

RESEARCH**MODERNIZING SMALL MANUFACTURERS IN JAPAN: THE ROLE OF LOCAL PUBLIC TECHNOLOGY CENTERS**

Philip Shapira

Japan's hundreds of thousands of small manufacturing enterprises not only provide high-quality inputs to large Japanese companies, but also are becoming innovators and growth generators in their own right. In addition to help from larger customers, small Japanese companies can call upon an array of public support mechanisms, including about 170 local Kohsetsushi examination and technology centers which provide research, testing, training, and guidance for firms with under 300 employees. With their intensive geographical coverage, broad range of technical services, and nominal fees, these centers offer small Japanese firms a readily available and effective source of assistance to improve their manufacturing operations, technology, and products. After reviewing the changing context for small manufacturers in Japan, the article examines the role of local Kohsetsushi centers in small firm modernization. This article considers the history, organization, and services of the Kohsetsushi system, explores the operation of five case study centers, and discusses how small Japanese firms benefit from Kohsetsushi services. Finally, there is an assessment of the strengths and weaknesses of the Kohsetsushi system.

In trying to understand Japan's achievement in building a strong and technologically sophisticated manufacturing economy, considerable attention is usually given to large well-known Japanese industrial companies, such as Toyota or Mitsubishi, and to central government policies towards these corporate giants. There is certainly much to learn here. However, the focus on big firms tends to obscure a key element in Japan's success: the substantial role played by small manufacturers supported by a comprehensive local system of technological assistance.

There are hundreds of thousands of small manufacturing enterprises in Japan with 300 or fewer employees (referred to in Japan as small and medium enterprises). These small firms not only provide high-quality inputs to Japan's large corporations but also are becoming increasingly important in their own right as propulsive

entities for innovation and economic growth. The specialized yet flexible proficiency of these small manufacturers has contributed greatly to Japan's industrial success. Close, long-term, relationships with larger customers have helped many small firms to improve their productivity and manufacturing abilities. In addition, small Japanese manufacturers are able to turn to an array of publicly-sponsored centers and programs which provide industrial extension services, technological support, and assistance with training, financing, and inter-firm networking. The Japanese public technology-infrastructure for small manufacturers far exceeds what is available for comparable small firms in the United States, and plays a significant role in developing Japan's manufacturing base.

Japan maintains an expansive set of policies and programs to support small firms, including financial support through quasi-governmental credit institutions and banks, tax reductions, special legislation, and the encouragement of small business associations and cooperatives. (2) There are also programs of information provi-

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sion, personnel training, and management assistance, organized by chambers of commerce, local governments, and the national Japan Small Business Corporation.(3) Over the last two decades, Japan's policies have shifted from the passive support of individual small firms to the active promotion of technological modernization and structural improvement in small enterprise industrial sectors. (4) A strong emphasis is now put on developing new products, diffusing new technologies, and increasing knowledge-intensity in small companies. An extensive system of small-firm technology promotion has been developed, which includes favorable loans, credit guarantees, and equipment-leasing programs provided by public agencies, cooperative organizations, and private institutions. Tax incentives are also offered to small firms investing in new equipment, while grants and low-cost loans are made available to encourage R&D and technology commercialization in small companies. The central government, through the Ministry of International Trade and Industry (MITI) and other ministries, sponsors numerous regional technology projects, as well as initiatives to stimulate technology information exchange, diffusion, and sharing among smaller firms.(5) Prefectural and local governments are pursuing similar strategies in partnership with, and in addition to, the central government. The variety of programs makes it hard to calculate total spending for small-firm technology assistance in Japan, but estimates run into billions of dollars.(6)

At the heart of Japan's system of technological support for small manufacturers is a nationwide network of about 170 public centers which extend research services, technology assistance, testing, training, and guidance to small enterprises employing 300 or fewer workers. These Kohsetsushi centers—an acronym from the Japanese words for public (*koh*), establishment (*setsuritsu*), and testing laboratory (*shikenjo*)—also administer a program for qualifying and registering private consultants who help small firms solve technical problems and upgrade their products and manufacturing processes. With their extensive geographical coverage and nominal fees, the Kohsetsushi

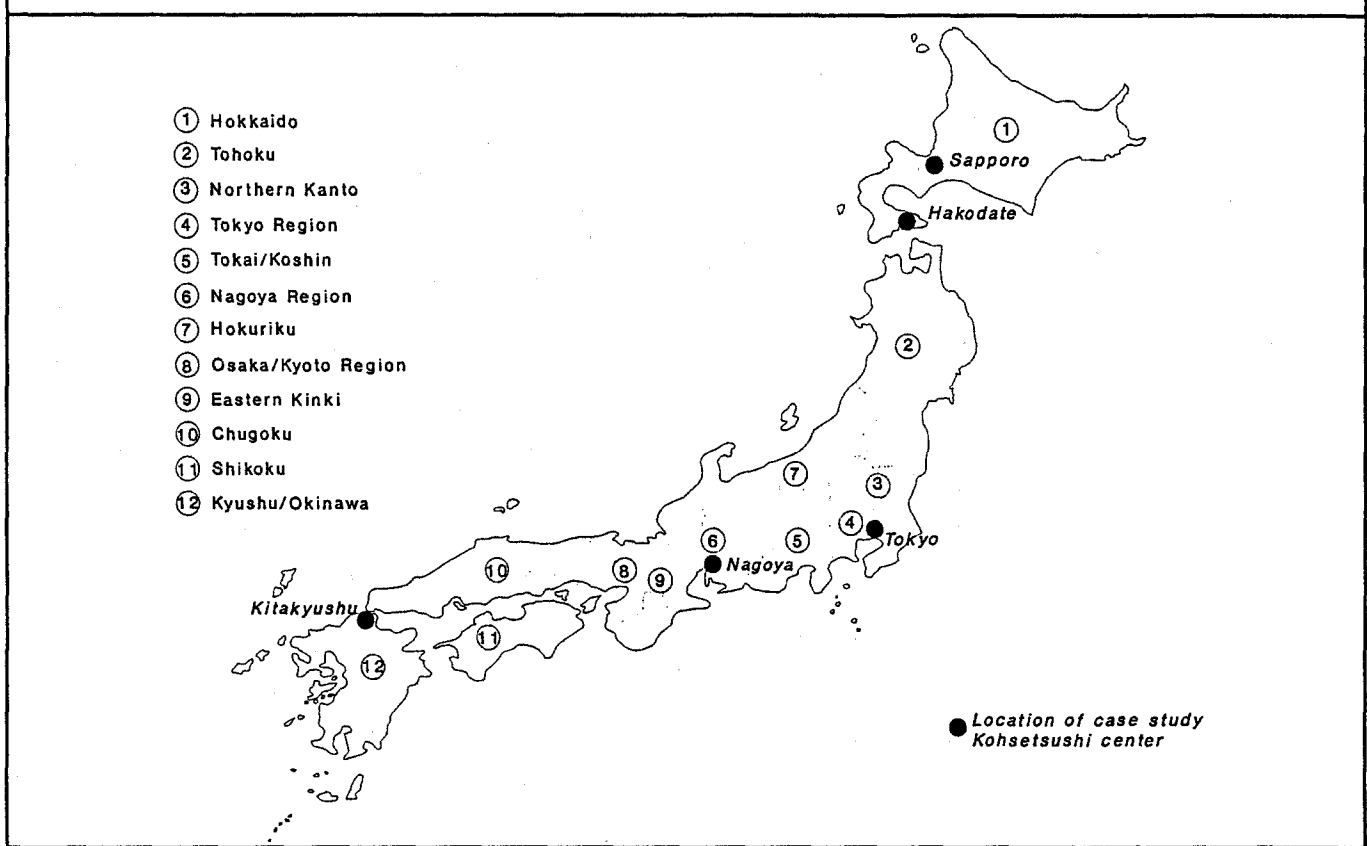
centers provide Japanese small firms with a readily available and effective source of assistance to improve their manufacturing operations and products.

Focusing on the Kohsetsushi system, this article investigates how Japan's public technology centers promote technology development and adoption for small firms. After considering the changing context for small manufacturers and their use of technology in Japan, this article examines the development, scope, and services of the Kohsetsushi network and presents studies of individual centers. Several examples are then discussed of how Kohsetsushi centers are used and perceived by small manufacturers. Finally, there is an assessment of the strengths and weaknesses of the Kohsetsushi system. This article draws on field research conducted in Japan in the Summer of 1990, involving interviews with program managers and engineers at five Kohsetsushi centers (Map 1), with firms assisted by the program, with government officials at local and central levels, and with researchers and other business and economic-development organizations.

SMALL MANUFACTURERS AND TECHNOLOGY IN JAPAN

The Japanese manufacturing economy is built on a foundation of small industrial firms. There are 875,000 manufacturing establishments in Japan—more than twice as many as in the US. Japan's manufacturing base includes hundreds of thousands of small individual proprietors, as well as a similar number of mostly small manufacturing corporations (Table 1). Over half of all Japan's manufacturers are micro-enterprises with fewer than 4 employees, leaving a core of about 418,000 small and mid-size manufacturing firms employing between 4 and 299 workers. Less than one-percent of Japan's manufacturers employ more than 300 workers.(7) Once considered a backward part of the economy, (8,9) small manufacturing enterprises in Japan have risen steadily in importance since the 1950s, until they now comprise nearly three-quarters of manufacturing employment and more than half of manufacturing value-added. In comparison, small manufacturers in the US

Map 1. Regions of Japan and Case Study Locations



(those with under 250 employees) account for less than one-half of manufacturing employment and under two-fifths of the manufacturing value-added.(10)

The small-manufacturing sector in Japan is not, of course, homogeneous. There are still numerous labor-intensive, low-technology operations, which depend on low wages, on unpaid family labor, and on long hours. Some still make traditional craft products.(11) Other small firms are labor-only subcontractors, with no plant or equipment of their own, sending their employees to work in the factories of larger customers. At the same time, a large and growing segment of Japanese small firms is directly engaged in modern manufacturing, frequently using advanced manufacturing technologies. Taken as a whole, small manufacturing firms in Japan are more likely to use new manufacturing technologies than small manufacturing units in the United States. For example, compared with small US plants, one-half again as many Japanese manufacturers use numerical control or com-

puter numerical-control machine tools, while more than four times as many small Japanese manufacturers as American units use advanced machining centers and handling robots (Table 2). Workforce training—a key element in the effective use of new technology—is more prevalent in small Japanese firms than in American ones.(12,13)

The diffusion of technology in Japanese small firms has been encouraged by the close links between many small enterprises and their larger customers. Unlike the US, where the relationships between major firms and their smaller subcontractors are repeatedly adversarial, short-term, and focused on price, large Japanese firms often maintain collaborative, longer-term associations with small suppliers, paying more attention to quality and product features. Traditionally, subcontracting in Japan is organized in a pyramid pattern, with large companies at the top supplied by smaller firms in multiple lower tiers. The larger firms higher up in the pyramid impose pressure to modernize by

Table 1. Establishment Organization, Enterprise Size Structure, and Employment in Japanese Manufacturing				
Private Manufacturing Establishments (1986)(1)				
Form of Organization	Establishments		Employment	
	thou.	%	thou.	%
Individual Proprietors	478.9	54.8	1,780	13.3
Corporations	394.5	45.1	11,549	86.6
Unincorporated	1.1	0.1	12	0.1
Total	874.6	100.0	13,342	100.0
Manufacturing Enterprises with 4 or More Employees (1989)(2)				
Employment Size	Enterprises		Employment	
	thou.	%	thou.	%
4-19	317.5	75.3	2,587	23.6
20-299	100.5	23.8	5,363	48.9
300+	3.8	0.9	3,011	27.5
Total	421.7	100.0	10,961	100.0
Sources: 1. Statistics Bureau, Management and Coordination Agency, <i>Japan Statistical Yearbook, 1991</i> , Tokyo, 1991 (Table 4-4).				
2. Small and Medium Enterprise Agency, <i>Small Business in Japan 1991</i> , Tokyo: MITI, 1991 (Table 3). Data for enterprises with 4 or more employees.				

exacting tough cost, quality, and delivery requirements from lower-tier smaller firms. Yet, simultaneously, larger firms may also help their smaller suppliers to upgrade by sharing information, technology, and sometimes personnel, and by maintaining long-run business links. These subcontracting arrangements have given large firms a flexible, specialized, and lower-cost supply base (wage levels generally decrease by size of firm in Japan). In turn, numerous smaller suppliers have gained long-term confidence and customer support to invest in new technology.(14,15,16)

Even under this customary, vertically-organized production pattern, public technology sources, such as the Kohsetsushi centers, are important providers of assistance in Japan. Technical personnel in larger firms may have little time to deal with the problems of the very smallest firms at the bottom of the supply chain.

In some cases, to ensure quality standards, large customers require smaller suppliers to have their measuring equipment and gauges regularly inspected by independent testing labs. In other instances, small suppliers are more specialized than their customers in particular products or processes, and so may go to outside technical experts when they need help. Small firms are also longstanding users of Kohsetsushi and other public sources of training.

In addition, the conditions for small manufacturing firms are changing in Japan—and doing so in ways which are giving further importance to Kohsetsushi centers and other local technology programs. As large Japanese firms restructure and internationalize, production is being rationalized or offshored in many industries, with direct consequences for smaller firms. Many smaller suppliers see shrinkage in their traditional business lines and are seeking to enhance their technologies so that they can diversity into new products and business areas.(17) In addition to competition from low-cost suppliers in other Asian countries, these trends are being accelerated by the tight labor market in Japan, especially for high-skill workers. Some small firms are responding to these pressures by exploiting the cheap, often undocumented, foreign labor now increasingly available in Japan. But many other small manufacturers are taking a longer-term approach, by investing in new, more versatile, labor-saving technologies, seeking innovative technological niches, developing up-market products, and upgrading working conditions.(18,19,20)

In some instances, large firms are diversifying too, and are encouraging their smaller suppliers to shift in step into new technologies in electronics, aerospace, biotechnology, new materials, and other emerging areas. More generally, a growing number of smaller Japanese manufacturers want to develop, control, and sell their own technologies in domestic and international markets—without the constraints established by larger customers. One sign of this switch is the decline in the proportion of Japanese small manufacturers exclusively engaged in subcontracting, which has fallen from two-thirds to just over one-half during the

Types of New Manufacturing Technology Japanese definition (closest US definition in brackets)	Technology Users, by Employment Size							
	Japan		US		Large/SME Ratio		Japan/US Ratio	
	Under 300	300+	50-499	500+	Japan	US	SME	Large
	[a]	[b]	[c]	[d]	[e]	[f]	[g]	[h]
	Enterprises		Establishments					
	%	%	%	%				
NC/CNC Machine Tools (NC/CNC Machine Tools)	57.4	79.4	39.6	69.8	1.4	1.8	1.4	1.1
Machining Centers (FMS Cells or Systems)	39.4	67.4	9.1	35.9	1.7	3.9	4.3	1.9
Computer-Aided Design (and Computer-Aided Engineering)	39.1	75.2	36.3	82.6	1.9	2.3	1.1	0.9
Automatic Transport Equipment (Automated Guided Vehicles)	34.9	68.3			2.0			
Automatic Inspection/Measuring (Automatic Inspection, Final Product)	30.1	66.7	10.5	44.3	2.2	4.2	2.9	1.5
Automatic Warehouse Equipment (Automatic Storage & Retrieval)	22.6	62.2	5.5	43.3	2.8	7.9	4.1	1.4
Handling Robots (Pick and Place Robots)	10.9	44.9	1.9	24.4	4.1	12.8	5.7	1.8
Assembly Robots (Other Robots)	8.3	41.4	3.9	35.0	5.0	9.0	2.1	1.2
Welding/Painting Robots	16.0	42.7			2.7			
Note:	Japanese technology definition is given (with matching US technology definition in brackets). The comparisons between Japan and the US are approximate since there are differences in technology definitions and employment size categories. Additionally, the Japanese data is enterprise-based, while the US data is establishment-based.							
Sources:								
[a], [b]	"Current Survey on the Manufacturing Industries 1988," reported in Ministry of International Trade and Industry, Small and Medium Enterprise Agency, <i>Small Business in Japan 1989: White Paper on Small and Medium Enterprises in Japan</i> , Tokyo, 1989.							
[c], [d]	US Department of Commerce, Bureau of the Census, <i>Manufacturing Technology 1988</i> , Current Industrial Reports SMT(88)-1, Washington, DC: May 1989.							
[e] = [b]/[a]	[f] = [d]/[c]	[g] = [a]/[c]	[h] = [b]/[d]					

1980s(21) Small Japanese manufacturers are increasingly developing, using, and marketing new technologies independently, in cooperation with other small manufacturers, or in joint ventures with a diverse range of larger corporations. Geographical clusters of these innovative small firms are forming, spurring regional economic growth and technology development, and promoting new horizontal links between and among firms and between firms and local technology centers.

An example of this emerging production pattern is found in Nagano Prefecture's Sakaki Township, in the mountains of central Japan east of Tokyo. Here, a dynamic complex of over 300 small independent manufacturers has developed using advanced production tools to make

innovative, high-value products. Interchange and cooperation among these firms is aided by voluntary local business associations and public centers.(22) Regional networks of innovative small firms have evolved too in other areas as well, especially in and around Tokyo. Sections of southern Tokyo and adjacent Kawasaki and Yokohama cities serve as hubs for thousands of small firms using or developing advanced technologies in machining, electronics, metals, and new materials. In this changing environment, the importance of locally-provided technology services is likely to grow in Japan, as smaller firms augment the support they have traditionally received from larger customers with new sources of assistance from public technology centers and services. Japan is fortu-

nate in that it has a network of local technology centers already in place.

THE KOHSETSUSHI SYSTEM

In the early years of the twentieth century, as part of its economic modernization effort, Japan began to establish prefectural agricultural experiment stations and extension services.⁽²³⁾ Unlike the US, where extension was mainly confined to agriculture, Japan also applied the concept to industry by founding a series of manufacturing-based Kohsetsushi experiment and testing stations. At first, national or university institutes were founded; then, in the 1920s and 1930s, a number of local governments constituted Kohsetsushi centers to promote local industries.⁽²⁴⁾ After World War II, centers began to be established in every prefecture; however, a few centers were founded quite recently. Today, each of Japan's 47 prefectures has at least one Kohsetsushi center. In some prefectures, especially in major industrial areas, the density of centers is higher. For example, Aichi prefecture, which includes the industrial metropolis of Nagoya, has eight centers.

With a few exceptions, Kohsetsushi centers are administered by prefectural and municipal governments, although the central government, through MITI and affiliated agencies, provides guidance and some additional funding. In total, Japan's Kohsetsushi centers employ about 6,900 people, including 5,300 engineers and other

technical personnel. A handful of centers, generally in the largest cities, have more than 150 employees. But most have under 100 employees, with the average center employing about 40 staff, according to an MITI listing of 169 centers (Table 3).

The geographical coverage of the Kohsetsushi system is extensive. Peripheral regions, such as relatively underdeveloped Tohoku, have a disproportionate number of centers compared with the size of their industrial base. Nonetheless, there is still a dense network of centers in the core industrial complexes of Tokyo, Nagoya, and Osaka (Table 4). Individual Kohsetsushi centers typically specialize in the industries active in their localities. On average, each center maintains three principal technology specialities. Many centers continue with a focus on traditional craft industries—a customary concern which centers have maintained since their founding many decades ago. However, a very large number of centers have developed expertise in modern manufacturing fields, especially in machinery, metals, chemicals, apparel and textiles, electrical and electronics, ceramics, and food processing, while some concentrate in such technological areas as pollution control, radiation, and information technology.

The services of Kohsetsushi centers include:

Applied research. On average, about 50% of Kohsetsushi staff time is spent on research, mostly on applied and industrially-oriented projects. Centers typically sponsor a mix of their own projects, joint projects which involve several companies, and contract projects with individual small firms. Funding comes mostly from center budgets, supplemented by enterprise contributions for contract research and central government funds made available for research in specified technological areas. Small firms frequently send one or two of their staff to work at Kohsetsushi centers on projects, giving these company personnel research experience, updating their technical knowledge, and helping them transfer technology back to the firms. Occasionally, researchers from universities or national laboratories are involved in projects as well. Here, Kohsetsushi centers serve as a bridge

Staff Size	Number of Centers	Percent
200 or more	3	2
150-199	2	1
100-149	9	5
50-99	26	15
40-49	22	13
30-39	22	13
29 and under	85	50
Total	169	100

Source: Small and Medium Enterprise Agency, Ministry of International Trade and Industry, Tokyo, 1990.

between small firms and higher-level research institutions.

Information dissemination. Most Kohsetsushi centers run seminars, study meetings, and even exhibitions to disseminate information on research and new technology to local small firms. The centers also publish newsletters and re-

search reports and maintain technical libraries.

Testing and examination. Center laboratories conduct examinations of materials and products, verify whether products meet Japanese, American and other foreign standards, calibrate measuring instruments, and make sophisticated testing equipment available. These

Table 4. Regional Location of Kohsetsushi Centers, by Technology Specialty

Region	1 Hokkaido	2 Tohoku	3 Northern Kanto	4 Tokyo Region	5 Tokai Koshi	6 Nagoya Region	7 Hokuriku	8 Osaka Kyoto	9 Eastern Kinki	10 Chugoku	11 Shikoku	12 Kyushu Okinawa	Japan
All Manufacturing Establishments (1986) '000	15.7	44.8	54.6	213.1	64.1	112.6	56.6	160.3	26.0	44.7	25.5	56.7	874.6
Kohsetsushi Centers (1990)	8	18	10	22	12	22	15	10	10	9	12	21	169
Center Technology Specialties	Number of Centers with Specialty												
Ceramics	3	6	2	1		5	3	3	2	5	2	8	40
Chemicals	4	8	3	5	3	8	3	5	3	5	4	9	60
Construction	1	1											2
Design		1					1	1	1	2	2	1	9
Distilling	2	6	3	2	1	3	2	2	1	4	5	4	35
Electrical/Electronics	2	7	4	4	4	4	3	5	1	4	2	6	46
Food Processing/Biotech	2	7	4	6	2	3	4	4	2	6	6	9	55
Information Technology					1				1		2		4
Leather				1					1				2
Lumber & Woodworking		2							1				3
Machinery	3	9	4	4	6	4	3	4	4	7	4	7	59
Medicine							2		2				4
Metalworking	3	8	4	5	4	5	3	5	4	6	4	8	59
Mining	2												2
Packing				2		1		1					4
Paper				1	1	1				2	2	1	8
Pollution Control	1	4				1		2		1	1	1	11
Radioactivity				2									2
Textiles/Clothing		4	4	5	6	5	3	2	3	4	1	3	40
Traditional Industries	4	7	5	6	3	5	9	6	4	6	5	10	70
Other		1		2	1								4
Total Specialties	27	71	33	46	32	45	36	40	30	52	40	67	519

Source: Translated and compiled from information provided by the Small and Medium Enterprise Agency, MITI. See Map 1 for regional definitions.

services help small firms to enhance quality, precision, and product development, as well as resolve problems in materials and components. Nominal fees are charged. In some centers, staff teach courses on quality control and statistical techniques and visit companies to provide quality assistance. Kohsetsushi analysis, test, and inspection services are used by small firms more than 900,000 times a year.

Advice and guidance. Each Kohsetsushi center provides advice to small companies to help them solve technical problems and implement new technology. Many simple requests are dealt with by telephone or by managers visiting centers to obtain information. For more complex problems, center staff visit companies to provide assistance. In 1989, Kohsetsushi centers dealt with about 450,000 cases of technical advice, including 25,000 in which expert teams and advisers were sent to firms. The Kohsetsushi centers also administer a program in which some 3,900 registered private technology-advisers, usually engineers or professors, are matched with and provide technology-consulting services. The initial services of registered technology-advisers are generally free to firms. The advisers receive nominal reimbursements from local and central funds.

Training and open laboratories. Small manufacturers send employees to the Kohsetsushi centers for group and customized training in new technologies. Many centers also offer open laboratories and access to equipment, allowing small firms to use specialized and advanced equipment at the Kohsetsushi centers for research, prototyping, employee training and even scheduled manufacturing. Kohsetsushi facilities and equipment are used by small firms about 64,000 times annually.

Technology diffusion groups. Kohsetsushi centers are among the many local organizations in Japan sponsoring groups of small companies which meet to exchange information and cooperate on sharing technology and developing new products and markets. Efforts to organize these groups began in the mid-1980s, as part of MITI-sponsored initiatives to promote small-firm networking and technology fusion and increase the role of small firms in regional

development. Participating Kohsetsushi centers often organize several groups, with each group involving up to 30 local small firms.

Total spending for Japan's Kohsetsushi centers is the equivalent of about \$500 million a year (Table 5). The bulk of this funding comes from prefectural and local government, with some fee income from private firms. Central government typically provides 10 to 20% of each Kohsetsushi center budget, from a variety of sources. MITI's Small and Medium Enterprise Agency provides budgetary support. Additional funding comes from other MITI-affiliated agencies, including the Japan Small Business Corporation (a quasi-governmental agency which provides finance and technical and marketing information, and supports training and mutual relief systems for small firms) and the Japan Bicycle Development Association (which uses the proceeds from organized bicycle races for improvement in the machinery and metalworking industries).

CASE STUDIES OF INDIVIDUAL KOHSETSUSHI CENTERS

To understand how specific Kohsetsushi centers work and the kind and quality of services they provide, case studies were conducted at five centers, in Kitakyushu, Hakodate, Sapporo, and Tokyo (see Map 1). These centers varied in location, industry specialization, and size. A summary of the characteristics of the five case-study centers is contained in Table 6, while a more detailed discussion of their operation, organization, and services follows.

	Yen Billion	\$US Million
Total expenses	69.5	496
Personnel expenses	42.6	304
Other expenses for facilities, equipment, R&D activities, etc.	26.9	192
Source: Small and Medium Enterprise Agency, Ministry of International Trade and Industry, Tokyo, 1990 (140Y/\$US).		

Table 6. Characteristics of Case Study Kohsetsushi Centers

Kohsetsushi Center	City & Year Founded	Total Staff (Profess.)	Budget	Funds Per Employee	Local Gvnt. [a]	Central Gvnt. [b]	Research Effort [c]	Exams/Analysis [d]	Advice/Guidance [e]	Open Lab/Equip Use [f]	Training [g]	Regist. Consult. [h]	Technology Diffusion [i]
		Number of employees	Y mill. \$ mill.	Y mill. \$ mill.	% of budget	% of budget	% of staff time	Number of cases	Number of cases	Number of cases	Number of trainees	Number of firms	Groups & firms
Kitakyushu Industrial Research Institute	Kitakyushu 1938	48 [37]	687 4.9	14.3 102.2	85%	13%	55%	2,352	1,161	11	157		3 groups 100 ca.
Nagoya Municipal Industrial Research Institute	Nagoya 1937	118 [98]	1,400 10.0	11.9 84.7	67%	19%	50%	9,959	5,596	1,850	299		1 group 30 ca.
Hokkaido Industrial Technology Center	Hakodate 1986	26 [19]	357 2.6	13.7 98.1	59%	28%	40%	370	466				3 groups 53 ca.
Hokkaido Industrial Research Institute	Sapporo 1922	116 [86]	1,090 7.8	9.4 67.1	91%	3%	50%	4,700	2,321	1,000	90	110	
Tokyo Metropolitan Industrial Technology Center	Tokyo 1922	207 [173]	2,600 18.6	12.6 89.7	76%	5%	50%	65,950	33,500 [1,000]*	6,100	2,000	150	7 groups 210 ca.

Source: Kohsetsushi reports and interviews conducted at centers in 1990. Data are on an annual basis.

Notes: [a] Percentage of funding from Local Government (Prefecture and City Government).
 [b] Percentage of funding from Central Government, including MITI, Japan Bicycle Development Association and Japan Small Business Association.
 [c] Percentage of staff time spent on individual, joint, or cooperative research projects.
 [d] Number of cases of examination, testing, and analysis.
 [e] Number of cases of technological advice and guidance.
 [f] Number of cases of use of center laboratories or equipment.
 [g] Number of company workers trained (in courses and individual training).
 [h] Number of companies assisted by registered consultants and technical advisers.
 [i] Number of technology diffusion groups, plazas, or exchanges, with total number of companies involved.
 * Companies receiving Tokyo Kohsetsushi staff site visit and field technical assistance.

Kitakyushu Industrial Research Institute (KIRI)

KIRI is located in Kitakyushu, an industrial city of just over 1 million people in northern Kyushu. Long a primary center for steelmaking, metalworking, chemicals, and other materials-related industries, Kitakyushu has seen its heavy industries undergo restructuring in recent years, and many of the city's small suppliers now have to develop new markets and technologies to survive.⁽²⁵⁾ KIRI's main mission is to apply its research and technical expertise to helping the city's small firms. Founded as a

prefectural metal industries center in 1938, KIRI is organized into a general affairs section and three technical departments: technology development, analysis, examination, and advising; production technology, manufacturing, and metal chemistry; and applied technology, automation, and machine functions. This structure reflects the region's metals and materials industrial base, but recently there have been efforts to extend research and expertise in electronics, computers, and software. Each year, KIRI staff provide advice and guidance to about 800 of the region's 3,300 small metalworking

companies. Some 2,300 examinations and analyses of materials, products, or gauges are conducted annually, at nominal cost. For example, an analysis of the strength of a material costs under \$9. KIRI trains about 150 workers from small companies each year in metalworking, electrical, electronic, computer, and automation technologies, allows local companies to use its advanced equipment for training and production, and sponsors three technology diffusion groups. KIRI has just under 50 staff and an annual budget of about \$4.9 million, of which more than four-fifths is provided by the prefecture.

Nagoya Municipal Industrial Research Institute (NMIRI)

Nagoya, Japan's fourth largest city with a population 2.1 million, is a leading industrial metropolis, with numerous firms involved in automobile production, precision machining, instruments, electronics, tool building, ceramics, and textiles. Many Nagoya firms serve as suppliers to Toyota, whose head office and chief manufacturing center is in nearby Toyota City. NMIRI assists many of Toyota's small suppliers, as well as small firms engaged in other industries. Founded by city government in 1937, NMIRI is housed in a new, purpose-built complex. The Institute is organized into sections devoted to general affairs and planning, technical consultation, training, and information, and four research departments: mechanical engineering, metal and inorganic materials, polymers, and electronics.

NMIRI conducts examinations and analyses, special studies requested by companies, and cooperative research with local firms, in addition to its own research projects. Over 1,000 companies use NMIRI's specialized equipment and facilities each year, generally at very low cost, if charges are made. In another 800 cases, NMIRI tools are used by companies for prototype or actual manufacturing. Staff also provide advice and guidance to firms. Advice may involve anything from a quick response to a question to a few hours work on a small problem and is free to the company. Guidance involves more substantial work, for which companies pay a fee.

Annually, there are about 5,000 cases of advice and 700 cases of guidance. The Institute offers training courses in new technologies for engineering and technical employees of small enterprises. NMIRI currently offers 13 different courses, with an average length of about 100 hours, although some courses are as short as 12-16 hours. The courses not only offer classroom instruction but also training in the Institute's laboratories so that company employees can get hands-on experience. Additionally, companies can send employees to NMIRI for special or customized training. In 1988, NMIRI trained 230 engineers from small medium companies through courses and 70 engineers in customized one-on-one training. NMIRI also runs a technology diffusion group. The Institute has 118 staff and an operating budget of about \$10.4 million a year. Funds for NMIRI's operating costs come from Nagoya City (67%), the Japan Bicycle Development Association (12%), MITI (7%), and fee income from research, studies, and equipment use (13%).

Hokkaido Industrial Technology Center (HITC)

Hakodate, an old-established port city of about 320,000 people at the southern tip of Hokkaido, has seen its traditional industries of shipbuilding, fishing, and fish-processing decline considerably in recent years. MITI, working with Hokkaido Prefecture and Hakodate City, is seeking to rebuild the local economy by developing new technological industries and technological upgrading in existing firms. Hakodate has been designated as one of Japan's 25 Technopolises.⁽²⁶⁾ The Hokkaido Industrial Technology Center (HITC) was established in 1986 by Hokkaido Prefecture and the Hakodate Technopolis Foundation as an integral part of the Technopolis program. Located in a new, purpose-built building, HITC undertakes research and development, analyses and examinations, special studies and other cooperative research, and programs of technology diffusion. HITC's R&D and diffusion programs focus on marine-related technologies, mechatronics, new materials, and biotechnology. Although largely publicly funded, HITC is somewhat unusual

among Kohsetsushi Centers in that it is governed by a private organization, the Hakodate Technopolis Foundation.

HITC's 26 staff spend about 40% of their time on research, with the other 60% on advice, guidance, examination, and training. Since 1986, HITC has conducted 46 special research studies with companies, or about 12-15 a year. In some cases, researchers from private firms spend about one to three years at the center working on projects. Additionally, HITC staff are involved in cooperative research projects with other research centers and universities. Currently, there are eight cooperative projects at HITC. Center staff respond to almost 500 requests a year from companies for advice and assistance. Mainly, these are questions, requests for information, or problems which companies bring to HITC staff via phone calls or visits to the center. HITC, like other Kohsetsushi centers, conducts examinations, analyses, tests of quality, and measurement and calibration for small companies. In 1989, the center conducted 370 examinations or analyses for 103 companies, including examinations of new materials and food products. HITC offers training courses and lectures on technology topics to employees from outside companies, running about 20 courses a year. The center also allows firms to use its specialized equipment and co-sponsors several technology diffusion groups with the Technopolis. HITC's operating budget is about \$2.6 million, with \$1.5 million provided by Hokkaido Prefecture and Hakodate City. HITC also receives about \$0.7 million from the Japan Small Business Corporation (JSBC) to support research on JSBC themes, and a further \$0.2 million through cooperative research, special studies, and other income from private companies. Funding for HITC's new building and some equipment is provided through the Hakodate Technopolis Foundation.

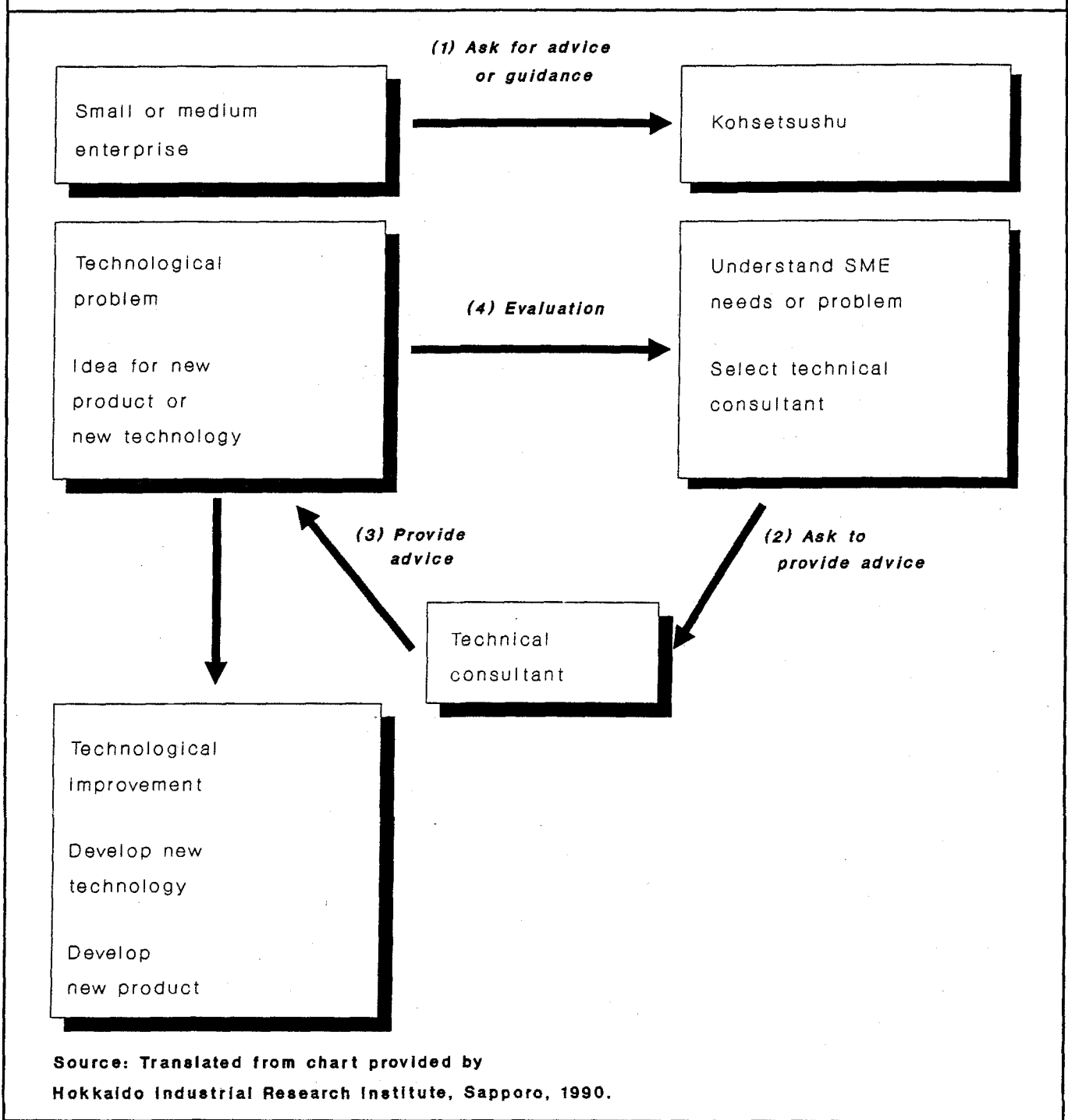
Hokkaido Industrial Research Institute, Sapporo

Sapporo, Hokkaido's prefectural capital and largest city with 1.7 million people, is home to the Hokkaido Industrial Research Institute (HIRI). The Institute was founded in 1922,

originally to improve manufacturing technology in Hokkaido's brewing and ceramics industries. In 1977, the Institute was reorganized and moved into a new building complex. A further reorganization in 1986 established six major departments and an office for planning, information, and technological consultation. The six major departments cover chemical and ceramics technology, machinery and metals, industrial arts and design, resources and energy, food technology, and electronic engineering. Within each department are two or three sub-sections for research and consultation in more specific technology areas. For example, within electronic engineering, there are sections for electronic control and for system technology.

HIRI conducts research and cooperative studies with small companies and provides technological consultation on the introduction and development of advanced technology, upgrading manufacturing technology and products, and improved use of resources and energy. To disseminate the results of its activities, HIRI holds seminars, study meetings, and exhibitions on technology in several locations in Hokkaido. About 1,000 to 1,200 companies participate in these activities each year. HIRI staff respond to about 2,300 requests a year for technical advice and guidance from companies. Usually, these are questions of problems that can be resolved fairly quickly. For more complex problems, HIRI operates a system of registered consultants that can be dispatched to small enterprises to help solve problems and provide information and technical assistance on new products and technologies (Figure 1). Based at universities and other research institutes or laboratories, these consultants spend up to ten days over a period of time working with individual companies. For the companies, this service is free; the consultants are reimbursed at a nominal rate through funds made available by MITI and the prefecture. Each year, just over 100 companies are assisted under this scheme. Other services of HIRI include analyses and special studies, instruction and free use of equipment, training, and the provision of technical information. The budget of the Institute is about \$7.8 million. The Hokkaido prefecture provides the bulk of the

Figure 1. System for Providing Advice to Small Enterprises through Registered Technical Consultants



budget (\$7.1 million), with additional funds from MITI, the Japan Bicycle Development Association, and fees. The Institute has 116 staff.

Tokyo Metropolitan Industrial Technology Center (TMITC)
 Located in an industrial-residential district

near Akabane in northern Tokyo, TMITC has origins that date back to the former Tokyo Metropolitan Industrial Research Institute (established in 1921) and the Tokyo Metropolitan Electrotechnical Laboratory (founded by the old Tokyo Power Company in 1924). In 1970, these two organizations were combined into the Tokyo

Metropolitan Industrial Technology Center, forming a comprehensive institution for technical research, testing, and guidance for small firms. A unit of the Tokyo Metropolitan Government's Commerce and Industry Division, TMITC is organized into four sections (general affairs, equipment, planning, and public relations) and ten departments covering such areas as electronics, electrical instruments and controls, illumination and acoustics, organic and inorganic chemistry, and metalworking and machinery.

TMITC's 207 staff spend about one-half of their time on research projects. Historically, TMITC has concentrated on electricity and lighting, but today the range of expertise is wider, including fine ceramics, new materials, and new manufacturing technologies. About 90% of the TMITC's research is focused on applied technology or manufacturing production. Research projects are initiated by center staff or companies, or developed (and partly funded) in conjunction with MITL. TMITC staff collaborate with MITI's National Research Institutes, visiting these Institutes for research projects and training.

TMITC devotes considerable resources to testing, guidance, and training. The Center verifies whether products meet Japanese, American, or other foreign standards, undertakes product examinations, and makes its sophisticated analysis equipment available to firms developing or improving products. Each year, the Center carries out over 65,000 examinations at an average fee of under \$12 per case. TMITC responds to over 33,000 requests a year from small firms for assistance and guidance on technology and productivity in a wide range of fields, including machinery, metals, electricity, chemistry, and industrial arts. Mostly, these requests are quickly dealt with by a separate advice section; the more complex cases—a small proportion of the total—are passed on to other TMITC specialists or to registered technical consultants. Center staff also visit about 1,000 plants a year to provide field advice and assistance. TMITC offers training programs and seminars, generally aimed at technical personnel and varying in length from 1 day to several hundred hours. About 2,000 workers attend

training courses each year, almost all from companies with between 30-300 employees. Small firms can use TMITC's labs and specialized tools and equipment at nominal charge; the Center provides equipment and machine training where necessary. In 1989, there were 6,100 cases where firms used Center equipment and about 2,000 cases where instruction or training was given. Demand is high for training in personal computers, CAD/CAM, and laser applications. The Center organizes seven technology diffusion groups, each with about 30 individual member enterprises. TMITC reckons that it is providing significant services to about 10,000 companies a year—more than 1% of metropolitan firms. TMITC's annual budget is about \$18.6 million, derived from the Tokyo Metropolitan Government (76%), MITL, the Japan Bicycle Development Association, and other central government sources (5%), joint research projects with companies (12%), and training fees (7%).

THE ENTERPRISE PERSPECTIVE

In interviews conducted with a number of small companies, managers provided information about how they used and benefited from Kohsetsushi services. Typical of these firms is Hamano Metal Working, an independent manufacturer of industrial bolts and parts for several major truck makers. Sited in a north Tokyo industrial-residential district, Hamano employs about 100 regular workers. Since the company's large customers do not provide technical assistance, Hamano uses the Tokyo Metropolitan Industrial Technology Center to gain access to the advanced equipment and technical skills it lacks in-house. When some of its bolts were unexpectedly breaking, the company turned to the Kohsetsushi to conduct x-ray and laser analyses which helped solve the problem. Similarly, to improve its manufacturing processes, the company has several times invited Kohsetsushi engineers to the factory to advise on machinery operation, energy efficiency, and the purchase of new numerical-control tools and robots. About 30 percent of the 200 machine tools that pack Hamano's small Tokyo factory are now programmable, including a large robotized manufacturing center. Hamano has also upgraded employee

skills and capabilities by sending company workers to the Kohsetsushi for training in new materials and analysis techniques. "If we have problems with technology," notes company director Toshio Hamano, "we go to the Tokyo Metropolitan Industrial Technology Center."

Even firms who are helped by customers find Kohsetsushi services valuable. Tokai Kyohan, a 53-employee firm, makes precision gauges and measuring instruments in a crowded but modern backstreet factory in Nagoya. The company uses computer-aided design and manufacturing (CAD/CAM), machining centers, and other programmable tools to produce small lots of customized tools primarily for Toyota and associated firms. While Toyota engineers provide assistance when requested, Tokai Kyohan also uses the Nagoya Municipal Industrial Research Institute to train employees in new technologies, for advice on technological problems, and to make prototypes using specialized Kohsetsushi measuring and machining equipment. Tokai Kyohan managers use the Kohsetsushi because its services are nominally priced and center staff respond to their needs, unlike universities which are generally interested in more sophisticated problems. Access to Kohsetsushi expertise, equipment, and services, helps Tokai Kyohan to design and build specialized precision tools which meet Toyota's often demanding requirements. Additionally, as a member of a Kohsetsushi-organized technology diffusion group, Tokai Kyohan keeps up with developments in CAD/CAM technologies and makes links with other small firms adopting these new technologies.

While companies like Hamano and Tokai Kyohan seek improvements in existing business lines, other firms are using Kohsetsushi services to diversify. Hokkai Spring Company, located in Otaru near the city of Sapporo, is a small manufacturer of farm machinery springs, employing 70 full-time and 30 part-time workers. The company is diversifying into making memory alloy springs, spirals, thermistor sensors, disk thermistors, and snow fall sensors for the automobile, aerospace, and electronics industries. Several of these new projects were successfully developed through cooperative research projects with the Sapporo Kohsetsushi, the Hokkaido

Industrial Research Institute (HIRI). With HIRI's assistance, Hokkai Spring evolved an existing thermistor product into a low-cost snow sensor. In another project, the company cooperated with NKK and the Kohsetsushi to make a cold-weather anchoring spiral for satellite dishes. In an ongoing project, Hokkai Spring is working with Kohsetsushi researchers to develop prototype carbon and glass fiber springs. For these cooperative projects, engineers from Hokkai Spring visit the Kohsetsushi up to three times a week. On separate occasions, two company engineers worked at the Kohsetsushi full-time for a month. Company employees have also taken Kohsetsushi metalworking training courses to improve their skills in making new products. Hokkai Spring is now planning to open a small plant in Arizona to supply US aerospace companies and US subsidiaries of its major Japanese customers.

Other small companies interviewed included a Kitakyushu firm developing innovative value-added products from steelmaking slag, independent electronics enterprises in Nagoya and Tokyo, and a chemical feed company and a marine components firm in Hakodate. In each company, managers discussed how they benefited from a range of Kohsetsushi services, including assistance with new-product development, improvement in production processes, equipment selection, training, and technology-diffusion groups. These small companies maintained long-term relationships with their local centers, using several different services over time.

In discussions with the visited companies, we found that managers appreciated the ready availability and proximity of Kohsetsushi services. The Kohsetsushi centers were seen as "their" centers, specifically designed for smaller firms. Managers noted that they were much more comfortable dealing with Kohsetsushi centers than with universities which were often more interested in their own academic concerns and where top professors had little time for smaller companies. Moreover, in Japan's national universities, the Ministry of Education has traditionally restricted relationships between professors and private businesses (although this

has loosened up a little recently). In contrast, the Kohsetsushi centers, guided by prefectural departments of commerce and MITI, were obliged to work with small private firms.

Small companies also enjoyed the free or nominal charges for Kohsetsushi services. Whether for training, examinations, or technical assistance, small companies noted that it was much cheaper to use the Kohsetsushi center than go to private-sector sources. The cost of participating in joint-research projects was also low, usually limited to the cost of the materials involved. There was no evidence that Kohsetsushi managers were under pressure to raise money from providing services, nor that the cost of accessing services presented problems for small firms.

Noticeably, each of the small Japanese firms interviewed was either run by an engineer or had engineers on staff. Several had their own small research and development programs, while most had devised technological diversification strategies. With in-house engineering and R&D capacity, these firms were in a good position to absorb and develop new technologies—unlike many US manufacturing firms which lack in-house engineering and research expertise.

ASSESSING THE KOHSETSUSHI APPROACH

Kohsetsushi centers are an important part of the foundation for Japan's extensive assistance network for small enterprises. The centers provide a wide range of services to small manufacturers and have an extensive geographical coverage, meaning that most smaller firms, especially those in urban areas, are able to access Kohsetsushi services easily. Center services are well used by firms. Indeed, the sheer number of interactions between the Kohsetsushi centers and small Japanese enterprises is remarkable. Over several decades, the Kohsetsushi system has helped to upgrade Japan's small firm manufacturing base and diffuse new technologies to small firms. According to officials at one Kohsetsushi center in Osaka, the technologies they have helped particularly to diffuse include numerical control/computer numerical control machine tools in the 1970s, and flexible manu-

facturing systems and computer-aided design and manufacturing in the 1980s.⁽²⁷⁾ Such success stories have been repeated in these and other technologies by Kohsetsushi centers around the country.

The emphasis on examination, testing, and analysis is an important aspect of the Kohsetsushi system. In Japan, there is a high level of concern with quality, performance, and precision. Kohsetsushi labs play a particularly valuable role in helping small firms meet these high standards by providing easy, local access to low-cost testing services, sophisticated measuring equipment, standards information and verification, training, and analytical and quality control expertise. Significantly, these examination and testing services were the most frequently demanded of all Kohsetsushi functions. American small firms rarely have as ready access to this range of examination and testing services.

Kohsetsushi advice and guidance services are also very frequently used by small firms. There are many other small-firm advice and assistance services in Japan, run by central and city governments, local industrial halls, and chambers of commerce, and at times these various services overlap. Kohsetsushi assistance is generally more technologically focused, with other offices providing assistance with management, marketing, and finance. As in the US, small firms in Japan still have to deal with a range of different offices and programs, although the stability and structure of Japanese programs seem to encourage more coordination.

Across the country, different Kohsetsushi centers offer quite similar services and programs. For example, all five Kohsetsushi centers visited pursued roughly the same policies, allocated about half of staff time to research, and divided the balance between examinations and analysis and technology advice and guidance. This national standardization is achieved with little direct central-government funding. The Kohsetsushi centers are administered and largely funded by prefectural or metropolitan governments, with the governors of these administrative units appointing the Kohsetsushi directors. However, since part of prefectural and local government revenue in Japan comes from

the central government, the indirect central-government cost may be somewhat larger than it first appears. Yet, while MITI directly provides only a small share of funding, the ministry does have significant influence over the Kohsetsushi system through several mechanisms. The first one is exercising "administrative guidance"—the extra-legal means of obtaining adherence to policies and practices deemed desirable by the government. This is a long-standing practice and prevalent in (although not unique to) Japan. The second mechanism operates through the linkages between the Kohsetsushi centers and MITI's national research laboratories, which many times guide Kohsetsushi research approaches. The third one operates through personal connections and personnel rotation: many government officials at the local level (both elected and appointed) have links with MITI or are former MITI employees. The fourth mechanism works by carefully leveraging small amounts of new project funding from MITI and MITI-affiliated organizations.

A prominent characteristic of the Kohsetsushi centers is their institutional and staffing stability. This has both advantages and drawbacks. Most Kohsetsushi centers have existed for decades and have little need for US-style "outreach" programs, since local firms generally know what the Kohsetsushi center does and where it is located. Kohsetsushi staff typically spend their whole careers with one center, and so become well known in the community and experienced in dealing with local firms. Only a small proportion of Kohsetsushi staff have doctoral or masters degrees; most are educated up to the bachelor level, usually in engineering, gaining apprentice-style research training on entering their center. Under this staffing system, tight relationships develop over time between staff and firms—a pattern which facilitates mutual confidence and effective technology transfer. On the other hand, the permanence of Kohsetsushi staff means that their average age is high, with the risk that skills are outdated in some cases. The low turnover of personnel provides few opportunities to recruit young staff in new areas of technology. Additionally, while Kohsetsushi staff can be

designated as "special qualified officials" and receive higher salaries than ordinary local-government personnel, some Kohsetsushi centers report difficulties in matching the wages and benefits offered to university graduates by the private sector. In Kyushu, Kohsetsushi centers are addressing this problem by seeking experienced older researchers who wish to return from metropolitan centers and by focusing recruitment on local college graduates.(28)

Generally, funding for Kohsetsushi centers has long been incorporated into prefectural and municipal budgets, and is regular and predictable. Kohsetsushi managers complain that they do not get as much money as they would like, while some centers have seen budget reductions. But Kohsetsushi managers do not appear to be preoccupied by fund raising—in contrast to their American counterparts who often expend inordinate efforts to generate enough money to allow programs to continue. When fees are generated by Kohsetsushi centers, they usually cover incremental cost, such as for extra materials used in cooperative research, rather than for core staff and facilities.

Some observers criticize the quality of research in Kohsetsushi centers, pointing out that it is not on the leading edge. There are certainly Kohsetsushi centers where the laboratories are visibly decayed, many projects are run by single researchers, the average age of staff is high, and the topics of research are relatively mundane. In other cases, Kohsetsushi research laboratories are well organized and equipped, and focused on ambitious research objectives. However, the general impression is indeed that most Kohsetsushi research is not particularly advanced. Paradoxically, this "weakness" in research can be considered an important strength of the Kohsetsushi system. Kohsetsushi staff remark that with their simultaneous responsibilities for guidance and assistance, it is a continual challenge to improve their knowledge about new developments in their fields. In this "catch-up" mode, few Kohsetsushi staff are at the frontier of their field; they are usually in an intermediate or broker position. But, precisely because they are not too far ahead of their small firm clients, Kohsetsushi staff can readily

transfer knowledge which is useful and close to application to smaller firms. There is some tension in this arrangement. Some Kohsetsushi managers said that their good research people would like to spend much more of their time on research than on working with smaller firms. But the managers added that staff knew when accepting employment that it was an important part of their job to assist firms, so it was possible to overcome this problem.

One corollary of national standardization and institutional stability is that there is less in the way of experimentation, diversity, and local customization in Kohsetsushi services than would be seen in comparable American programs. Japan's Kohsetsushi centers provide a comprehensive set of basic services throughout the country, offered fairly uniformly and with little program innovation by individual centers. Japanese public policy characteristically emphasizes consistency in services at the local level and, to date, most new Kohsetsushi program initiatives have been stimulated by MITI. But this may begin to change as Japanese local institutions become more active in promoting technology, economic growth, and small enterprise development. In some locations, Kohsetsushi centers are facing growing competition from regional universities, new local government projects, and private-contract organizations all seeking to upgrade technologies in area small firms. Similarly, as more small firms themselves are becoming increasingly technologically sophisticated, they are strengthening their own R&D sections, organizing independent technical collaborations with other firms, or seeking the higher-level research expertise of universities and specialized research laboratories.⁽²⁹⁾ Local Kohsetsushi centers, particularly in larger cities such as Tokyo and Osaka which contain many advanced small firms, acknowledge that they need to respond to these developments and tailor their programs to meet changing small firm needs. Some local centers are beginning to restructure themselves, by strengthening and upgrading their applied research efforts, seeking more cooperative research projects with area firms, and developing closer relationships with universities and advanced laboratories in the

public and private sector.

CONCLUSION

Within Japan's complex and evolving set of policies and practices created to stimulate small firm modernization, Kohsetsushi centers play an important role in helping Japanese small firms upgrade their technological capabilities, improve their products, and train their workers. The firm case studies showed that for some firms, Kohsetsushi assistance is critical. This is true of many firm-Kohsetsushi relationships.

From a US perspective, there are many interesting aspects to the Kohsetsushi system. The Kohsetsushi system is notable for its extensive range of services, broad geographical coverage, long-term stability, linkage of technology and training, emphasis on measurement and quality, and pragmatic approach to research. However, perhaps the most fundamental lesson is that technological modernization and deployment efforts for small firms need to be comprehensively and thoroughly implemented at the local level to be effective. Although some limited federal and state efforts are now under way, the United States has yet to establish a comprehensive system of industrial extension to support its manufacturing firms. Existing US efforts are patchy and fragmented, and have yet to attain anything like the stability, scale, and scope of Japan's Kohsetsushi centers.⁽³⁰⁾

In the future, changing patterns of small firm production and central and local policies created to actively promote technology will lead to increased demands on public technology providers and will start new rounds of technology projects. In some instances, Kohsetsushi centers will face competition from more energetic and innovative new local technology centers. But, in general, it is likely that Kohsetsushi centers will continue to form the cornerstone of local technology service provision in Japan.

ACKNOWLEDGMENTS

This research was supported in part by the National Institute of Standards and Technology, United States Department of Commerce, under award number 60NANBOD1047. Invaluable assistance in conducting this research was provided by Shuichi Hashiya.

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