CHAPTER 8

Human Resources: Education, Training, Management

Contents

List of Tables

List of Figures

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Overview

Among the questions this chapter addresses are: How good are the people an industry depends on? Is the pool from which they are drawn big enough? How do they get their training? And, the mirror image of these: Does industry use their abilities wisely?

Countries without adequate human resources cannot hope to design and manufacture products like computers; even televisions are beyond the capabilities of many developing economies. In the United States, people—unskilled or skilled workers, engineers and technicians, managers—are a vital resource for electronics firms; thriving semiconductor companies have been built around the talents of three or four engineers.

But people are only the starting point. How talents are developed, skills utilized, depends largely on management: managers shape the organization, decide on policies, set the style and tone. The sections that follow examine human resources as a factor in competitiveness, primarily from the standpoint of electronics in the United States. Matters of education and training are followed by an examination of management practices. One of the questions addressed is: To what extent does the vogue for Japanese management represent anything new and different in the American context, as opposed to a reemphasis of themes that have always been present? The comparisons on education also focus on Japan, in part because of the recent publicity given to that country's lead over the United States in numbers of engineers graduated.

Such topics are particularly appropriate at a time when rates of productivity growth have slowed in the United States. Is the education and training of American workers appropriate for technology-intensive industries like electronics? Do managements make the best use of the talents and abilities of the labor force? Are countries like Japan doing anything that is really different—or better? In the early part of the century, these questions were already being asked, as part of the "scientific" study of management. It is no coincidence that American management experts schooled Japanese executives now known for their dedication to quality (ch. **6).**

The popular press tends to oversimplify the set of issues covered by "human resources, " Some commentators define human resources narrowly, as encompassing the skills and attitudes of the work force; this approach often leads to stereotyping of employees in countries like Japan or West Germany. Seeing the Japanese worker as the product of a culture that rewards hard work and diligence captures part of the truth but obscures the larger institutional and economic context. Others stress management techniques, often narrowly defined, as a key to labor productivity, Quality control circles are the best-publicized current example. While certainly critical in the utilization of a firm's human resources, management should also be viewed as part of a broader picture. Management practices themselves reflect a mix of schooling and experience shaped by the structure of work and organization within a society.

This chapter views the American labor force —and the electronics industry—from two fundamental perspectives. First, workers bring with them a set of skills largely acquired prior to joining a company. The question then is to compare education and training in the United States—particularly of white-collar personnel, but also blue-collar employees–with that of the men and women who staff foreign electronics firms, Second: Will there be enough appropriately trained people to meet the needs of a rapidly expanding U.S. electronics industry?

Labor mobility is a separate but related issue. A growing industry, such as semiconductor manufacturing, may be able to meet its manpower needs by attracting workers from other parts of the economy, Within the industry, one semiconductor firm may be able to lure employees from its competitors, Mobility has traditionally been high in the United States for those with knowledge and experience.

But what of those left behind by technological change? To a considerable extent, other nations have used retraining programs as instruments of public policy for enhancing employee mobility and aiding those whose skills are out-of-date. This has been less common in the United States, where mobility and continuing education depend on individual initiative. Leaving aside questions of remedial education and the training necessary for entry level jobs, with which the United States has experimented largely for reasons of social welfare, a *strong case can be made for an enhanced Federal role in training and retraining programs to support the competitiveness of growing high-technology industries like electronics.*

The other perspective on human resources in this chapter relates to corporate management. Contrasting the practices of Japanese and American managers shows many of the lessons of effective management to be universal, the unique character of Japanese management something of a myth. Nonetheless, there are lessons to be learned from firms in Japan, as well as from successful organizations in the United States. Competitive firms here and abroad tend to share a common trait: management practices that give employees a say in decisions affecting their work, along with support for skill development. Emphasis on employee participation and human relations can contribute to productivity and worker satisfaction, but conclusive evidence linking particular management techniques (such as quality control circles)—here or in any country—to competitive success is conspicuously lacking.

Education and Training

The U.S. electronics industry is built on the capabilities of production workers, skilled technicians, and white-collar managers and professionals. On the shop floor, blue-collar employees operate semiconductor fabrication equipment, assemble computers or TV sets. Much of this work is essentially unskilled, meaning that a typical job can be learned in a few hours. Technicians—grey-collar employees—often with vocational school training, play an important role both on the factory floor and in research and development (R&D) laboratories. They maintain, troubleshoot, and repair sophisticated equipment—and sometimes fabricate it—as well as testing and inspecting components and systems. Technicians also build and help develop prototypes of new products. Other employees with specialized skills include draftsmen and nondegree designers, production foremen, field service installers and repairmen, computer system operators, and technical writers. White-collar workers—many with college degrees—perform functions ranging from plant management to accounting and financial control, business planning, and legal advising. Engineers and scientists—some with advanced degrees—design and develop products, plan manufacturing processes, specify production equipment, and carry out R&D projects in fields ranging from solid-state physics to computer architectures, All of these skills are essential to a competitive industry, not just those of the well-educated and well-paid professionals; grey-collar technical workers, in particular, have a critical place in technology-based organizations. Some jobs depend much more heavily on formal education and training than others, but it is fair to say that better skills and abilities at all levels will add to the competitive ability of an enterprise, as well as adding to peoples' upward mobility.

The United States has maintained a lead in many fields of technology and science since World War II, in large part because of the excellence of the educational system here. Nonetheless, other advanced industrial nations provide their work forces with training in technology, mathematics, and science that *on the average* is probably more intensive. It is easy to forget, in the publicity that surrounds Nobel Prizes, the Apollo program, or the nascent biotechnology industry, that competitiveness rests on the skills and abilities of great numbers of people whose contributions will never be publicized or even acknowledged. At a time when literacy levels in the United States decline as those elsewhere rise, and the Soviet Union graduates five times as many engineers, it makes sense to look at the foundations for the Nation's human resources as well as the pinnacles of its achievements.

In fact, the evidence of U.S. weakness in technical education and training is strong and continuing to mount.[1] The best people and best educational institutions in the United States are probably as good as ever, maybe better. But the *breadth of capability* that once distinguished the U.S. labor force may be diminishing, The National Science Foundation/Department of Education (NSF/DOE) report cited above concludes that American achievements in basic research remain unchallenged, but that the *average* high school or college graduate in this country has only the most rudimentary knowledge of mathematics or science. The trends are clear, beginning at secondary levels where students avoid courses in these subjects. Only one-sixth of U.S. secondary school students, for example, take courses in science or mathematics past the 10th grade. Technology, as opposed to science, is totally lacking in secondary schools, despite the abundant evidence of public fascination with technological achievements. Indeed, few people seem to distinguish technology from science, hence misnomers such as science fiction.

The NSF/DOE report, along with many others, also points to apparent shortages of entry-level computer professionals and several types of engineers, and the difficulties of secondary schools, vocational institutes, community colleges, and universities in finding and retaining qualified teachers in the physical sciences, mathematics, engineering and computer science, and in vocational programs, Moreover, equipment used for teaching laboratory courses in engineering and the sciences is years out of date and in short supply. In the future, American industry, particularly high-technology sectors like electronics, may simply not have an adequate supply of employees with the kinds of skills needed to maintain U.S. competitiveness.

U.S. Secondary School Education in Science and Mathematics

Falling mathematics and science enrollments in American high schools indicate that, while there is a small group of students who want and get advanced courses, the great majority avoid these subjects when they can. Average scores on national tests of achievement in mathematics and the sciences are lower than a decade ago. Students who elect to take Advanced Placement Tests in science or mathematics make about the same scores as in the past, indicating that the core of serious students gets good preparation; but overall, Scholastic Aptitude Test (SAT) scores fell for 18 consecutive years until holding steady in 1981. *

1"Science and Engineering Education for the 1980's and Beyond, " National Science Foundation and Department of Education, October 1980. See also *Today's Problems, Tomorrow L'rises: A Report of the National Science Board Commission on Precollege Education in Mathematics, Science and Technology* (Washington, D.C.: National Science Foundation, Oct. 18, 1982); *.'+. ience and Engineering Education: Data and information,* NSF *82-30* (Washington, D.C.: National Science Foundation, 1982), and *Science Indicators- 1980* (Washington, DC.: National Science Board, National Science Foundation, 1981), chs. 1 and 5. The L', S.-[".S. S R. comparison in engineering graduates comes from p. 209 of the last-mentioned report.

*According to the Educational Testing Service, Princeton, N.J., mean scores in 1981 for college-bound high school seniors were *424* for the verbal portion of the SAT and 466 for the mathematics

Some of the decline can be attributed to the greater percentage of students who now attend college and thus take the tests, but an advisory panel convened to examine the SAT concluded that, since 1970, other factors—including lower educational standards and diminishing motivation on the part of students—have been much more important.[2]

Fewer American high school students are electing mathematics and science courses, particularly the two fundamental physical sciences, chemistry and physics; of those who do elect science, more chose the life sciences. While the majority of U.S. high school graduates have taken biology, only about a third have had chemistry; the fraction drops to about one-tenth for physics.[3] The situation is replicated in high school mathematics, where only one-third of U.S. graduates take 3 years of coursework. Regardless of how good their grades may be, three-quarters of American high school graduates do not have the prerequisite courses to enter a college engineering program.[4] What this means for industries like electronics is not only that the average high school graduate is unprepared to study engineering or one of the physical sciences in college, but may be unable to enter a career calling for middle-level technical skills without a good deal of additional training.

Secondary Schooling Abroad, Especially in Japan

U.S. enrollments in science and mathematics contrast starkly with the picture in Japan. Not only do about 90 percent of Japanese high school students graduate—compared with 75 to 80 percent in this country—but all are required to complete 2 years of mathematics plus 2 years of science. Competition for entry into the best colleges is intense; Japanese students choose rigorous electives and spend much more time on homework than their American counterparts. Those who wish to attend college study mathematics each year, moving beyond trigonometry—the point where many U.S. high school curricula still stop, s The stress in Japanese secondary schools on science and mathematics for all students is far from unique. The Soviet equivalent of the American high school curriculum includes a heavy dose of coursework in these areas—for instance, 2 years of calculus. West German secondary school students, even those who wish to specialize in fields such as the classics or modern languages, get extensive training in mathematics and science; by the same token, those planning technical careers receive their liberal arts education in high school. Neither curricula nor academic standards vary as widely among West German schools as in the United States.[6]

In Japan, large numbers of students who do not go to college get technical, vocational, or semiprofessional schooling as preparation for jobs in industry where they will work with and provide support for engineers and scientists. The result is a large pool of well-prepared candidates for entry-level grey-collar jobs.[7]

The investments that students in Japan make in science and mathematics yield measurable benefits. On a number of international achievement tests, Japanese students score consistently above their counterparts in other industrial nations, a Nonetheless, secondary education in

(footnote continued from p. 303)

portion, identical to 1980 scores, In 1966, the means were 466 for verbal and 492 for mathematics. While testing criteria may not have remained precisely the same over this period, the downward trend is unambiguous.

"'Science and Engineering Education for the *1980's* and Beyond," op. cit., pp. **107-108.**

³P. D. Hurd, ''Falling Behind in Math and Science, *Washington Post,* May *16, 1982,* p. C7. See also Science *and Engineering Education: Data and Information,* op. cit., pp. *57, 59.*

4"Engineering: Education, Supply/Demand and Job Opportunities," Electronic Industries Association, Washington, D. C., October *1982.*

⁵M. W. Kirst, "Japanese Education: Its Implications for Economic Competition in the 1980's," *Phi Delta Kappan,* June 1981, p. *707.* Only about *30* percent of U.S. high schools offer calculus, and fewer than 10 percent of American high school students take the subject; see Hurd, op. cit., and *Science and Engineering Education: Data and Information,* op. cit., p. *59.*

⁶*Engineering Our Future: Report of the Committee of Inquiry into the Engineering Profession* [London: Her Majesty's Stationery Office, January **1980), p. 219. Also, D. W.** Sallet, **"Education** of the Diplom Ingenieur," *Journal of Engineering Education,* vol. *59,* June 1969, p. 1105.

⁷S. B, Levine and H. Kawada, *Human Resources in Japanese Industrial Development* (Princeton, N. J.: Princeton University Press, 1980), pp. *74, 80.* Engineers in Japan are evidently supported by many more technicians than in the United States.

⁸R. S. Anderson, *Education in Japan* (Washington, D. C.: U.S. Government Printing Office, 1975), p. 130.

Japan has major weaknesses. The most obvious is the strong traditional emphasis on rote learning and imitation, coupled with a dependence on textbooks and lectures rather than demonstration and learning-by-doing (in reality, U.S. education is probably no better in this regard). Critics of the system argue that this stunts the development of creative abilities.[9] Academic competition in Japan is, furthermore, so intense that the Japanese Ministry of Education has expressed concern that other aspects of child development are being neglected. Despite the undoubted validity of some of these criticisms, the fact remains that high school students in Japan receive training in science and mathematics that is, on average, more extensive than in the United States. Even for students who do not go on to technical or professional jobs, such training contributes to quantitative skills, precision in thinking, and to an understanding of the physical world. Such a background helps people to comprehend the technologies that their daily lives depend on. In the future, their employment opportunities may depend on this as well.

University and Continuing Education in the United States

In some respects, the Japanese and American educational systems are opposites. The Japanese concentrate their efforts on precollege training where the United States is weak. On the other hand, the quality of university education in Japan is much inferior. In a very real sense, the American system of higher education must compensate for secondary schooling that is generally poor.

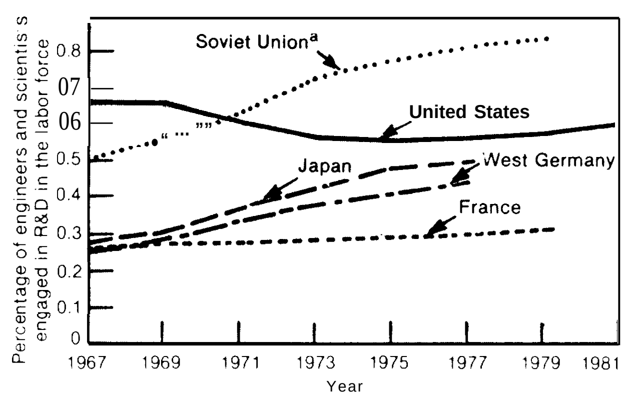
Although this comparison may be qualitatively valid, it begins to break down in terms of numbers. While the United States continues to produce more Ph.D.s in science and mathematics than Japan, Japanese undergraduate programs have been turning out greater numbers of engineers since 1967. In 1981, Japan graduated 75,000 engineers compared to 63,000 here, despite a population half that of the United States. The margin is a little greater for electrical engineering graduates—25 percent. 10

As figure 53 shows, the United States once held a commanding lead in the proportion of engineers and scientists in the work force, While the advantage over other Western nations probably still exists (various countries categorize scientists, engineers, and technicians differently, making comparisons ambiguous), it has narrowed greatly, And, as table 67 demonstrates, engineering graduates are now a smaller proportion of their age group in the United States than in Japan or West Germany—countries where a far greater fraction of engineers in any case devote their efforts to commercial rather than defense industries.

[9]See, for example, the assessment of M. Nagai, former Japanese Minister for Education: "Higher Education in Japan, " *Japan Quarterly*, vol. 24, 1977, p 308. While many Japanese are quite self-conscious about their country's supposed lack of innovation and originality in engineering and the sciences, the product developments flowing in recent years from Japan's industries show great creativity in the *application* of technology.

[10]The 1981 breakdown by disciplines is not available for Japan, but in 1980, 19,355 13, S.-level degrees were awarded in electrical and computer engineering, compared to 15,410 in the United States. Figures for Japan are from the Ministry of Education, those for the United States from P. Doigan, "Engineering and Technology Degrees, **1981** ," *Engineering Education*, April 1982, p. 704, and P. Sheridan, "Engineering and Technology Degrees, 1980, " *Engineering Education*, April 1981, p. 713

Figure 53.— R&D Engineers and Scientists in the Labor Force



[a]Lower bound estimate

SOURCE *National Patterns of Science and Technology Resources 1982* (Washington DC National Science Foundation 19821 p 33

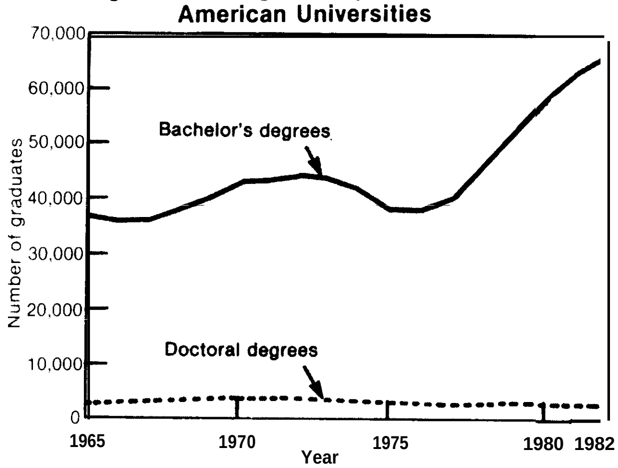
Table 67.— Engineering Graduates as a Percentage of Their Age Group[a]

United States	1.6°/0
Japan	4.2
West Germany	2.3
France	1.3
United Kingdom	1.7

[a]First degree graduates, including foreign nationals, in 1978, except for West Germany and France, where the percentages refer to 1977 Inthe Unifed States a significant fraction of engineering graduates are from overseas" in 1982, 8 percent of B.S degrees in engineering went to foreign students,29 percent of M.S degrees, and 40 percent of Ph D degrees See P. J Sheridan, "Engineering and Technology Degrees, 1982," *Engineering Education*, April 1983, p 715

SOURCE *Engineering Our Future Report of the Committee of Inquiry into the Engineering* Professlon (London Her Majesty's Stationery Office, January 1980), p 83

Figure 54.—Engineering Graduates of American Universities



SOURCES *1965-79*—"Data Related to the Crisis in Engineering Education, " American Association of Engineering Societies, March 1981, p 17
1980—P J. Sheridan, "Engineering and Technology Degrees, 1980, " *Engineering* Education, April 1981, p. 713
1981—P Doigan, "Engineering and Technology Degrees, 1981 ." *Engineering Education*, April 1982, p 704
1982—P J Sheridan, "Engineering and Technology Degrees, 1982, " *Engineering Education*, April 1983, p 715.

Engineering Education

As table 68 indicates, graduates in engineering, the physical sciences, and mathematics in the United States accounted for steadily falling proportions of new degrees at both undergraduate and graduate levels during the 1970's. The number of degrees in the mathematical sciences, including statistics and computer science, actually fell between 1970 and 1980.

In engineering, undergraduate enrollments have jumped since the mid-1970's–and the number of graduates has followed, as shown in figure 54—leading to overcrowded classes, overloaded faculty, and severe pressures on the quality of education. The number of full-time undergraduates enrolled in U.S. engineering schools went from about 20,000 in the early 1970's to an all-time high of more than 400,000 in 1982.[11] At the graduate level, the trends are quite different—but not encouraging. The number of master's degrees in engineering has increased slightly over the past decade, but the number of Ph.D.s has declined—one reason for faculty shortages in engineering schools. Figure 54 illustrates the trends at both B.S. and

[11]P. Doigan, "Engineering Enrollments, Fall 1982, " *Engineering Education,* October 1983, p. 18. At the bottom of the most recent trough, in 1973, 187,000 students were enrolled in engineering; by 1982, the total was 403,000.

Table 68.—U.S. Degrees Awarded by Field

	Engineering	Physical sciences	Mathematics[a]	Total as percentage of degrees awarded in all fields
1980: B.S.	*37,808*	*16,057*	11,437	17%
M.S.	6,989	3,387	1,765	17
Ph. D.	786	NA	NA	NA
1970: B.S.	42,966	21,551	29,109	12%
M.S.	15,548	5,948	7,107	13
Ph. D.	3,620	4,400	1,222	31
1980: B.S.	58.742	23,661	22,686	10%
M.S.	17,243	5,233	6,515	10
Ph. D.	2,751	3,151	963	21

NA = Not Available
[a]Including statistics and computer science.

SOURCE" Engineering—"Data Related to the Crisis in Engineering Education, " American Association of Engineering Societies, March 1981, p 17, Physical Sciences and Mathematics—National *Patterns of Science and Technology Resources 1981,* NSF 81-311 (Washington, D. C.. National Science Foundation, 1981), pp. 78-80

Ph. D. levels. Not only have doctoral enrollments failed to keep up, but about half of all Ph.D. engineering candidates are now foreign nationals; many of them leave the United States after graduation. *

An important cause of declining enrollments of Ph. D. candidates in engineering has been the high starting salaries that holders of new bachelor's degrees command–in 1982, about $26,000. Swelling demand by industry for engineers has attracted undergraduates to the field, at the same time siphoning many off from the pool of prospective graduate students. To someone who might otherwise consider a Ph. D. followed by a teaching career, the rewards of immediate employment can seem much more attractive than several years of low-paying stipends or graduate assistantships, then the salary of a junior faculty member. While pay for college teachers has always been well below that in industry, the other attractions of an academic career have diminished in these days of overcrowded classrooms, outdated equipment, and limited research funding.

Poor facilities and an escalating student-to-faculty ratio are leading to declines in the quality of education provided in American engineering schools. For many years, the proportion of programs in engineering and computer science that were unconditionally reaccredited during periodic reviews held steady at about 70 percent, but in 1981 only 50 percent of the programs examined received full accreditation.[12] *This sudden change indicates the gravity of the problems facing engineering education in the United States.*

The most common and most serious causes of declining educational quality are faculty shortages and obsolete laboratory equipment.

Photo credit General Motors

Engineer holding bracket designed with computer assistance

Even when funds have been available to hire new faculty, good candidates are rare because of the low numbers of new Ph.D.s and the uncompetitive salaries offered by universities. Estimates of the number of unfilled faculty positions in U.S. engineering schools have been in the range of 1,400 to 2,000--about 10 percent of the total number of faculty positions in engineering.[13] Furthermore, universities can no longer depend on graduate students to relieve some of the load on regular faculty by assisting in classroom teaching and laboratory instruction.

The equipment problem is equally serious. While faculties do their best with the resources available, it is difficult to teach a digital design laboratory with equipment from the analog era. And laboratories, as well as classrooms, have become overcrowded as undergraduate enrollments have climbed. Quality suffers when students have less contact with faculty, as well as less exposure to up-to-date laboratory equipment and computing facilities. Many univer-

*See note to table 67. In 1982, 1,167 of 2,887 engineering Ph. D.s went to foreign nationals; both industry and universities have become heavily dependent on foreign-born engineers, especially at the doctoral level. Figures on graduates reflect earlier enrollments; currently, nearly 50 percent of Ph. D. candidates in U.S. engineering schools are foreign nationals.

[12] "Adequacy of U.S. Engineering Education," *Emerging Issues in Science and Technology, 1981* (Washington, D.C.: National Science Foundation, June 1982], p. 60. Programs with deficiencies may be reexamined after a shorter than normal interval or placed on probation

[13] As of the fall of 1982, a survey of U.S. engineering school reported 1,400 authorized and budgeted faculty positions vacant, of a total of about 18,000. The number should be regarded as a lower bound because few universities have increased the number of authorized faculty positions at rates commensurate with growth in undergraduate enrollments. The most severe problems are in computer specialties. See J. W. Geils, "The Faculty Shortage: The 1982 Survey" *Engineering Education*, October 1983, p. 47.

sities, hurt by past slumps in engineering enrollments, are reluctant to put scarce funds into expansion to meet what may be a transient demand, More fundamentally, universities have had great difficulty in adjusting to shifting student choices at a time when total enrollments have stopped rising. Tight budgets have caused programs in the sciences as well as engineering to fall behind the times.[14]

The well-publicized situations at large, State-supported schools such as Iowa State University and the University of Illinois, typical of the institutions that form the core of the U.S. system of engineering education, are representative.[15] Iowa State simply ran out of facilities to handle enrollment increases in computer engineering, despite operating on a 6-day schedule. Because of overcrowding, students were warned that they might not be able to complete their programs in 4 years. Transfer students at Illinois must have a grade-point average of 4.2 on a scale of 5 to enter engineering, while the universitywide requirement is only 3.25. Shortages of facilities and teaching faculty forced 16 of 30 large American engineering schools to adopt some form of restriction on the number of students they admit.[16]

Only the elite universities have been largely spared such problems, and even these have had trouble attracting enough good graduate students. But because the best schools have always limited their enrollments, they have been able to raise the average quality of incoming students while keeping expansion to manageable rates, Engineering departments at schools like Stanford or MIT have also been able to retain their faculties. One of the dangers implicit in responses by industry or the Federal Government to the problems afflicting engineering education is that resources may flow disproportionately to the top-ranked, research-oriented universities. Of the nearly 300 colleges and universities that offer engineering in the United States, it is the middle tier—both public and private—that turns out the vast majority of graduates and faces the most serious problems,

Supply and Demand

Even though enrollments are still climbing, and the number of B.S. graduates in engineering has been going up at about 10 percent per year (fig. 54), it is not at all certain that the number of engineering graduates in the United States will meet future needs. As discussed in more detail later in the chapter, there will almost certainly be entry-level shortages at some times in some specialties—e.g., computer engineering—and the shortfall in Ph.D.s for teaching is bound to continue; according to one estimate, there is a current shortage of 3,500 doctoral-level engineers in industry beyond that of Ph.D.s for university faculties.[17]

While the rapid rise in engineering enrollments has led to fears by some that the United States might be headed for an oversupply by the 1990's, such concerns seem overstated if only because many graduates of engineering programs move on to other fields. Competent engineers have virtually always been employable in the United States, regardless of economic conditions. Nevertheless, the American labor force contains nearly 1½ million engineers, and some portions of the engineering community deny the reality of the current "shortage," claiming that what industry really wants is a large pool of entry-level people to help keep

[14] "Science and Engineering Education for the **1980's and Beyond,** " op. cit., pp. 68-69. Courses in physics and chemistry also depend on laboratory and computer facilities. For a discussion of laboratory equipment shortages with the emphasis on research needs, see "Obsolescence of Scientific Instrumentation in Research Universities," *Emerging Issues in Science and Technology, 1981,* op. cit., p. 49.

The nine State-supported engineering schools in Texas have reported equipment needs totaling $88 million, about 70 percent of this for undergraduate teaching laboratories, The situation in Texas is probably fairly typical; an extrapolation to the United States as a whole results in an estimate of about $1 billion for new laboratory equipment in engineering alone. See "$1 Billion for Instructional Equipment, " *Engineering Education News,* June *1982,* p. 1.

[15] "Engineering Education Under Stress, " *Science,* Sept. 25, 1981, p. 1479; C. Phillips, "Universities in U.S. Are Losing Ground in Computer Education, " *Wall Street journal,* Jan. 14, 1983, p. 1.

[16] "Universities Limiting Engineering Enrollments, " *Engineering Education News,* March 1981. The limitations are based simply on numbers; as at Illinois, qualified students are being turned away.

[17] "National Engineering Action Conference, " *Engineering Education News,* April **1982, p. 1.**

salaries of midcareer engineers low. There is a good deal of truth to this. Entry-level shortages arise in part because employers prefer to hire new engineers with fresh skills at lower pay. This is an easier and perhaps cheaper way of meeting their needs than coupling the experience of midcareer engineers-many of whom find themselves with increasingly obsolescent skills—with well-designed continuing education programs.

Regardless, at least some specialties seem bound to face continuing shortages by almost any criterion. These specialties include a number that are particularly relevant for the future competitiveness of the U.S. electronics industry; most notably, entry-level computer professionals are expected to be in high demand well into the 1990's, Programs of instruction in computer science and engineering still tend to be small and underdeveloped. Some are in engineering schools—often within electrical engineering departments—others in schools of arts and sciences, where computer science may be associated with mathematics departments. Many teaching departments lack the critical mass that would help them thrive, not surprising in a field which did not exist 25 years ago. In computer science, the United States graduates only 250 Ph.D.s each year, a number which has been declining—one reason computer science and engineering faculties are suffering greater proportional shortages of faculty than (other) engineering departments.[18] At present, qualified software engineers are in short supply; although people with many types of training can fill jobs as applications programers, there are far fewer candidates for jobs in the design and development of computer-based systems themselves.

Other new and/or specialized fields suffer similar problems. Perhaps half-a-dozen American universities have the facilities needed to design and fabricate large-scale integrated circuits. Microprocessor applications courses may require equipment that schools cannot afford, Few universities have adequate resources for computer-aided design in any of the fields of engineering. At the same time, such difficulties can be viewed as similar to those that have always existed. It has never been easy to give students a sense of the development effort that goes into an airplane or a nuclear powerplant. In this sense, the adaptations required by the emergence of large-scale integrated circuits or cheap computing power are nothing new.

Industry Initiatives

To help meet the needs of their members, two of the trade associations in electronics have established programs to support engineering education. The American Electronics Association has asked for money to augment faculty salaries and establish chairs in electrical engineering, as well as to expand fellowship programs for students; the Semiconductor Industry Association is funding research, thus providing indirect support to both students and faculty members through stipends and salaries, as well as money for equipment.[19]

A different approach has been taken by Wang Laboratories, which manufactures minicomputers and office automation equipment. The Wang Institute, located near Boston, offers a master's degree in software engineering through its School of Information Technology. Initially endowed by An Wang, the company's founder, the Institute is now an independent, nonprofit organization. With a curriculum designed to give training both in the technical aspects of computer software and in planning, management, and human relations, the school —which graduated its first students in 1982— grew directly out of the inability of companies like Wang to meet their personnel needs. Tuition is about $8,000 per year, less than half the actual cost of the program; the difference is

[18] Seventeen percent of faculty positions in computer science and engineering were vacant at the beginning of 1982, versus about 9 percent for engineering as a whole. See "Universities in U.S. Are Losing Ground in Computer Education, " op. cit.: "The Faculty Shortage: The 1982 Survey" op. cit.

[19] "AEA, SIA to Vie in Fund-Raising Efforts, " *Electronic News*, Nov. 16, 1981, p. 36. Companies in other industries have begun parallel efforts.

covered by endowments and contributions.[20] Because of the emphasis on job-related skills, candidates for admission must have at least 2 years of professional experience, in addition to a B.S. degree in an appropriate field. The Wang Institute is one of a number of experiments presently underway in nontraditional training in specialized technical fields.

University-Industry Relations

Despite these and other examples of new and close relationships between business and educational institutions—for instance, the industry-supported Center for Integrated Systems at Stanford—university-industry relations, in the United States as in most countries, tend to be uneasy. Tensions between the theoretical learnings of faculty members and the more practical concerns of private firms, particularly smaller companies that do not engage in much research, are common. This also holds for professions such as business administration; to some extent it applies to the sciences as well.

In engineering, these tensions have deep historical roots; by the first decade of the 20th century, the academic perspective had largely won out over the shopfloor orientation that many in industry had advocated.[21] Later, between the wars, U.S. engineering education began to stagnate, During World War II, numerous R&D efforts—including many in electronics—were spearheaded by scientists (particularly physicists) with engineers filling subordinate roles. This lesson was one of several pointing to the need for reevaluations of engineering education.

The resulting turn toward theory led to "engineering science" as the core of undergraduate curricula. In the post-Sputnik period beginning in the late 1950's, engineering schools emphasized quantitative, analytical skills even more. Accompanied by a strengthening of mathematics requirements, the focus on engineering science came at the expense of engineering design, as well as manufacturing and production processes. This was also a time when the spread of digital computers made numerical solutions to many previously intractable problems a reality, further strengthening the movement toward analysis at the expense of synthesis. In recent years, there has been something of a swing back.

Industry has always wanted graduates who can go to work immediately, while acknowledging the virtues of theoretical preparation in the engineering sciences as preparation for advancement and for continuing education. Demand for the "old-f ashioned," practically oriented engineer has led to a proliferation of curricula in what is usually called engineering technology.

Engineering Technology

Technology programs—some 2 years in length and leading to an associate degree, others full 4-year B.S. courses of study—represent an attempt by American colleges and universities to equip entry-level employees with immediately applicable job skills. Graduates of these programs—more than 26,000 at the associate and bachelor's levels in 1981 (40 percent of the total in engineering)—can be thought of as paraengineers; they get less extensive and less rigorous training in mathematics, the sciences, and in engineering science, but considerable exposure to routine technical problems.[22] While B.S. technology graduates are bet-

[20] Information supplied by Wang Institute. See also M. A. Bengs, "A Unique Institution for High-Tech Training, " *Boston Globe*, Mar, 2, 1980, and "Institutionalizing the Students of Software," *Computer Design*, December 1982, p. 189.

[21] M. Calvert, The *Mechanical Engineer in America, 183G191O: Professional Cultures in Conflict* (Baltimore, Md.: Johns Hopkins University Press, 1967).

[22] In 1976, 16,685 associate degrees and 5,721 B.S. degrees in engineering technology were granted in the United States; in 1982, the figures were 17,198 for associate degrees, and 8,325 at the bachelor's level. The 1976 data are from "Engineering and Technology Degrees, 1976, " the 1982 from "Engineering and Technology Degrees, 1982, " op. cit.

Well over 200 schools have technology programs, about the same number as for engineering. Most of the associate degrees are awarded by community college and vocational-technical schools. In a university, B.S. programs in technology and engineering may be offered by different colleges, particularly where the technology curriculum has grown out of an industrial arts setting; alternatively, both programs may be found in a "College of Engineering and Technology, " Many faculty members in engineering have resisted the movement toward technology education, feeling that it detracts from the profession and threatens their own image. Outside the community of educators, a good ter prepared for advancement and for creative work than technicians, their upward mobility is considerably less than for engineers. In at least one sense, the problems that have hit engineering education are more serious still for technology: the practical, hands-on experience that these programs seek to provide depends heavily on equipment similar to that actually used in industry.

Community Colleges and Local Initiatives

In recent years, community colleges have expanded more rapidly than any other segment of higher education. Many offer engineering technology, as well as preengineering programs that send students on to universities. Moreover, community or junior colleges and vocational-technical schools train many of the technicians who take jobs in U.S. industries like electronics. While the number of students earning associate degrees in technical fields has grown in the last decade, there is little information on the quality of these programs. Some offer up-to-date training in needed specialties, while others are accused of turning out people for jobs that have already disappeared.

Public 2-year and community colleges face chronic problems in funding their programs and retaining faculty.[23] Even in Silicon Valley (the area near San Francisco where so many electronics firms have located)—which is now getting a great deal of attention as a model for industrial development—these institutions have never been well-integrated into the local environment, and seem isolated from industry as well as from the mainstream of university-oriented education.[24] Despite the concentration of electronics companies, the six community colleges in the area have faced severe shortages of equipment for student laboratories, and a relationship with industry in which each group seems generally supportive of the other but in which the various parties do not always manage to communicate or cooperate effectively.

Only a few States or localities have thus far attempted to meet needs for technology-based

deal of confusion persists concerning the role and function of technology education—not surprising when associate programs graduate men and women trained essentially as technicians, while a B.S.-level technologist is much closer to an engineer. Differences in academic standards among technology programs may be even greater than in engineering. In contrast to countries like West Germany, where all technical universities are held to similar standards, quality in American engineering and technology programs varies widely, even among those that are fully accredited.

[23] "Science and Engineering Education for the 1980's and Beyond,'" op. cit,, p. 93.

[24] E. L, Useem, "Education and High Technology Industry: The Case of Silicon Valley, " Institute for the Interdisciplinary Study of Education, Northeastern University, Boston, Mass., September 1981, pp. 12-18. Useem's study, based on more than 100 interviews, finds that neither educators nor companies are responding very well to the regions educational needs—particularly at the secondary level.

Photo credit Ted Spiegel 1983

Computer-assisted test to determine design data on metal fatigue

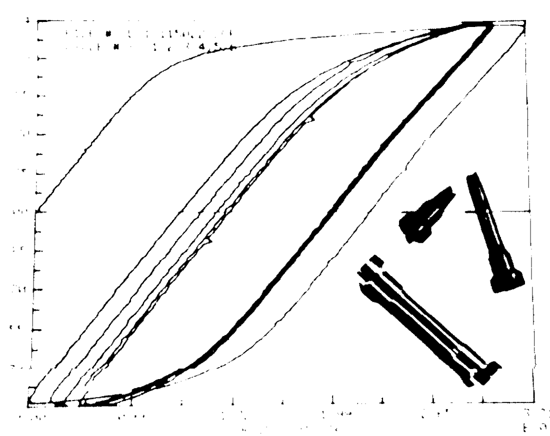


Photo credit: Ted Spiegel. 1983

Results of test shown in adjacent photograph. Many engineering schools have had difficulty in acquiring modern equipment of this type education and training outside their college or university systems. North Carolina has established a Microelectronics Center linking several universities and industry at Research Triangle Park near Raleigh; the State has also set up the North Carolina School of Science and Mathematics for high school students with unusual ability. But this is more the exception than the rule, and budgetary constraints in many localities may limit further development of nontraditional alternatives.

Continuing Education

Ongoing education and training for engineers and other technical workers—including those without degrees—is a vast and amorphous activity, Colleges and universities enroll large numbers of students in graduate or continuing education programs, some of whom take only a few courses while others actively pursue degrees. Such programs, many of which cater to part-time and evening students, face problems paralleling those of undergraduate engineering and science curricula. The low visibility and lack of prestige of continuing education aggravates the difficulties; faculty turnover is high, quality uncertain. For example, enrollments in New York University's adult education courses in computer programing have been increasing by 20 to 25 percent per year, but budget limitations have made it difficult to purchase needed equipment, as well as to find and keep competent faculty.[25] This situation is replicated in private and public colleges and universities throughout the country.

Many professional societies are active in continuing education, principally through short courses—sometimes offered in conjunction with universities—on topics of interest to their members, Current favorites in electronics include microprocessor-based systems, and programing in newer computer languages like Pascal. Colleges and universities offer their own short courses, as do private, profit-seeking enterprises. Some companies have operated educational arms—e.g., RCA Institute. Short courses and related noncredit programs vary widely in quality and rigor. Some hold to high standards, others offer little more than can be gleaned from trade magazines.

Although many firms offer on-the-job training and continuing education for their engineers, scientists, and technicians, it is impossible to generalize concerning the extent and effectiveness of such efforts. Some companies allow employees to spend several hours per week taking college courses on company time; others will pay tuition provided the student gets a good grade. Some develop in-house programs. Others refuse any assistance, relying entirely on individual initiative. Some organizations have a companywide policy covering continuing education; in other cases, decisions are left with lower level supervisors. In many companies, internal training programs are intended primarily for new employees; in other instances, firms organize or support programs aimed at a broader slice of their work force. While extensive in-house training is most common in large corporations, smaller electronics firms have also been turning to such efforts to help meet their manpower needs,

Beyond case-by-case insights, the overall dimensions of company-run training programs in the United States are largely unexplored; the American Society for Training and Development estimates that business and industry allocate some $30 billion to $40 billion a year to education and training, but little information is available on how such moneys are spent, and by whom, or just what is counted in arriving at the total.[26]

Looking more narrowly at engineers and scientists, perhaps 10 to 15 percent of those with at least a bachelor's degree are taking further

[25] G. Anders, "Colleges Faltering in Effort to Ease Critical Shortage of Programmers, " *Wall Street Journal,* Aug. 24, 1981, p. 15.

[26] Information from the American Society for Training and Development. Also "Addition to the Record: Statement of Anthony P. Carnevale, for the American Society for Training and Developmerit, " *Projected Changes in the Economy, Population, Labor Market, and Work Force, and Their Implications for Economic Development Policy,* hearings, Subcommittee on Economic Development, Committee on Public Works and Transportation, House of Representatives, Nov. 18-19, 1981, p. 233. Carnevale notes that 35 percent of firms surveyed by the Conference Board offer remedial programs in reading, writing, and arithmetic for their employees.

academic coursework at any given time.[27] The great majority are probably recent graduates, with many of these pursuing advanced degrees on a part-time basis.

In electronics, a number of larger U. S. semiconductor firms—for example, Intel, which has also been a leader in the Semiconductor Industry Association's research cooperative—have instituted programs of on-the-job training for personnel at a variety of levels. Almost all semiconductor manufacturers evidently provide some training, but the intensity and length of the programs vary from company to company. Continuing education for electronics and computer engineers in Silicon Valley is readily available for students who can meet the entrance requirements of schools like Stanford or the University of California at Berkeley; Stanford has also pioneered interactive television links enabling it to offer in-plant courses throughout the area. However, local electronics companies—with a few notable exceptions like Hewlett-Packard—have had little involvement with secondary-level public education in Silicon Valley, and most of the interactions with universities seem to center on the elite institutions where faculty consulting strengthens ties with industry. [28]

Semiconductor firms are not alone in offering in-house training to their employees. Some electronics manufacturers report that, during their initial year on the job, new employees spend up to 7 hours per week in formal coursework.[29] Hughes Aircraft's training program for new graduates in electrical engineering is especially comprehensive. so Bell Laboratories and IBM are also well-known for continuing education and training; low employee turnover at large companies like Hughes or IBM favors investment in human resources just as it does in Japanese electronics firms. In contrast, smaller U.S. semiconductor manufacturers may have annual personnel turnovers of 35 percent or more; such companies are understandably reluctant to devote resources to training men and women who may then jump to competing firms. High turnover rates in electronics hold for grey-collar technicians as well as engineers.[31]

In contrast, organizations like Bell Laboratories can finance continuing education for employees—even send them back to school full time—with less fear that people will quit once they have a new M.S. or Ph.D. in hand. In part, this is simply because many engineers and scientists view Bell Labs as an exciting and prestigious place to work; for some, it is more a goal than a stepping stone, Bell supports part-time graduate study at local universities, as well as full-time, on-campus programs at a number of leading engineering schools; the company also offers a variety of in-house training activities, plus a tuition reimbursement plan for employees pursuing undergraduate or vocational training. [32]

While it is thus true that a considerable number of American engineers and scientists elect to take additional academic coursework, many individuals make such commitments independently, often with little or no encouragement from their employers. Smaller companies, and some large ones, often feel that they cannot afford to support such efforts–i.e., that the payback would be insufficient. As the NSF/DOE study notes:[33]

> At present, continuing education is a fractionated, uncoordinated set of operations in which academia, industry, professional societies, and individual entrepreneurs pursue their own individual paths in response to what they perceive as their individual needs. There has been virtually no Federal support for con-

[27]The figure was 13 percent for 1978. A somewhat larger nun]-ber took non-credit courses of various kinds, See "13a attelle Study Shows 80 Percent of Organizations Support Continuing Education for Scientists, Engineers, " *Information From Battelle*, Mar, 5, 1980.

[28]Useem, op. c it., pp. 9-12

'Q'' Employment in the [J, S Electronics Industry, Volume I," prepared for OTA by Sterling Hobe Corp. under contract No. 033-1210, p. 234.

[30]See R. Connolly, "(companies Still Short of EEs, " *Electronics*, May 19, 1982, p. 105.

[31]See R. W. Comerford, "Automation Promises To tighten the Field-Service Load, " *Electronics*, Apr. 7, 1982, p. 110. These turnover rates are good evidence that personnel shortages have heen real and ac ut e.

[32]'' Educational opportunities at Bell Labs, " Education Center, Bell Laboratories, Holmdel, N.J., 1981.

[33]'' Science and Engineering Education for the 1980's and Beyond," op. cit., p. 96.

tinuing education, in part because the costs of industrial programs have been regarded as business expenses.

Because retraining for midcareer engineers and skilled workers will be increasingly important in the years ahead, particularly in view of the aging of the American labor force, the Federal Government may need to reconsider its involvement.

The Government already plays an important role as direct employer. In 1978, nearly 90,000 engineers worked for the Federal Government, about 6 percent of the country's total engineering labor force. Many are employed by the Departments of Defense and Energy, and the National Aeronautics and Space Administration. The Air Force alone faces a shortage of over 1,000 engineers; if the Nation's defense budget is to increase during the 1980's **as** planned, demand for engineers—both within the Government and among defense contractors—will swell even further. Some have argued that engineering manpower shortages could jeopardize the country's security.[34] As one response, the Defense Communications Agency is planning **a** National Science Center for Communications and Electronics, intended **to** help cope with the shortfall in the defense community. Funded with the aid of corporate contributions, the Center, to open in 1983, will develop education and training courses for participating secondary schools and universities. as

Over the past several decades, nearly half of all U.S. engineering students have received financial assistance of one sort or another from the Federal Government. Funds for laboratory equipment intended for teaching and research, as well as for curriculum development, have come from Washington—for science and engineering, principally through the National Science Foundation. Tight *Federal budgets for education may have the unfortunate consequence of shrinking the pool of graduates in engineering and science, and their quality, at a time when the United States already finds that it does not have enough skilled professionals to staff its commercial industries or meet its military needs,*

University and Continuing Education In Japan

If Japanese secondary school students study mathematics and the sciences more extensively than their counterparts in the United States, at the university level Japan's educational system is inferior. Postsecondary education expanded rapidly over the postwar period; many private colleges were founded, some with low standards. While the small group of elite universities provides more rigorous training, they have faced the same criticisms as Japanese secondary schools—excessive reliance on rote learning and the acquisition of facts, rather than more general skills in analysis and synthesis. In neither science and mathematics, nor in engineering, does the quality of university-level education in Japan match that in the United States.

Engineering

Electrical engineering students in Japan spend many hours in the classroom and laboratory, and take a series of courses rather like that of Americans, but Japanese companies continue to find graduates unprepared to go to work, while faculty members point to major weaknesses in curricula.[36] Programs in engineering and computer science leave little room for unstructured or independent learning. Electives are limited. Students tend to work in groups; according to critics, this fosters conformity at the expense of creativity and individual initiative. The education that Japanese college students receive outside their technical fields, moreover, is less demanding than here. Deficiencies in higher education are among the reasons that Japanese companies place great stress

[34] "Testimony of Gen. R. T. Marsh, Commander of Air Force Systems Command," *Engineering Manpower Concerns,* hearing, Committee on Science and Technology, House of Representatives, Oct. 6, 1981, p. 11. Perhaps one-quarter of the country's engineers work in defense-related fields.

's'' The NSCCE: A New National Program, " *Electronics,* Dec. 29, 1981.

[36] S. Tubbs, "Electrical Engineering at Kyoto University, " *Engineering Education,* May 1982, p. 812; T. Sugano, ''Preparation of New Electronics Professionals in Japan: Note for Presentations Given at the Japan Society Meetings of May 1, 1981, in Palo Alto, Calif., and of May 4, 1981, in New York. "

on internal training—they must, simply to bring new employees up to a satisfactory level of competence.

Far fewer engineering students in Japan go on to the graduate level—either M.S. or Ph.D. —than in the United States. Table 69 illustrates the stress on undergraduate training and the comparatively small numbers in graduate school. In 1980, undergraduate enrollments in Japanese engineering programs were almost the same as those in the United States, but the number of graduate students was about four times less.[37] Those students who do choose to attend graduate school find that—as in undergraduate programs-course work and research are less rigorous than in American universities.

As the figures in table 69 suggest, while academic competition is keen at secondary levels, with Japanese students vying for places in the most prestigious universities, postgraduate training brings few rewards. Because corporations in Japan rely heavily on in-house training to impart job-related skills, and because research does not have the prestige that it carries in the United States or Europe, Japanese engineers have little incentive to go on to graduate school. Patterns are similar in other professions. Graduate work in business or law is a popular road to career advancement in the United States, but not in Japan, where business schools are virtually nonexistent and lawyers form a miniscule part of the labor force.

[37]American engineering schools enrolled 72,600 M.S. and Ph.D. students in 1980, about 40 percent on a part-time basis—"Engineering Enrollments, Fall 1982," op. cit. Although only 337,800 undergraduates were enrolled in Japanese engineering schools compared to nearly 400,000 in the United States, the retention rate is much higher in Japan. Once admitted, Japanese students face far fewer hurdles than Americans, and a higher percentage graduate.

Table 69.—Enrollments in Japanese Colleges and Universities

	Number of students, 1980				
	Junior college	Technical college	University	M.A./M.S	Ph.D
Engineering	20,100	46,300	337,800	14,900	2,400
Physical science	·		54,600	3,740	2,590
All other programs	346,100	—	1,349,100	17,160	13,210
Total	366,200	46,300	1,747,500	35,800	18,200

SOURCE: Kagaku Gijutsu Benran (Indicators of Science and Technology) Kagaku Gijutsucho Keikakukyoku (Science and Technology Agency, Planning Bureau) 1981 pp 100103

Continuing Education and Training

Despite the self-criticism that Japanese level at their institutions of higher education, the performance of the country's engineers and scientists across many fields, along with the demonstrated competitiveness of Japanese corporations in high-technology industries like electronics, demonstrates that the system, taken as a whole, functions well. Indeed, some of the self-criticism appears to be no more than a mechanism for urging people and organizations to greater efforts.

Deficiencies in universities are at least partially offset by informal mechanisms for self-education, as well as company-run training programs. western observers repeatedly note that men and women in Japan are voracious readers with a strong penchant for self-study, The average Japanese not only spends more time reading than the average American, but more of what he reads is job-related. The spread of quality control methodologies through Japanese industry, outlined in chapter 6, depended heavily on self-study through books, magazines, and radio and TV broadcasting. The national broadcasting company, NHK, transmits nearly a hundred educational programs to attentive audiences each week, including the popular "science classroom" series.

Japan's Government also provides free training for recent high school graduates, as well as for workers who need improved skills before they can join or rejoin the labor force, Over the years, courses taken by those in the second category—adults already in the job market—have expanded greatly. They fill many of the same functions for smaller companies as the in-house training programs conducted by large corporations. Data collected by the Ministry of Labor indicate that more than 200,000 trainees were enrolled in publicly supported vocational programs in 1977, although the content of these programs has been criticized for not keeping up with the needs of industry.[38]

Company-Run Training Programs

Internal training and continuing education comprise an integral part of organization and management in larger Japanese companies. This is perhaps the most fundamental difference between the Japanese and American approaches to technical education. While many American corporations engage in such activities, Japanese programs are much more comprehensive, Developed in part to compensate for deficiencies in formal education, training has evolved to complement employment patterns in which many employees spend their entire careers within a single organization.

Of course, not all Japanese firms or workers fit this pattern. Table 70 shows that big companies provide much more training than small. One reason is that managers are generally rotated within large organizations, a practice often accompanied by study programs. More important, long-term employment within a single firm—sometimes called "lifetime" employment—is the rule only in the major corporations (and then only among male employees).

While training programs within Japanese companies generally impart specialized skills—e.g., computer programing—they serve other purposes as well, purposes that may seem paternalistic or coercive to Western observers.

[38]H. Shimada, "The Japanese Employment System, " Japan Institute of Labor, Industrial Relations Series, Tokyo, 1980, p. 21.

Table 70.—Distribution by Size of Japanese Firms Providing In-House Training

Size of company by number of employees	Proportion of companies with training programs (as of 1974)
1,000 or more employees . .	95.1 0/0
500-999	85.3
300-499	75,9
100-299	58.8
30-99	26.3
5-29	10.1
All firms	41 .3 "/0

SOURCE' H. Shimada, *The Japanese Employment* System, Japan Institute of Labor, Industrial Relations Series, Tokyo, 1980. Based on data from Ministry of Labor, *Jigyonai Kyoikukunren Jisshi Jokyo Chosa* (Survey of Intra-Firm Vocational Training and Education), 1974

For example, corporations rely on in-house training to help build a sense of loyalty to the group and to the organization.[39] The widely remarked cooperative spirit of Japanese employees is no accident.

well-known features of Japanese organizational structures such as quality control circles also serve a training function, one in which the informal elements—and the stress on intergroup cooperation—are at least as important as any knowledge imparted. In an unusually comprehensive program in a Japanese automobile plant, engineers teach other employees in a "workshop university."[40] After completing an extensive program of after-hours study—2 years or more, with no special remuneration—the workshop university graduate is rewarded with a certificate from his section chief. The aim is not only to improve individual skills, but to keep employees intimately involved in day-to-day matters that affect productivity and manufacturing efficiency—ranging from workplace organization, job flows, and task descriptions to interpersonal relations.

Among the most systematic of the industrial training programs in Japan have been those developed by leading manufacturers of electronics and electrical equipment, Since the 1920's, firms such as Mitsubishi Electric and Matsushita have been known for recruiting promising young employees directly from high school, and giving them extensive and formalized in-house training." Such programs emerged in response to shortages of qualified workers in the aftermath of World War I. Japan's Government fostered universal primary education, but

[39]For a detailed analysis of training within a Japanese bank, see T. P. Rohlen, *For Harmony and Strength: Japanese White-Collar Organization in Anthropological Perspective* (Berkeley, Calif.: University of California Press, 1974). In the bank studied by Rohlen, some of the training programs emphasized technical skills while others were directed at "character building. " Both varieties were designed to help integrate workers into the corporate community. Over the course of a year, about one-third of the staff went through one or more programs at the bank's own training institute,

For a comprehensive treatment of training practices at Toyota, see R. E. Cole, *Work, Mobility, and Participation* (Berkeley, Calif.: University of California Press, 1979).

[40]*Work, Mobility, and Participation*, op. cit., pp. 183-184.

A: Levine and Kawada, op. cit., p. 267.

during that period gave little attention to secondary schooling. Vocational training was left to the private sector, where companies designed their own programs to train the workers needed for expansion and industrialization. If the government had pursued a more comprehensive manpower policy, including the support of secondary and vocational education, Japanese firms probably would not have moved so far in this direction.

Initially, then, internal training was a direct response to shortages of skilled labor, and effort was directed at blue- and grey-collar workers rather than managers or engineers. Despite vast improvements in Japanese secondary education since the 1920's, most large companies retain—indeed have continued to develop—these programs. Many operate their own educational institutes; Hitachi, for instance, maintains two, sending graduates of technical high schools for year-long courses of study.[42] The company, which is not untypical, also offers a large number of specialized training courses on an ad hoc basis. Hitachi has given more than 1,000 over the past two decades (some many times); they include foreign languages and topics in management, with specialized subjects such as international business available for executives. As Students in a typical course spend 30 hours in the classroom and twice that on outside assignments; the average skilled worker or technical professional at Hitachi takes two such courses a year,

It is difficult to compare the direct costs of such activities with the corresponding benefits to the firm. But even in large organizations with extensive training programs, such as Toyota, expenditures reportedly total less than 1 percent of salaries and wages.[44] The returns—tangible and intangible—appear substantial.

[42]R. Dore, *British Factory—Japanese Factory* (Berkeley, Calif.: University of California Press, 1973), p. 65.

[43]M. A. Maguire, "Personnel in the Electronics Industry: United States and Japan," prepared for OTA under contract No. 033-1360, pp. 54-56. (In training for managers in Japan, see T. Amaya, "Human Resource Development in Industry,)' Japan Institute of Labor, Industrialized Relations Series, Tokyo, 1983, pp. 21-24.

44 *Work, Mobility, and Participation*, op. cit., p. 185.

International Differences in Education and Training

A principal conclusion from the preceding sections is that, while American universities continue to provide an excellent education for this country's engineers and scientists—as witnessed by the large numbers of foreign graduate students who come here to study—the *average* American high school or college graduate is poorly prepared to function in a technologically based society. Compared to their counterparts in a number of other advanced industrial nations, American students get less training in mathematics and science, and even if they study these subjects, learn virtually nothing about technology.

Deficiencies in mathematics are particularly serious. Mathematics acts as a filter at the entrance to many careers, Although the importance of mathematics to the practice of engineering is sometimes exaggerated, a high level of competence relative to the average is needed to complete a degree program. A student who does not master algebra and trigonometry in high school drops immediately into the class of those needing remedial work; he or she will not be admitted directly into a university program in engineering or science, Those with deficiencies who try to catch up often fail. Part of the problem is simply that as many as one-fourth of high school teaching posts in mathematics are currently vacant, and a comparable fraction are filled by individuals only temporarily certified to teach, many of them marginally qualified at best.[45] Industry has hired away many high school mathematics teachers at attractive salaries, in part to fill vacancies for computer programmers and systems analysts.

The American educational system also does a poor job of preparing those who do not go to college. Even among high school graduates, functional illiteracy is common (estimates for the population as a whole range around 20 percent). Vocational education and training vary

[45]' A Science Dean Describes Teaching as in Sorry State," *New York Times*, Mar. 6, 1982, p. Cl, Shortages of teachers in science as well as mathematics appear to be worsening; see Science *and Engineering Education: Data and Information,* op. cit., p. 7.

widely in quality; excellent programs and inadequate ones can be found virtually side-by-side.[46] Other countries have developed more coordinated and comprehensive approaches to vocational training, with benefits both to individual workers and to industry.[47]

Skilled technical workers are a vital resource for the U.S. electronics industry, and deficiencies throughout the middle levels of the American labor force could constrain the future growth and development of semiconductor and computer firms, as well as companies in other high-technology fields. Technicians, designers and draftsmen, and field service personnel must be literate, have basic quantitative and technical skills, and, ideally, understand something of the logic of the systems they work with. Without such abilities, they cannot use advanced production and R&D equipment to greatest effect, nor exercise sound judgment in the technical problems they face on a day-to-day basis. Individuals without these skills have little upward mobility; an assembly line worker needs at least some quantitative facility to be able to move into jobs such as machine repair, quality control and inspection, or shop-floor supervision.

The demand for grey-collar technical employees in industries like electronics is high; one study has estimated a growth rate in the United States of nearly 18 percent per year, faster than the projected growth in demand for engineers.[48] But in pointed contrast to countries like Japan or West Germany, the American educational system has not responded in any large-scale fashion to these needs, In Germany, fully 60 percent of the labor force has specialized training in grey-collar technical skills, while in the United States the figure may be as low as 10 percent.[49]

A scarcity of adequately trained technical workers could be just as serious a problem for American industries like electronics as constraints on capital investment or a stagnating overall economy. Labor mobility has traditionally been a mechanism for opening manpower bottlenecks; indeed, the U.S. electronics industry already depends heavily on foreign-born—though U.S.-educated—engineers. The next section looks more closely at the structure of the U.S. labor market, particularly mobility,

[46]See, for example, G. W. Wilbur, ''Va. Vocational Education Seen As Hindrance to Development,'' *Washington Post, Nov. 29, 1982.*

[47]The extensive system in West Germany is described in *Vocational* 'f'raining in *the* Federal Republic of Germany (Brussels: Commission of the European Communities, 1978). See also S. Hutton and P. Lawrence, *German Engineers: The Anatomy of a Profession* (Oxford: Clarendon Press, 1981), pp. 94-95; and J. M. Geddes, "Germany Profits by Apprentice System, " *Wall Street Journal,* Sept. 15, 1981, p. 33.

[48]'' Technical Employment Projections of Professionals and Paraprofessiona]s, 1981 -1983-1985," American Electronics Association, May 1981; see also "Testimony of Robert P. Henderson, Chairman and C. E. O., Itek Corp., Lexington, Mass., " *Forecasting Needs for the High Technology Industry,* hearing, Subcommittee on Science, Research, and Technology, Committee on Science and Technology, House of Representatives, Nov. 24, 1981, pp. 61-97.

[49]. J. Prais, "Vocational Qualifications of the Labour Force in Britain and Germany, " *National Institute Economic Review,* November 1981, p. 47; response of R. H. Hayes, *Business Management Practices and the Productivity of the American Economy,* hearings, Joint Economic Committee, May 1 and 11, and June 1 and 5, 1981, p. 46.

Supply and Mobility of Labor

Shortages of men and women with knowledge and skills at a time of high overall unemployment point to weaknesses in U.S. labor market policies, including manpower training and adjustment assistance.[50] While "full employment" has been a policy goal for many years, the upward trend of the unemployment rate over the past decade has combined with

[50]For a relatively comprehensive, and critical, analysis of labor market policies in the United States, see R. J. Vaughn, "The Job Development Administration: A National Employment, Education and Training Policy, " *Projected Changes in the Economy, Population, Labor Market, and Work Force, and Their Implications for Economic Development* Policy, op. cit., p. 33. During 1981, perhaps 1 million U.S. jobs went unfilled, while 10 million people were without work, See K, Sawyer, ''Learning Jobs in School, " *Washington Post,* July 28, 1982, p. 1.

sporadic shortages of workers having specific skills to create a new circumstance, one to which the Federal Government has failed to respond.

Over its history, the United States has seen periodic labor shortages, for both skilled and unskilled workers. More recently, it has begun to seem that—even if the general quality of American education were to remain high–the labor market might simply not be able to supply the right numbers of people, in the right places, at the right time, There are a host of reasons for such concerns, ranging from changing attitudes toward work, to the aging of the U.S. population, to local constraints such as high housing costs, * As the work force ages, and the needs of the U.S. economy shift, retraining will be the only way to utilize people's talents fully.

This section asks whether the development of the U.S. electronics industry will be constrained by limited supplies of engineers and computer scientists (overall employment trends are examined in the next chapter), together with a related question: Are the high levels of labor mobility that have characterized some parts of the U.S. electronics industry essential for continued growth and competitiveness? The comparative neglect of training and retraining in the United States stems in part from the ease with which companies have been able to hire new employees with needed skills; this in turn has reinforced tendencies for workers to move from job to job in search of fresh opportunities or higher pay. The labor market in Japan functions much differently, There, the system emphasizes long-term employment (for some) and loyalty to the firm; mobility is low. Management practices in Japan have sought to compensate for the weaknesses of such a system, while taking advantage of the stability it brings; rather than looking for new people to revitalize faltering efforts, Japanese firms redeploy those they have.

"In Silicon Valley, a housing shortage has driven prices so high that semiconductor firms have found it difficult to hire from outside the area: few candidates c a n afford to move.

Overall Labor Market Trends

The labor forces of Japan and the United States expanded swiftly during the 1960's, largely as a result of postwar baby booms. Table 71 shows the rates of increase in both countries to have been considerably greater than in Western Europe. Japan's labor force grew from 49 million in 1966 to 56 million in 1979, while that in the United States went from 79 million to 105 million over the same period.[51] Although Japan has experienced some labor shortages, the relative abundance of working-age men and women in both Japan and the United States contributed to economic expansion during the postwar period. Younger workers made up an especially large proportion of Japan's labor force during the 1950's. During the 1970-80 period, both countries continued to experience rapid increases in their working-age populations (table 71); growth in their labor forces will slow during the 1980's.

Rising employment levels in industrialized economies over the past two decades have been accompanied by shifts toward the service sector; agricultural employment has declined, with manufacturing roughly stable or declining slowly (see ch. 5, fig. 32). Japan has been something of an exception, with a rise in industrial employment coupled with a sharp drop in agriculture; both the industrial and the service sector grew as a result of migrations from the farm. Such trends will continue as in-

[51] *Labour Force Statistics* 1968-1979 (Paris: Organization for Economic Cooperation and Development, 1981), pp. 18-19.

Table 71 .—Labor Force Growth in Several Countries

	Average annual increase in labor force	
	1960-70	1970-80
United States	1,80/0	1.5 %
Japan	1.3	1,3
West Germany	0,3	0.7
France	0.8	1.1
United Kingdom.	0.2	0.3

SOURCE 196070—W Galenson and K Odaka, "The Japanese Labor Market ," *Asia's New Giant*, H Patrick and H Rosovsky (eds) (Washington, D C Brookings Institution, 1976) p 590
1970-80—*World Development Report* 1980 (Washington, D C The World Bank, August 1980), p 147

dustrial employment in the advanced countries slowly shrinks relative to services.

It is perhaps understandable that, during a period of rapid overall labor force expansion and continuing movement into services, the U.S. Government paid little attention to manpower policies: the economy was growing rapidly; periods of high unemployment were viewed as transient; people could take advantage of a relatively broad range of opportunities. The situation today is much different: aggregate expansion has slowed; the skills needed by industry are more specialized; unemployment has become persistent. Current unemployment is especially troubling because it is caused in part by mismatches between the capabilities of people looking for work and the jobs available; in such circumstances, more rapid aggregate expansion may do little good, and may even be impossible if growth industries cannot hire the people they need.

Personnel Supplies for the U.S. Electronics Industry

In the United States, shortages of software engineers and semiconductor designers have been heavily publicized over the past few years. Not only has demand been high—even through the deep recession of 1982—but warnings of longer term shortfalls have been common. One educator predicted that American schools will graduate a cumulative total of 70,000 new B.S. degree-holders in electrical engineering and computer science over the period 1982-85, while nearly 200,000 will be needed.[52] As discussed in the next chapter, demand for computer service technicians is expected to double during the current decade, with job openings for programmers and systems analysts going up almost as fast.

A number of job-market surveys and estimates of aggregate demand for engineers have been conducted in the recent past. The Labor Department estimated that in 1980 there were 17,000 unfilled entry-level engineering positions throughout the Nation. Other estimates have ranged up to 25,000.[53] NSF's projections for engineers together with scientists indicate that the total supply of new graduates should meet the demand by the end of the decade. However, NSF may be overestimating the extent to which scientists can function in engineering jobs; in any case, shortages are anticipated even by NSF in the computer field, for statisticians, and in several engineering specialties. About one-third of the 1.4 million job openings in science and engineering over the 1978-90 period are expected to be computer related (including programmers). Despite NSF's relative optimism, other forecasts—admittedly often conducted by or for industry, and thus perhaps skewed by the preference of companies to be able to pick and choose when hiring new employees—have projected massive shortages of engineers, perhaps as many as 300,000 by 1990.[54] All such forecasts should be approached with considerable skepticism. None of the methodologies—whether based on simple trend analysis, on survey techniques (as for many of the engineering manpower studies), or on econometric models (as used by the Bureau of Labor Statistics)—has a good record for projecting employment; there are too many imponderable.

While forecasts and projections can warn of possible future shortages, insight also comes from current levels of unemployment in some occupations. Unemployment rates have been remarkably low in technical fields. During 1980, when overall U.S. unemployment averaged about 7 percent, only 0.6 percent of computer specialists found themselves out of work.[55] The unemployment rate for engineers

[52] "Congress Warned of Shortages in Electric], Computer Engineers, " *Electronic News, Nov.* 23, 1981, p. N. The rather alarmist estimates were those of K. Willenbrock, Southern Methodist University.

[53] Henderson, op. cit., p. 63.

[54] Henderson, *op.* cit., p. 66; "Science and Engineering Education for the 1980's and Beyond, " op. cit., pp. 48-50, 60; M. A. Harris, "Manpower Surveys Continue to Disagree," Electronics, July 28, 1983, p. 108. NSF concludes that interfield mobility–particularly influxes of those trained in mathematics—will mitigate but not eliminate the shortage of computer specialists. One potential problem is that, even if the total supply of engineers roughly meets the demand, small firms with limited resources may still be unable to hire new people.

[55] *National Patterns of Science and Technology Resources 1982,* NSF 82-319 [Washington, D. C.: National Science Foundation, March 1982), p. 68. This amounts to only 2,000 people. While unemployment rates for professionals of all types are normally well below the overall unemployment rate, the 0.6 percent figure for computer specialists is unusually low.

(as a group) in 1980 was less than 1 percent; engineering unemployment averaged 1.8 percent over the decade of the 1970's, a period that included the aerospace "collapse, " when the unemployment rate for engineers reached 2.9 percent.[56] Aggregate unemployment levels during the decade averaged 6.2 percent, more than three times as high.

The persistence of unemployment rates far below the national average indicates that an "oversupply" of new graduates in engineering is unlikely. And, while mathematicians and physical scientists, as well as engineers, may sometimes have trouble finding the jobs they consider most desirable, men and women with training in such fields can move into a wide variety of occupations; many scientists eventually find themselves practicing engineering. It is hard to argue that the United States could have too many graduates of science, mathematics, or engineering curricula.

Data on salaries and job offers for new engineering graduates provide additional evidence of high demand. In 1981, engineers made up only 8 percent of new college graduates, but received more than 65 percent of all job offers—and at starting salaries twice as high as for those in the humanities.[57] Salary offers to engineers and scientists rose at higher rates than for other categories of graduates throughout the 1970's, Demand remained high even during the recession of 1981-82.[58]

Another indicator of personnel shortages is mobility across disciplines—the number of people who switch to fields other than those in which they got their formal education. Much of the demand for computer specialists has been filled by men and women with training in mathematics, engineering, and the physical sciences; fewer than one-third of those working as computer professionals have degrees in computer fields.[59] High turnover rates are part of the same picture; as noted earlier, turnover has been rapid among both engineers and technicians in the U.S. electronics industry.

Regardless of uncertainties in the projections, then, few people are worrying that the United States will have too many engineers in the years ahead; capable individuals with training in engineering comprise one of the most employable parts of the labor force. *The prospects of shortage are real in the sense that various projections differ mostly in the magnitudes of the shortfalls predicted.*

In contrast to the wide public awareness of potential shortages of engineers and computer scientists, supplies of grey-collar manpower have received remarkably little attention. Thus, it is impossible to discuss needs for technicians, service personnel, and other skilled workers in quantitative detail. But the situation for machinists illustrates the kinds of problems to be expected. The Bureau of Labor Statistics estimates that annual job openings will average 22,000 over the near future; meanwhile, in 1978 only **2,300** machinists completed registered programs of apprentice training.[60]

The Question of Mobility

Lateral mobility helps moderate sporadic shortages of workers with particular sets of skills. Just as clearly, individuals can only move within a limited realm; a surplus of physicists might help compensate for a scarcity of computer engineers, but few biologists would be able to function in such jobs.

'Science *Indicators— 1980,* op. cit., p. 320. The peak year for unemployment among engineers was 1971.

[57]P. Abelson, "Industrial Recruiting on Campus, " *Science,* Sept. 25, 1981, p. 1445. The data comes from a survey by the College Placement Council covering more than 60,000 offers to new recipients of bachelor's degrees. The salary data also points out the big differences between industrial and academic starting salaries,

[58]In 1982, two-thirds of computer and office equipment firms surveyed by NSF reported difficulty in hiring electrical and computer engineering graduates, as opposed to 95 percent in 1981, See "EEs Still Needed, Though Shortage Has Eased, Says NSF," *Electronics,* Jan, 13, 1983, p. 69.

'9'' Science and Engineering Education for the 1980's and Beyond, " op. cit., p. 39. This reflects in part the slow development of academic programs in computer science and engineering.

[60]S. Qualtrough and J. Jablonowski, "Filling the Need for Skilled Workers, " *American Machinist,* June 1979, p. 131. But see also N.H. Rosenthal, "Shortages of Machinists: An Evaluation of the Information, " *Monthly Labor Review,* July 1982, p. 31. Although the electronics industry employs machinists, far greater numbers work in heavier manufacturing industries, Regardless of the statistics, a good deal of anecdotal evidence bears out the difficulty that manufacturing firms of all types have had in finding journeyman machinists, tool and die makers, and other skilled craftsmen.

American workers move within and across technical fields further and more frequently than their counterparts in other industrial nations. Managers and technical professionals change jobs much more often in the United States than in Japan; mobility is greater in Europe than in Japan, but still considerably less than here.[61] In the U.S. electronics industry, turnover has been high among unskilled workers, where unions have been weak, as well as among those whose abilities have been in high demand.

The effects of labor mobility cut several ways. It is little solace to a firm losing key people if they start a new enterprise that contributes to U.S. competitiveness. At the same time, organizations with low rates of personnel turnover—in any country—must guard against stagnation, find ways to generate new ideas; this is one of the reasons for internal training and job rotation programs in Japan, The pluses and minuses of high or low rates of labor mobility depend on factors such as rates of technological change, current economic conditions, and corporate strategies.

Patterns of mobility across industries and countries depend, among other things, on incentives such as promotion policies and wage/benefit packages; managements have considerable latitude in tailoring these to enhance or discourage turnover. Government programs dealing with adjustment—e.g., training and retraining, unemployment assistance—also act as incentives or disincentives. While generalizations emphasizing cultural differences are sometimes advanced to explain mobility patterns in the United States as compared to Japan, examining incentives—and the ways in which public policies affect them—provides a sounder basis for understanding. Although Japan's labor force tends to be less mobile than that of the United States, a good deal of variation exists across industries and firms in *both* countries.

[61] On West *Germany, see German Engineers: The Anatomy of a Profession,* op. cit., p. 48ff.

Labor Force Mobility in the United States

The United States draws strength from the mobility of its labor force, not only in moderating skill shortages, but as a stimulus to innovation, technology diffusion, and entrepreneurship. New firms in rapidly growing segments of electronics—semiconductors, computer software and peripherals—are often built around engineers and managers who leave one company to start another. On the other hand, rapid staff turnover, as pointed out above, works against company-run programs of education and training. In part to counteract the attractions of entrepreneurial ventures, a number of large and successful American electronics firms—including Hewlett-Packard, Texas Instruments, and IBM—have adopted personnel policies aimed at retaining their employees. Likewise, merchant manufacturers such as National Semiconductor and Intel attempted to maintain staffs and avoid layoffs during the semiconductor sales slump of 1981-82. In this regard, American electronics manufacturers are quite consciously emulating their Japanese competitors.

Still, white-collar mobility has been a sine qua non of the more dynamic merchant semiconductor firms, which have competed aggressively for both technical and managerial talent, Silicon Valley manufacturers have offered a wide range of benefits, including extensive recreational facilities, to recruit white-collar professionals. Some have even paid bounties to employees who bring in new people, prospects for rapid advancement—and the lure of someday getting in on the ground floor of a new organization—have helped attract managers and engineers, as has the California setting, The mobility of talented people has helped diffuse electronics technology, contributing to rapid commercialization of new developments—which in turn has helped build an internationally competitive industry.

The lawsuits occasionally filed against ex-employees by firms seeking to prevent leakage of their technology are among the more strik-

Photo credit Ted Spiegel, 1983

Many electronics technicians get their original training in the military

ing illustrations of the relation between personnel mobility and technology diffusion, Motorola's unsuccessful 1968 case against executives who went over to Fairchild was an early example. In 1980, Intel sued a group of former employees who left to start a company named Seeq; the basis of Intel's suit, which ended in a negotiated settlement, was that the ex-employees intended to base part of their business on trade secrets dealing with the design and manufacture of large-scale programmable ROMs (read only memories).[62] Legal action to prevent technology outflows is an extreme case; more commonly, firms adopt positive programs of rewards and incentives to keep valuable employees, Again, the semiconductor industry has been a leader—helped by a working environment that many employees find stimulating. Of course, features that help retain people also serve a company well in attracting new employees,

Turnover has also been high among unskilled blue-collar workers in many parts of the U.S. electronics industry. In domestic semiconductor plants, production employees tend to be female and ethnic. According to one estimate, women make up 40 percent of the Silicon Valley work force, and are heavily concentrated in lower paying jobs; three-quarters of assemblers are women .[63] In contrast to the mobility of top-echelon managers and technical professionals, turnover among unskilled production workers is associated with a lack of skills; they can be laid off during business slumps and replaced later.

Mobility in Japan

The stereotype of Japan's "lifetime" employment system contrasts sharply with patterns in the U.S. electronics industry. According to the popular view, the Japanese system ensures job security until retirement. Also part of the stereotype is a sequence of promotions based largely on seniority rather than merit, with employees waiting patiently to move up the pay scale, assured of their ultimate reward. These aspects of the Japanese system have been viewed as integral parts of a company-as-family model, making unions in the American or European style superfluous. "Enterprise unions, organized on a company basis rather than by trade or occupation, have been seen as part-and-parcel of a socioeconomic milieu characterized by harmony among workers and managers—this in turn leading to low interfirm mobility coupled with high employee motivation and productivity. While pieces of this model are visible within Japan's economy, it

[62] S. Russell, "s~(;q Loses B id for Rehearing," *Electronic News*, Jan. '25, 1982, sec 1, p. 50

[63] R. Howard, "Second Class in Silicon Vane\," *Working Papers*, September-October 1981, p. 25, See also M. Chase, "Semiconductor Firms Get Mixed Review on Safety in Study by (California Agency" *Wall Street Journal*, Jan. 1, 1982, p. 6.

applies to only a minority of the labor force; moreover, the stereotype obscures crucial details that affect the working lives of all Japanese.

To begin with, labor relations were far from smooth in Japan as recently as the 1950's. Furthermore, lifetime employment is typical only of large Japanese companies, and many of these encourage their employees to retire at a relatively early age—commonly around 55 or 60. Afterward, many "retirees" must find new work—which may turn out to be a part-time or lower paying job with a subsidiary of their former employer—because retirement benefits are low.[64] Moreover, in small firms especially, but also in large enterprises, Japanese workers *do* leave their jobs, Horizontal mobility—i.e., movement from one firm to another without advancement—is fairly common among younger Japanese workers, particularly those with low skills, Women seldom have much job security or upward mobility, much less the many temporary employees that are another feature of Japan's labor market.[65] Women are generally encouraged to resign upon marriage—certainly at childbirth—and if they return have no seniority. The 3.4 million temporary and day workers, men and women—accounting for about 6 percent of the work force–are the first to be let go in the event of recession. Temporary employees provide flexibility to cope with economic slumps without laying off regular workers, The proportion of temporary employees in Japanese manufacturing firms has increased markedly since the recession of the mid-1970's.[66] Furthermore, although corporations in Japan attempt to adjust to business downturns by reducing working hours before laying off regular employees, when recessions deepen—as in 1974-75—they reduce employment levels at rates quite comparable to those in Europe, if not the United States. Smaller Japanese companies have seldom been reluctant to cut back their labor forces.

Nor does the stereotyped picture of seniority-based wages in Japanese corporations (the *nenko* system) hold up under scrutiny. One study finds that promotion is based on a "compromise" between seniority and ability, the particulars varying considerably across firms.[67] Smaller, more rapidly growing organizations tend to emphasize meritocratic promotion, while older, established firms remain less willing to single out talented individuals from others of their age group. Age and ability are, furthermore, weighted differently depending on level, with progress in the upper ranks a stronger function of ability. Clark concludes that the ambiguity built into Japanese promotion practices encourages people to do their best: while promotion has generally been automatic after a certain period of service, there is also the possibility that outstanding performance will be rewarded with rapid advance. And, although the *nenko* system may appear to underpay well-trained and able young workers, over the longer term they can expect to attain salary levels well above those in their age bracket who have lower skills or less education; salary profiles for older male workers in Japan show considerable spread.

Finally, as the Japanese labor force has aged, employment practices have begun to change. With the fraction of older workers increasing, salary competition for the best qualified recent graduates will intensify; recent surveys of hiring suggest that, in certain fields, including electronics, shortages of younger employees are likely. Data compiled by the Ministry of

[64] Japanese electronics firms, along with the rest of Japanese industry, have been under some pressure to extend retirement ages. In the mid-1960's, retirement in the major electronics firms was generally compulsory at 55 to 57 for men, perhaps 50 for women. By the mid-1970's, many companies had extended these ages by about 5 years. See S. Takezawa, et al., *Improvements in the Quality of Working Life in Three Japanese Industries* (Geneva: International Labour Office, 1982), pp. 66-67, 95.

[65] A. H, Cook and H, Hayashi, *Working Women in Japan* (Ithaca, N.Y.: Cornell University Press, 1980). See also F. Ginsbourger, "Japan's Dark Side," *World Press Review*, July 1981, p. 32.

%.-y. Lin, "Wage-Price Behavior Under External Price Shocks and Productivity Slowdown: A U.S.-Japan Comparison, " Discussion Paper No. 402, Economic Growth Center, Yale University, April 1982, p. 22a.

[67] R. Clark, *The Japanese Company (New* Haven: Yale University Press, 1979), pp. 115-116. On the development of the *nenko* system, see T. Inagami, "Labor-Management Communication at the Workshop Level, " Japan Institute of Labor, Industrial Relations Series, Tokyo, 1983. Inagami also includes data on promotion patterns (pp. 10-14).

Labor indicate that younger Japanese workers can choose between two or three entry-level jobs, but those aged 55 and over must win out over 5 to 10 other jobseekers to find a position.[68] As a result of such trends, wage compression for older employees seems likely to intensify, retirement ages may be extended further, and the role of seniority in promotion decisions will diminish. Generational conflict between younger employees, for whom high demand will push up salaries, and older workers who stand to lose by comparison, may follow.[69] If and when such events come to pass, the features that now make the Japanese employment system seem unique will stand out less.

The United States and Japan Compared

While the contrasts are often exaggerated, Japanese and American employment practices do lead to quite different patterns of mobility. HOW do these interact with the structures of the electronics industries in the two countries to affect international competitiveness? Firms in each nation have alternatives in seeking the people they need. One option is to hire employees away from other companies, an approach more likely to be successful in the United States. An alternative is *internal* recruitment—intrafirm mobility—in conjunction with retraining, an avenue particularly appropriate in a system such as Japan's, where people tend to identify more strongly with the corporation than with a vocation or profession. Still another method of coping with shifting occupational needs is to alter or expand the potential pool of new entrants. Despite the vitality that the U.S. electronics industry has drawn from employee mobility, there is no need to associate either high mobility or a lack of mobility—in and of themselves—with enhanced competitiveness; nor should high mobility be considered more "modern" than low (or vice versa). High mobility in the United States goes with other aspects of the U.S. economy, just as low mobility is consistent with Japan's socioeconomic environment.

Public policies influence the choices made by corporations among the options outlined above. Government support for training technicians can enlarge the talent pool. Vigorous manpower policies, designed to support expanding sectors of an economy, will stimulate interfirm and interindustry mobility, Tax writeoffs for company-run programs of education and training would encourage intrafirm mobility, High turnover rates have made American corporations wary of investments in training or retraining that may pay off to their competitors. "Talent raiding''—so characteristic of American semiconductor firms—often becomes the alternative.

Employment practices in the United States may change as a result of the demographics of aging, just as the aging of the Japanese labor force is altering patterns in that country. As the U.S. population grows older, continuing education for those in midcareer—blue- and grey-collar workers, as well as white-collar professionals—will become a necessity, When the labor force was expanding rapidly, employers could count on new graduates to fill many of their needs; this is less true today, particularly in light of current inadequacies in technical education, American firms may find themselves emulating the internal training efforts of their Japanese competitors, with management practices designed to enhance a company's human resources becoming critical elements of corporate strategy. The remainder of this chapter turns to questions of management and the organization of the workplace, asking—among other things—whether there really is a uniquely Japanese approach to management.

[68] Clark, op. p. 32.

[69] R.E. Cole, "Changing Labor Force Characteristics and Their Impact on Japanese Industrial Relations," *The Paradox of Progress*, L.E. Austin (ed.) (New Haven, Corm,: Yale University Press, 1976), p. 194.

Organization and Management

As the end of the 19th century brought rapid economic growth and technological change to American industry, new management techniques arose to deal with shopfloor organization. The old ways, developed during the days of hand work, proved a poor guide to factory production using mechanized equipment, particularly in the emerging mass production industries

Frederick W. Taylor, founder of the scientific management school, is the best remembered of those who pioneered new methods.[70] Taylor began as an engineer at an ironworks, and his approach to management—including plant layout and job flows, and the man/machine interface—reflects the bent for rationalization associated with his profession. While Taylor himself, and the techniques he developed and advocated around the turn of the century, showed considerable appreciation for the human element in factory work, many of his followers carried scientific management to the extreme of treating people as another variety of machine, Scientific management still bears this stigma—and "Taylorism" is a dirty word for many who associate it with the Chaplin of *Modern Times*.

Taylor believed that, for every task in manufacturing, there was an optimum method that could be "scientifically" discovered. By reducing each job to its essential elements—employing, for instance, the techniques of what has come to be known as time-and-motion study—the workplace was to be rationalized and productivity maximized. Although Taylor thought that this approach should also increase cooperation among workers, one of the chief criticisms of scientific management has always been its rather mechanistic conception of the individual, leading to an emphasis on simple, repetitive tasks,

Photo credit: *Westinghouse*

Integration of programmable robots into the factory environment poses a new set of problems for manufacturing industries

The idea of a scientific means for organizing factory work attracted American businessmen. New machine tools, the assembly line, mass production of durable goods like bicycles, home appliances, and automobiles, presented a rapid succession of new problems; industrialists eagerly embraced Taylorism as a means of dealing with them. The management science movement springing from Taylor's early work has continued to thrive and to spread internationally; it still shapes curricula and textbooks in American business schools and industrial engineering programs.

The human relations approach to management was developed primarily by industrial psychologists, beginning a decade or two later,

[70] F. W. Taylor, *The Principles of Scientific Management* (New York: Norton & Co., 191 1). N. P. Mouzelis, *organization and Bureaucracy: An Analysis of Modern Theories* (Chicago: Aldine Publishing Co., 1967), gives a useful historical overview of various approaches to organizational management.

In contrast to the engineers who espoused Taylorism, the human relations school stressed peoples' attitudes and motivation as keys to productivity and manufacturing efficiency. Studies in the human relations vein explored the workplace as a social organization and the individual employee as a member of the group; practitioners saw their goal as fostering an amicable working environment, one built around the existing shopfloor culture. While advocates of scientific management tended to be antiunion, the human relations school accepted unions as an integral part of the social system of the factory,

Just as the reductionist tendencies of scientific management have been criticized, so the human relations approach has been faulted for its stress on harmony to the neglect of the real conflicts of interest characteristic of work life, and for overemphasizing small group behavior while failing to deal with the organization as a whole.

Variants of these two attitudes toward management—which reflect contrasting theories of organization—continue to proliferate. The two are based on fundamentally different notions of what makes organizations—whether factory, store, or office—function, and hence on methods for improving their operation. At present, the human relations approach has become identified with the popular view of Japanese management, but both schools have American origins. This is not, of course, to say that Americans cannot learn from foreign experience. Organizations in other countries have adapted management practices originating in the United States to their own needs, and it may be time for a reverse flow into American corporations.

Organizational Types and Management Styles

The Manager as Professional

In the United States, management is a discipline with its own graduate schools and advanced degrees; M.B.A. programs increased by an order of magnitude over the past two decades, and now graduate more than 50,000 men and women each year. In contrast to Japan and Western Europe, where top managers tend to move up from the ranks—and a few individuals still reach high levels having started on the shop floor-American firms, especially the larger, publicly held corporations, have tended to bring new employees directly into management-track jobs. Typically graduates of academic programs in business administration, some of them fill staff positions, others move quickly into middle management, Thus the management profession—with its extensive network of specialized academic programs—has become a principal vehicle for transmitting and validating the techniques used in American business.

Management training in this country prepares people for work in hierarchical organizations. Distinctions between those who plan and those who do the work are more sharply drawn in American corporations than elsewhere; this division—and the equally sharp distinctions between those responsible for production, or "operations, " and the rest of management—has increasingly come under scrutiny and criticism.[71] In contrast, Japanese and European business practices are rooted in on-the-job experience and company-run training programs. Management institutes exist, but are typically oriented toward the needs of midcareer executives seeking fresh perspectives.

While the ideal types of "American" and "Japanese" management are exaggerations that fail to capture the variety existing within the two countries, they nonetheless point to differing conceptions of the nature of modern organizations. The Japanese model is based on authority stemming from tradition and socialization; the American approach is less personal and more legalistic. Central to the Japanese model are group decisionmaking, cooperation between labor and management, and long-term tenure in an organization viewed as analogous

[71] See ch. 6. The following pair of articles in the July-August 1981 issue of the *Harvard Business Review* are typical examples of this criticism: R. H. Hayes, "Why Japanese Factories Work, " p. 56, and S. C. Wheelwright, "Japan-Where Operations Really Are Strategic, " p. 67.

to a family. Ideally, these result in a well-integrated system, with human resources as the firm's most important long-term asset.[72]

Decisionmaking in Japan

Symbolic of the Japanese approach is the *ringi seido* (approval system), through which middle-level personnel obtain sanction and approval from the top echelons by circulating a document to which each person affixes his seal or signature.[73] The process yields systematic but slow "bottom-up" decisionmaking. A decision is final once the company president adds his seal; since many individuals participate, there is considerable communication—if not always true consensus—and, once the outcome has become apparent, little uncertainty. Contrasts are frequently drawn between the tendency of "individualistic" Americans to continue pushing their own views, even after contrary decisions by upper management, and the Japanese case—where, as the saying goes, "when the train leaves the station, everyone is on board. " The point is that whatever disagreements precede the *ringi* decision, they are supposedly buried afterwards, the policy fully supported by all.

While authority in a Japanese company is vested in the president, employees at many levels participate in the consensus-building process. Not all of them have the precise and well-defined responsibilities that characterize job descriptions in an American corporation. Ambiguity attaches to organizational structure in Japan, rather than to people as in the United States. The Japanese system does not involve much bargaining among managers and subordinates, nor is it participative in the sense often used in the West. In contrast to U.S. practice, where management decisions and business planning get detailed attention, the *ringi* system allows people throughout the firm to agree on generalities, with the specifics to be worked out later.

Group decisionmaking as embodied in the traditional Japanese approach is a good fit with corporate organizations that offer individual employees considerable security and involve them with the company outside their immediate duties and working hours, Company housing and recreational facilities, group outings and even vacations, along with internal training programs, can all be viewed as incentives for building loyalty among a fairly immobile labor force. In best light, the system is "wholistic" in orientation; in worst light, it is a sophisticated brand of industrial paternalism.[74] The widespread acceptance of company rather than craft or trade unions and the comparatively few days lost to strikes in Japan (table 72) indicate that this labor-management system—oriented toward consultation and conformity—has worked to the benefit of the corporations that have designed and implemented it. As table 72 illustrates, large numbers of workers participate in strikes even in Japan, but little time is lost because work stoppages are short, often serving functions that are at least partially symbolic.

Contrasts With the United States

Extensive involvement with the company outside normal working hours and group decisionmaking diverge markedly from patterns in the United States, where—rather than spreading responsibility for decisions through the organization—top management is expected to

72 N. Hatvany and V. Pucik, "Japanese Management and productility," *Organizational Dynamics*, spring 1981, p. 8.

73 For a detailed description of the *ringi seido, see* M. y. Yoshino, *Japan Managerial System: Tradition and Innovation* [Cambridge, Mass.: MIT Press, 1968), pp. 254ff.

74 As]at as 1976, more than one-quarter of Hitachi's male employees still lived in company housing; the figure had been nearly 40 percent in 1967, See *Improvements in the Quality of Working Life in Three Japanese Industries,* op. cit., p. 69.

Table 72.—Work Stoppages Due to Labor Disputes in Several Countries (1978)

	Total number of participants in work stoppages	Total number of employee work-days lost
United States . . .	1,600,000	39,000,000
Japan	660,000	1,360,000
West Germany . .	490,000	4,280,000
France	1,920,000	2,200,000
United Kingdom .	1,040,000	9,400,000

SOURCE: "Japan, An International Comparison —1980," Keizai Koho Center, p. 49.

provide leadership. Corporate cultures in the United States give pride of place to strong-willed executives who leave their mark on an organization. Power, status, and privilege also attach to Japanese executives, but with real differences. The ability of managers to show immediate results—profitability over the next quarter being the current target of critics—is central to the American model, group effort to the Japanese. Well-defined and often narrow responsibilities, centralized authority, rigidly hierarchical organization charts—plus the possibility of swift promotion and high rewards—characterize the "results-oriented" management styles of American firms. Ambiguity is viewed as undesirable, expertise cultivated; men and women enter the firm as specialists in accounting or finance, marketing or strategic planning. Individualism is tolerated, but within well-defined bounds–witness the "white-shirt syndrome" still hanging over companies like IBM.[75] The comparatively high levels of personnel mobility in the United States, and the tradition of adversarial relations between unions and management, are part of this picture.

A further difference between Japanese and American management practices—discussed in more detail in chapter 6—is the emphasis companies in Japan place on manufacturing and its integration with the rest of the firm. Toyota's much-noted system of just-in-time (kanban) production and inventory control is only one example. Since Japanese managers tend to rise relatively slowly through the ranks, with periodic lateral moves, stress on manufacturing is perhaps natural. In contrast to the situation in the United States, where production—more especially quality control—has little prestige, is even viewed as a dead-end job, a number of Japan's top corporate executives began their careers as quality control or manufacturing engineers.

Both Japanese and American approaches to management have their strengths and weaknesses. Few corporations exhibit management styles as clear-cut as the stereotypes suggest; in both countries, firms have identities that may vary from division to division as well as changing over time. The wholistic orientation of the Japanese style carries strong paternalistic overtones, with discrimination against women and minority groups a fundamental part of the system.[76] And, although Japanese management is sometimes viewed as people-oriented, personal interactions are marked by pervasive if subtle status distinctions. Paternalism does lead to job security for some fraction of the labor force in Japan, security which is less common in the United States, The American approach, while often assumed to maximize opportunity, does so in part by encouraging competition—some would say to excess—among individuals seeking advancement and personal gain.

Comparisons of American and Japanese management often focus on particular techniques—e.g., quality control circles in Japan, management by objectives in the United States—rather than the schools of thought, such as scientific management or human relations, from which these techniques derive. But improvements in management seldom result from the isolated adoption of some technique. This quotation from a Japanese engineer points out the difference between technique and underlying attitude:[77]

> One difference I find hard to explain to my Western colleagues is that we do exactly the same things that the industrial engineer does in Detroit or Pittsburgh; but it means something different. The American industrial engineer lays out the work for the worker. Our industrial engineers are teachers rather than masters. We try to teach how one improves one's own productivity and the process. What we set up is the foundation; the edifice the worker builds. Scientific management, time and motion studies, materials flow-we do all

[75] "Life at III M-Rules and Discipline, Goals and Praise Shape IBMers' Taut World, " *Wall Street Journal,* Apr. 8, 1982, p. 1.

[76] Even the more bemused commentators on the Japanese model, such as Ouchi, note its racism and sexism, See W. G. Ouchi, *Theory Z: How American Business Can Meet the Japanese Challenge* (Reading, Mass,: Addison-Wesley, 1981), p. 91.

[77] Quoted in P. F. Drucker, "What We Can Learn From Japanese Management, " *Harvard Business Review,* March-April 197], p. 117.

> that, and no differently from the way you do it in the States. But you in the States think that this is the end of the job; we here in Japan believe it is the beginning. The worker's job begins when we have finished engineering the job itself.

It is too easy to write off such statements as empty philosophizing.

Worker Participation

The past decade has seen continuing interest in industrial democracy, more so in Western Europe than in the United States.[78] Stemming at least in part from persistent economic problems, some companies and some governments have experimented with methods for increasing the involvement of the labor force—particularly blue-collar employees—in decisionmaking and work design. One aim has been to moderate wage demands. This section outlines several of the modes of employee participation that have evolved in Europe, as well as the quality control circles originating in Japan. The purpose is to capture some of the variety of foreign approaches, and ask how such mechanisms might help the productivity and competitiveness of American industry. A large number of specialized techniques for redesign of the working environment and employee involvement have been developed, both here and overseas; no attempt has been made to describe any except quality circles, which are covered because they have attracted so much attention.[79]

[78] Much of the material on European countries in this section is based on A. L. Ahmuty, "Worker Participation in Management Decision-Making in Western Europe: Implications for the United States," Congressional Research Service Report No. 79-136E, Apr. 23, 1979. See also B. C. Roberts, H. Okamoto, and G. C. Lodge, "Collective Bargaining and Employee Participation in Western Europe, North America and Japan, " The Trilateral Commission, 1979.

[79] For an overview of a number of these, see R. M. Kanter, "Dilemmas of Participation: Issues in Implementing Participatory Quality-of-Work-Life Programs, " *National Forum*, spring 1982, p. 16. Several case studies can be found in J. A. Fadem, "Automation and Work Design in the United States, " Working Paper Series No. *43*, Center for Quality of Working Life, Institute of Industrial Relations, University of California, Los Angeles, 1982.

Participative Mechanisms

In the United States, industrial democracy has been associated with collective bargaining by labor unions—an interpretation of worker participation neither so encompassing as in Western Europe nor quite so narrow as in Japan. While American unions have continued to bargain over wage-benefit packages, European workers have succeeded in extending their influence over workplace and organizational decisions. In some contrast, quality control (QC) circles were developed by managers in Japan as tools for improving labor productivity and product quality. Most of the interest in QC circles among Americans has also originated with management. If American workers, particularly in companies with strong unions, have sometimes been reluctant to embrace QC circles, quality-of-work-life programs have found a better reception with labor.

The worker participation movement in Western Europe is based on two presumptions: first, that labor is just as important to production as capital; second, that blue-collar employees have the right to be represented in corporate decisionmaking. Participatory mechanisms include work groups at the shopfloor level, work councils at the plant or enterprise level, collective bargaining, labor representation on boards of directors, employee-owned enterprises, and worker representation on socioeconomic advisory bodies to governments, Beyond these direct involvements, publicly owned companies are a longstanding fixture on the European scene, with governments paying more or less attention to their management depending on political pressures and economic conditions.

At the shopfloor level, work-life programs give employees a voice in determining how individual tasks should be performed, with the aim of increasing job satisfaction as well as improving productivity. Employee involvement in work methods can be viewed as a reaction against the scientific management tradition, in which an expert—typically an industrial engineer—has full responsibility for task design. Sometimes, work-life programs reduce productivity (as traditionally measured), a sacrifice that firms like the automobile manufacturer Volvo appear to have accepted in the interests of employee satisfaction, (Volvo replaced a number of assembly lines with batch assembly operations, giving workers more variety.)

At the enterprise or plant level in Europe, work councils—independent of unions—give employees a voice in codetermining a firm's future, Labor representatives on these councils participate in financial and other business decisions, although at the head of the agenda tend to be matters like personnel policy, health and safety, and shopfloor organizational practices. American-owned companies in West Germany have seldom been comfortable with codetermination; in the United States, the few labor-management committees that have been established tend to have a much narrower focus, and to be viewed primarily as vehicles for enhanced communication. One of the best known is the National Committee to Improve the Quality of Work Life, established by the United Auto Workers and General Motors in 1973. Current economic conditions may motivate more such experiments.

One of the most far-reaching experiments in employee participation has been instituted in West Germany. In the early 1970's, the Ministry of Research and Technology, in cooperation with the Ministry of Labour and Social Affairs, began a program aimed at the "humanization of work, " Based on the Work Councils Act passed by the German parliament in 1972, the premise is that government should not only safeguard employee health and safety, but undertake to improve opportunities for individual development and participation in decisionmaking.[80] In general, the response of workers to these initiatives seems to have been less positive than for earlier programs of codetermination, particularly in industries like electronics where the workplace is already relatively benign. West German workers have remained more interested in power over matters such as hiring and firing practices,

Blue-collar employees in the United States have restricted their attempts to influence company policies and decisions to the traditional concerns of labor-management relations. Union officials have been ambivalent about moving beyond questions of wages, benefits, and working conditions—probably for fear of losing some of the bargaining power that comes with an adversarial stance, al In contrast to Western Europe, participation by American workers on boards of directors has been rare—mostly brought on by circumstances such as Chrysler's recent financial plight. Although the many plant closings in industries like steel have led to proposals that employees purchase facilities scheduled to be shut down, few such plans have gone forward,

While collective bargaining is virtually universal in advanced market economies, there are man y differences of form and substance, In Japan, about 95 percent of all unions are organized on an enterprise basis.[82] In addition to collective bargaining between unions and management, negotiations take place each spring between groups of firms and unions, The "spring offensive" is most visible in the steel, electrical machinery, shipbuilding, heavy machinery, and automobile industries, as well as public corporations (where a special mediation committee decides on the settlement). Wage decisions during the spring offensive help set patterns for smaller firms. Still, compared with the United States or many European nations, labor in Japan has little real power.

Quality Control Circles

QC circles have been heavily publicized as mechanisms for worker participation. Quality circles are relatively autonomous, composed

[80] "Research on the Humanization of Work, " Action Programme of the Federal Minister for Labour and Social Affairs and the Federal Minister for Research and Tech nology," Dec. No. 2181/74e. See also *Programm Forschung zur Humanisierung des Arbeitslebens*, Der Bundesminister fur Forschung und Technologies, 1979.

[81] For an evaluation of labor-management committees in the United States, see K. Frieden, "Workplace Democracy and Productility, " National Center for Economic Alternatives, Washington, D.C., 1980, p. 31.

[82] "Labor Unions and Labor-Management Relations, " Japan Institute of Labour, Japanese Industrial Relations Series, Tokyo, 1979.

of a small group of workers—perhaps a dozen—typically led by a foreman or senior employee.[83] In Japan, financial incentives play a relatively minor role, without the emphasis on prizes for suggestions or improved performance that some American firms have adopted. QC meetings in Japanese companies are often held outside normal working hours, and workers may not be paid for their time. Although the circles now work on job-related problems beyond quality control per se—e,g., production methods, worker training—they grew out of the postwar stress on quality inspired by Americans such as Deming (ch. 6). The contribution made by Japan's business leaders was the expansion of quality control to involve participation by virtually everyone in the firm. Employee training via circles, for example, is intended to reduce the need for specialists in quality assurance and production engineering. As discussed in chapter 6, the quality and reliability of electronic products depends on factors ranging from engineering design to relationships with suppliers; while the quality of many Japanese goods is now excellent, it would be a mistake to attribute this to any one technique such as the QC circle.

Cole notes that even in Japan enthusiasm within a QC group tends to wane, and circles need to be periodically revitalized. It would be no surprise to find a Hawthorne effect at work in many of the success stories involving QC circles (i. e., a situation in which any of a wide variety of changes in the workplace environment would improve employee motivation and productivity, at least temporarily). The effectiveness of QC circles also depends on the extent of employee identification with the company; members participate more fully if they feel that their work is recognized and appreciated within the organization. A group-oriented Japanese corporation is more likely to foster such attitudes than many of the American firms now experimenting with QC circles. But even in Japan, QC circles are sometimes perceived as a coercive management tool. Overenthusiastic accounts of quality control circles in Japan sometimes give the impression of a panacea; in reality, Japanese firms vary widely in the extent to which they utilize QC circles—regardless of commitment to circle activities, they are only one management technique among many.

Over a hundred American firms—including General Motors, Ford, and General Electric—have experimented with QC circles, but the question of whether or not they will work as well in the United States as in Japan has not been answered. Certainly there are obstacles here that do not exist in the typical Japanese organization. In the U.S. context, for example, monetary incentives may be essential; the Lockheed program is typical in that employees are not expected to meet after hours, or without extra pay.[84] Experience also shows that American middle managers must be persuaded to accept and support the QC approach, else they may perceive the circles as challenges or as implicit criticisms of past performance.

Unionized firms add another dimension. Where QC circles have been introduced into American companies without the consultation and support of union leaders, they have not been successful. Organized labor remains ambivalent; AFL-CIO spokesmen have felt that QC circles could be a tool for breaking up unions, and the evolving attitude appears negative, as

Japanese firms with plants in the United States have generally introduced circles gradually and with considerable care, if at all. Quasar, owned by Matsushita since 1974, did not install its first circles until 1982; the company plans to have 25 in operation by the end of 1983.[86] QC circles in Japan function in a con-

[83] Cole has carried out the most systematic studies on quality circles. The discussion below is based largely on *Work, Mobility, and Participation*, op. cit., pp. 135ff. Also see R. E. Cole, "Will QC Circles Work in the U.S.?" *Quality Progress*, July 1980, p. 30; *Improvements in the Quality of Working Life in Three Japanese Industries*, op. cit., pp. 76ff; and Inagami, op. cit., pp. 31-34.

[84] "Quality Control Circles Save Lockheed Nearly $3 Million in Two Years," *Quality*, May 1977, p. 14.

[85] R. S. Greenberger, "Quality Circles Grow, Stirring Union Worries, " *Wall Street Journal*, Sept. 22, 1981, p. 29.

[86] Information from Quasar. Thus far, the company views its experience in the United States with QC circles as successful, but perhaps not so successful as in Japan. For examples of other experiences in electronics, see J. D. Couger, "Circular Solutions, " *Datamation*, January 1983, p. 135.

text that includes enterprise unions, a relatively immobile work force, and seniority-based wage increases, Not all the elements in the Japanese approach or in QC circles themselves are likely to prove attractive to workers and managers in the United States.

Japanese and American Management Styles: How Much Difference?

Do Japanese firms operating in the United States exhibit a distinctive management style? Or in adapting to the new setting do they act more like American firms? Keeping in mind the structural differences that have been outlined, how different are management styles even within Japan from those in the United States? By comparing a foreign subsidiary both to its parent and to local competitors, variables of ownership and geography can be separated. This section presents the conclusions of a study of managerial differences among U.S. and Japanese firms, The survey sample included upper and middle managers from: 1) Japanese subsidiaries of American companies, 2) Japanese-owned subsidiaries in the United States, and 3) both American and Japanese firms in their home country. Appendix 8A, at the end of this chapter, explores the data on national differences in management style more systematically.[87]

The survey results show that *American- and Japanese-owned electronics firms do not diverge greatly in management style.* In many respects, managerial practices were more closely associated with geographical location than with ownership; i.e., Japanese-owned firms in the United States acted more like American firms, U.S. subsidiaries in Japan more like Japanese companies. In itself, this should be no surprise, given that foreign subsidiaries everywhere are mostly staffed by local people. Even if upper managers come from the parent, there is only so much they can import and implement.

The one respect in which Japanese-owned firms in *both* the United States and Japan stand out is their emphasis on employee motivation and participation, and on diffusion of responsibility through the ranks. The survey results indicate that the anecdotal evidence on Japanese concern for employee motivation reflects a genuine distinction: in terms of the models of management style outlined earlier, the Japanese approach is closer to the human relations pole. At the same time, the range in behavior across both Japanese and American firms is wide.

Japanese-owned firms stress communication and personal interaction both horizontally and vertically, At least some aspects of consensual decisionmaking have been transported to the United States, One can question the extent to which Japanese managers accept and act on the information received through these communication channels, as opposed to using them to manipulate opinion and impose top management decisions. Nonetheless, in employee surveys, managers in Japanese-owned firms both here and in Japan were more often described as sensitive to others and accessible to subordinates than managers of American-owned companies. This in itself contributes to employee motivation and satisfaction.

Such behavior patterns can be associated with the human relations school of management. The principal contrast with American-owned firms is along the *informal* dimensions of organizational behavior; there was little difference between the U.S. and Japanese firms surveyed in terms of organizational hierarchy or formal lines of communication. The distinguishing features of Japanese management appear to be rather intangible, matters of attitude more than method.

U.S. subsidiaries of Japanese companies have generally found this emphasis on human relations and employee participation to work well. Typically, the firms surveyed have modified management techniques imported from Japan to fit the American context without abandon-

[87]App. 8A, together with the summary here, is based on a report prepared for OTA by M. A. Maguire. It includes an independent analysis of data from a project directed by R, T. Pascale, The subset dealing with electronics has been of primary interest to OTA, For a discussion based on all the data, including other Industries, see R. T. Pascale and A. G. Athos, *The Art of Japanese Management* (New York: Simon & Shuster, 1981).

ing the human relations thrust. Furthermore, some of the best performing American firms display a similar concern for employee participation, with the implicit goal of giving individual workers a stake in the success of the enterprise. While it is impossible to determine the precise degree to which human relations-oriented management contributes to the performance of particular companies, it does appear to be a common trait in well-managed and competitive organizations in both countries.

Summary and Conclusions

Commitment to the development and utilization of human resources is closely associated with corporate success, and, through this, with industrial competitiveness. In electronics, U.S. manufacturers have had difficulty filling critical positions in engineering; a concurrent shortage of skilled technicians, while not so well publicized, could prove as serious a bottleneck. At present, the United States seems *in danger of falling behind other countries at training people in the skills needed for high-technology industries like electronics;* deficiencies exist in both public and private sectors. Education, provided first and foremost by the public schools, determines the skills and capabilities that people bring with them to the work force. The ability to continue learning—on the job as well as off—also depends on the quality of that formal education. While some American firms provide or encourage continuing education and training for their employees, others do little or nothing.

Inadequacies in the education and training of the American labor force are growing more serious, Beginning at secondary levels, the preparation of Americans in science and mathematics is simply not on a par with other industrialized nations—e.g., Japan. A smaller fraction of U.S. college students major in technical fields. While many American universities are, at the moment, limited in their ability to handle greater numbers of engineering students, a more fundamental problem is the relatively small fraction of the college-age population qualified to enter such programs. The typical U.S. high school graduate is not only poorly prepared in mathematics and science, but uninformed concerning technology. *Deficiencies in mathematics are most serious; these disqualify people at an early age from a broad range of career opportunities, depriving the Nation of a vast potential resource.*

For those qualified for admittance, programs in engineering, mathematics, and the sciences offered by American colleges and universities —both undergraduate and graduate—remain unsurpassed. Nonetheless, they have slipped relatively; engineering schools, in particular, are suffering from a lack of qualified faculty and from inadequate and obsolete equipment. The pressures of expanding undergraduate enrollments have led to a deterioration in the quality of education. Continued low enrollments of ph. D. students mean that the shortage of engineering teachers will continue; *what might have been a transient problem is rapidly turning into a serious long-term concern.*

Moreover, the *average* American worker is less prepared than his or her counterpart in a number of other countries for productive employment in industries like electronics. As a result, the United States is heading toward more shortages of skilled blue- and grey-collar workers—technicians, designers and draftsmen, engineering aides, field service personnel. Likewise, many white-collar jobs are filled by people with little understanding of mathematics, science, or technology—and with little preparation for comprehending technical subjects even on a lay basis. Meanwhile, *unemployment in the United States has been rising—in part the result of a mismatch between what people are able to do and what needs to be done.*

One way private firms can compensate for deficiencies in formal education is to establish in-house training and retraining programs; in addition to such efforts, many American firms support continuing education outside the company. The incentives for such efforts, however, are lower here than in Western Europe or Japan because of the mobility of the U.S. labor force, The frequency with which Americans take new jobs heightens the risk that the company will lose its investment. Nonetheless, a number of U.S. electronics companies have developed ambitious employee training efforts, and the semiconductor industry is developing programs in conjunction with universities that will help to educate new people, as well as supporting the R&D base. Despite their promise, such initiatives will not by themselves be sufficient to meet the skill requirements of the electronics industry in the years ahead, much less the broader needs of the U.S. economy.

Government in the United States–Federal, State, and local–has traditionally carried the major responsibility for education and training; expanded public sector programs for training and retraining appear necessary for building the competitiveness of American industry, As demographic forces tilt the labor force toward greater proportions of older workers, retraining will be essential if the talents of mid-career employees are to be effectively utilized. As U.S. industry continues to advance technologically, workers who find themselves displaced by structural change will be dependent on retraining to find productive employment elsewhere. As job opportunities shrink for those with limited skills, men and women with poorer educations, and without the developed ability to learn on the job, will more and more find themselves unemployable. Given the competition and mobility characteristic of the American economy, the *private sector cannot reasonably be expected to provide the needed training and retraining; only government bodies—at all levels—can take on this responsibility*.

The efforts of private industry begin with the people available in the labor pool. In large measure, the art of management lies in maximizing the contributions of existing and prospective employees—to which end a number of the more successful electronics companies, in the United States as well as Japan, have developed management systems that emphasize employee participation. Giving individuals a voice in decisions that affect them increases motivation and commitment to the organization.

Despite the vogue for Japanese management techniques, the human relations approach is in no way unique to Japan or to Japanese corporations; the similarities among competitive firms in Japan and the United States are more striking than the differences. Specific mechanisms, such as quality control circles or labor-management committees, appear of secondary importance compared to less tangible signs of attentiveness by management to the attitudes and talents of employees.

While many U.S. corporations have developed their own brands of human resources-oriented management, others could profit by more attention to worker participation; American managers seem to be gradually realizing that they may be underutilizing their employees. Table 73 shows that executives of U.S. firms rank employee participation as the most important single influence on productivity. Whether they *act* on such beliefs is another matter; but, of the forces that affect competitiveness, management is the most immediately amenable to change by individual companies. A renewed commitment by American companies to the development and utilization of human resources could pay large dividends in international competition.

Table 73.— Rankings by American Managers of Factors Contributing to Productivity

Factor	Average rank[a]
Employee participation programs	3.61
Better communications	4.11
Better labor-management relations	4,45
Increased training	4.46
Quality improvement	4.81
Increased automation	5.02
Productivity incentive programs	5.13
Cost reduction programs	6.01
Increased R&D	6.28

[a]Based on a scale of 1 to 10, with l being the most effective and 10 being the least

SOURCE Mechanical Engineering, September 1981

Appendix 8A.—Japanese and American Management Styles: A Comparison

Survey Results

A survey covering managers and other employees in four electronics companies provides the basis for this comparison:

- *company A* 1, an American consumer electronics firm operating only in the United States;
- *company J,* a Japanese consumer electronics firm with operations both in the United States (J-A) and in Japan (J-J); and
- *companies* A2-) *and A3-J,* the Japanese subsidiaries of two American firms, one a manufacturer of computers, the other of semiconductors (not necessarily in that order),

All the firms were high performers in their respective portions of the electronics industry,

The data can be grouped in several ways. For instance, a geographic grouping gives: first, the two organizations in the United States—one American-owned (Al), and one Japanese-owned (J-A]; and, second, the three operations in Japan—one Japanese-owned (J-J] and two American-owned (Az-J, A3-J). Alternatively, grouping the sample by ownership yields a set of three American-owned firms (Al, A2-J, A3-J) which can be compared with the Japanese-owned organizations [J-A and J-J). For most purposes, the ownership distinction is more illuminating, probably because top managers who set the tone of an organization generally came from the parent firm. In contrast, most of the middle-level managers had been recruited locally; thus in organization J-A they were largely Americans.

The survey covered both middle and upper managers, utilizing interviews as well as written responses. Nonmanagerial employees were also sampled via questionnaires to gather data on job satisfaction. The data must be interpreted with caution because of the small number of organizations. At the same time, the survey results for electronics come from a much larger body of data covering 10 industries; differences across industries were few,

A primary objective was to gather information on communications and decisionmaking styles. Survey questions were designed to indicate whether American firms differed from Japanese in the extent to which decisionmaking and communications could be described as hierarchical and formal (the hypothetical U.S. model) rather than informal and cooperative (the hypothesis for Japan).

The results show that all the American-owned firms—Al, A2-J, and A3-J—relied more heavily on written communications, both here and abroad. More surprisingly, firm J-A—the U.S. subsidiary of a Japanese company—was in many respects more "Japanese" in decisionmaking and communications than the parent organization (J-J); the data show a greater proportion of upward communication and a lower proportion downward in the United States than in the same firm's home offices. Overall, however, the survey results–table 8A-1–showed much less variation in patterns of communication among these firms than the pure Japanese and American models would predict. Additional survey questions indicated that the subsidiary A2-J is more "dependent" on its American parent, as measured by written communications with headquarters, than the subsidiary J-A was on its Japanese parent.

The survey results also shed light on hierarchy and formalization in the organizational structure of each company in terms of the *size/level ratio:* the total number of employees in the organization divided by the number of hierarchical levels. The *lower* the size/level ratio, the *more* formal and hierarchical is the firm's structure, Again, the results may seem somewhat surprising: the Japanese company was the most hierarchical, with its domestic and U.S. operations scoring the same—133 (J-J) and 134 (J-A). One of the American electronics firms measured 150 in its Japanese organization (A3-J), little different from the Japanese-owned company, The other two American-owned organizations had ratios of 284 (A2-J) and 533 (Al). In other words, none of the American firms are particularly formalistic or hierarchical on this measure (which can be rather sensitive to differences in the overall size of the companies compared). Another indicator, the extent to which they make use of written job descriptions, found the American-owned companies ranked higher in formalization.

'This appendix is based on "Personnel in the Electronics Industry: United States and Japan, " prepared for OTA by M. A. Maguire under contract No. 033-1360. The report includes an independent analysis of data collected for a project directed by R. T. Pascale. Pascale's own treatment, including discussion of companies in other industries, can be found in R. T. Pascale and A. G. Athos, *The Art of Japanese Management [New* York: Simon & Shuster, 1981),

Table 8A-1 .—Responses of Middle and Upper Managers to Questions Dealing With Communications and Decisionmaking Styles

	Companywide averages				
	Al	J-A	J-J	A2-J	A3-J
Questions dealing with manager's own behavior:					
Number of telephone calls and face-to-face contacts per day	81	69	72	24	55
Number of written communications per day	10	4	3	8	7
Hours in meetings per day	2	2.5	3	2.3	3
Percentage of calls to those higher in the organization	21 °/o	25°/0	23°/0	14°/0	36°/0
Percentage of calls to those lower in the organization	40%	31%	31 °/o	56%	37°/0
Percentage of meetings with those higher in the organization	13%	16°/0	4 %	80/0	10O/o
Percentage of meetings with those lower in the organization	640/o	56°/0	84°/0	88°/0	80°/0
Questions *dealing with manager's evaluations of their supervisors' decisionmaking styles:*					
Percentage of decisions supervisor makes alone	**36°/0**	**21 °/o**	**29°/0**	**23°/0**	**25°/0**
Percentage of decisions supervisor makes after factual input from subordinates	**20°/0**	**30%**	**20°0**	**40°/0**	**25°/0**
Percentage of decisions supervisor makes with participation by subordinates	43°/0	49°/0	51 °/o	37%	50°/0

SOURCE M A Maguire Personnel in the–Electronics Industry United States and Japan, " prepared for OTA under contract No 0331360 p 8

Responses to questions about characteristics essential to managerial success revealed a greater emphasis in the Japanese-owned firms on communication within the organization both vertically and horizontally; this was true both in domestic (J-J) and American (J-A) operations. Managers in the American company A1 would tend to "make as many decisions as possible at his/her level without bothering senior management, " and "respect the chain of command, discuss ideas with immediate superior before discussing them with members of other departments. " In contrast, managers in the American subsidiary of the Japanese company J-A thought it important to "communicate extensively with managers in other departments;" managers in the parent firm (J-J) also stressed communication. Within one of the American-owned subsidiaries in Japan, A2-J, the responses indicated a feeling that each manager should make as many decisions as possible at his/her own level. Here the survey results do confirm a difference in management attitudes between Japanese- and American-owned companies, with the American-owned electronics firms exhibiting a greater degree of independent decisionmaking even within their overseas subsidiaries.

Questions calling for a composite picture of the manager immediately above the respondent elicited several distinctions among the five organizations. On eight dimensions, those questioned were asked to describe the actual characteristics of their superiors (not the attributes they would like to see). The managers in the U.S. subsidiary J-A were described as: "readily accessible to subordinates several echelons below," "permits broad latitude for subordinates to work out solutions to problems in their own way, " and "sensitive to others who work for him, " In the parent firm in Japan (J-J), the typical manager "tries to achieve consensus" and "permits broad latitude for subordinates, " but is also described as aggressive.

While a reasonably uniform picture emerges for the subsidiary J-A and its parent J-J, there was much greater diversity among the characteristics of managers within the American-owned firms. This was especially notable in company Al. Likewise in company A2-J, respondents agreed on only one thing: that their superiors were aggressive. Coupled with the similar characterization in the Japanese organization J-J, this suggests that, while aggressiveness has not always been viewed as central to Japanese management, it may in fact be common in high-performing firms in both countries. The survey results do paint a more heterogeneous picture of the managers in American-owned organizations. American companies operating in Japan exhibit some of the traits associated with Japanese management, but it is the Japanese company which, as expected, has managers who most strongly emphasize consensual decisionmaking and human relations. On this dimension, the composite managerial portraits indicate a clear difference in American and Japanese styles.

The human relations school stresses sensitivity to subordinates. Table 8A-2 compares responses of *nonmanagerial* employees to questions related to job satisfaction, together with data on rates of absenteeism and expenditures on employee programs. The Japanese-owned firms might be expected to exhibit a greater degree of manager-employee interaction—presumably leading to greater satisfaction among the labor force. The results in table *8A-2* show that very few workers

Table 8A-2.—Data Related to Employee Satisfaction

	Location of organization				
	United States			Japan	
	Al	J-A	J-J	A2-J	A3-J
Percentage of workers rating themselves "very satisfied" with their jobs	**20°/0**	**28°/0**	**2°/0**	**O**	**0**
Percentage of workers rating themselves "satisfied" or "very satisfied" with their jobs	**74°/0**	**88°/0**	**58°/0**	**63°/0**	**95°/0**
Daily absenteeism	**3°/0**	1%	<10/0	<1 "/0	1%
Social/recreational expenditures per worker	$1.40	$15	$33	$50	$38

SOURCE M A Maguire, "Personnel in the Electronics Industry United States and Japan, " prepared for OTA under contract No 033.1360, pp. 19, 20

in Japan are willing to describe themselves as highly satisfied with their jobs, but the picture changes considerably—with firms in Japan comparing more favorably—if "satisfied" responses are included. z Japanese firms, known for their company-as-family approach, might also be expected to spend more on social and recreational opportunities for employees, As table 8A-2 indicates, this is indeed true for organizations within Japan, regardless of ownership. In any case, the results in table 8A-2 on job satisfaction should be interpreted with caution, as such questions typically yield high proportions of positive responses. Moreover, clear-cut relationships between expressions of job satisfaction and measured productivity levels are rarely found, '

The differences observed between subsidiaries here and parent firms in Japan may result from conscious decisions to downplay Japanese management practices. The style that emerges is likely to be a hybrid of American and Japanese practices, In any event, this conclusion follows from the survey data as a whole: there *is no sharp contrast between the management approaches of American- and Japanese-owned companies.* Many of the patterns observed are more closely associated with the geographical location of the organization than with ownership. Upper managers from the parent firm tend to adopt many practices of the host country. On some dimensions—e.g., accessibility of managers to lower level employees—the Japanese-owned firms do stand out. But in other cases, there are no clear distinctions; only on measures of sensitivity to employee attitudes and participation are these consistent.

'Japanese workers also express relatively low rates of satisfaction with activities such as quality circles. See S. Takezawa, et al., *Improvements in the Quality of Working Life in Three Japanese Industries,* (Geneva: International Labour Office, 1982], pp. 77, 98.

[3]S. E. Weed, T. R. Mitchell, and W. Moffitt, "Leadership Style, Subordinates' Personality and Task Type as Predictors of Performance and Satisfaction in Supervision, " *Journal of Applied Psychology, vol. 61, 1976.*

Matsushita's Purchase of Quasar

What happens when a Japanese corporation takes over an American firm? Changes in management practices might offer insight into the Japanese approach. The purchase in 1974 by Matsushita Electric of Motorola's Quasar division—which produced televisions–provides a case in point. (Unfortunately, conspicuous examples of a U.S. firm taking over a Japanese enterprise are lacking.)

After Matsushita took control of Quasar, the new owners reorganized the factory operations, located near Chicago, invested in new equipment, and began redesigning the product line. At the center of these efforts was the goal of improved product quality. In contrast to the old production system, which relied on as many as seven quality control inspectors per assembly line, Matsushita adopted a more integrated approach with responsibility for quality spread broadly. By 1980, the defect rate on Quasar's assembly lines was about 2 defects per 100 sets, compared to I/Z defect per 100 sets for Matsushita's factories in Japan.[4] These quality improvements were the result of *system wide* changes. While resulting from a series of decisions made by Matsushita's management, they comprised far more than just matters of style or technique. For example, the company's extensive modernization of the capital plant entailed expenditures of about $50 million for automated equipment, as well as an entirely new chassis factory in Mexico. s Motorola officials stress that they knew just as well what had to be done to make the Quasar facility more efficient, but had decided to allocate available resources to other parts of the company's business,

If Quasar's gains in product quality and plant efficiency came at considerable cost in new equip-

'J. Mihalasky and A. B. Mundel, "Quality and Reliability of Semiconductors and CTVs: United States v. Japan, " Report No. *C972* prepared for OTA by Consultant Services Institute, Inc., under contract No. *033-1170.0,* p. 77.

'T. C. Hayes, "The Japanese Way at Quasar," New *York Times,* Oct. 16, 1981, p. D1.

ment investments, the emphasis on worker participation and responsibility for quality is also significant. Quality control circles were not introduced until recently, but Quasar employees have been encouraged to set their own production targets and to meet in informal weekly discussions about plant operations with foremen. Such practices are hardly unique or exotic, but the attentiveness to all aspects of the manufacturing process stands out. Still, none of this has helped Quasar expand its market share substantially.

Quasar, like other Japanese subsidiaries in the United States, shows a flexible and adaptive management style, with manufacturing operations and quality control having a central place. Nonetheless, if and when Japanese companies hire still larger proportions of American managers, and adapt further to the U.S. environment, they may become more like wholly American organizations. [6]

Conclusion

130th the survey results and the Matsushita example indicate that well-run organizations tend to be open to new ideas and methods, including those coming from the lower levels of the organization. Distinctions between Japanese- and American-owned firms are fewer and less clear-cut than sometimes claimed. While American employees might resist some of the techniques associated with Japanese management, worker participation-even loyalty to the firm—can be fostered in a variety of ways, Some of these methods smack of paternalism, but not all. As a number of American firms have amply demonstrated, worker participation and attention to human relations can be a big help in building competitive organizations.

[6] A recent study by the Japan External Trade Organization (JETRO) on Japanese-owned manufacturing operations in the United States indicates that the number of Japanese nationals transferred to subsidiaries tends to decrease over time. See "Japanese Manufacturing Operations in the U.S.," Japan External Trade Organization, September 1981. Data on managerial styles collected for the JETRO study confirm the trends described here: Japanese subsidiaries evolve styles that mix features common to the Japanese model with other practices more characteristically American.