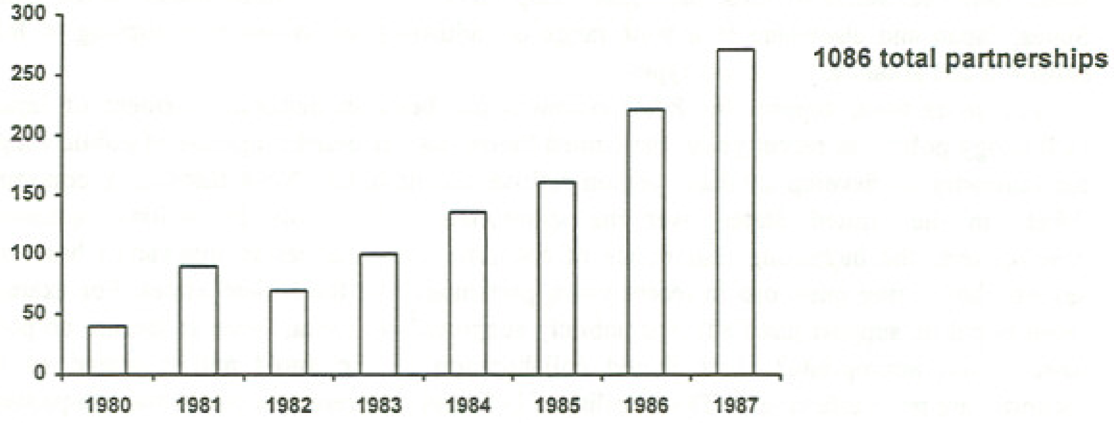


FIGURE 4-3 U.S. R&D: basic research source of funds. SOURCE: National Science Foundation.



4-4

FIGURE ~~3-8~~ Number of interfirm partnerships announced, 1980–1987. SOURCE: LAREA/CEREM database cited in *Mytelka*, 1992.

Update from new "Indicators"

gaining flexible access to the innovative capabilities of suppliers with specialized technical skills. As revealed in a recent survey of executive managements in Japan, the United States and Europe, in the case of development, alliances were second after internal R&D as a source of technology.[11] Although, the survey also showed that internal R&D was the overwhelming source and preference of most managers irrespective of country, firms based in the United States, Japan and elsewhere in a wide range of industries are increasingly turning to R&D consortia and alliances of various types.

For some time, support for R&D consortia has been an important element of Japan's technology policy. In recent years, the United States has expanded programs of public support for consortia to develop civilian, precompetitive technologies. Notwithstanding continuing debate in the United States over the appropriate federal role in civilian technology development, the increasing importance of consortia and alliances in innovation has raised several challenging questions in recent years, particularly for the United States. For example, when is public support justified? For publicly supported consortia, when is foreign corporate participation appropriate? How should collaboration be structured and managed so that consortia are most effective?[12] The inability of U.S. and Japanese semiconductor companies to unite in a common effort to develop new manufacturing technologies to process 12 inch silicon wafers illustrates that international cooperation is difficult to structure, even where the technological rationale is strong.[13]

CONSORTIA FOR INFORMAL STANDARDIZATION AND RELATED TECHNOLOGY DEVELOPMENT

A final example of increased reliance on external sources of innovation are alliances and consortia formed to develop or diffuse *de facto* standards. These consortia are increasingly prevalent in information technology-related businesses. Products and services are becoming more intertwined, with customers expecting more complete systems solutions to their needs. With strong competition, few firms can for long dominate all the elements in a service/product system so that many are now embracing open systems that enable competition at the subsystem level. Access to complementary assets is an increasingly important competitive factor. This has given rise to large numbers of industrial consortia, created to negotiate standard interfaces and protocols in the quest for *de facto* standardization. In the computer-communications industry

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Technology Indicators database (MERIT-CATI) has several drawbacks and limitations which probably result in understating alliance activity.

[11] Roberts, op. cit., Figure xxx. Alliances are followed by central corporate research, supplier-provided technology, and licensing. For research (not technology) universities were the third most important source after central corporate research and divisional research. The survey also suggests that Japanese firms benefit more than do U.S. firms from university relationships, with U.S. universities rather than Japanese universities being most prominent as the source of benefits.

[12] One expert on Japanese consortia concluded that their real value was not in developing precompetitive R&D nor in the pursuit of significant technological advances but rather in fostering competitiveness. See Gerald J. Hane, "The Real Lessons of Japanese Research Consortia," *Issues in Science and Technology* Winter 1993-94, pp. 56-62.

[13] Dean Takahashi, "U.S.-Japan Chip Pact Could Facilitate Push to Manufacture Larger Equipement," *The Wall Street Journal,* August 5, 1996, p. B5.

there are over 100 such consortia (cite?). With outsourcing of components and subsystems rising, standards processes are unlikely to remain domestic for very long.

The rise in *de facto* standardization is due to the fact that the formal standards process is too slow and too open to meet all the needs of firms, especially in information industries, to find a path to open systems that is consistent with their business objectives. The formal system is intended to ensure fairness through broad participation of manufacturers and users and through consensus decision-making. The rapid rise of business consortia for the purpose of negotiating consensus in the industry on standard interfaces is leading to more open product systems, itself a welcome trend that will encourage trade.

De facto standardization also raise international policy challenges in areas such as antitrust and competition policies, which up to now have been set and enforced in a national context. Where the *de facto* standard is the proprietary product of a particular company or group of companies, such as MS-DOS, antitrust questions that were previously domestic in nature may assume international significance. At the same time, national governments and groups of companies may seek to develop their own standards to compete with emerging market-driven standards, and use these as trade barriers. Some consortia that fall into this category are from a single country, and many are transnational. Antitrust exposures may be latent in their operations. So far informal standards consortia in the United States, and presumably in Japan, appear to have worked relatively well, in the sense that competing standards have not significantly delayed the introduction of new technologies. To date, the potential abuse of market power by standards developers appears to have been held in check by U.S. competition policies, enabled by the fact that the United States constitutes the largest market for advanced information technology products. This may not necessarily be the case in the future.

In addition, a second concern might well deserve the attention of technology leaders. It is well-known from almost every example in consumer electronics how tightly linked standards questions are to competitive issues. The struggle to define HDTV standards around the world is one example, and there are many others. Another recent example is the agreement of five U.S. computer related firms (IBM, Compaq, H.P., Microsoft, and Apple) to adopt a single standard for digital video disk (DVD) storage media. This apparently is a welcome development among rival DVD storage media suppliers in Japan led by Sony and Toshiba because it removes a major barrier to the development of the DVD industry.[14] It also demonstrates the role which *de facto* standards-setting plays in the complex relationships among Japanese and U.S. companies.

What steps might be taken to insure opportunities for equitable participation and returns as the number and influence on markets of such consortia grow? What are responsibilities of and legitimate roles for governments in such consortia? This deserves more study in depth to divert what seems likely to become a growing source of friction, as debates about the WTO role in technology already illustrate[15]

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[14]"IBM Nado Kikaku-an: Bei Go-sha Yuza Shudo e Kessoku," (Standards agreement between IBM and others: five American user-companies take the lead), *Nihon Keizai Shimbun*, May 5, 1995, p. 1.

[15]Toward the end of the Uruguay Round negotiations, concerns were raised in the United States about the implications of emerging rules governing R&D subsidies. The U.S. government sought and achieved modification of these provisions.

5

Theory and Practice: Developing New Frameworks for Analyzing Systems of Innovation

A number of frameworks have been developed by U.S. and Japanese scholars in recent years in order to improve analysis and understanding of systems of innovation, with implications for individual firms, industries and nations. This work addresses several major issues and questions concerning innovation that are also central to the Joint Task Force effort.

One area of interest is the concept of national systems of innovation.[1] Are systems of innovation sufficiently different from one country to another and internally coherent to justify the use of the term? If so, what are the appropriate models for evaluating them.[2] In what areas are national systems converging or diverging in their essential elements?

Another trend has been the increasing focus on the importance of demand aspects of R&D and technology in driving innovation forward. These efforts are aimed at understanding phenomena that are difficult to account for utilizing frameworks that emphasize the supply aspects of national R&D systems.

In addition, the trend toward increasing globalization of innovation-related activities, discussed in Chapter 3, has also attracted interest from scholars.

Although the literature in this area is too extensive to review thoroughly in a report of this type, the Joint Task Force discussions highlighted several approaches of particular relevance to U.S.-Japan discussions. The issue of whether currently available data are adequate for international comparisons of R&D inputs and outputs, focusing on the United States and Japan, is also discussed.

DEMAND ARTICULATION

One possible framework for comprehending the demand aspect of R&D is the concept of *demand articulation* defined as "a dynamic interaction of technological activities that involves integrating potential demands into a product concept and decomposing this product concept into development agendas for its individual component technologies."[3] Demand articulation is

[1] Nelson, op. cit.

[2] Lynn, op. cit., observes that most writing on Japanese innovation by both Japanese and foreign scholars has been more concerned about what is good or bad about the system than with accurate descriptions. Also, evidence linking some attribute to a Japanese national innovation system is more often a result of deduction rather than of demonstrated causal relationships. Often such deductive reasoning leads to opposite conclusions depending on the evidence cited. He calls for developing a theoretical framework to understand Japan's system of innovation.

[3] Fumio Kodama, "National System of Demand Articulation and its International Implications," a presentation made at the bilateral meeting of the Task Force on Corporate Innovation, Makuhari, Japan, September 12-13, 1994. A fuller discussion of demand articulation may be found in Fumio Kodama, *Emerging*

a two-step process: "first, market data must be translated into a product concept; and second, the concept must be decomposed into a set of development products."[4] Furthermore, "Through the process of demand articulation, the need for a specific technology manifests itself, and *R&D efforts are targeted at developing and perfecting that technology* [emphasis added]."[5] In other words, the need for technology drives R&D rather than R&D driving technology.

Demand articulation has the virtue of including both the sources of the drive for new technology and its diffusion and adaptation. It emphasizes the integration of the pieces of the system, and does not assume that any one initiative triggers innovation. Furthermore, by emphasizing the importance of developing R&D agendas in response to market needs, it points out one of the main strengths of Japanese corporate innovation practice. As pointed out in a recent survey, European and American corporate executives, like their Japanese counterparts, are giving much more emphasis to this aspect of innovation.[6]

INDICATORS OF JAPANESE AND U.S. TECHNOLOGY RESOURCES AND ASSETS

Comparisons of Japanese and U.S. technology resources and assets are frustrated by the absence of defensible means for converting data on R&D investments in different countries to a common base. Comparisons of U.S. and Japanese R&D investments are strikingly different, depending on whether one uses market exchange rates (MER) (which depend on foreign trade, while most R&D is domestic) or GDP-based purchasing power parity (PPP) (which depends on consumer costs). Thus, when measured by market exchange rates, the U.S.-Japan gap in R&D spending is largely closed, but not in PPP (see Figure 5-1). Neither method, moreover, properly reflects the collection of costs inherent in performing R&D. Although the development of R&D cost deflators for various countries could partly address this problem, this effort is unlikely to be taken up any time soon by government statistical agencies or the relevant international organizations such as the United Nations and the Organization for Economic Cooperation and Development (OECD). Until better indicators are developed, the Joint Task Force believes that comparisons of R&D resources will be more useful if side-by-side reporting of MES and PPP figures becomes standard practice.

Patterns of Innovation: Sources of Japan's Technological Edge. (Boston, Massachusetts: Harvard Business School Press, 1995)

[4] Ibid. p. 2.

[5] Ibid.

[6] Roberts, op. cit., p. 2. In his recent book, *Emerging Patterns of Innovation: Sources of Japan's Technological Edge* (1995), Professor Kodama provides a detailed account of his theory of demand articulation. He addresses questions as to how it differs from *technology-push vs. demand-pull* analysis and how it can be used as an analytical tool.

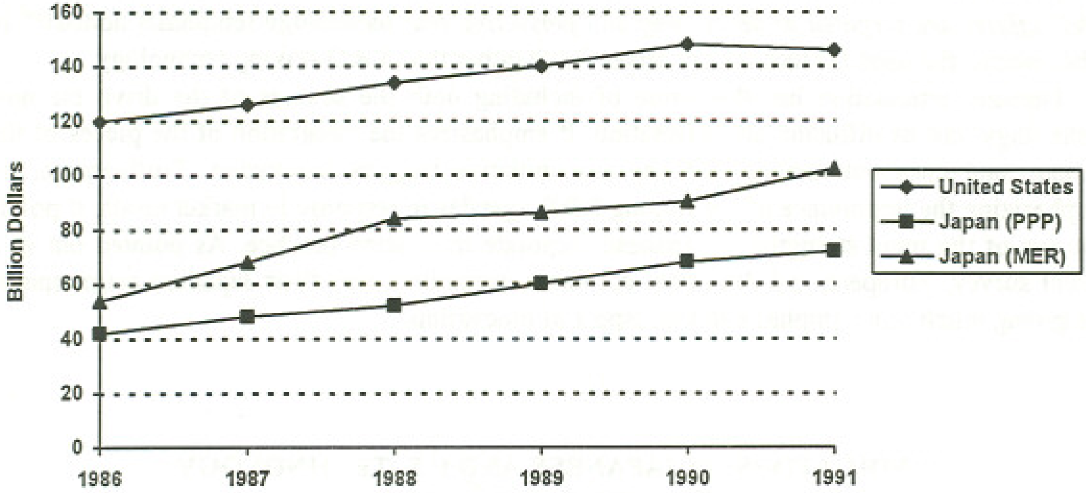

FIGURE 5-1 U.S. vs. Japan R&D, purchasing power parity vs. market exchange rates. SOURCE: National Science Foundation.

CORPORATE TECHNOLOGY STOCK MODEL

One possible method of placing financial value on R&D activities is to treat R&D as an investment rather than an expense.[7] One approach to this is the *corporate technology stock model.* It requires knowledge of depreciation times and quantified risk factors. If such a system could be developed and accepted by the accounting profession it might make business judgments about R&D investment more consistent with the economists' computation of private returns from R&D. However, it might also have a less desirable effect if taxation authorities used this method to require firms to capitalize R&D rather than expense it. At present, no companies in Japan or in the United States are known to be employing this method, except in the case of U.S. firms which, under special rules, are allowed to capitalize all or some of their software development efforts.

INNOVATION-MEDIATED PRODUCTION AND THE ROLE OF KNOWLEDGE

One possible framework for comprehending the emerging patterns in the process of the globalization of innovation is the concept of *innovation-mediated production* which highlights the increasing role of knowledge and ideas as a source of value across the production chain from the R&D laboratory to the factory floor.[8] Others have advanced concepts of the *knowledge-based* economy and the *knowledge-creating* company to capture aspects of this transformation.[9] This shift to innovation-mediated production and knowledge-based economic activity can be clearly seen in the globalizing patterns of Japanese companies.[10]

On the one hand, on an international scale, there is the growing decentralization of R&D activity, referred to as *global localization,* to support global production operations and harness off-shore sources of knowledge and ideas. However, on a regional scale, knowledge is often concentrated in regional networks or complexes of human talent and expertise. Some scholars have asserted that this spatial reshaping of innovation development is premised on a deep and fundamental transformation in the nature of technologically-advanced capitalism. In this formulation, capitalism is undergoing a shift from a *mass production* system of industrial organization based on physical inputs such as capital and labor as the main sources of value-

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[7]This concept was described by Sei-ichi Takayanagi at the meeting of the U.S.-Japan Corporate Innovation Task Force (September 11-13, 1994) in a paper entitled *Corporate Technology Stock Model: Determining the Corporate R&D Expenditure and Restructuring R&D Organization.* This paper was based on Dr. Takayanagi's original publication "Research and Development Reviewed from the Viewpoint of Assets" (in Japanese) from the keynote speech of the Proceedings of the Symposium of the Japan Society for Science Policy and Research Management, June 4, 1993, pp. 3-6. Also, the Bureau of Economic Analysis of the Department of Commerce has created a test account which treats R&D as an investment. See Department of Commerce, "A Satellite Account for Research and Development," *Survey of Current Business,* November 1994, pp. 37-71.

[8] Martin Kenney and Richard Florida, *Beyond Mass Production: The Japanese System and Its Transfer to the United States* (N.Y.: Oxford University Press, 1993)

[9] Peter F. Drucker, op. cit. and Nonaka and Takeuchi, op. cit.

[10] Florida and Kenney, "The Globalization of Innovation"

creation, and with an attendant functional and spatial separation of innovation and production, to a new system of *innovation-mediated production.* In contrast with mass production, innovation-mediated production is premised upon a synthesis of intellectual and physical capabilities, the functional integration of innovation and production, and greater interaction between R&D and manufacturing. Leading Japanese industries have been prominent in pioneering aspects of this new system.

6
Conclusions and Recommendations

The concrete background and rationale for the conclusions and recommendations of the Joint Task Force on Corporate Innovation are contained in the Executive Summary. This Chapter lists the specific conclusions and action items identified by the Joint Task Force.

CONCLUSIONS

Globalalization of Corporate Innovation

From its comparative study of trends in corporate innovation by Japan- and U.S.-based companies, the Joint Task Force observes that important forces in the world economy are affecting the innovation strategies and capabilities of leading edge companies worldwide. Corporate innovation in the United States, Japan and other countries is undergoing important, fundamental shifts. The most important underlying force for these shifts is the globalization of markets and competition, with the accompanying increased pressure on companies to deliver high quality products to demanding end users quickly and at reasonable cost. In the view of the task force, the trend toward increased reliance on external sources of innovation by companies is the most important development in global technology management. In order to make effective use of external sources of innovation and prioritize internal R&D more optimally, companies are adjusting their internal structures, and forming a variety of new alliances with domestic and foreign partners.

U.S.-Japan "Problem Convergence" and Continued Disparities in Environments and Approaches

Increasingly, leading edge companies based in Japan, the United States and other countries are competing in the same global market, and are responding to similar pressures to deliver technological solutions to a worldwide customer base in a rapid and cost effective manner. In this sense, the problems addressed by corporate innovation throughout the world have more in common than they once did. The Joint Task Force believes that such *problem convergence* is evident between companies based in the United States and Japan, and will likely accelerate and broaden to affect companies based in other countries. As such, *problem convergence* may serve as an effective framework for addressing the globalization of corporate innovation mentioned above.

Although there is a consensus among Joint Task Force members that *problem convergence* is occurring between U.S. and Japanese companies, there is a variety of views concerning the implications. Most of the Japanese members and several of the U.S. members believe that as the problems faced by companies become more similar, the innovation systems of the two countries will converge toward each other as they approach a new innovation model relevant to all players. While the specific structures for innovation naturally differ among industrial nations, such trends may lead to a stronger level of functional equivalence among the structures. In this way, increased similarity of the problems addressed by corporate innovation in the two countries tends to increase the similarity of corporate innovation approaches, but does not necessarily imply that the approaches will become the same. These members emphasize trends and examples of recent years, such as the outstanding U.S. companies that have adapted aspects of Japanese innovation strategy, and recent policy changes in Japan aimed at building a stronger publicly funded research base, as indicating that *problem convergence* is leading to convergence in corporate and even government approaches based on a new model of innovation.

On the other hand, several of the U.S. members point to evidence of continued disparity in the innovation strategies of U.S. and Japanese companies, based on their policy environments, past organizational experience and accumulated capabilities. These differences include the relatively larger role of defense-related R&D in the U.S. system, greater exclusivity and long-term obligation built into Japanese OEM-supplier relationships and human resource development practices, and differences in financial environments. While not denying the possibility that significant U.S.-Japan convergence in corporate innovation approaches will occur in the future, these U.S. members believe that the trend is not yet clear enough to draw policy conclusions, and also raise the possibility that important aspects of Japanese and U.S. innovation approaches will not converge.

Need for Further Work

Although the Joint Task Force agrees on the significance and fundamental nature of trends in corporate innovation approaches in Japan and the United States, the rapid pace of change and paucity of information in several important areas make it inherently difficult to specify action items. The Joint Task Force therefore decided to develop focused suggestions for future work for scholars, policy makers and companies. The recommendations section identifies several key questions and challenges, including the need for international efforts to improve the quality and quantity of data on trends in global innovation trends, the need to continue efforts to develop models of innovation that reflect real world trends, and the need for the U.S. and Japanese governments and multilateral agencies to begin addressing the policy issues emerging from shifts in innovation practices and patterns.

RECOMMENDATIONS

Need for International Efforts to Improve the Quantity and Quality of Data on Innovation

The Joint Task Force believes that there is an emerging, pressing need for more and better data on many aspects of innovation, including government policies and programs, corporate activities and international linkages. Such an effort would ideally be international in scope, and might involve multilateral bodies such as the Organization for Economic Cooperation and Development, the United Nations, the World Trade Organization, the Asia Pacific Economic

Cooperation forum, and others that have been involved in improving the comparability of data and statistics of various nations. The U.S. and Japanese governments can make a major contribution by promoting and providing leadership in these efforts.

Although developing a specific program along these lines is beyond the scope of the current study, the Joint Task Force has identified several areas where these efforts might be focused.

Comparability of Data on R&D Spending

For the time being, comparisons of U.S. and Japanese R&D statistics should include figures using both market exchange rates and purchasing power parities. In the future, the development of price deflators and purchasing power parities reflecting the mix of goods and services utilized in R&D and innovation should be explored. Wage statistics for R&D related work is one example of the data that might be needed.

Data on the Changing Institutional Context for R&D, Including Expanding International Links

From anecdotal information, scholarly research and the testimony of committee members, it appears to the Joint Task Force that increased reliance on external sources of innovation is the most important trend in corporate innovation strategy in the United States and Japan. The committee is not aware of statistics collected by any country that allow for adequate measurement of this trend, including industry comparisons. Through periodic surveys or regular data collection, efforts should be made to track trends among Japan and U.S.-based companies in areas such as 1) relationships between original equipment manufacturers and suppliers (number of suppliers, nature of linkage), 2) relationships between industry and universities, 3) reliance on international sources of innovation, both within and outside firms, including alliances between vertically integrated firms in the same or different industries, exclusive long term vertical relationships with suppliers, and "diagonal" relationships with formerly exclusive suppliers emerging to serve broader markets. This work should be aimed at confirming the existence and extent of the trend toward increased reliance on external sources of innovation, and capturing the specific nature of these relationships.

Need for Additional Work on Models and Conceptual Frameworks for Innovation, and Research on Similarities and Differences Between Countries

In recent years, scholars in the United States, Japan and elsewhere have developed a number of models and analytical frameworks that have improved understanding of innovation processes and dynamics. Many of these concepts have been discussed in this report, such as *demand articulation, core competence, national systems of innovation, communities of practice,* and the *corporate technology stock model.* Significant studies comparing the innovation approaches of companies based in Japan, the United States and other countries have also been completed. The Joint Task Force believes that these two streams of scholarly effort are both extremely important and complementary. International comparisons provide very useful context for the development of new models and conceptual frameworks, and the development of models and concepts advances understanding of national similarities and differences. Issues and questions related to

by the United States and Japan, to exchange perspectives aimed at improving the effectiveness of national civilian technology programs, including development of new mechanisms for evaluation, would improve the international base of knowledge in this area. Such an effort could also eventually contribute to expanded, mutually beneficial collaboration in research.