Chapter 6

Technology Transfer and Diffusion: Some International Comparisons

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Technology Transfer and Diffusion: Some International Comparisons

Compared to our strongest competitors, the United States is lacking in institutions to diffuse technology to manufacturing companies. This is true in both the public and private sectors, and it applies especially to small companies. For example, scattered Federal and State efforts to help small U.S. firms raise their technological level are no match for the dense nationwide program of financial and technical assistance to smaller manufacturers in Japan. Not many major U.S. manufacturers give their suppliers technical help, as Japanese firms customarily do. Nor is there anything in this country to compare with the apprenticeship training taken by half the young people of Germany and Sweden and credited with producing a high level of technical skills in the work force. In those countries, good worker skills are a key factor in the diffusion of manufacturing technology.

Large companies as well as small ones suffer from failures in technology transfer. With their typically standoffish relation to suppliers, large U.S. manufacturing firms rarely get the benefit of collaboration with suppliers on developing and applying new technologies —a common practice in Japan (see ch. 5). Moreover, many U.S. firms are not as good as their foreign competitors at scanning the outside world for new technologies that would improve their company's products or manufacturing techniques. Often, the company culture is inimical to anything Not Invented Here—the NIH syndrome.

There is one kind of technology transfer in which American companies do have an excellent track record. That is in taking fundamentally new ideas out of the laboratory and using them as the basis for new families of products. Whole industries have been founded on science-based inventions. For example, the transistor, an invention that depended on accumulated knowledge in quantum mechanics and solid-state physics, was the progenitor of the complex of microelectronic industries, including semiconductors and computers. In the same way, commercial biotechnology has risen on the foundation of scientific advances in molecular biology.

But U.S. firms are weaker at the more ordinary kind of technological advance in which improvements are added bit by bit to existing products and manufacturing processes. Over the past quarter century, Japanese manufacturers have repeatedly beaten American producers with incremental product and process improvements-first in transistorized radios and TVs, then autos, now semiconductors.[1] Some companies in Europe also excel at this kind of evolutionary advance. For example, the Germans, with their mastery of mechanical engineering and metalworking, are leaders in making high-quality industrial machinery.

The strengths and weaknesses of American firms in adopting new technologies reflect our institutional biases. U.S. Government science and technology policy is light on technology diffusion and heavy on the traditional government missions of defense, health, and basic research.[2] In the private sector, there is plenty of venture capital to support attempts to commercialize science-based innovations coming out of research labs, and there are plenty of footloose managers and engineers ready to shift to promising new ventures. Thus, public policy supports the kind of R&D that sometimes leads to technological breakthroughs, and private institutions are suited to exploiting them commercially.[3] What is lacking is a web of institutions to spread throughout manufacturing, to small as well as large firms, the more mundane and more gradual improvements in technology that spell success in the later phases of a product's lifecycle.

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[1] Japanese success is not confined t. improvements of familiar products. For example, although the video cassette recorder was a descendant of the U, S.-made Ampex commercial video tape recorder, it embodied so many new engineering ideas that it might be regarded as a new invention. And more and more, the Japanese are putting efforts into scientific work as the basis for new technologies, as in high-temperature superconductivity.

[2] For a discussion comparing "mission. oriented' technology policy (as practiced in the United States, Britain, and France), "diffusion- oriented" technology policy (Germany, Sweden and Switzerland), and a combination of the two (Japan), see Henry Ergas, "Does Technology Policy Matter?' in Bruce R. Guile and Harvey Brooks (eds.) *Technology and Global Industry: Companies and Nations in the World Economy* (Washington, DC: National Academy Press, 1987).

[3] At least, the institutions are suited t. supporting start-up firms. However, high-tech start-ups often falter in the transition to large-scale production.

Government technology policies in other countries are much more strongly directed toward technology diffusion than are U.S. policies. Japan's long-established programs of general financial assistance to small firms and special measures to encourage small manufacturers to adopt modern technologies are of particular interest. Although there are many differences between small manufacturers in Japan and the United States, some features of the government programs that have worked well there might be translated into American terms.

Small firms have received special attention from the Japanese Government for several reasons. First, they are numerous. The Japanese economy as a whole is heavily weighted to small fins, and this is true of manufacturing as well. Small and medium size firms account for three quarters of manufacturing employment in Japan, compared to a bit over one-third in the United States. Also, small Japanese firms have often been technologically backward, paid low wages, and operated under primitive working conditions. Despite these disabilities, many small Japanese manufacturers have turned in remarkable performances-especially those that are suppliers for Japan's world champion industries (e.g., electronics, automobiles). Technology assistance given by the major customer firms has helped the performance of these supplier companies, but the government's technical and financial assistance programs get much of the credit too.

Many of Japan's large firms have now entered the ranks of the richest and most successful in the world and no longer need much of the government assistance that helped them get established. More of the nation's resources, public and private, are available to smaller fins. This chapter describes at some length the extensive technical and financial programs available to small Japanese firms today, keeping in mind their possible relevance to U.S. policy. The relatively sparse Federal and State technical and financial assistance available to small manufacturers in the United States is described in chapter 2 and chapter 7.

DIFFUSION OF ADVANCED MANUFACTURING EQUIPMENT

One measure of technological sophistication in manufacturing is the presence of advanced equipment—such things as computerized machine tools, robots, flexible manufacturing cells. This is only one kind of measure, and by no means a complete one. Other factors, especially the so-called soft technologies involving organization of work and use of people, are at least as important as hardware to manufacturing performance. Nevertheless, an industry that falls behind the international competition in installing advanced machinery will very likely find itself falling behind in the cost, quality, and variety of its products.

In the use of robots-defined as programmable, multifunctional manipulators—U.S. industries are far behind the foreign competition, especially the Japanese.[4] Although the invention and first use of industrial robotics was in the United States, it is no more than a minor factor in American manufacturing today. Even in Japan, where robots have been adopted far more aggressively, they are mostly confined to special uses in a few industries (mainly autos and electronics). A much more broadly used technology is numerically controlled and computer numerically controlled (NC and CNC) machines (also invented here). These machines are the kind of computerized production equipment most commonly found on manufacturing shop floors in the United States, West Germany, and Japan (and in other industrialized countries as well).

American manufacturers are closer to their top foreign competitors in the use of NC machines than in robotics.[5] However, Germany leads by a fair margin, and the margin is wider if U.S. military production is omitted. The Japanese, who started later than American firms in adopting NC machine tools, were nearly even by the late 1980s and were on a faster track. In a few years, unless things change, NC machine tools will be more common in Japanese factories than in American ones.

In 1988,41 percent of U.S. manufacturing establishments with 20 or more employees in five major

[4] Kenneth Flamm, "The Changing Pattern of Industrial Robot Use, " in Richard M. Cyert and David C. Mowery (eds.), The *Impact of Technological Change on Employment and Economic Growth* (Cambridge, MA: Ballinger Publishing Co., 1988); Edwin Mansfield, Department of Economics, University of Pennsylvania, "Technological Change in Robotics: Japan and the United States, " *Managerial and Decision Economics*, Special Issue, spring 1989, pp. 3-12.

[5] In the following discussion, the term NC includes CNC.

industry groups were using one or more NC machines, according to a survey by the Bureau of the Census.[6] The figure for German plants of the same size in a similar group of industries is 48 percent.[7] The Japanese data are shown on a different basis, that is, NC machine tools as a percent of all the machine tools in the shop. In 1987, 12.2 percent of machine tools in Japanese establishments with 50 or more employees in metal machining industries were NC. The comparable figure for U.S. establishments of the same size, at the same time, was 13.1 percent[8] (tables 6-1 and 6-2). The seeming parity of U.S. and Japanese metalworking plants in ownership of NC machine tools may be misleading, however, since the Japanese firms are acquiring the machinery at a faster rate. U.S. metalworking firms increased their installed computerized automation (mostly machine tools) at an estimated rate of nearly 16 percent a year from 1983 to 1988;[9] the Japanese added NC machine tools at a rate of 24 percent per year from 1981 to 1987.[10]

Another complicating factor in making these comparisons is U.S. military procurement. The Census Bureau's survey of U.S. metalworking establishments found that plants producing for the military are more likely than the general run of plants to use NC machines. Of all the plants in the survey, 41 percent used this automated machinery.

Table 6-l-Adoption Rates of NC Machine Tools in Five Major industries, United States (1988) and West Germany (1986)

Size of establishment (number of employees)	West Germany (percent)	United States (percent)
Under 20	15.8	
20-29	36.0	35.9
100-499	55.9	50.0
500 and over	87.3	69.8
20 and over	47.7	41.4

NOTES: "Adoption hate" means the percentage of surveyed firms reporting installation of at least one NC machine tool. "NC machine tools" include CNC machine tools.

The five major industry groups are SIC 34-36 (Fabricated Metal Products, Industrial Machinery and Equipment, Electronic and Other Electric Machinery, Transportation Equipment, and instruments and Other Related Products) for the United States. The German industry groups are similar although they may not be identical.

n.a. = not available.

SOURCES: ***West Germany***: Hans-Jürgen Evans, Carsten Becker, and Michael Fritsch, "The Effects of Computer-Aided Technology in Industrial Enterprises: It's the Content that Counts," in Ronald Schettkat and Michael Wagner (ads.), *Technical Change and Employment* (New York, NY: de Gruyter, in press), and Michael Fritsch, Technische Universität Berlin, personal communication. United States: U.S. Department of Commerce, Bureau of the Census, *Manufacturing Technology 1988*, SMT (88)-1 (Washington, DC: Department of Commerce, 1968), table 6-B.

For plants making products to military specifications, the figure was 58 percent; for those making no mil spec products, only 36 percent reported using NC machines. Similar discrepancies were reported

[6] U.S. Department of Commerce, *Manufacturing Technology* 1988, Current Industrial Reports, SMT (88)-1 (Washington, DC: U.S. Government Printing Office, 1989). The survey covered 10,526 establishments, selected to represent a total universe of 39,556 manufacturing establishments in SIC Major Groups 34, fabricated metal products; 35, industrial machinery and equipment; 36, electronic and other electric equipment; 37, transportation equipment; and 38, instruments and related products.

[7] Hans-Jürgen Ewers, Carsten Becker, and Michael Fritsch, "The Effects of the Use of Computer-Aided Technology in Industrial Enterprises: It's the Context That Counts, ' in Ronald Schettkat and Michael Wagner (eds.), *Technical Change and Employment (New* York, NY: deGruyter, in press), and personal communication, Michael Fritsch, Sept. 21, 1989.

[8] For the United States, data are from the 1987 National Survey Data about Machine Tool Use in Manufacturing Plants in Maryellen R. Kelley and Harvey Brooks, *Modernizing U.S. Manufacturing (Cambridge,* MA: MIT Press, forthcoming), and personal communication, Maryellen Kelley, Sept. 20,1989. The survey covered a representative sample of establishments of all sizes, including 1,368 metalworking plantsin21 industries. "Computerized automation' in the study was defined to include programmable numerically controlled (NC) machine tools, whichare controlled by tape and have been commercially available for more than 20 years; computer numerically controlled (CNC) machine tools, which include a microprocessor and a keyboard at the machine, so that programs can be written and edited at the machine; and flexible manufacturing systems (FMSs), which consist of a number of programmable machines (either NC or CNC) connected by automatic materials handling devices (e.g., conveyors or robots). At the time of the survey, 38 percent of computerized machine tools in use were the older NC type.

For Japan, data are drawn from a survey covering establishments of 50 or more employees in metal machining industries, conducted every 6 years by the Ministry of International Trade and Industry (MITI). The MITI survey, like the Kelley-Brooks study, combines NC and CNC machine tools. Data from the two surveys are only roughly comparable, because the industries covered differ somewhat. The source for the data in English is D.H. Whittaker, ''NC/CNC Penetration in Japanese Factories," Appendix 1 to "New Technology in Small Japanese Enterprises: Government Assistance and Private Initiative," contract report to the Office of Technology Assessment, May 1989. In Japanese, the source is Tsusansho, *Showa* 62 *nen dainanakai kosaku kikai setsubito tokei chosa hokokusho* (Report of the 7th Survey on Machine Tool Installation) (Tokyo: Tsusan todei kyokai), Appendix 1, pp. 282-284.

[9] Maryellen R. Kelley and Harvey Brooks, *The State of Computerized Automation in U.S. Manufacturing*, Harvard University, John F. Kemedy School of Government, October 1988, p. I-6. The average annual rate of adoption from 1968 to 1983 was 13.7 percent, with a slowdown in the years 1973-78 (8.4 percent per year) and a speedup in 1978-83 (18,6 percent per year). Anderson Ashburn, "The Machine Tool Industry: The Crumbling Foundation," in Donald A. Hicks (cd.), /s New *Technology Enough* (Washington, DC: American Enterprise Institute for Public Policy Research, 1988), p. 55. Sources of the data are the 10th through 13th American Machinist Inventories.

[10] MITI surveys feud that Japanese plants in metal machining industries had 4,861 NC/CNC machine tools in 1973, 19,549 in 1981, and 70,465 in 1987. Whittaker, op. cit. and D.H. Whittaker, ''Machine Tool and NC Development in Japan, " mimeo, n.d.

Table &2—Penetration Rates of NC Machine Tools in Manufacturing Industries, United States and Japan, 1987

Size of establishment (number of employees)	United States (Percent)	Japan (Percent)
Under 50	8.1	
50-99	12.6	10.7
100-299	13.7	11.2
300-499	12.7	12.6
500-999	12.3	13.5
Over 1,000	13.8	12.8
Total over 50	13.1	12.2

NOTES: "Penetration rate" means the ratio of NC machine tools to the total number of machine tools installed in the establishments surveyed. "NC machine tools" includes CNC machine tools. The metalworking industries surveyed are similar but not exactly the same in the United States and Japan.
For Japan, the category "other machine tools" was excluded In this table, because it was not included in the U.S. survey.
n.a. = not available.

SOURCES: ***Japan:*** Ministry of international Trade and Industry, *Report of the 7th Survey on Machine Tool Installation (Showa 62 nen dainanakai kosaku kikai setsubito tokei chosa hokokusho)* (Tokyo: Tsusan todei kyokai), pp. 282-84; The source in English is D.H. Whittaker, "NC/CNC Penetration in Japanese Factories," Appendix 1 to "New Technology in Small Japanese Enterprises: Government Assistance and Private Initiative," contractor report to the Office of Technology Assessment, May 1989.
United States: 1987 National Survey Data about Machine Tool Use in Manufacturing Plants; Maryellen R. Kelly and Harvey Brooks, *Modernizing U.S. Manufacturing* (Cambridge, MA: MIT Press, forthcoming), and Maryellen R. Kelly, Carnegie-Mellon University, personal communication.

by prime defense contractors and subcontractors for their military and non-military products (table 6-3). This means that NC machines are used in American plants much more for producing military goods than for commercial goods, and thus contribute less than it might appear to the Nation's trade performance and competitiveness.

The differences in NC machine tool use in the United States, Germany, and Japan reflect differences in government policy. The policy with most effect in the United States is satisfaction of military needs. Numerical controls for machine tools were invented here in the 1940s, and MIT developed a highly sophisticated version for the Air Force in the 1950s. NC machining offered the great precision that was needed for making integrally stiffened wing skins for aircraft. The first substantial use of NC machining, in the late 1950s, was in five-axis milling machines that could hollow out the wing, leaving stiffeners in place, and contour the outside skin to the airfoil shape—all in one piece from a solid thick plate of metal (an advance from the old method of riveting the skin to ribs and stringers). The Air Force bought the first 100 of these machines (after the aircraft industry refused to invest in them) and put them in its contractors' factories.[11] Around the same time, other machine tool builders were developing simpler, cheaper, more flexible machines, taking advantage of the progress in NC controls.

Just as defense contracts were critical in developing NC machining, military requirements have had a continuing effect on its diffusion. The U.S. Government has given little attention to specific policies that would promote adoption of NC technology outside the military-industrial complex. An exception, perhaps, was the investment tax credit, in effect off and on from 1962 to 1986, that allowed firms to deduct from their income tax 7 to 10 percent of the price of any productive capital equipment, including machine tools. There is some evidence that the investment tax credit may have encouraged orders for NC machine tools. 'z

Many people expected NC machine tools to sweep U.S. metalworking shops soon after their invention. They did not. Nevertheless, diffusion of these machines has not been slow by historical standards.[13] Says Ashburn Anderson, an expert on the machine tool industry, "It is not so much that technology diffuses more slowly in the United States than in the pastas that it now diffuses more rapidly in Japan."[14]

Early on, the Japanese licensed NC technology and within 10 years had adapted the American invention into simple, cheap, and robust machines of their own design. Computerized controls (also a U.S. invention) were added in the 1970s, and Japanese firms became the world's premier producers of sturdy, relatively inexpensive workhorse CNC machine tools. The Japanese Government supported these efforts, contributing generous amounts to research and development consortia, and encouraging the thousands of small firms making machine tools to coalesce and specialize in different segments

[11] A. Anderson, Op. Cit., pp. 44-47.

[12] A. Anderson, op. cit., pp. 69-71.

[13] See, for example, Edwin Mansfield, "The Diffusion of Industrial Robots in Japan and the United States," mimeo, n.d., which found that it took the relatively short time of 5 years for half the major potential users to adopt NC machine tools.

[14] A. Anderson, op. cit., p. 79.

of the market to achieve economies of scale. (This advice was not always heeded; firms tended to stay small, but they did specialize more.)15

At the same time, Japanese government policy actively supported widespread adoption of NC machine tools. The government's equipment leasing systems bought machine tools and leased them at low rates to small and medium-size manufacturers, thus providing both a stable market for machine tool builders and subsidies for machine tool users. The government also provided low-cost capital to a quasi-public leasing company that bought machine tools and leased them to companies of any size. Japan's nationwide technology extension services (discussed below) have helped small firms learn to use the equipment effectively. In addition, Japanese tax law was changed in 1984 to allow very rapid depreciation of investments in high-technology equipment (including NC machine tools) by small and medium- size firms. This seems to have set off a flurry of buying; one Japanese manufacturer calls it the "NC-ization period. "

In Germany, emphasis in many industries on medium batch production rather than mass production may account in part for high adoption rates of NC machine tools (hard-wired automation is often more efficient in mass production) but basically, both the production and use of NC machine tools reflects Germany's tradition, more than a century old, of excellence in vocational and technical training. The German training system is supported by both government and industry; it includes 3-year apprenticeships from ages 16 to 19 for operators and further rigorous training, practical and theoretical, for the master craftsmen who become foremen and often middle managers.

Production machinery is an important export for Germany, and that includes CNC machine tools at the high end of the range. Germany's dominance in producing these complex and costly machines is due in large part to the quality of its workers. The training system also pays off in the use of NC machine tools. A study of matched metalworking plants in Germany and Britain (described in *Chapter* 4: *Human Resources)* found productivity two-thirds higher in the German plants, with most of the difference credited to training, especially of foremen. Computerized machinery worked far more smoothly in the German plant, with little downtime.

Table 6-3-Defense Production and Use of NC Machines in U.S. Manufacturing Establishments, 1988

	Number of establishments	Percent using NC machines
All establishments	39.556	41.4
Products made to military specifications		
Yes	14,588	58.1
No	19,439	36.1
Don't know[a]	2,141	38.4
Not specified	3.388	1.5
Prima defense contractor		
Yes: percent of products shipped to defense:		
1 to 25 percent	10,010	51.7
26 to 75 percent	1,012	62.5
Over 75 percent	683	61.2
Don't know[b]	601	37.3
No	22,874	41.2
Don't know[c]	1,028	42.0
Not specified	3,349	2.0
Subcontractor to defense		
Yes: percent of products shipped to prime defense contractor		
1 to 25 percent	11,533	53.7
26 to 75 percent	2,738	67.1
Over 75 percent	880	67.4
Don't know[b]	1,83	44.3
No	12,901	32.9
Don't know[c]	6,070	42.0
Not specified	3,605	4.1

NOTE: "NC machine tools" includes CNC machine tools.

a "Don't know" means the respondent didn't know what percentage of products are made to military specifications.

b "Don't know" means the respondent didn't know what percentage of products in the plant are shipped to Federal defense agencies or to prime contractors of defense agencies.

C "Don't know" means the respondent didn't know whether any of the plant's products are shipped to Federal defense agencies or to prime contractors of defense agencies.

SOURCE: U.S. Department of Commerce, Bureau of the Census, *Manufacturing Technology 1988*, Current Industrial Reports, SMT (88)-1 (Washington, DC: US Government Printing Office, 1989).

To summarize: the U.S. Government policy with most effect on both the invention and diffusion of CNC machine tools has been concern to meet military requirements. In Japan, the government supported efforts by machine tool builders to make incremental improvements in the known NC technology, and it underwrote diffusion of the technology to machine tool users through subsidized leasing, tax breaks, and technology extension services to smaller firms. In Germany, training was the

15For a detailed account of the development of NC controllers and machine tools in Japan, see Ezra Vogel, *Comeback (New* York, NY: Simon & Schuster, 1985).

most important contribution the government made to the production, diffusion, and effective use of computerized equipment.

None of this means that government policies were the only or most important factor in either the development or diffusion of NC machine tools in these countries. A great deal depended on the private actions and decisions of the companies and people involved. For example, Fanuc, under the direction of Dr. Seiuemon Inaba, has from the start combined excellence of product with exemplary manufacturing practice, in which the latest automated equipment is used to make reliable, inexpensive controllers. (In Fanuc's factory near Mount Fuji most of the machining and some of the assembly is done without operators.) American NC machine tool builders have been much slower to install the very kind of equipment they make-a case of the shoemaker's child, according to Anderson. Most important, Japanese designers applied microprocessors (an American invention) to CNC controls in 1976, a full 4 years before U.S. companies followed suit. That 4-year lead was probably decisive in giving Japanese NC machines first place in the U.S. market.[16] In 1988, half the NC machines sold here were made in Japan and, according to preliminary estimates, the Japanese share of the U.S. market rose to two-thirds in 1989.

Finally, the point that hardware is only one part of manufacturing success bears repeating. For example, studies of auto assembly plants in Japan, North America, and Europe for the International Motor Vehicles Program found that automation and a "lean' Japanese-style management system are each, separately, important factors in manufacturing performance.[17] But they contribute most to high productivity and high quality when they occur together. The best performing, world class companies (mostly Japanese) first established a lean management system, and then improved their performance with higher levels of automation. U.S. and European companies that automated first and then tried to improve their management of people and organization of work had a harder time reaching top performance.

LOOKING OUTSIDE THE FIRM FOR NEW TECHNOLOGIES

Incremental improvement of an existing product is part of the "cyclic development process" in manufacturing.[18] It is engineering-dominated, compared to the science-dominated process of making commercial products from radically new technologies bred in the laboratory. Despite its less dramatic character, cyclic development is no less significant than radical breakthroughs, for its cumulative effects can be profound. For example, just 20 years ago, memory chips held 1,000 bits. The newest generation of commercial chips are capable of holding 4 million bits.

If U.S. manufacturing firms have fallen behind foreign competitors in pursuing cyclic development, one reason is their backwardness in exploiting technological advances that originate outside the company (the NIH syndrome). A well-known study comparing R&D in a random sample of major firms, 50 Japanese and 75 American, found that the Japanese companies spent less time and money than their U.S. counterparts in developing new products and processes.[19] But the Japanese advantage lay entirely in innovations based on external technology. For innovations based on technology developed internally, U.S. companies performed as well as the Japanese. (The study did not attempt to assess what opportunities these large U.S. firms might have missed altogether because of their weakness in exploiting external technologies.)

The timing demands of the product development cycle suggest a possible reason for this seemingly impervious attitude. Ralph Gomory, former chief scientist for IBM, explains it this way:

> If you want to get new ideas into the development and manufacturing cycle from outside, timing is

16 A. Anderson, op. cit., p. 58.

17 John F. Krafcik and John Paul MacDuffie, ' 'Explaining High Performance Manufacturing: The International Automotive Assembly Plant Study,' paper presented to the IMVP International Policy Forum, May 1989, available from International Motor Vehicles Program, Massachusetts Institute of Technology, Cambridge, MA. The authors described the lean production system as one ' 'that runs 'lean' in its avoidance of problem-hiding buffers and stays 'fragile' in its willingness to rely on a skilled, flexible, motivated workforce for problem-solving and continuous improvement. "

18 This term and much of the following discussion is drawn from Ralph E. Gomory, ''Reduction to Practice: The Development and Manufacturing Cycle," in National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council, *industrial R&D and U.S. Technological Leadership* (Washington, DC: National Academy Press, 1988).

19 Edwin Mansfield, "Industrial Innovation in Japan and the United States, " *science,* Sept. 30, 1988.

> crucial. . . . You must propose these ideas at the *beginning* of the cycle. . . . Halfway through is too late . . . no matter how good the proposal, The company is not going to interrupt the cycle, delaying the whole project by a year and thus ending up with a noncompetitive product.[20]

It may seem that this constraint should apply to Japanese as well as to U.S. manufacturers. If it does not, or does less, one reason is that major Japanese industries contrive to keep the product cycle shorter. Thus, the point at which new ideas can be plugged in comes around faster. As noted in chapter 5, U.S. and European auto manufacturers typically take 63 months from design to introduction of a new model, while Japanese producers, on average, take 42 months-and use fewer engineering hours to do it. Likewise, Japanese electronics companies gained a critical advantage in the early 1980s when they got the 64K Dynamic Random Access Memory (DRAM) chip to market faster than most American producers; their success in taking the lion's share of this market early was one of the factors that drove all but three U.S. companies out of DRAM production. A shorter development cycle can be a particular advantage in a fast-moving field. The company that gets a product incorporating the latest technology to market soonest reaps the reward of the innovator-even if it was not the source of the new technology and has no monopoly.

Two of the major factors that enable leading Japanese companies to cut short the development cycle and get new products to market fast are in brief: 1) the supplier group system, in which subcontractors take on some of the design and development burden; and 2) frequent, close communication between the product designers and manufacturing engineers and rotation of people from design to production. This second feature may be thought of as a form of technology diffusion itself, one that takes place within the company.

The time constraints of the development cycle mean that people inside the firm must be instigators in collecting new technologies from the outside world. They are the only ones who know the cycle well enough to bring new ideas in at the right time. Government can help make this easier, by removing impediments to the transfer of technology from government-supported labs, and universities can structure cooperative research programs to mesh with industry needs.[21] But the main task of bringing the results of research to industry lies with a company's own engineers. Encouraging their engineers to attend professional meetings, read the literature, keep in touch with research in government and university labs, and learn about their competitors' products are necessary steps for companies that mean to keep up with the competition. Most big Japanese companies do it. So do many U.S. firms. Still, many U.S. firms regard outside activities for engineers as indulgences that might advance the engineer's own professional career but are of little direct benefit to the company.

Staying abreast of technology advance means keeping up with developments abroad as well as at home. In the past, U.S. manufacturers were good collectors of technical information from other countries and good imitators of new products and processes invented elsewhere. They had to be. Only after World War II did the United States become so pre-eminent in scientific research, and U.S. technology pre-war was by no means superior to that of other countries. Yet our dominance in manufacturing was established early in the 20th century, when the majority of scientific discoveries and a great many technological advances based upon them were still being made in Europe.[22]

In the postwar period, American industry has continued to adopt and develop commercial technologies of foreign origin (e.g., the jet engine, polyester fibers, the CAT scanner), but in some cases adoption by U.S. producers has been years behind the competition (e.g., radial tires and anti-skid braking systems for automobiles). A special problem is inattention to technologies from Japan. As the Japanese concentrate more and more on leading technology advances, rather than following and improving on what others have done, Japan's importance as a source of innovation is rising fast.

[20] Gomory, op. cit., p. 14.

[21] See ch. 7 for a discussion of how R&~ results from Federal laboratories and government-supported university research might be more effectively transferred to private industry.

[22] As early as the 1880s, U.S. manufacturing had already begun its rise to dominance, in part because the continental scale of the market allowed U.S. manufacturers to benefit from economies of scale and learning curve effects earlier than the Europeans. By the 1920s, the United States produced twice as much steel and electricity per capita as Europe's leading industrial powers, Britain, France, and Germany.

Interest in technology transfer from Japan to the United States is growing. Several public and private programs encourage U.S. scientists and engineers to learn Japanese, work in Japanese labs, and follow the Japanese technical literature. But the results of these programs are still modest. Most of the technology flow still runs the other way.[23]

TECHNOLOGY DIFFUSION TO SMALL FIRMS

Technological sophistication in small American manufacturing firms runs the gamut. Firms at the frontier of new technologies often start small; the Silicon Valley computer company that started in somebody's garage is legendary. On the other hand, the ranks of small manufacturing firms are also filled with shops that make humbler items. Significantly, small companies are suppliers of thousands of parts and components for major manufactured products that are leading items in the U.S. market and world trade (e.g., cars, computers, farm and factory machinery, medical instruments). The cost, quality, and prompt delivery of these supplies are key factors in the Nation's manufacturing performance. The level of technology in small American manufacturing firms-in product design, production equipment, organization of work, training and use of workers—is highly uneven. But technological backwardness is common enough to be a real drag on U.S. competitiveness.

For many small companies, the bedrock of technological competence is having up-to-date production equipment. It is not always easy for small firms in the United States to decide what equipment best fits their needs, or how to use it efficiently .24 Added to that are difficulties in financing; getting funds for the purchase of new equipment is usually harder for small fins, even creditworthy ones, than for larger ones, and it costs more.

More important than simple possession of advanced equipment is an educated grasp of how to use it. For example, staff members of several State industrial extension services report that small companies fairly often buy computerized equipment without fully understanding the training that workers-and managers as well—need in order to use the equipment; then, they often do not know where to turn to get the training. 25 Note also the studies mentioned above that compared German and British metalworking plants and found productivity much higher in the German factories. The difference was not in the age or sophistication of machines, which were much alike in both places, but in training.

As noted, NC machine tools are about as common in U.S. metalworking plants as in Japanese; and in both countries, small to medium-size plants (50 to 500 employees) have about the same proportion of NC machines as larger ones—11 to 13 percent of all the machine tools used in the shop (table 6-2). But in using the machinery effectively-especially in applying the soft technologies that involve organization of work and use of people—small Japanese firms seem to outperform American firms, at least in the flagship industries that have led Japan's economic growth and export success. An example is in the motor vehicle industry. Many U.S. suppliers of parts and components have not been able to meet the standards demanded by Japanese-owned auto companies operating in the United States. The small to mid-size U.S. companies that have established themselves as suppliers to the Japanese transplants have usually required months or years of training in Japanese methods (mostly soft technologies) before they could match the cost, quality, and delivery times of their Japanese competitors.[26]

Further evidence of the importance of things other than hardware to the performance of small manufacturing firms comes from Tokyo's Ota Ward, famous for its thousands of innovative small factories (of about 9,000 plants, 95 percent have 30 or fewer employees). Only about one-third of the metalworking firms responding to a 1988 survey had even one NC machine.[27] Evidently, most of Ota-ku's very small firms still rely more on their traditional

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23 For discussion of programs to encourage technology transfer to the United States from Japan, see ch. 7.

24 For a description of some of the problems small companies face in getting advice from consulting firms, see ch. 7.

25 In the past few years, a growing number of States have established programs to extend technical assistance and information to smaller manufacturing fins. OTA examined five of these programs in visits and interviews in 1988, as discussed in ch. 7. Findings from this examination also appear in Philip Shapira, "Industrial Extension: Learning from Experience, " contractor report to the Office of Technology Assessment, November 1988.

26 See the brief account below of the training of North American suppliers for NUMMI, the Toyota—GM joint venture.

27 Of 464 metal machining fires responding t. the survey, 150 (32.3 percent) said they had at least one NC/CNC machine tool. This was up from 18 percent in 1981, 22 percent in 1983, and 29 percent in 1986. Whittaker, op. cit.

strengths of flexibility, quick response to customers' needs, and worker skills than on advanced equipment.

The situation in Japan seems to be changing. Traditionally, Japan's smallest fins-especially those in sectors with no direct connection to the leading growth-and-export industries--have been backward. Many of the tiny "street-corner factories' in Japan are still quite primitive, with no heat, no indoor toilets, and only the simplest equipment. However, purchase and sales data collected by the Japan Machine Tool Builders' Association (JMTBA) suggest that small plants have recently kept up with their bigger brothers in purchases of computerized equipment. According to the MITI survey of establishments with more than 50 employees, 32 percent of machine tools bought in the 3 years 1985-87 were NC. In the same 3 years, the JMTBA figures show that 35 percent of *all the* machine tools sold domestically to *all sizes* of firms (including those with fewer than 50 employees) were NC.[28]

Anecdotal evidence also indicates that a wide range of up-to-date equipment can now be found in many small family-run factories in Japan. For example, one investigator who interviewed more than 100 small automotive subcontractors in Japan in 1986 reported that many were heavily equipped with advanced technologies, including NC machines, laser machines, robots, and computer-aided design. He described several scenes like this one:

> In one second-tier subcontractor of Isuzu I saw eight NC lathes, of which four were fed by robots. The rest were minded by two skilled workers, two semi-skilled workers and a part-time worker. The firm was being run by an entrepreneur whose wife was working as receptionist, secretary, finance manager and "Jack of all trades. " These were the entire personnel of the firm![29]

The success of small and medium-size Japanese manufacturing firms in the soft technologies and their recent rapid advances in installing up-to-date equipment owe a great deal to a web of supporting institutions, public and private. These include the transmittal of new technologies by major manufacturers to suppliers and a broad range of government programs for all small and medium-size manufacturers. These forms of technology transfer are uncommon, incomplete, or missing in the United States.

Major Companies and Their Suppliers

One of the many strong points of close, collaborative, long-term relations between lead manufacturers and their parts and components suppliers is that they favor transfer of technical know-how from the lead company down the supplier chain to medium-size and smaller companies.[30] In Japan, major companies often lend engineers and technicians to their first tier suppliers to help them learn how to use new equipment or arrange work more efficiently. It is also quite common for parent companies to advance funds to their subcontractors for operating costs+ specially in cases where the subcontractor's sales to tile parent company are expanding, but the subcontractor has to pay his own suppliers before he finishes work on the product, delivers it to the parent company, and receives payment.[31]

Sometimes parent companies help suppliers obtain financing for capital investment as well, but this practice is less common than in the past.[32] Japan today has so much investment capital that banks are aggressively looking for business among small and mid-size firms, since larger ones are able to meet most of their capital needs from retained earnings. However, small companies applying for a bank loan often find it is still a help if they are stable suppliers to a large, famous company.

[28] Japan Machine Tool Builders' Association, *Machine Tool Industry, Japan 1988* (Tokyo, The Association, 1988). The domestic sales figures are derived from figures on production, less exports, plus imports, omitting the category "Other Machine Tools"; they are in numbers of machine tools, not value. The JMTBA figures show that NC/CNC machines accounted for 36 percent of all Japanese domestic machine tool sales in 1985, 39 percent in 1986, and 30 percent in 1987.

[29] Toshihiro Nishiguchi, "Competing Systems of Automotive Components Supply: An Examination of the Japanese 'Clustered Control' Model and the 'Alps' Structure," paper prepared for the International Motor Vehicles program (Cambridge, MA: Massachusetts Institute of Technology, May 1987), p. 22.

[30] See ch. 5 for further discussion of how major Japanese manufacturers transfer technology to their suppliers.

[31] Yoshitaka Kurosawa, Japanese Development Bank and John F. Kennedy School of Government, Harvard University, personnal communication, Sept. 7, 1989.

[32] Toyota spokesmen, for example, told OTA in 1989 that financial aid plays no part in their close relations with suppliers; they concentrate entirely on technical advice.

Technical assistance remains a prominent feature in the relation of major Japanese firms to their suppliers. For example, Toyota's principles are to select good companies to begin with, communicate with them often from the very beginning of the relationship, and give technical assistance as often as needed to help the suppliers meet Toyota's unbending requirements for low cost, high quality, and prompt delivery. The suppliers must take an active part in raising their own standards. They know their problems better than anyone else, and must be involved in the solutions.

That the Toyota system of technology transfer to suppliers is no fluke, but is characteristic of Japanese manufacturers, was shown in a 1984 survey of manufacturing subcontractors, done by the Small and Medium Size Enterprise Agency *(chusho kigyo cho)* of MITI. Some 45 percent of respondents said they received technical assistance from a parent company, 37 percent received information, 28 percent were loaned or leased equipment, 24 percent got training for their employees, and 14 percent received financial assistance.[33] Moreover, 39 percent of respondents said they introduced new technology at the urging of parent companies (77 percent said the reason was to raise their technological level).[34]

In their survey of computerized automation in U.S. manufacturing, Kelley and Brooks found that close links between supplier firms and their customers, of a kind that would help or spur the suppliers to adopt computerized machinery, were not common in America.[35] But in the infrequent cases where such links existed, they made a difference. Only 3 percent of suppliers got any financial help from customers in buying new equipment; just 9 percent reported that their customers requested or required the use of computerized machinery. However, 20 percent of supplier firms said that customer firms had loaned engineering or programming staff. This kind of exchange was linked with a higher probability of having at least one computer-controlled machine in the supplier firm, suggesting that the loan of technical people from a customer firm to a supplier is an important conduit in the transfer of up-to-date technology.[36]

As noted earlier, the joint Toyota-GM venture, New United Motor Manufacturing, Inc. (NUMMI), is an outstanding U.S. example of technology transfer from a lead manufacturer to suppliers. After 4 years of interaction with NUMMI engineers, North American suppliers of parts and components for the autos assembled in NUMMI's Fremont, CA plant were able to match Japanese suppliers in cost, quality, and delivery time.[37] The NUMMI case exemplifies technology transfer not only from auto assembler to supplier, but also from Japan to the United States.

In Japan, the vertical transfer of technology sometimes develops to such a point that suppliers take over major functions formerly performed by the lead manufacturer. For example, both Toyota and Nissan have totally delegated assembly of some of their cars to companies that were formerly suppliers of major components. This strategy *(itaku seisan,* or consignment manufacture) enables the lead manufacturer to concentrate on high-volume production of a relatively small number of platforms,[38] while spinning off to its deputies the production of cars that are low or fluctuating in volume. In the Toyota group, for instance, Kanto Auto Works produces three different platforms on one assembly line; namely, the high-volume Corolla, the luxury passenger car Mark II, and the low-volume sports car MR2. Thus, Toyota exploits the economies of high-volume mass production in its home factory, while preserving the flexibility to make a varied range of products in the factories of its consigned assembiers.[39]

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33 Whittaker, op. cit., p. 23, citing Chusho kigyo cho (Small and Medium Size Enterprise Agency) cd., *Chusho kigyo hakusho* (SME White Paper) (Tokyo: Okurasho insatsu kyoku, 1985).

34 Ibid.

35 Kelley and Brooks, *The State of Computerized Automaton (1988)* op. *cit.*

36 The probability of a supplier's adopting computer-controlled machinery with no technical support from customers was estimated at 0.49; with customer-provided technical support, the probability rose to 0.58—about 20 percent higher.

37 In this case, much of the technology transferred was soft. Suppliers learned to apply Toyota's lean production system, with its emphasis on teamwork, training, and getting it right the first time, rather than relying on a cushion of big inventories of parts and work-in-process, to compensate for late deliveries and poor quality.

38 A "platform" refers to all cars produced on the same wheelbase; one platform may include several different models-cars with different sheet metal skins and interiors.

39 Nishiguchi, Op. cit., pp. 10-12.

Companies farther down the chain of suppliers sometimes employ a similar strategy of first transferring technology to the level below them, and then turning over major tasks to their feeder fins. Not infrequently, talented employees of small third or fourth tier companies leave to form their own companies, but they still maintain close ties with their former bosses, working for them as sub-subcontractors. The ex-employers consider this hiving off natural, and often help out the new firm with technical assistance, sometimes even financing.[40] In their view, skilled, enterprising workers are likely to be more productive when working for themselves than when working for somebody else, especially in a small family-run firm where advancement possibilities are limited.

Nishiguchi offers the example of a subcontractor who specialized in prototype manufacture for the electrical, motor vehicle, and precision instrument industries. His strong suit was meeting short deadlines; for this he could command premium prices. He furnished his own factory with a facsimile machine and such up-to-date equipment as CAD/CAM systems, laser milling machines, and CNC machines, and he cross-trained his workers on several kinds of equipment. Beyond this, he set up an ''educational factory" nearby, where he trained selected workers, lent them money to buy machines and, after a year or two of training, provided financing for them to set up their own businesses, attached to the mother firm. In 1986, when Nishiguchi interviewed him, this man had a network of 62 subcontractors-all equipped with advanced machinery-30 of whom had been incubated at his firm. When he received a rush order on his facsimile machine, he could spread the work out among his own employees and his subcontractors, and often deliver the order within hours.[41] The result of such ties between patron companies and suppliers is superior flexibility, combined with advanced technology.

Japanese Government Programs for Small and Medium-Size Firms

In Japan's combined public-private support system for small and medium-size manufacturing fins, the government role is pervasive.[42] Spending and loans by the national government for help to all small business (including non-manufacturing) amounted to about 4.4 trillion yen in 1989, or $31.2 billion at 140 yen to the dollar. Of this, only $1.4 billion appeared in the regular general account budget, which is supported directly by taxes. The rest, $29.8 billion, was in the Fiscal Investment and Loan Program, a capital budget often called the second budget, which derives its revenues from government trust funds and the country's huge, government-subsidized postal savings program.[43] Altogether, spending for small business programs amounted in 1989 to nearly 5 percent of the total regular and capital budgets of the national government.[44] This sum does not include spending by prefectures, cities, and city wards, which also contribute handsomely to programs for small businesses, matching the national government's contribution in some cases.[45]

Modernization of small firms has long been a concern of the Japanese Government; some loan programs targeted to small businesses date back more than 20 years. Reasons for the focus on small and medium enterprises (SMEs) are social and political as well as economic. SMEs play a very big part in the Japanese economy. In 1986, in the manufacturing sector alone, SMEs (300 or fewer regular employees, and capitalized at 100 million

[40] Ken-ichi Imai, Ikujiro Nonaka, and Hirotaka Takeuchi, ''Managing the New Product Development Process: How Japanese Companies Learn and Unlearn," in Kim B. Clark, Robert H. Hayes, and Christopher Lorenz, *The Uneasy Alliance: Managing the Productivity-Technology Dilemma* (Boston, MA: Harvard Business School Press, 1985), pp. 365-366; also, Mari Sake, "Neither Markets nor Hierarchies: A Comparative Study of Informal Networks in the Printed Circuit Board Industry,' Lecturer, Industrial Relations Department, London School of Economics and Political Science, mimeo, May 1988.

[41] Nishiguchi, Op. Cit., pp. 23-24.

[42] The material in this section is drawn mostly from D.H. Whittaker, "New Technology Acquisition in Small Japanese Enterprises: Government Assistance and Private Initiative,' contract report to the Office of Technology Assessment, May 1989; and from OTA interviews in Japan in March 1989. Yoshitaka Kurosawa, on leave to Harvard University from the Japanese Development Bank, contributed additional information in a letter to Julie Fox Gorte, OTA project Director, dated Sept. 7, 1989.

[43] The main government subsidy for postal savings is in the form of a tax exemption for interest. Also, during the many years that Japanese financial institutions were strictly regulated, the interest rate on postal savings was higher than for time deposits elsewhere.

[44] In fiscal year 1989, the total budget of the Japanese national government was 92.7 trillion yen ($662 billion), including 60.4 trillion yen in the general account, and 32.3 trillion yen in the Fiscal Investment and Loan Program. Japan Economic Institute, *JEI Report*, May 12, 1989.

[45] For example, in fiscal year 1988, the prefectures matched the national government's provision of 2 billion yen ($154 million) fOr the Equipment Modernization Loan System and the Equipment Leasing System for smaller enterprises.

yen or less) represented 99.5 percent of establishments, 74.4 percent of employees, and 56.5 percent of value added.[46] At the same time, wages in these small manufacturing firms are at least 25 percent lower than in the major companies, working conditions are frequently dismal, and technologies have often lagged behind the leaders. Besides these reasons for government concern, there is the political fact that small business has been a steadfast, strong supporter of the ruling Liberal Democratic Party. Every election brings new pledges of measures to improve the climate for small business.

The Japanese national programs for SMEs include both financial and technical assistance, and the two are intertwined. In the 1980s, special attention has been given to programs aimed to help small business adopt high-tech equipment such as computerized machinery and robots. Some key assistance programs that encourage purchase of advanced equipment are open only to still smaller firms, with no more than 20 to 100 employees.[47]

Among the multiple services the government offers SMEs are a big program of direct loans for operating funds or plant and equipment investment and a still bigger program of government guaranteed loans. Other services include: a system to lease new equipment to SMEs on generous terms or sell it on the installment plan; loans to groups or cooperatives of SMEs; management analysis for individual firms —a condition for government loan approval; public testing and research centers, where SMEs can use expensive equipment for a nominal fee and can consult with engineers on technical problems. SMEs also get tax breaks for investment in new equipment, especially high-tech equipment. For example, a 1984 law allows SMEs the option of taking a special first year depreciation of 30 percent for investments in electronic and ''mechatronic' technology, which includes NC machine tools, computers, and robots.

The national government, mainly through MITI and the Ministry of Finance, is the grand overseer of the SME programs and is the top provider of funds. The actual dealings with business people fall to the prefectural and local governments, and to quasi-public organizations such as chambers of commerce (in cities, or "societies of commerce and industry" in towns and rural places) and federations of small business associations.

In 1987, loans to SMEs via the three main government financing institutions amounted to 3.8 trillion yen, or $27 billion.[48] Japanese loan guarantee programs for SMEs are still larger. The 52 nationwide credit guarantee associations underwrote 7.8 trillion yen ($56 billion) in loans to SMEs in 1987. By way of comparison, U.S. small businesses (up to 500 employees) got $47.3 million in direct loans from the Small Business Administration in fiscal year 1989, and loans were restricted to special disadvantaged groups. Federally guaranteed loans are available more generally to U.S. small businesses; they amounted to $3.6 billion in 1989. These figures are only illustrative; they do not include, for either country, financial aid available from State (or prefectural) and local governments. And, to put the comparison in perspective, small businesses play a bigger part in Japan than in the United States. Even considering the larger size of the U.S. economy, small and medium-size manufacturing firms are more numerous and employ more people (10.7 million v. 6.8 million) in Japan than in the United States. Finally, keep in mind that these figures for government loans and loan guarantees are for all small businesses in both countries, not just for manufacturing firms. With all this, it is still notable that the Japanese Government provides about 20 times more financial aid to small business than the U.S. Government does.

Even so, government financing is not as important to Japan's SMEs as it was just a few years ago. (Box

[46] By comparison, in the United States in 1986, small businesses (enterprises with fewer than 500 employees) represented 85 percent of manufacturing establishments, 35 percent of employment, and 21 percent of value added. An establishment is a single physical location where business is conducted. An enterprise is a business organization consisting of one or more establishments under the same ownership or control. *The State of Small Business: A Report of the* President transmitted to the Congress, 1989 (Washington, DC: U.S. Government Printing Office, 1989), p. 21; table 13, p. 21; table A. 15, pp. 80-81; table A.20, pp. 92-93.

[47] Japanese firms with fewer than 100 employees constitute 97 percent of establishments, 55 percent of employment, and 39 percent of value added in private manufacturing in Japan; comparable figures for firms with fewer than 20 employees are 87 percent of establishments, 29 percent of employees, and 15 percent of value added.

[48] This figure is net of repayments; it includes 1.80 trillion yen from the chushokigyokinyu (Small Business Finance Corporation), 1.85 trillion yen from the kokumin kinyu koko (Peoples' Finance Corporation) and 128 billion yen from the shoko chukin (which is not always included in the group of government financial institutions because it raises part of its funds from association members). The gross amount of loans made to SMEs in 1987 by these three institutions was 5.6 trillion yen—2.26 trillion, 2.89 trillion, and 493 billion yen respectively.

6-A offers a Yokohama factory owner's account of his "graduation" from government financing and technology transfer programs over the years.) In the late 1980s, with the quick recovery from the rise of the yen and the great prosperity that followed, Japan was awash in capital. The august city banks, which once gave most of their attention and funds to large companies, were now scrambling to do business with SMEs. In March 1981, for example, 25 percent of city bank loans went to SMEs, but by August 1988 the figure was 64 percent. Even though the government loans are usually pegged at lower rates-e. g., 4 percent instead of 5 percent to individual firms in 1989, as low as 2.7 percent when provided through cooperative associations, and zero for the government's half share of certain equipment modernization loans-companies often prefer the greater simplicity of dealing with a bank.

Government loans are still an essential source of financing for small startup companies with no track record, for firms changing direction, and as a safety net in times of adversity. For example, many of the 9,000-odd small manufacturers in the Ota ward of Tokyo were hard hit by the yen's rise in 1986-87. In those 2 years, Ota-ku's firms borrowed 1.5 billion yen ($11.5 million) in emergency loans to cover operating costs. But the overall trend in the late 1980s was for private loans to edge out government financing. Government loans dropped from 13 percent of all outstanding loans to SMEs in 1980 to 9 percent in 1988. These figures understate the government role in financing of SMEs, however, because they omit the system of loan guarantees. And despite the decline of Japanese Government financing for SMEs, the volume remains huge in U.S. terms.

Besides its big, general program of direct loans available to all SMEs, the Japanese national government offers a whole menu of SME ''measures,' funded at about 225 billion yen ($1.6 billion) in 1987. Among these are two special programs designed specifically to encourage SMEs to acquire modern technology. One of these, the Equipment Modernization Loan System, made 6,000 loans in 1987, totaling 41 billion yen ($293 million) in 1987. The program is open only to firms with 100 or fewer employees, as shown in table 6-4. It provides up to half the amount of the funds needed for the modernization project; notably, that half is interest free. According to officials of MITI's Small and Medium Enterprise Agency, no collateral is required for these government loans because commercial banks can provide loans requiring collateral.[49]

The Equipment Leasing System, through which firms can lease new equipment or buy it on the installment plan, is another key technology-promoting measure. Nothing better illustrates the Japanese policy of fusing financial assistance with promotion of technological advance than this program. Founded in 1966 and open only to firms with 20 or fewer employees, its direct purpose is to help small, struggling companies invest in new equipment at affordable terms (easier terms than those offered by private leasing companies, and easier even than the Equipment Modernization Loan System). The system has the added effect of providing a quite substantial, assured market for producers of capital equipment suitable for small shops, especially machine tools. A high-tech equipment and machinery leasing system, added in 1986, is open to firms with as many as 80 employees, giving added support to the market for such things as NC machine tools, robots, and computers. In 1987, about 4,500 leases or installment purchases, amounting to 49 billion yen ($350 million) were made under this program. About one-third of the loans and leases went to SMEs producing machinery and other metal goods, mostly for buying or leasing NC machines .50

In this connection, it should be noted that the government is also a partner in quasi-private leasing companies that serve large as well as small companies. For example, the Japan Electric Computer Corporation (JECC), founded in 1961 to buy computers and lease them to users at subsidized rates, got half its capital from the Japan Development Bank, a government institution. The similar Japan Robot Leasing Company (JAROL) was founded in 1979, with 60 percent of its capital coming from the Japan Development Bank. In addition, in 1980 the Small Business Finance Corporation allocated funds specifically for loans to small businesses buying robots.[51] The existence of these leasing and loan

[49]OTA interview with Kazuhiko Bando and Kazumi Suda, Small and Medium Enterprise Agency (*chusho kigyo cho*), MITI, Mar. 16, 1989.

[50]In Tokyo, 37 percent of the loans made under the Equipment Modernization program in 1987 were for buying CNC machines. (Tokyo Metropolitan Government Labour Economics Office, untitled mimeo, 1989, cited in D.H. Whittaker, op. cit.)

[51]Ezra Vogel, Comeback (New York, NY: Simon & Schuster, 1985), pp. 90, 122-123.

Box 6-A—A Small Plant in Yokohama

Showa Precision Tools Co., Ltd., of Yokohama, Japan makes plastic processing dies, blanking dies, progressive dies, and measuring and testing equipment.[1] The company's name is well chosen. Everything about its newly built factory in Kanazawa Industrial Park speaks of precision, from the understated architecture of the front office to the neatly pressed company uniforms worn by the company president and founder, Mr. Masanari Kida, and his chief engineer, Mr. Y. Yokoyama. Showa tools are esteemed for their quality and design. Because of that reputation, the company is prospering. The first sentence in the company outline booklet says, "We are enjoying a convenient life, thanks to the tools and machinery which have been developed. "

Although Showa provides all its own capital now, Mr. Kida is well acquainted with Japanese Government programs that offer financing for small and medium enterprises. Showa made frequent use of them from the time it was founded 30 years ago until about 10 years ago. Even more recently, when Showa built a new factory in Kanazawa Industrial Park, government financing filled a gap. Mr. Kida had the proceeds from the sale of his old factory and a substantial loan from a bank, but was still short of what he needed for new machinery. Financing from the government's small and medium enterprise program made up the difference.

Although government financing is cheaper than a bank loan—the difference is a percentage point or so, or about 4 percent instead of 5 percent-going through government programs is a hassle, Mr. Kida said. "If I go to the bank, I can get the money today," he explained. "If I borrow from a government program, it takes a month, and I have to fill out a lot of forms. This hassle is still worth it, he believes, for brand new businesses that have no track record or an established relationship with a bank. Indeed, government financing was essential for Showa in its earlier years.

One part of the government program is still useful to Showa———technical advice. When Mr. Kida last used government financing, advisors from the guidance center in the Yokohama city office gave him an analysis of his financial arrangements. At his request, an advisor also evaluated some of his plans for new machine purchases. His relationship with that advisor has lasted to the present day through the city's yearly management service, which provides technical information and evaluation to small and medium-size firms. In return, the advisor uses the information he gets about the firm to enlarge his understanding of technology use and other conditions of small businesses. The service also gives Mr. Kida general information on what his competitors are doing.

Firms like Showa can also get some training from the Yokohama city office. On request, the office will send a sensei (teacher, or master) to train the employees total quality control techniques. This training is fairly extensive. Between June and October 1988, the *sensei came* to Showa for eight 2-hour sessions to train 14 group leaders (these are quality circle group leaders, not necessarily the formal authority figures). The ***sensei*** brings written materials **to every** class, and then the group leaders are responsible for teaching the other people in the-group. The lessons were:

- What Are Small Group Activities?
- Why Are Group Activities Necessary?
- Small Group Activities and Total Quality Control
- What Is Quality?
- How To Introduce Small Group Activities
- Let's Master Quality Control Methods
- The Way of Leadership
- How To Succeed in Small Group Activities

The lessons do not accomplish miracles. Although the classes may get the group leaders ail fired up, other workers are not always so enthusiastic. However, the group leaders do impart to others in the group what they learn, and eventually the lessons of Total Quality Control are learned by all. Mr. Kida did not think the services offered by Yokohama prefecture were unique. He admitted that Yokohama and Kanagawa were more positive about such activities than other prefectures-but only a bit more.

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[1]Information for this box comes from interviews conducted by OTA staff in Yokohama, March 1989.

Despite its present independence from government financing, Showa is still part of a government-supported cooperative association for small companies. Members can get up to 65 percent of their investment costs from the small and medium enterprise public corporation, at 2.7 percent interest. The maximum term of such loans is 15 years, and the money is provided for additions to plant and equipment. The preferential financing is a strong incentive to join a cooperative association. There is also a down side to joining. Money borrowed as a group has to be repaid as a group, so if one member fails or gets into trouble, all the other members are responsible for his debts and his recovery. Also, the land belongs to the group, and every inch of the precious stuff is used. So, if a company wants to expand, it can do so only if someone else in the group goes under and their land becomes available, and even then approval of the group is needed. Others may want to expand, too.

In response to questions about the drive to innovate in small fins, Mr. Kida's unhesitating answer was competition. 'You must innovate or you get beaten,' he said. Since 1986, Showa has bought 11 new NC machines. and now about 70 percent of all his machines are NC. He never leases the machines, on principle, because leasing costs a bit more than buying. However, companies that can't secure the capital up front need to be able to lease machines. Like government financing programs, leasing is a nice option for fledgling companies.

Mr. Kida has an extra incentive to be right at the cutting edge of new technology. His business is an independent one, not in anyone's supplier group or *keiretsu.* Companies in cooperative associations tend toward being more independent, according to Mr. Kida. Many firms would like to be on their own, but it is harder than being somebody's supplier. ''If you want to be independent, you have to study unceasingly,' he says. He gets no technical advice from his customers, although engineers do come from customer companies to discuss their technical requirements. He has never gotten any financial assistance from a customer, either. But even in companies that are in a supplier group, the parent companies are giving less advice and less financing than they used to, perhaps because it isn't necessary, and perhaps&cause of other changes in the environment of large companies—-moving offshore, for example.

Finally, Mr. Kida was asked why he didn't just sell up. "You could be a millionaire, and live anywhere you wanted," said the interviewer. "You could buy a *ramen* (noodle) shop, and stop the struggle. " Mr. Kida seemed speechless at the thought, so Mr. Yokoyama, the chief engineer, answered. He was horrified at the suggestion. "We have 100 employees here," he said earnestly, "and they have families. That's 400 people. We're responsible for those people. What would they do if the owner bought a ***ramen*** shop? Where would they go? No, we have to stay in business. Four hundred people depend on this business. '

Table &4-Japanese Government Equipment Modernization Loan and Equipment Leasing Systems for Small and Medium Enterprises

	Equipment leasing system			
	Equipment leasing (installment plan)			Equipment leasing
	Equipment modernization loans system	General equipment	High-tech, information processing equipment	High-tech, information processing equipment
Main recipients	Small and medium enterprises with 100 or less employees	Small and medium enterprises with up to ***20*** employees	Small and medium enterprises with up to 80 employees	Small and medium enterprises with up to 80 employees
Maximum amount of loan or value of leased equipment	Half of funds required up to 30 million yen	Equipment worth up to 25 million yen	Equipment worth up to 50 million yen	Equipment worth up to 50 million yen
Interest or charge	Free	4.5% of the cost of equipment as per annum charge (an additional 1 0°/0 guarantee money is required)	4.5% of the cost of equipment as per annum charge (an additional 10% guarantee money is required)	About 7°% as per annum charge (including tax and insurance premium)
Period, ... , ...	5 years with l-year grace period	4 years and 6 months (11 years and 6 months for anti-pollution equipment)	6 years and 6 months(11 years and 6 months for anti-pollution equipment)	Up to 7 years (84 months)

SOURCE: Ministry of International Trade and Industry, Small and Medium Enterprise Agency (*chusho kigyo cho*) SMEA mimeograph, 198 (untitled) programs assured equipment producers of a solid market, which probably encouraged them to gear up for expanded output-even though, as it turned out, not all the programs were heavily used. For example, purchases of robots by Japanese firms turned out to be so great that JAROL leased only 790 units in 1982, when shipments were almost 10,000.[52]

Still other national government "special measures" are designed to help bring SMEs up to speed technologically. According to MITI officials, the SME programs were originally formed with the view that small companies needed information more than financing. To get public financing under some programs, firms must have a management analysis, paid for by government funds and provided free by local governments, associations of commerce, or federations of small business associations. Often the analyses focus on finance, sales, and marketing, but advice on technology and production methods is also given. As illustrated by Mr. Kida's experience (box 6-A), small businessmen may form a lasting relationship with the person who does the original analysis for the loan, often coming back repeatedly for consultation on technical or other business matters.

Public testing and research centers also play a big part in technology diffusion, Japan had 185 of these centers in 1985, with 7,000 employees and an annual budget of 66 billion yen (about $470 million), half from the national budget and half from the prefectures. SMEs can come here and, for a small fee, use inspection equipment that is too costly or used too seldom to make purchase worthwhile. They can also find consulting engineers for research and advice on special problems, and they can bring the consultants to their own factories if necessary.

Local technology demonstration centers supplement the national testing and research centers. The industrial hall in Tokyo's Ota ward is a good example. Advisors at the hall have regular consultation hours for the Ota-ku's thousands of tiny businesses—Tuesday, Thursday, and Saturday, from 10 to 4, on mechanical matters, and the alternate weekdays on electrical matters. The hall has about 500 consultation meetings a year in seven areas. In order of popularity, they are: machines, measuring devices, materials, machining process, electrical problems, controllers, and a miscellaneous category including legal problems. An example of an electrical problem: there are frequent, unpredictable daily fluctuations in the voltage delivered by the city. Small businesses need to learn how to cope with the fluctuations and how to make machinery last in spite of them. According to the managers of the hall, small firms could figure out many of these problems themselves, but they don't have time.

Besides these regular consultations at the hall, which are free, firms may ask advisors to visit their plants for a fee of 10,000 to 20,000 yen a day (about ***$70 to $140).*** For knottier problems, firms may be referred to the Technology Experimental Center in metropolitan Tokyo, which has about 160 highly qualified consultants—30 in technical fields—and 200 technical advisors (this is one of the 185 national public testing and research centers). Another service the Ota industrial hall offers is use of specialized measuring and calibrating machines, at a fee of about $4 for half a day. In addition to all this, the hall puts on exhibitions three times a year showing machines made in the wards to buyers in the area. Sometimes buyers from other countries are invited as well. Occasionally, the prefecture exhibits Ota-made machinery at shows in other places.

According to surveys of small businesses, public programs rank low on the list behind parent companies and machine and equipment makers as sources of technical information. This is no reflection on the public programs; services like those at Ota-ku's industrial hall are used by SMEs and seem to be well regarded.[53] It is more an indication that the level of technology diffusion to SMEs in Japan, including the active role taken by parent companies, is extremely high. The role of parent companies may be diminishing a bit, however, as the bonds between parent companies and subcontractors are weakening somewhat, The reasons are first, that major firms are doing more subcontracting offshore; and second, that small supplier firms, more prosperous than ever

[52] Kenneth Flamm, "Changing Pattern of Industrial Robot Use, " in Richard M, Cyert and David C. Mowery (eds.), *The Impact of Technological Change on Employment and Economic Growth* (Cambridge, MA: Ballinger Publishing Co., 1988), p. 299. According to Vogel (op. cit.) virtually no robots were exported from Japan in the early 1980s because domestic demand was so great.

[53] The small business owners interviewed by OTA staff in Japan spoke favorably about government technical assistance. One, who said he generally prefers his own resources to government programs (though he had taken a large government loan to finance a new building for his factory), had no reservation in praising the Tokyo technology center. He goes (here about once a month for testing of materials and inspection services. The service is cheap-about 3,000 yen per visit—and the consulting engineer is very kindly and knowledgeable (''a good study person' '),

before, are able to be more independent. In Ota-ku, officials say, about 1,000 of the 9,000 manufacturing firms are now independent, with no strong ties to major firms. Many of these companies can make good use of public technical assistance. The government is encouraging small independent firms to form cooperative associations, to work together on R&D and share technical, management, and marketing information among themselves (see the discussion below on horizontal links between small firms).

Government programs offer specific help to startups, in addition to loans. An example of public-private partnership to encourage high-tech startups is the Kanagawa Science Park (near Yokohama). Building began in 1989. When completed, it will provide common research facilities, including precision measuring and calibrating equipment, plus the usual business incubator services such as accounting and payroll. It is intended to be a communications center as well, the hub of an electronic information network that will extend to many businesses in the prefecture. Finally, there are plans to make the Science Park an international convention center--complete with hotels, banks, and restaurants-designed especially to serve resident companies. The Science Park is set up as a stock company, with construction and initial subscriptions financed by funds from the Yokohama Bank and the Kanagawa prefecture. Other prefectures are planning similar schemes, but Kanagawa is the first to take action.

To sum up, financing new technologies seems to be no big problem for Japanese SMEs, and the abundance of government assistance is surely one reason. Where small U.S. firms may find the availability of capital a real barrier to investing in modern equipment (e.g., a CNC machine tool), their Japanese competitors can turn their attention to whether the equipment precisely fits their needs, whether it is better to buy it or lease it, and whether getting a 4 percent loan from the government rather than a 5 percent loan from the bank is worth the bother of waiting a month instead of a day. In addition, technical assistance is very broadly available from many sources, often linked with some kind of financial assistance. Small manufacturers in the United States are not nearly so richly supplied with guidance in adopting and using new technologies.[54]

Horizontal Links Between Small Firms

Another way to promote the widespread adoption of advanced technology, down to the level of tiny family-run firms, is through horizontal networks that give member firms help in developing and acquiring new technologies, and advice on financing, management, and marketing as well. Such systems are prominent in the textile and metalworking industries of both Japan and Italy. They can be found elsewhere too, as in Denmark's textile and furniture industries. These networks involve a considerable degree of cooperation and information-sharing among competitive fins-practices that are quite foreign to U.S. business tradition. In some countries, the networks are supported by a range of government programs that are mostly missing in the United States.

A well-known example of horizontal links among small firms is in the northeast-central part of Italy, known as the Third Italy .55 Networks of small, technologically sophisticated textile and metalworking firms began to develop in this region in the late 1960s. By the early 1980s, these small enterprises were supporting a prosperous economy. In Emilia-Romagna, for instance, manufacturing wage rates in 1980 were 125 percent of the Italian average. In 1985, the region ranked second among Italy's 21 regions in per capita income, having risen from 17th in the 15 years since 1970.

The cooperative networks that were key factors in the region's economic success were founded with the help of local governments, but later on were largely financed and operated by the firms themselves. Artisans' trade associations, technical schools and universities, and labor unions have also supported the networks' programs. The networks provide technical advice on new equipment, products, and processes; financial help in acquiring new

[54] See the discussion in ch. 7.

[55] The many writings on cooperative networks in the Third Italy include Giacomo Becattini, "The Development of Light Industry in Tuscany: An Interpretation," *Economic Notes*, vol. 3, 1978; Sebastian Brusco, "The Emilian Model: Productive Decentralization and Social Integration," *Cambridge Journal of Economics, vol. 6, No. 2, 1982;* Michael Piore and Charles Sabel, *The Second Industrial Divide (New* York, NY: Basic Books, 1984); Edward Goodman, Julia Bamford, and Peter Saynor (eds.), *Small Firms and Industrial Districts in Italy* (London and New York: Routledge, 1989); Daniella Mazzonia and Mario Pianta, "An Innovation Strategy for Traditional Industries: Experience of the Italian Textile Districts of Prato and Como," mimeo, September 1986; Robert E. Friedman, "Flexible Manufacturing Networks," and Richard C. Hatch, "Learning From Italy's Industrial Renaissance," in Corporation for Enterprise Development, *Entrepreneurial Economy*, July-August 1987.

machinery and training in using it; business services such as making up payrolls and sending out bills; and advice on markets and assistance in parceling out work on large orders. Local governments, together with the artisans' trade associations, have also developed industrial parks where factory space is offered at reasonable, stable rents. The concentration of small firms in the same area carries an added bonus, making it easier for the firms to divide up large contracts or find subcontractors if they get jammed with too much work at one time.

A notable feature in the small firms that makeup these manufacturing networks is their use of advanced equipment. Part of the reason lies in the nature of the industries--cloth and clothing, shoes, furniture, metal parts for machinery or precision instruments. The investment needed for an efficient unit of production in such industries is not formidably high. A cluster of CNC machine tools or electronic sewing machines or weaving machines is not beyond the financial means of a family-run enterprise-especially when help in arranging financing is available to the small firm, as it is in this part of Italy. Loan guarantee cooperatives (established by the trade associations) may arrange preferential bank financing for buying the equipment; alternatively, members of artisans' trade association can lease machinery. Not only is the equipment affordable but objective advice on what to buy and consultation on using it is also available from Service Centers serving specific industries (organized by trade associations together with local governments, labor unions and other business groups).

Government support of the networks is mostly confined to the regional and municipal levels. The national government has had little to do with it. The distinctively Italian Eurocommunist government of Emilia-Romagna was the pioneer, but rightist regional governments, such as the Christian Democratic one in the Veneto, have also lent their support. As noted, the major contributions from the regional government were made at the beginning, in the form of financial and planning support for starting up networks.

Whether these largely voluntary horizontal networks are sturdy enough to last through changing economic conditions is an emerging question. Vertical as well as horizontal networks have always been a part of the scene in the Third Italy; many small firms are regular subcontractors for big enterprises (e.g., Benetton in apparel). However, the presence of strong horizontal networks has probably given small firms an extra measure of independence and bargaining power. Today there may be a trend toward greater dominance by lead firms. A recent study of the textile districts of Prato (in Tuscany) and Treviso (in Veneto) and the food-producing machinery sector in Emilia-Romagna found increasing top-down control.[56] The pattern is for small firms to continue decentralized production, but under the growing financial and strategic control (including the choice of technology and subcontractors) of locally dominant firms or outsider corporations.

Japan also has regional centers that are outstanding examples of network manufacturing, especially in metalworking and textiles. Sakaki Township in rural central Nagano Prefecture is one such.[57] This mountainous little community, with a population of 16,000, had 321 manufacturing enterprises in the mid- 1980s, of which 257 had fewer than 10 employees and only 4 had more than 300. Among them, these firms owned nearly 600 computer-controlled machine tools.

Sakaki's small metalworking firms began to flourish in the 1960s, at first on the basis of auto subcontracting. They have since become much more diversified, branching out into general machining, electronics, and plastics, thus escaping dependence on the extremely demanding auto industry. The financial underpinning for this growth was Japan's extensive national program of government loans and loan guarantees to small business, administered by the local association of commerce (shokokai). The *shokokai* provides technical support along with its financial aid, reviewing the plans of borrowers and often proposing specific changes. It routinely arranges classes in computer programming to supplement the basic introductory course given by the manufacturer of NC machine tools, and sometimes

[56] Bennett Harrison, "Concentration Without Centralization: The Changing Morphology of the Small Firm Industrial Districts of the Third Italy," paper presented to the International Symposium on Local Employment, National Institute of Employment and Vocational Research, Tokyo, Sept. 12-14, 1989.

[57] For a detailed description of the regional metalworking industry of Sakaki Township, see David Friedman, *The Misunderstood Miracle: Industrial Development and Political Change in Japan* (Ithaca, NY and London: Cornell University Press, 1988), ch. 5.

brings in specialists to help individual companies with particular problems. In Sakaki, factory operators say that they know more about using the equipment than the large firms they supply .58

In the Japanese textile industry, big firms predominate upstream in fiber making and spinning.[59] But weaving and knitting is done mostly in small family-run firms with no more than 20 looms (usually installed in a shed or annex to the weaver's home), a few family-member workers, and two or three employees. This system of family weaving is an outgrowth of the centuries-old custom of landlords providing looms for tenant farmers to use in the winter slack season. With land reform, the tenants became owners. These tiny enterprises are well--suited to producing short runs to order—a good fit with the Japanese textile industry strategy of competing on the basis of diversity, high quality, and responsiveness to customers' needs.

Most of these small firms are part of vertical networks; they are tied to one of the great spinning companies or to trading companies that supply them with yarn, buy their cloth and, quite commonly, give them free technical advice. A second important source of technological help is the regional industry cooperatives. These are voluntary associations, funded mostly by members but aided by the many government programs for SMEs and cooperatives. Typical activities are to organize training programs in new techniques and the use of new machinery, and to help firms apply to special industry banks that serve small and medium-size firms for government guaranteed loans. Some cooperatives are more active. For example, the Nishiwaki Weaver's Cooperative, located in a rural area, owns and leases to members about 2,000 of 11,348 looms in use by the membership. Typically, the cooperative pays two-thirds of the purchase price and the weaver pays one-third, plus lease payments for the remainder. The cooperative may also guarantee loans for members who want to buy looms outright.

The state-operated system of research institutes also helps small firms keep abreast of new technologies. Japan has 46 textile research institutes in its 47 prefectures. Besides collecting industry information and providing a computer connection with the Scientific Research Center in Tokyo, the institutes conduct experiments and research for small firms, charging a fee for service. The research is directed toward practical problems (e.g., why a color may fade), rather than broader, more basic topics that would interest a university research team.

The Japanese networks, much more than the Italian, have solid, consistent support from government programs, some available both to individual small firms and associations, and some targeted only to cooperative groups. The main program targeted to groups is the SME Upgrading Capital System, administered by the Japan Small Business Corporation (JSBC).[60] It lends money to the prefectures which, in turn, add funds of their own and make loans to groups and cooperatives. Loans, for periods of 7 to 16 years, are at low interest (2.7 percent) for general activities and at zero interest for special activities. In 1987, government-supported upgrading loans to groups and cooperatives amounted to 395.3 billion yen ($2.8 billion). Another source of low-cost financing for cooperatives is the shoko chukin bank, which collects money from coop members, supplements it with government funds, and then makes loans to members. In addition, a small government program (national and prefectural) promotes joint R&D by small fins. It makes awards at the level of $2 million to $3 million yearly to a couple of dozen cooperative associations. Cooperatives can also take advantage of the free or low-cost public technology extension services.

The Japanese Government particularly encourages the formation of cooperatives in industries with many very small, weak firms. Box 6-B describes the activities of a cooperative of 18 plastic mold equipment manufacturers in and around Tokyo and Yokohama, and some of the government programs that support it.

[58] Ibid., p. 192, note 17.

[59] Main sources for this part, in addition to standard works on the world textile industries, are Ronald Dore, *Flexible Rigidities: Industrial Policy and Structural Adjustment in the Japanese Economy, 1970-1980* (Stanford, CA: Stanford University Press, 1986); and The MIT Commission on Industrial Productivity, "The U.S. Textile Industry: Challenges and Opportunities," in *The Working Papers of the MIT Commission on Industrial Productivity* (Cambridge, MA: The MIT Press, 1989), vol. 2.

[60] This program is in addition to the loan programs for individual SME firms,

Box 6-B—A Plastic Mold Equipment Cooperative in Japan

The Keihin Plastic Kanagata, or plastic mold equipment cooperative, is an association of 18 small companies in Ota-ku (a city ward in Tokyo), other places in Tokyo, and Kanagawa-ken (a prefecture near Yokohama). [1] The cooperative's modest offices are located in a compact building in a pleasant but unpretentious Tokyo neighborhood. Within this rather humble exterior is a dynamo of activity.

The Japanese die and mold industry is characterized by a great diversity of products, custom manufacturing, heavy reliance on skilled workers, and a great preponderance of small and medium-size enterprises. Nine of ten plastics toolmakers are small firms with fewer than 19 employees. This kanagata is typical: the 18 member companies are all very small, and for them the 6 million yen ($43,000) price of admission is steep.[2] The rewards for joining are large, however. Members can rely on the kanagata to collect orders from larger customer firms and apportion them to members so that all are kept busy, and customers can usually be accommodated even when business is booming. When business is slow, kanagata staff can pound the pavement in search of new orders. "We try to make sure all the members are working at full capacity, explained Mr. S. Sugano, director of the cooperative.

The kanagata also helps with purchasing, giving member firms both technical assistance in finding good equipment and quantity discounts. The discounts are not inconsequential; on some machines they are as much as 60 percent. (Discounts on quantity purchases are available not only to members of the coop but to a wider circle of 53 firms, in an organization the coop founded.) Another benefit is in machine leasing. For example, 4 years ago, the kanagata bought 24 CNC machines and leased them out to members. Altogether, the machines cost 450 million yen ($3.2 million). The kanagata used government loan programs to aid in buying them; one program provided two-thirds of the money at 2.7 percent interest over 10 years, and another provided the other one-third at 7.6 percent interest, also over 10 years.

Even with quantity discounts and leasing on favorable terms, it doesn't always pay for members to acquire their own equipment, if it is used quite infrequently. For example, a few years ago, the kanagata bought a CAD system; a member of the coop staff who formerly worked for a plastic design company trains members to use it. Another low-cost government loan, for 28 million yen ($200,000), helped the kanagata buy the equipment. Eventually, the coop wants to be able to hook up the CAD system to computer- aided manufacturing in members' plants. lt is exploiting government programs to establish computer networks to make possible the CAD-CAM connection.

In addition, the cooperative can provide both long and short term loans to member companies. Long-term loans are funneled through the kanagata from the shoko chukin bank, which collects money from coop members, adds government funds, and makes loans on favorable terms to the members. A committee of the kanagata approves the loans. Typically, long-term loans are used for operating capital. Members can also borrow up to 6 million yen ($43,000--the same as the membership fee) for 6 months at a rate of 1 percentage point above the commercial bank prime rate (about 5 percent in 1989). These short-term loans are used mainly for special purposes such as employee bonuses or debt service that firms are temporarily unable to cover (a common occurrence when firms were adjusting to the rapid rise of the yen in 1986-87). Also, members can buy insurance from the coop to cover possible losses if one of their customers goes bankrupt.

Finally, the cooperative also provides many kinds of education and information sharing services. For example, members study CAD/CAM applications together, and in 1989 the kanagata had a study group examining the implications to members of the new consumption tax.

The kanagata supports its staff and activities not only through membership fees but also by taking 1 percent of the order value of the customer orders it handles. Also, in selling equipment to members at the discount price, it adds a charge of 3 percent of the regular, undiscounted price and puts that into the coop's operating fund (which was about 600 million yen, or $4.3 million, annually in 1989).

Throughout Japan, there are about 12,000 Kanagawa associations. In the kanagata prefecture alone are 1,300 cooperative groups, with over 370,000 firms participating at some level. Probably most of the groups do not provide such comprehensive services as the Keihin Plastic Kanagata, but they do typically offer financing assistance, if not purchasing and order services.

[1] Information for this box comes from interviews conducted by OTA staff in Tokyo, March 1989.

[2] In addition t. paying the fee, companies must have the recommendation Of another member.