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Japanese Engineers and American Myth Makers*

Earl H. Kinmonth

Introduction

JAPANESE success in manufacturing and exporting has produced a steady stream of explanations for that success. Over the years, cheap labor, industrial policy, business-government links (Japan, Inc.), general trading companies (*sôgô shôsha*), high leverage (gearing), high savings rates, QC (quality control) circles, the *kanban* (just in time) system, and others have been offered as keys, or even the key, to Japanese success. Some of these explanations, such as cheap labor, no longer receive a hearing. Others such as general trading companies and high gearing no longer enjoy the attention they did when first put forward. Still others such as QC circles are pushed only by special interest groups.

One genre of explanation that emerged in the early 1980s is still part of popular and academic writing on Japan. It explains Japanese manufacturing success in terms of Japan having more engineering students, more engineers in the work force, and more engineers in management than does the U.S. or the U.K. This notion has had some of the widest publicity of any explanation for Japanese success, elements of it having figured in two State of the Union addresses during the Reagan administration.[1] It has been endorsed in blue ribbon commission reports in England and by the National Science Foundation in the U.S. Congressional committees have

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Preparation has been helped by materials and comments from Takeuchi Yô, Haneda Hiromasa, Matsumoto Ryûichi, Okubayashi Koji, Nihon rikuruuto senta, *Engineering Education*, and the National Science Foundation. It is part of a long-term study of the middle classes in Japan. This research has been funded at various times by the Social Science Research Council, the National Endowment for the Humanities, and the Fulbright Commission.

Japanese names are given in their natural order, family name first.

[1] Gijutsusha kyôiku seisaku kenkyû fooramu, *Haiteku Nihon no hitozukuri senryaku* [Strategy for creating high tech people in Japan] (Tôkyô Tsûshô sangyô chôsa kai, 1987), p. 70, states that Ronald Reagan spoke of Japan as having "twice as many engineers per capita" as the United States. My recollection is that this claim was actually in the Democratic Party rebuttal.

heard the message and it has been broadcast to the informed public by academics and journalists.

Compared to other explanations for Japanese success, the notion of numerical superiority in engineers has much going for it. Certainly the Japanese have succeeded in manufacturing and design areas where engineering is an essential ingredient. Therefore, they must have had a substantial stock of engineers. The explanation is not based on cultural differences or impossible-to-replicate, "uniquely Japanese" patterns of behavior. Engineers are not peculiar to Japan. The problem is numerical with rather specific indicators of what competitors must do to match or exceed the Japanese.

Unfortunately, the notion of Japanese numerical superiority is entirely a myth. Every component of it can be shown to be the product of differences in definition and methodology between U.S. and Japanese data sources. Nevertheless, because Japanese engineering success remains a fact, attention must shift to qualitative differences in engineers and how they are used in industry. Two significant points emerge from this examination. First, Japanese engineers are almost exclusively employed by civilian industry with few in government, the military or arms manufacturing. Second, compared to their U.S. or U.K. counterparts, Japanese engineers are closer to skilled blue-collar workers in pay, status, and outlook, and work closely with workers to improve productivity.

Graduates

The first widely cited popular presentation of the myth of Japanese numerical superiority appeared in 1983 in an article entitled "The Engineering Gap" in the *Far Eastern Economic Review*. The author was Gene Gregory, a professor at Sophia University in Tokyo, who observed "[A]bout 20% of all baccalaureates and about 40% of all master's degrees in Japan were [are] granted to engineers with about 5% at each level in the United States."[2] Although these percentages are reasonably accurate, they cannot be used to measure the relative importance of engineering in the two societies. Engineering in Japan is a male field (98.5% in 1980, 96.9% in 1988) and Japanese universities (as contrasted with junior colleges) are predominantly male (78% in 1980, 76.1% in 1988). American institutions have a more nearly equal sex ratio. Adjusting for this difference more than doubles the U.S. percentage in 1980 to 13.1 percent. Moreover, if science

[2] Gene Gregory, "The Engineering Gap," *Far Eastern Economic Review*, vol. 122, no. 51 (22 December, 1983), p. 71 . Essentially the same claim also appears in Committee on Science and Technology. House of Representatives, *U.S. Science and Engineering Education and Manpower*, ed. Edith Fairman Cooper (Washington, D.C.: USGPO, 1983), p. 101, citing National Science Foundation, *Science & Engineering Education for the 1980's & Beyond* (Washington, DC: NSF, 1980), p. 59.

Aside from presenting questionable numbers, Gregory and others play loose with the language. Students who have studied engineering are not engineers until they are employed and practicing.

and engineering are combined, the ratio of U.S. university students following such courses was actually higher (27 percent versus 25 percent).[3]

The issue with graduate education is even simpler. Japan has virtually no graduate education except for that designed to train replacement academics. The one exception is engineering where a master's level degree has developed as a credential in and of itself. In 1980 the U.S. actually awarded more master's degrees in engineering (16,846) than Japan had students (14,864) in such programs! The U.S. percentage was low because the absolute numbers were vastly larger. In 1980 there were 299,095 U.S. master's degrees awarded in the U.S. In the same year, Japan had only 35,781 students in master's programs.[4]

A more serious problem with Japan-U.S. comparisons is that Japanese data is reported in terms of students in or graduates of *kôgakubu*. Although *kôgakubu* is translated as "faculty of engineering," their remit is far broader than "engineering" (U.S. or U.K. definition). Missing this difference and failing to correct for it could be traced to sloppy research, but oddly, even authors who know of the Japanese definitions choose to present uncorrected data.

Lawrence Grayson found Japan graduating more engineers than the U.S. as early as 1967 and claimed, "Excluding foreign nationals, on a per capita basis Japan currently is graduating 2.3 times as many engineers as is the United States." He made this claim even though he himself observed, "The Japanese, however, graduate a substantial number of people with concentrations in engineering management or administration backgrounds. Unlike U.S. schools, the Japanese include architecture as part of civil engineering."[5] Had Grayson done what his own article implied, adding U.S. figures for such fields as architecture and environmental planning to "engineering," Japanese numerical superiority would have almost entirely

[3] Japanese ratios calculated from Sôrifu tôkeikyoku, *Nihon tôkei nenkan 1982* [Japan statistical yearbook 1982] (Tokyo: Nihon tôkei kyôkai, 1982), p. 360, table 420; Sôrifu tôkeikyoku, *Nihon tôkei nenkan 1989* [Japan statistical yearbook 1989] (Tokyo: Nihon tôkei kyôkai, 1989), pp. 659, table 19-16. The composite ratios were calculated by combining U.S. disciplines included in the broad Japanese divisions *rika* (science) and *kôgaku* (engineering). U.S. data from U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States* (Washington, D.C.: USGPO, 1984), p. 167, table 278.

[4] National Science Board, *Science Indicators 1982* (Washington, DC: NSF, 1983), pp. 271, table 3-28; *Tôkei nenkan 1982*, p. 633, table 423. Roughly one-quarter of U.S. graduate students in engineering are foreign. Even if adjustment is made for those who leave after completing their education, there was still a U.S. *numerical* superiority. For data on foreign students in the U.S., see *Science*, p. 227, table 1-38.

[5] Lawrence P. Grayson, "Japan's Intellectual Challenge," in *Engineering Excellence*, ed. Donald Christiansen (New York: IEEE Press, 1987), pp. 209, 225, and table 21-6.

disappeared as early as 1976 and for subsequent years U.S. output would have exceeded that of Japan by an increasing margin.[6]

THE STOCK OF SCIENTISTS AND ENGINEERS

Even more exaggerated claims have been made about the stock of engineers in Japanese society. Writing in the *New York Times Magazine* in 1989, Robert Reich of the Kennedy School of Government at Harvard University asserted, "Out of every 10,000 citizens in Japan, only 1 is a lawyer and 3 are accountants; in the United States, 20 are lawyers and 40 are accountants. Out of the same group in Japan, 400 are engineers; in the United States, only 70 are engineers."[7] Data in the 1980 Japanese census gives a very different picture. Converting the raw numbers into ratios yields 179 "engineers" (*gijutsusha*) per 10,000 of the total employed population aged fifteen and over. When these figures are adjusted to a gross population basis (a reasonably proxy for "citizens" in the Japanese case), the ratios fall to 85 and 114 respectively.[8] When even a small allowance is made for the inclusion of "technicians" in the *gijutsusha* category, the alleged difference between the U.S. and Japan disappears.

National Science Foundation reports are only slightly better in their presentation of Japanese data, and then only in recent publications. In 1988, the NSF report *The Science and Technology Resources of Japan: A Comparison with the United States* asserted, "Japan's 1985 ratio of manufacturing R&D scientists and engineers per 10,000 employees was 470 compared to the 400 full-time equivalents for the United States." This figure with its eighteen percent "superiority" for Japan (rather than Reich's 471 percent) is in the realm of the possible. Nevertheless, as other NSF sources note, U.S. data is for

[6] The most consistent data on Japan is found in Maekawa Tsutomu, "Kôtô kyôiku ni kansuru tôkei shiryô" [Statistical materials pertaining to higher education], *Daigaku kenkyû nooto*, vol. 58 (November 1983), pp. 54–55, table 15. This article discusses the many problems with Japanese data albeit in a strictly Japanese context. The U.S. numbers are from National Science Foundation, *National Patterns of Science and Technology Resources 1984* (Washington, DC: NSF, 1984), p. 86, table 82. Grayson, "Challenge," p. 209.

[7] Robert B. Reich, "Leveraged Buyouts: America Pays the Price," *New York Times Magazine*, (29 January 1989), p. 40.

[8] *Gijutsusha* numbers from Sôrifu tôkeikyoku, *Tokubetsu shûkei kekka* [Results of Special Tabulation] (Tokyo: Sôrifu tôkeikyoku, 1981), p. 3 (table 1). The total population is from *Tôkei nenkan 1989*, pp. 24–25 (table 2-1). It is probable that by "citizens" Reich means "populace" rather than "Japanese nationals." Excluding non-citizens would produce an adjustment of at most one or two percent.

It is possible that Reich used data from the 1985 census. This was not available to me when preparing this paper. The essential information to test one key element of Reich's claim can, however, be pieced together. The 1989 *Kagaku gijutsu hakusho* cites the 1985 census for a figure of 1,445,000 *gijutsusha*. Divided by the population in 1985 (121,049,000), this yields a figure of 119.4 per 10,000 populace. Since, as explained below, *gijutsusha* includes "engineers" *and* "technicians," Reich's claim about "engineers" is patently absurd.

The *gijutsusha* figure is from Kagaku gijutsu chô [KGC], *Kagaku gijutsu hakusho 1989* [White Paper on Science and Technology] (Tokyo: Kagaku gijutsu chô, 1990), pp. 54 (table 1-1-50). Total population is from *Tôkei nenkan 1989*, pp. 24–25 (table 2-1).

full-time equivalents while Japanese data is for "primarily engaged" persons, a difference that inflates Japanese counts.[9]

Moreover, Japanese sources on engineering and scientific personnel show a consistent pattern of definitions which will, if used without correction, overstate Japanese strength vis-à-vis the U.S. A prime case in point is the numbers for "researchers" (*kenkyûsha*) per 10,000 work force given in the annual *Kagaku gijutsu hakusho* (White Paper on Science and Technology) issued by the Kagaku gijutsu chô (Science and Technology Agency). For example the 1989 edition claims 441 "researchers" per 10,000 in the total work force, 537 in manufacturing, and 862 in electrical goods.[10] As is typical of Japanese government sources, definitions and methodology are not given with the data itself. It is only by diligent searching and page flipping that one finds that (a) only firms capitalized at 5,000,000 yen or more are surveyed and (b) only firms reporting research activities are counted.[11] Even then, the significance of these exclusions is not explained, although it is potentially very high because of the widespread use of subcontract suppliers that do no research and subcontract labor that does not count in the employment of firms doing research.

What is an engineer?

The NSF, the U.S. Census, and other U.S. sources generally define engineering in terms of certain fields of specialization, typically aeronautical-astronautical, chemical, civil, electrical-electronics, industrial, materials, mechanical, mining, nuclear, petroleum, and all other engineers.[12]

This definition understates the U.S. position because it excludes "computer specialists" from engineering. As one study observes:

> The category is separate from engineering, but many computer specialists may be converted engineers. In any event, the number of people who reported to surveys as computer specialists more than doubled during 1970–1982, to about 750,000; the growth pattern was about the same for systems analysts and programmers.

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[9] Ratios from Maria Papadakis, *The Science and Technology Resources of Japan: A Comparison with the United States* (Washington, DC: NSF, 1988), pp. 21, 22 (chart 22).

The numbers 470 and 400 suggest that the Reich claim discussed above may have been based on a mishmash of these two numbers. Nevertheless, in response to a letter from me, he defended his figures.

For a note on these differences, see National Science Foundation, *Science and Technology Resources in U.S. Industry* (Washington, DC: NSF, 1988), p. 6 (table 3, note).

[10] *Hakusho 1989*, pp. 441 (table 13–2).

[11] These limits are given in *Hakusho 1989*, p. 147.

[12] Michael F. Crowley, *Science and Engineering Personnel: A National Overview* (Washington, DC: NSF, 1980), section a, 41; National Science Foundation, *US Scientists and Engineers: 1986* (Washington, DC: NSF, 1987), section a, 1; National Science Foundation, *US Scientists and Engineers: 1988* (Washington, DC: NSF, 1988), section a, 1.

We know that computer specialists make up a large and growing segment of the technically trained work force, but the specific relationship of this group to the engineering work force is unknown.[13]

Nevertheless, even if the precise relation for the U.S. cannot be known, the Japanese case is quite clear. Computer specialists are folded into "engineering" in Japan. Any U.S.-Japan comparison that does not do the same for the U.S. inherently understates the U.S. position.

An even greater overstatement of the Japanese position occurs because Japanese statistical sources present data on *gijutsusha*, a term that embraces not only engineers (U.S. definition), but also technicians and even some blue-collar workers. The Japanese census specifies they "will ordinarily have specialized knowledge equivalent to that obtained from studying the natural sciences at a university, etc. (*daigaku nado*)."[14] But, cross tabulations in the Japanese census make it clear that figures based on *gijutsusha* are singularly inappropriate when used in the context of asserting a U.S. need for more university-trained engineers. According to the 1970 census, only 55.1 percent of *gijutsusha* had completed higher education. By 1980 this figure had risen to only 59.8 percent. Even within the more restrictive *kagaku kenkyûsha* (scientist), 22.7 percent had *not* completed higher education in 1970 although by 1980 the share was down to 12.8 percent. Moreover, "higher education" in this context does not necessarily mean "university education." The Japanese census counts junior colleges and higher vocational (*kôgyô kôtô senmon gakkô*) schools as higher education.[15]

Moreover, there is no requirement that those categorized as *gijutsusha* have studied or practiced the disciplines associated with engineering in the U.S. (or in Japan). Indeed, architects, specialists in aerial mapping and surveying, and a whole host of specific occupations such as dairy products analysts (*gyûshitsu kensain*), synthetic pearl specialists (*shinjû yôshoku gijutsusha*), recording engineers, fertilizer analysts (*hiryô kensain*), etc., are included in the census category *gijutsusha*. The categories used in Japanese labor statistics include a still larger range of occupations that would be labeled "technician" by U.S. standards.[16]

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[13] National Research Council (NRC). Commission on Engineering and Technical Systems. Committee on the Education and Utilization of the Engineer. Panel on Engineering Employment Characteristics, *Engineering Employment Characteristics* (Washington, DC: National Academy Press, 1985), p. 9.

[14] Sôrifu tôkeikyoku, *Shôwa gojûnen kokusei chôsa ni mochiiru shokugyô bunrui* [Occupational categories used in the Shôwa 55 [1980] census] (Tokyo: Sôrifu tôkeikyoku, 1980), p. 25.

[15] Shares from Sômuchô tôkeikyoku, *Kyôiku kara mita Nihon no jinkô* [The Japanese population seen in terms of education] (Tokyo: Sômuchô tôkeikyoku, 1981), p. 84 (table 5-3). Definitions from Sômuchô tôeikyoku, *Nihon no jinkô — Saishû hôkokusho* [Final report — the population of Japan] (Tokyo: Sômuchô tôkeikyoku, 1981), p. a-22.

[16] Census examples from *Shokugyô bunrui*, pp. 28-29. For the labor statistics equivalents see, Gyôsei kanrichô gyôsei kanrikyoku tôkei shukan, *Nihon hyôjun shokugyô bunrui* [Japanese standard occupation categories] (Tokyo: Gyôsei kanrichô gyôsei kanrikyoku tôkei shukan, 1980), pp. 27-28.

Discovering that definitional differences will lead to an illusory Japanese numerical superiority does not absolutely require reading knowledge of Japanese. An interesting case in point is a study commissioned by the National Science Foundation in 1986. This provides generally accurate although not highly detailed documentation of the differences between U.S. and Japanese notions of "scientist" and "engineer." The authors of this report, both specialists with the Bureau of the Census, found it impossible to produce comparative figures for "engineers" using narrow U.S. definitions.[17] Instead, they reported on "scientists and engineers" (S/E) while recognizing that term included many who would be considered "technicians."

According to Way and Jamison, "the typical Japanese S/E" was "a 34-year-old civil engineer who works in a service industry and has less than a full university education."[18] This is a remarkably different view of scientists and engineers compared to that appearing in other NSF publications. So too were their conclusions about stock.

> If only persons with university degrees (at the bachelor's level or higher) are considered to be scientists or engineers, then the United States leads [over France, Germany, Japan and the U.K.] with 8 scientists and 10 engineers per 1000 members of the labor force. If persons with less than 4 years at the university or with technical diplomas are included as well as university graduates or higher, the U.S. still has more scientists per 1,000 labor force than the other countries and, along with West Germany, a higher number of engineers per 1,000 labor force. Thus, it is only when all S/E are included, regardless of their educational background, that the U.S. falls to second place.[19]

The results of this study, however, appear to have been largely ignored by those who paid for it. It certainly cannot have figured in Reich's research.

Although recent NSF reports are somewhat more circumspect than *Science and Engineering Education for the 1980's & Beyond*, with its full statement of mythical Japanese superiority, recent publications always seem to stop short of applying all possible corrections in order to standardize U.S. and Japanese data, especially those corrections that might tip the balance in favor of Japan.[20] Subsequent NSF reports have not noted the contradiction between earlier and later claims. My publications are not cited and the Way and Jamieson study appears to have been essentially buried. It is difficult not to suspect that data that appears to support NSF budget requests gets more attention than that which does not.

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[17] Peter O. Way, and Ellen Jamison, *Scientists and Engineers in Industrialized Countries: A Comparison of Characteristics for France, West Germany, Japan, the United Kingdom, and the United States* (Washington, DC: Center for International Research, US Bureau of the Census, 1986), pp. 6–7.

[18] Way and Jamison, *Scientists and Engineers*, p. 49.

[19] Way and Jamison, *Scientists and Engineers*, p. 2.

[20] The moderation of claims about Japan between *Education for the 1980's,* and Papadakis, *Science Resources of Japan,* is most striking.

Mythological Electrical Engineers

At approximately the same time that Gregory and the NSF raised the spectre of overall numerical superiority in engineers, Okimoto, Sugano, and Weinstein postulated a special superiority in the training of electrical engineers. They presented data in their 1984 book *Competitive Edge: The Semiconductor Industry in the US and Japan*, that showed the U.S.-Japan ratio falling from 11,375 vs. 11,035 in 1969 to 12,213 vs. 19,572 in 1979.[21] It appears the authors assumed that what is taught under the rubric of *denki kôgyôgaku* in Japan is the same as that taught under electrical engineering in the U.S. This is not in fact the case.

With rare exceptions, computer science is taught by electrical or other engineering faculties in Japan. In the U.S., computer science is often a distinct department, often in L&S, but it may also be part of a mathematics department. Without a detailed analysis of representative U.S. and Japanese programmes, it is not possible to say definitively whether all U.S. computer science should be folded into electrical engineering for comparability. The exercise is, nevertheless, instructive. In 1980, just before the myth-makers discovered Japanese superiority, the U.S. had only 13,800 EE graduates compared to more than 19,400 for Japan. But, with the addition of computer science, the U.S. had 25,000 graduates.[22]

In the 1980s, U.S. enrollments in (narrow definition) EE increased more rapidly than those of (broad definition) Japan. Even without the addition of computer science programmes, U.S. EE output was 28,642 (EE + computer engineering) in 1988. This was one-third again as many as Japan was graduating. This result obtains even though demographic change was reducing the pool of all potential college students.[23] The growth was such that by 1988 NSF was reporting more EE students in the pipeline than Japan (132,917 vs. 95,429) and that EE was more popular in the U.S. among all engineering specialties (34.6 percent vs. 27.8 percent).[24] Moreover, the U.S. had numerical superiority in electrical engineering even without the inclusion of computer science in EE totals. Nevertheless, despite this massive upswing, pessimistic articles from the early 1980s were being reprinted without correction or emendation in the

[21] *Competitive Edge: The Semiconductor Industry in the U.S. and Japan*, ed. Daniel I. Okimoto, Sugano Takuo, and Franklin B. Weinstein (Stanford: Stanford University Press, 1984), p. 30 (table 1). Others that appear to have copied this source include Christopher Freeman, *Technology Policy and Economic Performance* (NYC: Pinter, 1987), p. 47 and Gene Gregory, *Japanese Electronics Technology: Enterprise and Innovation* (Tokyo: Japan Times, 1986).

[22] US Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States* (Washington, D.C.: USGPO, 1985), pp. 158–59; Monbushô, *Gakkô kihon chôsa hôkokusho* [Report on the fundamental survey of schools] (Tokyo: Monbushô, 1981), p. 290.

[23] Richard A. Ellis, "Engineering and Engineering Technology Degrees, 1988," *Engineering Education* (June-July 1989), pp. 511–12.

[24] Papadakis, *Science Resources of Japan*, p. 29.

late 1980s.[25] This pattern suggests an interest in Japan only so far as it can be used as a bogey man to further a predefined agenda.

The Military Draw Down

Estimates of the number of scientists and engineers connected to the U.S. military vary widely. In 1982 the Defense Economic Impact Modeling System (DEIMS) estimated that "only" 14 percent of U.S. scientists and engineers were in "military induced employment."[26] Even if this figure could be accepted, it would point to a much bigger U.S.-Japan difference than most of those alleged by the myth-makers. Similar calculations for Japan would show less than one percent of Japanese scientists and engineers being diverted.[27]

Moreover, there are a number of solid reasons for regarding the 14 percent figure as designed more to meet criticism than to make clear the usage of U.S. scientists and engineers. Lloyd Dumas has criticized this estimate because "the methodology used in the DEIMS excludes from the 'defense-induced' category all employment related to arms exports: nuclear weapons research, design, testing, production programs (all of which are located outside the Department of Defense's budget), and the military-oriented part of the space program."[28] More importantly, the DEIMS model assumes that the military and civilian sectors have an equal propensity to use engineers. This assumption is contradicted by a wide range of data that shows military contractors have higher ratios of technical staff to operatives than do civilian producers.[29]

One need not go to sources critical of the military to find estimates substantially higher than in the DEIMS model. The NSF put the figure for engineers at 18 percent in 1986. The Pentagon has placed the figure at 17 percent.[30] Using the Pentagon or NSF figures still suggests that nearly one in five scientists and engineers is *not* engaged in work that directly adds to U.S. civilian competitiveness. Even if the Japanese case is assumed to be understated by 100 percent and adjusted upward accordingly, only one out

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[25] For example, Grayson, "Challenge," pp. 203-52.

[26] Lloyd L. Dumas, "University Research, Industrial Innovation, and the Pentagon," in *The Militarization of High Technology*, ed. John Tirman (Cambridge, Mass.: Ballinger, 1984), p. 138.

[27] This figure is my own, based on using *reported* military R&D in Japan as a proportion of all R&D to assign scientists and engineers to this category.

An OTA report observes, "There is no international information on the proportion of researchers working in the civilian versus the defense sector, but the Japanese defense sector is relatively small; most resources devoted to R&D are on the civilian side." Office of Technology Assessment [OTA], *Paying the Bill: Manufacturing and America's Trade Deficit* (Washington, D.C.: USGPO, 1988), p. 28.

[28] Dumas, "University Research," p. 138.

[29] Congressional Research Service, Library of Congress, *Science Support by the Department of Defense* (Washington, D.C.: USGPO, 1986), p. 362.

[30] *Science Resources*, p. 24. For earlier NSF estimates, see Robert W. De Grasse, Jr., *Military Expansion Economic Decline* (Armonk, New York: M.E. Sharpe, 1983), p. 80. For the Pentagon estimate, see *Science Support*, pp. 19, 361.

of fifty Japanese scientists and engineers would appear to be diverted from the civilian sector.

Within particular engineering disciplines, the impact is far greater. Aside from the obvious aerospace sector (60 percent range), 35 percent of electronics engineers are estimated to be lost to the military.[31] At the graduate level, the military consumption of the available pool of scientists and engineers must be even greater. In some critical fields (electronics, for example) a significant fraction of those receiving advanced degrees are foreign nationals who cannot be employed in most military projects.[32] This has the side effect of leaving a still smaller pool of native speakers of English to staff college and university engineering and science programmes. While Japan has made massive expenditures for military hardware, most of which is produced in Japan, it has spent relatively little on military R&D. By purchasing already proven technology from the U.S. and other sources and by licensing that technology for production at home, Japan has been able to avoid a major diversion of scientists and engineers from its civilian sector. Japanese firms have been able to learn from technologies developed at the expense of the U.S. taxpayer.

The Military Way of Engineering

This diversion of technical talent means that nearly one in five U.S. scientists and engineers is either conforming to or being socialized in a set of values and procedures that have repeatedly been demonstrated to lead to cost overruns and missed deadlines, patterns that are generally fatal in the civilian sector. The literature on the peculiarities of miltiary R&D and military procurement is voluminous.[33] Engineers working in this environment are driven to (1) develop equipment that performs to certain arbitrary standards no matter how expensive; (2) devote a great part of their activity to the drawing up of specifications following cumbersome, rigid, arbitrary, and often counterproductive, guidelines; (3) work in an environment where security considerations limit intellectual exchange and criticism; (4) oversee production in facilities that may owe their location more to a congressman's need for votes than to economic rationality; (5) cope with extreme boom/bust cycles caused by off-again, on-again, funding of

[31] De Grasse, *Military Expansion*, p. 80, citing NSF estimates.

[32] In 1984 between 40 and 50 percent of Ph.D. students in materials, computers, robotics, and micro-electronics were foreign. *Science Support*, p. 365.

[33] For a thoughtful review by an explicitly conservative critic, see Amitai Etzioni, "Do Defense Contractors Map Our Military Strategy?" *Business and Society Review*, vol. 51 (Fall 1984), pp. 29–34. The section following is largely derived from testimony and material presented in Subcommittee on Science, Research, and Technology (SSRT). Committee on Science, Space, and Technology. House. Congress. United States, *The Role and Balance of Federal Research and Development Support* (Washington, D.C.: USGPO, 1988).

procurements; (6) have no incentive to increase the efficiency of the production or assembly process because once a major contract has been secured there is no danger of losing the market to a more efficient competitor.

By no means can the military draw be blamed for all U.S. failures. It was probably relatively unimportant in the automobile industry, for example, but may have loomed very large in the case of certain electronics firms. Jerome Wiesner, president emeritus, MIT, has, in congressional testimony, described how large-scale military projects diverted electronics firms from the incremental research necessary to maintain viability in the civilian sector.[34]

Engineers as Managers

Science and Engineering Education for the 1980s and Beyond from the National Science Foundation was responsible for giving credence to one of the more outlandish myths concerning Japanese engineers. Borrowing from a British publication, the Finniston Report, the NSF claimed that in Japan "managerial positions in both government and industry are heavily populated by people with engineering degrees" and further "about 50% of all directors have engineering qualifications." It went on to assert that only half of those with engineering degrees went into engineering as such, the rest entering management or government service.[35]

The authors of this claim made no attempt to explain how, if government service or management were so popular with graduates, private industry could have so many engineers. And the authors did not attempt to reconcile their claim with Japanese Ministry of Education statistics. These reported that in 1981 only 5.6 percent of new engineering (*kôgakubu*) graduates were employed in the public sector. Only 4.5 percent were listed as going into managerial or clerical positions while most (85.2 percent) were shown to be employed in technical jobs.[36]

This is a pattern that exists through most of modern Japanese educational history. It was only for a brief period in the 1890s that 50 percent (or more) of university graduates may have gone into management or government rather than engineering as such.[37] In the 1980s only the Construction Ministry (*Kensetsushô*), roughly equivalent to the U.S. Corps of Engineers, was known for a significant percentage of engineers in its ranks. As B.C. Koh has observed, the general pattern for the national government bureaucracy is described by the term *hôka bannô* — the dominance of law

[34] *Role and Balance*, pp. 88–89.

[35] *Education for the 1980's*, p. 58. The original source is *Engineering Our Future* (London: HSMO, 1980). These claims also appear in Gregory, "Gap," p. 71.

[36] Monbushô, *Kihon chôsa*, pp. 322, 328.

[37] See Iwauchi Ryûichi, "Institutionalizing the Technical Manpower Formation in Meiji Japan," *The Developing Economies*, vol. 15, no. 4 (1977: 12), p. 427.

graduates. Although engineering students take and pass the higher civil service examination in some numbers,

> [T]he proportion of successful candidates in law who are actually hired has consistently surpassed that of all candidates by 15 to 20 percent, reaching an all-time high of 29 percent in 1986. Moreover, law offers the widest range of options to the successful candidate in terms of government employment, for virtually every agency recruits law specialists every year. The other fields that offer relatively abundant options to the candidates are economics and public administration, but neither can match law.[38]

Even if one looks at MITI (Ministry of Trade and Industry), credited by many with playing a major role in the modernization and development of postwar Japanese industry, this pattern obtains. In 1984 the educational background of senior officials at MITI was 18 law, 2 economics, 1 engineering, 1 science.[39]

Historically, it has been the U.S., not Japan, where those with engineering backgrounds accounted for a disproportionate share of top corporate management. In a comprehensive survey of the Japan business elite as of 1970 (the peak of Japan's "miraculous" growth), Mannari Hiroshi and James Abegglen found that only 23 percent of chief executives had an engineering *or science* background. The U.S. figure was more than double: 53 percent. Business and economics majors were *more* important in Japan (44 percent) than in the United States (32 percent) as were those with law backgrounds (24 percent in Japan, 9 percent in the U.S.). The Japan–U.S. pattern held in comparisons of Japan with other western nations leading the authors to conclude, "The proportion of men [chief executives] who studied engineering and science is the lowest in Japan." Similar results for Japan in the 1960s have been obtained by Mannari and other Japanese scholars.[40]

In studying two of Japan's largest electrical and steel firms, Vladimir Pucik found that even in these quintessentially engineering-based firms, those from an administrative background stood a better chance of promotion. Even with engineers at the top in both firms, the proportion of engineers advancing into management rank was smaller than that of those coming from administrative backgrounds. Thus Pucik concluded, "In other

[38] B.C. Koh, *Japan's Administrative Elite* (Berkeley: University of California, 1989), p. 96. Koh observes that a high proportion of candidates with technical backgrounds withdraw to take up private sector jobs.

[39] Japan Trade and Industry Publicity, *MITI Handbook* (Tokyo: Japan Trade and Industry Publicity, 1984), pp. 175–87. Whether MITI actually played such an important role is open to debate. The case for the importance of MITI guidance is argued most thoroughly in Chalmers A. Johnson, *MITI and the Japanese Miracle: The Growth of Industrial Policy, 1925–1975* (Stanford: Stanford University Press, 1982). This same source documents that law and economics background of MITI officials from its inception through the 1970s.

[40] Mannari Hiroshi, *The Japanese Business Leaders* (Tokyo: University of Tokyo Press, 1974), pp. 185 (for 1960) and 227 (for 1970). See also the survey by Aonuma cited in Kono Toyohiro, *Strategy and Structure of Japanese Enterprises* (Armonk, N.Y.: Macmillan, 1984), p. 4. This found that in 1962, of fifteen hundred top managers, only 23.0% had "engineering" backgrounds where that term is taken to include those with prewar technical high school and even vocational school educations.

words, fewer technicians succeed as managers, but those who do may go a long way.''[41] This is quite a different order of opportunity than that suggested by the myth-makers.

In this context it is worth noting that in Japan guidance works, for students do not portray engineering as a fast track into management. Indeed, a 1981 guidance manual for would-be mechanical engineers explicitly described them as having a ''handicap'' in competing with candidates from the clerical side of business.[42] The reports that appear in Japanese business magazines during promotion season either share this view of engineering or ignore discipline altogether.[43] Those graduating in an engineering disciplines are credited with having very good employment prospects in terms of the prestige rankings of would-be employers but not with singular promotion prospects.

In 1975 a comprehensive survey of occupational prestige in Japan found civil and mechanical engineers ranking just above airline stewardesses (19th, 20th, 21st respectively) and well below the law-based professions of judge (1st) and higher civil servant (6th).[44] In a mid-80s study of some five thousand graduate engineers, Okubayashi Koji of Kobe University found that a majority considered their social status inferior to that of ''chartered accountants'' and a still larger proportion thought engineers were less well paid.[45]

When the myth-makers first discovered Japanese engineers, competition ratios for various university programs did *not* indicate engineering as an exceptionally popular field with would-be students. In 1980 business administration and law were more popular (by this measure) than engineering.[46] More recent data show a decline for law and an increase for engineering. Nevertheless, business administration remains more popular than engineering.[47]

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[41] Vladimir Pucik, ''White-Collar Human Resource Management in Large Japanese Manufacturing Firms,'' *Human Resource Management*, vol. 23, no. 3. (Fall 1984), pp. 272–73.

[42] Yoshikawa Hideo and Teraoka Toshiteru, *Enjinia shinrô senryaku* [Advancement strategy for engineers] (Tokyo: Nihon kôgyô shinbun sha, 1981), p. 207.

[43] This view is based primarily on articles appearing during the 1980s in *Daiyamondo* and *Nihon keizai shinbun*.

[44] *Nihon no kaisô kôzô* [Strata in Japan], ed. Tominaga Ken'ichi (Tokyo: Tôkyô daigaku shuppan kai, 1979), p. 446.

[45] Okubayashi Koji, ''Social Status of Professional Engineers in Japan,'' *Annals of the School of Business Administration, Kobe University*, vol. 33 (1989), pp. 31–33.

[46] Calculated from *Tôkei nenkan 1982*, p. 631, table 421. Note that for most undergraduates in Japan, the study of ''law'' does *not* mean preparation to become a lawyer. It is more a preparation in the commercial code and political science than law as taught in the U.S.

[47] *Tôkei nenkan 1982*, pp. 660, table 19–17. ''Business administration'' is taken to be the sum of ''business management,'' ''commerce,'' and ''commerce and economics.''

Are Engineers Good Managers?

Even if there was fact rather than myth behind the assertion that a high percentage of Japanese managers have engineering backgrounds, there is no body of research to show a positive correlation between engineers in management and superior economic performance, either at the micro- or macro-economic level.[48] Casual historical evidence would, indeed, suggest the contrary. The Soviet Union and other East Block countries have long emphasized engineering and engineers as managers — with results that are all too clear.

Perhaps engineers moving to management (rather than staying with engineering) is indicative of a value system that discourages growth. One of the most striking differences between Japanese and English engineers is the very strong desire of the latter to move into management. This desire is not part of any general sense that engineers in managerial positions can raise corporate performance or revitalize British industry. Rather it is a matter of engineers seeing management as the one and only route to the perks, prestige, and respect that they are otherwise denied.

Early career U.K. engineers look for training opportunities to get on the fast track to management. U.K. engineers believe that higher education would be more useful if it included more work to prepare them for managerial positions. Japanese engineers expect to find fulfillment first as engineers and only secondly as managers. Their expectations for in-house training are in terms of raising their skills as engineers. Similarly, the changes they wish to see in university education are in terms of their roles as engineers — more foreign language training and more basic science courses in areas with future commercial potential.[49]

Unfortunately, there is no comparable U.S.-Japan study, but it is probable that the U.S. is far closer to the U.K. than to Japan.[50] U.S. engineers, while very highly paid, see themselves as unrecognized unless they can move to management. This is a theme that appears regularly in the pages of professional journals such as *IEEE Spectrum*. And this drive for management positions was very much in evidence while I was an engineering student in the U.S. in the early 1960s. It was generally understood that the "hot shots" would as a matter of course take an MBA. Those who did not were doomed

[48] Attempts, which never rise above impressionism, to make this connection are cited in Ian A. Glover, "How the West was Lost? Decline in Engineering and Manufacturing in Britain and the United States," *Higher Education Review*, vol. 17, no. 3 (summer, 1985), pp. 3-34.

[49] This and the preceding paragraph are based on Seisansei jôkyû gijutsusha mondai kenkyû iinkai, *Eikoku no gijutsusha — Nihon no gijutsusha* [English technicians — Japanese technicians] (Tokyo: Nihon seisansei honbu, 1989), chap. 4. This is an interesting and careful study that deserves wide English language distribution.

[50] Sakakibara Kiyonori and D. Eleanor Westney, "Comparative Study of the Training, Careers, and Organization of Engineers in the Computer Industry in the United States and Japan," *Hitotsubashi Journal of Commerce and Management*, vol. 20 (1985), p. 8, note the "career" (defined as promotion to management and out of hands-on engineering) orientation of U.S. engineers.

to labor as "mechanics" and "slide rule jockeys." There was, in my recollection, no sense whatsoever that having an EE/MBA combination would allow one to bring an engineering perspective to managerial problems. The sense was that, like a colonial administrator who knew the local language, one could monitor the "natives" and perhaps avoid trouble.

Salaries for Engineers

Just as the myth makers have avoided mention of the military draw on U.S. engineers, they have said nothing about salaries, although here a truly striking U.S.-Japan contrast is found. Unlike their American counterparts, young Japanese graduates trained in engineering *do not* command a significant pay premium relative to those who have studied other subjects. The annual surveys by the Personnel Agency (Jinji'in) show *at most* a 1 or 2 percent pay premium for engineering graduates, a difference that is probably the result of engineering graduates being employed on average by somewhat larger firms.[51] This pattern has not changed in recent years even though engineering graduates are enjoying a sellers' market in Japan.[52] The 1989 survey, for example, reported the starting pay for those university graduates employed for technical (*gijutsukei*) positions by Japanese companies (five hundred or more employees) to have been 161,877 yen/month. This was only 2.05 percent higher than the starting pay of those hired for administrative (*jimukei*) positions.[53]

Data from the same survey indicate that if historical patterns hold, engineering will not command significant pay premiums in the future. At the "section chief level" (*buchô*), the top managerial level below true executive status, those on the technical side were receiving on average 572,943 yen/month. This was 5.4 percent *less* than those on the administrative side. The only apparent advantage enjoyed on the technical side was the achievement of *buchô* rank at a slightly earlier age (49.5 vs. 50.5)[54]

[51] I have used Jinji'in kyûyo kyoku (JJI), *Minkan kyûyo no jittai 1989* [The situation in private employment compensation 1989] (Tokyo: Jinji'in, 1989) for generalizations about Japanese salaries. This is an annual survey conducted to establish parity for civil servants vis-à-vis employees in the private sector. References to engineers derived from this source are to university educated *gijutsusha* working for firms with more than five hundred total employees. Persons included in this category are largely but not exclusively those who have studied "engineering." Data more closely conforming to U.S. definitions do not appear to be available.

[52] In the last few years, popular journals have made the claim that university graduates in engineering were turning away from manufacturing, perceived as offering dirty jobs and low pay, for the financial services sector, which offered cleaner work and higher pay. Some of the more hysterical treatements have seen a "de-industrialization of Japan." The trend became an issue of official concern when it was taken up in the 1989 *Kagaku gijutsu hakusho* (White Paper on Science and Technology). In fact the absolute numbers are quite small, and the proportion of engineering graduates going into nonmanufacturing jobs has been higher in the past without attracting such concern.

For the official concerns, see *Hakusho 1989*, pp. 56-63.

[53] *Minkan 1989*, p. 13.

[54] *Minkan 1989*, p. 24.

In contrast to the Japanese situation, during the 1980s young graduates from U.S. engineering programmes were able to command premiums of up to 50 percent over humanities and social science graduates. Indeed, the pay for engineers in the U.S. was such that starting salaries for B.Sc.-level graduates in engineering have equaled or exceeded the salaries for experienced *Ph.D.*s in the humanities and social sciences.[55] To add insult to injury, this widening gap was caused by a steady decline *in real terms* of salaries for non-engineers while those for engineers held steady or increased. As yet, there is no evidence of a substantial change in this pattern. Moreover, high starting salaries have been matched by high average earnings. A 1981 Bureau of Labor Statistics survey showed that average salaries for employed (as contrasted with private practice) engineers exceeded even those of (employed) medical practitioners in the U.S.[56]

How Engineers Work

A proper analysis of how Japan has out-engineered the U.S. with fewer engineers requires careful comparison of what Japanese and American engineers do at their respective work places. Unfortunately, the literature on what American engineers actually do and how they do it in conjunction with other engineers and other workers is quite thin. American engineers are even less interested in what their counterparts in other nations do. In the last decade *IEEE Spectrum* has had one substantive article on Japanese engineers.[57] An extensive search of conventional bibliographies and on-line data bases added only a few brief articles. These were, like the one *Spectrum* article, autobiographical impressions by single American engineers. Although not without interest, the paucity of literature points to the degree to which Japanese engineering is ultimately not taken seriously in the U.S.

The situation is no better in terms of Japanese language sources. A few impressionistic accounts written by Japanese engineers can be found, but they are dominated by the broad and often ludicrous if not racist generalizations of the *Nihonjin ron* or *Nihon bunka ron* genre. There is but one serious comparative study in Japanese, and the non-Japanese comparisons are entirely with the U.K. situation. Although there are doubtless similarities between the U.K. and U.S. situation, there are also very great differences.

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[55] On relative compensation, Fred Landis, "The Economics of Engineering Manpower," *Engineering Education*, vol. 73 (December 1983), p. 160; *Science*, pp. 265, table 3-18; Richard A. Ellis, "Engineering and Engineering Technology Enrollments, 1987," *Engineering Education* (October 1988), p. 52.

In 1984 the average starting salary for U.S. bachelor's level graduates was $26,100. Engineering Manpower Commission, *Engineers Salaries: Special Industry Report 1984* (Washington, DC: American Association of Engineering Societies, 1984), p. 22. As an associate professor with a Ph.D. and ten years experience teaching, I received $26,300 in the same year!

[56] Nancy F. Rytina, "Earnings of Men and Women: A Look at Specific Occupations," *Monthly Labor Review*, vol. 105, no. 4 (April 1982), pp. 26–29.

[57] Daun Bhasavanich, "An American in Tokyo: Jumping to the Japanese Beat," *IEEE Spectrum*, vol. 22, no. 9 (September 1985), pp. 72–81.

To supplement the meager materials available in either language, I made a *usenet* posting asking for the impressions of engineers who had cross-cultural work experience in either the U.S. or Japan.[58] The bulk of the replies turned out to be questions for me or requests for my writings on Japanese engineers. The latter were primarily from Americans facing posting to Japan. They had discovered that there was virtually nothing in English about life as an engineer in Japan.[59] Nevertheless, a dozen or so interesting replies were received. Used together with the few previous treatments in English, it is at least possible to develop something of a research agenda for that day when the U.S. may start taking Japan seriously.

Group Orientation

Not surprisingly, many respondents reported a group orientation on the part of their Japanese colleagues. Some reacted quite negatively to this. One responded observed, "The company would expect engineers to work through the night when tight deadlines approached — as a team." While not objecting to the late night work, the problem was "*Everybody* worked through the night and most of them were doing noncritical tasks like stripping down and rewiring harnesses — probably injecting more faults and doing absolutely nothing to advance the project." Even this critical respondent did find a logic in the Japanese approach. Even though many problems ultimately had to be solved by individuals, putting a team on the task meant that the next time the problem arose, there would be more than one person who could bring experience to bear. Similarly, the team approach was good for raising average performance levels. Another respondent observed that Japanese engineers were quick to interrupt their own work to answer the questions of another. "The paradoxical efficiency of such an approach occurred to me after a while. By following the usual pattern in the U.S. of putting off the query until one's present work has reached a convenient break point, one person is productive and one not. But by stopping to answer the question when it is asked, both workers are productive; the one answering the problem would eventually have to address the question anyway, and by doing so sooner rather than later, the confused engineer can be back on his project sooner." According to the same respondent, Japanese engineers would immediately focus on any failure and seek to correct it whereas in the

[58] *Usenet* is a noncommercial network linking tens of thousands of computers (primarily at universities and government research stations) worldwide. It carries a variety of forums ranging from artificial intelligence to kinky sex and everything between.

[59] The only partially relevant handbook currently available is *Gaijin Scientist*, ed. British Chamber of Commerce in Japan (London: British Chamber of Commerce in Japan, 1990).

United States "whenever an unforeseen problem arose in a project, the first objective was to protect oneself from blame."[60]

Engineers and Operatives

Japanese engineers apparently have little problem in working with production line workers and operatives. Indeed, the notion that there could be such a problem is rather surprising to the Japanese.[61] Japanese industrial sociologists have noted that engineers in Japan are socially and economically closer to production workers. Indeed, Japanese engineers are physically closer to workers. Engineers assigned to factories have a desk on the shop floor next to the foreman, not an air-conditioned office in a separate building, as is often the case in the U.S. Even research and design engineers will not have a private office or even a private phone. In many large Japanese companies, all employees from operatives to president wear the same uniform. Engineers punch time clocks and are paid by the same hybrid salary-plus-overtime scheme used for explicitly blue collar workers.[62] In Japan engineers and production workers belong to the same union, and the former have little of the (would-be) management-versus-worker attitude that can be found in the U.S. There is no strong demarcation between (clean) design and (gritty) production nor is there a sharp split between the activities of engineers and technicians. Japanese observing American firms are struck by the concern with jurisdiction and specialization in the U.S. and by the failure of American firms to upgrade capable technicians or blue-collar workers to engineer.[63]

Moreover, Japanese companies do not take it for granted that Japanese social values will prevent engineers from developing an inflated opinion of themselves. It is common for engineers to clean their own work areas just as operatives clean the shop floor and elementary school children scrub their classrooms. As one American has observed, this kind of activity, which may go so far as having electrical engineers weed the lawn in front of their research center, "may not seem an efficient way to use trained professionals [but] it certainly helps to quench any sense of elitism among company workers."[64]

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[60] This is from one of the responses to my *usenet* bulletin board posting. Those responding were promised anonymity.

[61] Okubayashi, "Social Status," pp. 38–39.

[62] These generalizations are based on my own observations of two large engineering firms and conversations with their managers. See also Bhasavanich, "Jumping," pp. 72–81; Okuda Kenji, "The Role of Engineers in Japanese Industry and Education," *Journal of Japanese Trade and Industry*, vol. 5 (1983), pp. 23–26. For a comprehensive treatment of Japanese salary schemes in large firms, see Robert J. Ballon, *Salaries in Japan: The System* (Tokyo: Institute of Comparative Culture, Sophia University, 1982).

[63] Yamada Tomihisa, "Flip Side: Japanese Engineer Takes on US Work," *IEEE Spectrum*, vol. 22, no. 9 (September 1985), pp. 78–79. Similar observations are also found in Kawai Mikio, *Gijutsu ôkoku Amerika no chôraku* (Tokyo: Nihon keizai shinbun sha, 1981).

[64] Bhasavanich, "Jumping," p. 72.

Such treatment is unthinkable for many Americans. Some years ago I used a film from JETRO entitled "A Day in the Life of a Japanese Engineer." In several scenes, the "engineer," explicitly identified as a college graduate, is seen helping production line workers repair or adjust equipment. He gets dirty and greasy with the men on the production line. A few students always reacted to this by questioning the authenticity of the film.[65] Assurances to the contrary notwithstanding, they found such scenes hard to believe.

Their expectations of an "engineering education" may be gleaned from a float in the Picnic Day Parade at U.C.-Davis a few years ago.[66] The float featured a Mercedes-Benz. Stage money $100 bills had been inserted in the wheel covers. Engineering students in formal dress stood around the Mercedes and sipped champagne (more likely Budweiser). A sign on the side of the float said "Hard Work and Study *Pays*." Even allowing for a certain amount of tongue-in-cheek humor, no survey of attitudes is needed to confirm the U.S. student perception that engineering is a route to high pay, not to the factory floor.

The negative attitude of American engineers to workers is well documented. The notion that a worker can be trusted let alone have some positive intellectual contribution to make is quite difficult for many American engineers or managers to accept. One respondent to my survey, who found the Japanese environment quite congenial, reported that in the U.S. he had actually had the experience of being told to *stop* asking the opinions of the workers who were going to be using the equipment (robotics) that he was installing! In contrast a study by Okubayashi Koji of Japanese engineers in manufacturing found 21.2 percent of engineers talking to shop floor workers several times a day, 27.6 percent several times a week, 23.6 percent several times a month, and only 5.4 percent never and 13.2 percent only a few times per year.[67] In contrast, in the U.S., an oft-stated design goal is to "idiot proof" equipment.[68] This means limiting the options operatives have with their equipment. Given this perception of workers, it goes virtually without saying that few American engineers will seek the opinions of operatives.

Innovation

While working closely with operatives is essential for tuning equipment for maximum output under real life conditions, the incremental progress

[65] As well they might, given the silly scenes in other JETRO films.

[66] Picnic Day is an annual festival at UC-Davis, something of an open house for parents and members of the surrounding community.

[67] Okubayashi, "Social Status," pp. 37-38. Another 9.0 percent did not answer.

[68] Robert E. Cole, *Work, Mobility, And Participation: A Comparative Study Of American And Japanese Industry* (Berkeley: University of California Press, 1979), p. 198.

implied by such contact is something that earns only grudging acknowledgment from some American engineers. For example, in the words of one respondent, "I conclude that Japanese engineers fail consistently and thoroughly in design functions. Japanese automotive engineers consistently go for trendy solutions rather than good ones. But they perform very well at development (testing and detail refinement) and manufacturing functions." Others noted what they saw as an American preference for "big bang" (major breakthroughs) while the Japanese aimed at steady improvement.

While finding Japanese engineers somewhat lacking in originality, another writer gave them high marks for preparation, especially in terms of finding exactly what a customer wanted. His U.S. experience had been that relatively complex projects were begun with limited and vague design documentation only to be followed by a series of disputes and cost overruns. In contrast, Japanese engineers were careful to specify every aspect of a project. Even the color of equipment cabinets was carefully specified.[69] In this respondent's view, U.S. managerial philosophy could be summed up by such statements as "There is never time to do it right, but there is always time to do it over," and "The only measure of software productivity is 'lines of code per day.' Not good code, working code, not validated code. Just code." Nevertheless, despite a few such comments, the general impression conveyed was a belief in the ultimate superiority of American engineering if not in American managers. Japanese incrementalism was damned with rather faint praise even by those not overtly hostile.

Overall, American engineers seem to be heir to a value system that relishes being first to do something even if it is not done well or profitably. Nobel prizes and other indicators of "big bang" breakthroughs show unquestioned superiority for the U.S. The rate of increase in average real income and other indicators of distributed technological benefits show unquestioned superiority for Japan. It has a vigorous auto industry that has a shortage of workers. The U.S. industry has shed massive numbers of workers and contributed to the decay of urban centers. The U.S. runs an enormous trade deficit that must be covered by borrowing. Japan runs a massive surplus, some of which is recyled into loans for the increasingly indebted U.S.

Of the two strategies, the "big bang" approach would seem easier to replicate or at least easier for others to capitalize on. There have been relatively few technologies where the one and only one viable method could be legally protected and monopolized. More typically, a breakthrough gives guidance to others who can invent alternative but similar technologies. Or, the breakthrough may be simply licensed. Although the follower *may* have

[69] This observation contrasts sharply with the Japanese perception that U.S. companies are prone to overspecification reported by Westney and Sakakibara. Sakakibara and Westney, "Comparative Study," p. 15. The difference may be that internally Japanese companies are less given to rigid specification.

to pay high fees, there is little lost to following up technological dead ends. The follower is left to concentrate on incremental improvements. These by their very nature are difficult to reproduce. Major developments are publicized. Incremental improvements depend on specific, in-house skills or corporate secrets.[70] The "big bang" approach depends on a few creative individuals. The incremental approach requires the cooperation and contribution of the whole work force.

Racism in the American Approach to Japan

In recent years various Japanese commentators have responded to one-sided criticism of Japan with charges of "racism." Whether this charge is warranted or not is open to question. One-sided praise of Japan is not so branded, but there are similarities in the two genres, and even in western writing that heaps fulsome praise on the Japanese, it is possible to detect rather strong assumptions of ultimate western, particularly American, superiority.

Many of those celebrating Japan are as illiterate (in Japanese) as those bashing the country. The prominence given to those incapable of speaking or reading Japanese might be acceptable if they limited themselves to the U.S. side of U.S.-Japan issues. This is not the case. Some with no knowledge of Japanese and no more experience in the country than a flying tour feel themselves capable of pronouncing on the finer details of Japanese education, society, industry, and economics. Moreover, these illiterates are given prominent official and media forums. This treatment in effect says that even with all of their technological and economic accomplishments the Japanese and their society are ultimately so simple that they can be readily analyzed by mono-lingual western experts with no previous background in any aspect of Japanese studies, least of all the language.

The suspension of conventional academic skepticism and precision for dealing with Japan points to a double standard that is at least ethnocentric if not racist. It is difficult to imagine academic writers comparing two U.S. states or even the U.S. versus a European country without at least some attention to definitional differences, methods for gathering statistics, the reliability of the data, etc., and all of the other things that are taught in elementary courses on research methods in sociology, political science, history, education, etc. Nevertheless, the universal pattern has been to suspend conventional investigative rigor when dealing with Japan.

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[70] Very little attention has been given to the issue of information flows resulting from the two research styles. Scattered references in writings by Gary Saxonhouse are, however, most suggestive and represent a line of research that should be further developed. See Gary R. Saxonhouse, "Industrial Policy and Factor Markets: Biotechnology in Japan and the United States," in *Japan's High Technology Industries: Lessons and Limitations of Industrial Policy*, ed. Hugh Patrick (Seattle: University of Washington, 1986), pp. 119, 129–30; Daniel I. Okimoto and Gary R. Saxonhouse, "Technology and the Future of the Economy," in *The Political Economy of Japan*, ed. Yamamura Kozo and Yasuba Yasukichi (Stanford: Stanford University Press, 1987), pp. 413, 417.

It is difficult to say that Americans really take Japan seriously when one can easily find "expert" testimony in congressional hearings that has behind it no more than a few hurried phone calls to the Japanese Embassy.[71] Despite Japan's emergence in the early 1970s as the major competitor to the U.S. in technology-driven industries, it is not until 1988 that one can find an NSF publication that contains references to Japanese language sources and some concern about data equivalency. But even with this improvement, the overall presentation continues to leave the impression that NSF is mining Japanese sources for material to support its budget requests, not to find out the constituent elements of Japanese technological and managerial success.[72]

University-level job postings reflect the casualness with which Japan is viewed. Frequently teaching on Japan or of Japanese is advertised as a desirable *secondary* field in a position primarily on China or Chinese. The notion that Japan is a cultural and linguistic offshoot of China and that the "mother culture" deserves the bulk of resources is reflected in the structure and staffing of all but a handful of universities. Even though Japan is challenging the U.S. in super computers while the Chinese show off their bicycles to George Bush, Japan still does not warrant dedicated specialists in most American colleges and universities, especially in economics and politics. The few economists or sociologists who do have expertise on Japan are warned away from doing too many "area studies" courses (i.e., courses focused on Japan).

This odd pattern may be seen in other areas. Even though it is well documented that Japanese school children outperform comparable samples of U.S. school children in science and math,[73] there are no American journals devoted to Japanese elementary and secondary education. There are, however, such journals for China and the USSR. American notices of the mechanics of Japanese education seldom goes beyond the recitation of dubious statistics about school days per year. There has been virtually no

[71] For example, *U.S. Science*, p. 104. Here generalizations about Japanese graduate education are made on the basis of two telephone conversations and citations from Ezra F. Vogel, *Japan as Number One: Lessons for America* (Cambridge, Mass.: Harvard University Press, 1979). Also, *Education for the 1980's*, pp. 61, esp. notes 5–8, 20–24.

[72] This is not a new problem and not specific to data about Japan. Naive and in some cases sloppy use of statistical sources by NSF was identified as a problem as early as 1972. See William Kruskal, "Taking Data Seriously," in *Toward a Metric of Science: The Advent of Science Indicators*, ed. Yehuda Elkana et al. (New York: John Wiley & Sons, 1978).

[73] One of the more thoughtful discussions of this is David H. Uttal, Max Lummis, and Harold W. Stevenson, "Low and High Mathematics Achievement in Japanese, Chinese, and American Elementary-School Children," *Developmental Psychology*, vol. 24, no. 3 (1988), pp. 335–42.

interest in what Japanese actually do in their classrooms.[74] This suggests that Americans believe they have all the pedagogical answers, that the issue is entirely quantitative, not qualitative. American failures are to be met by doing more of what always has been done because it is assuredly good. There is no allowance made, it seems, for the possibility that the Japanese have developed more efficient teaching techniques than the Americans.

Behind the praise of Japan and the exaggeration of the Japanese position, there is the latent assumption that it is only necessary for Americans to find that one trick the Japanese have accidentally discovered, utilize it, and the U.S. will once again be restored to its rightful place. The whole emphasis on monocausality and dubious numbers avoids confronting the possibility that rather than having killer gimmicks, the Japanese have simply been doing a whole range of things better than Americans, and that it is this across-the-board superiority that accounts for their success. The emphasis on monocausality avoids confronting the possibility that to really learn from Japan, Americans must study Japan in the detailed and humble way Japanese have studied the U.S. (and Europe) in the past.

The readiness of NSF and some academics to repeat extreme unfounded claims about Japan would be laughable in some situations but is dangerous in the present context. With the acceptance of such claims, Japan may well become something of a second Sputnik, a stimulus to engineering and science education but of a type that does not lead to an increase in American industrial productivity. The U.S. can ill afford still greater diversion of limited financial and intellectual resources into areas that have been responsible for weakening the U.S. industrial base. Currently the U.S. seems willing to approach its chief economic and technological rival with a cavalier and perhaps racist disrespect. Any high school football coach in any cow town in the country would be given his walking papers if he approached his rivals and their "stats" the way the myth-makers have approached Japan.

University of Sheffield, U.K., May 1991

[74] The standard cliché is that Japanese children attend school 240 days per year versus an average of 180 for the U.S. This comparison ignores (a) the forty half days in the Japanese school year; (b) the relatively large number of days without instruction (for *undôkai* and the like); (c) the greater number of holidays (interruptions) in the Japanese school year; (d) the actual length of time in class, etc.

One of the few studies that actually looks at Japanese teaching methods documents major differences in approach. James W. Stigler and Michelle Perry, "Mathematics Learning in Japanese, Chinese, and American Classrooms," *New Directions for Child Development*, vol. 41 (Fall 1988), pp. 1272–85.