PUBLIC TESTING AND RESEARCH CENTERS IN JAPAN

Control and Nurturing of Small- and Medium-sized Enterprises in the Japanese Automobile Industry

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Many industrialised economies have seen a relative increase in the number of small- and medium-sized enterprises (SMEs) compared with large companies since the 1980s. To foster the rise of SMEs, many governments have established centers to promote innovation and diffusion. This paper examines the role of the Japanese Public Testing and Research (PTR) centers, which have been proposed as a model for other countries. The paper outlines the background and overall activities of the PTR centers, and then focuses on how PTR centers have assisted SMEs in the vicinity of Japan's five large car makers. It is found that in 1986 the PTR center near Toyota's main assembly facilities performed the largest number of test inspections. The extraordinary number of inspections indicates that the Toyota production system calls for a particularly high degree of outside certification. Technical consultations played a greater role at PTR centers in the vicinity of other Japanese auto producers, indicating that suppliers gained more independence from their client firms.

1. Introduction

Many researchers have documented a gradual shift since the late 1970s or early 1980s from large-scale enterprises (LSEs) towards small and medium-sized enterprises (SMEs) in the industrialized economies. Caroll (1994:29) estimated that "the size of the average business organization in the U.S. declined by 30-40 percent from 1960 to 1989". Thurik & Dijksterhuis (1994:1032) indicated that whereas large firms in 1970 still accounted for 20 percent of US employment, this share declined to only 10 percent by 1994. In the former European Community (EC), the long-term pattern looks somewhat more varied.[1] However, recent figures show that nine of the twelve former EC member states during 1988-1990 displayed significant SME growth rates and declining numbers of large firms (ENSR, 1994).[2]

Abundant reasons have been given for the (re-)emergence of small scale enterprising (Storey, 1994:35). One the best-known is that product life cycles have shortened, making innovation more costly and more difficult for larger firms to control. As Schumpeter (1934) already argued, small firms are better able than large firms to introduce totally new products. A similar perspective was offered by Piore and Sabel's *flexible specialisation thesis* (1984), which argued with emphasis on Italy's Emilia-Romagna and Germany's Baden-Württemberg regions, that small artisan firms in sectors such as ceramics, clothing, knitwear and shoes could adapt more readily to continuous change and innovation. Firms in such regions were expected to pose a significant alternative to traditional mass production.

Looking at the increase of SMEs from the perspective of large-firm strategies, the business literature has discussed two trends that may help to account for the growing importance of SMEs. Firstly, LSEs have been urged to diminish their levels of horizontal integration: in other words, cut back on diversification and shift "back to the core" (Prahalad & Hamel, 1990). It is not entirely clear to what extent LSEs have actually reduced diversification nor what the

[1] Acs, Audretsch & Evans (1991, cited in Storey, 1994:33) found that seven of the former twelve EC member states (Belgium, Germany, Ireland, Italy, Portugal, Spain and the UK) displayed increasing levels of self-employment (as a percentage of the total labor force) between 1977 and 1987. Five former EC member states however showed declining levels of self-employment (Denmark, France, Greece, Luxembourg and the Netherlands). The correlation between self-employment levels and SME activity clearly differs from country to country (reflecting international differences in average firm size) and over time even within one country (reflecting domestic changes in the composition of the SMEs segment), making conclusions regarding the actual rise or fall of the number of SMEs more difficult. However, these data indicate that the rise of SMEs in Europe is not as pervasive as is sometimes suggested.

[2] The exceptions were Ireland, Spain and the UK, countering the longer-term trend of growing levels of self-employment in these countries. However, these two year deviations may also be due to variations in the business cycle. Large companies are defined in the European Union as employing 500 or more people.

effects of doing so are on company performance (cf. Markides & Williamson, 1994). In any case, reduced diversification may leave LSE-SME interactions unchanged; it often implies that other firms, including smaller firms, simply perform activities that were peripheral for larger companies.

A second trend featured in the business literature is that LSEs have started to reduce levels of vertical integration by outsourcing supply and technology development activities. Many North American and European companies have at least *attempted* to set up "lean enterprise" experiments in an effort to emulate the strategies, as defined in a flood of management literature, of successful Japanese car and electronics assemblers (cf. Womack & Jones, 1994). The nature and results of these attempts have varied widely. Companies which for many decades have been accustomed to high levels of vertical integration and in-house control over parts supply are unlikely to change their behavior unless they have established some kind of longer-term control over external suppliers. Thus, US car makers such as General Motors and Ford over the early 1990s have reduced the *number* of suppliers rather than increasing the suppliers' share of total production (Ruigrok & Van Tulder, 1993:339ff). In *strategic* terms, reducing the number of suppliers could well be a first step towards increased outsourcing. If the level of outsourcing subsequently increases, or as such choices are increasingly confronted, this may have direct implications for the LSE-SME relationship: large companies relying, or planning to rely, more on external parties for vital components and subassemblies will search for ways to manage these newly emerging dependencies.

Even if the data on the trends in LSE strategies are not conclusive, a restructuring of the LSE-SME relationship does seem to be taking place in many industrialized countries. The changing relationship between LSEs and SMEs in turn contributed to renewed academic interest in network theories. The dominant approach in this area still is the transaction costs approach (Williamson, 1975 and 1979), which presents a scale between markets and hierarchies and three "objective" cost criteria that lead companies to decide whether to "make" or "buy". Other authors interpreted SMEs and SME networks as "something in between" markets and hierarchies or even as the emerging shape of "post-Fordism" (Powell, 1990).

Although Freeman put the network "hype" of the late 1980s and early 1990s into perspective with the reminder that supply and innovation networks "are as old as industrialized economies" (1991:510), recent interest in networks has become varied and more sophisticated. Examples include Aoki, Gustafsson and Williamson's image of the firm as the *nexus of treaties*

(1990) and Håkanson's perspective of the firm searching for *complementary network partners* (1989). Several authors pointed out that network structures matter in the nature of the diffusion process (e.g. Midgley *et al.*, 1992:533). Some stressed the "symbiotic" nature of LSE-SME networks (Smith *et al.*, 1991:467; Gonda, 1994:27), in which LSE growth depends on a healthy and sizable segment of SMEs. Others have been more critical of networks and the increase of SMEs. Harrison, for example, regards "the emergent paradigm of networked production as one of *concentration without centralization*" (1994:142, original italics) and argues that the growth of SMEs has not led to an end of the "unequal power among firms" (*ibid.*).

The literature on the LSE-SME relationship has drawn many examples from Japan, where SMEs make up an especially large proportion of the total number of firms, and LSEs have traditionally maintained close links with SMEs.[3] Particularly in the car and electronics industries, studies have often focused on the nature of LSE-SME supply and innovation networks. While some Japanese authors envisioned Japanese corporate and industrial networks as offering a new type of egalitarian production system (Imai, 1989), others spoke of "clustered control" in the supply system of the Japanese car industry (Nishiguchi, 1989).

Changes in the composition and proportion of large and small businesses directly influence the nature of innovation. While smaller companies experience less bureaucratic conflict or rigidity, they tend to lack the financial resources or personnel that larger firms may reserve for product and/or process innovation. Consequently, SME innovations tend to develop less systematically, are less controllable, and tend to depend more on individual entrepreneurial initiative. In Japan, large firms have sought to mitigate SME weaknesses through staff exchanges, regular meetings with their supplier associations, financial assistance, and technical guidance. In exchange, SMEs often submit to a wide range of accompanying surveillance measures.

Governmental policies are forced to change when the locus of innovation shifts towards SMEs. High levels of vertical integration led governments to focus their innovation policies on a small number of "national champions". Guided by the perception that national economic competitiveness is becoming more dependent on SMEs, many governments over the 1980s

[3] Freeman (1991:512) refers to Goto (1982) who stated that "the idea of networks as a 'third form' intermediate between markets and hierarchies was originally suggested by Williamson himself in a footnote about the Japanese *zaibatsu*", although he regarded this as a "culturally specific" Japanese phenomenon.

established administrative and financial support policies for SMEs to address problems stemming from their limited human, capital and technological resources (cf. Storey, 1994:302).

In addition to these programs, many governments established institutes supporting production innovation and/or diffusion of improved manufacturing practices and technology. Such Innovation and Diffusion Institutes (IDIs) have long been regarded as important contributors to SME competitiveness and have, in some countries, a history stretching back several decades. In Canada and Germany, for instance, certain *regional* governments established IDIs in the late 1940s. This example was followed by the US during the 1950s, and by Germany (again) and Italy during the 1970s. During the 1980s, national as well as European level support for IDI programs became much more salient, with *national* IDI programs appearing in Britain, France, the Netherlands, and the US. Meanwhile, already-established national programs, such as in Denmark, began to tap into growing *European* level support for IDIs (cf. table 1).[4]

[4] We prefer the concept of *Innovation and Diffusion Institute* over the more familiar "Regional Technology Center" or "Industrial Extension" labels. There are five reasons for this. 1) The emphasis on regions made most sense when public support came from regional governments but can be misleading now that national and European-level initiatives have come to the forefront. 2) Institutes supporting industrial competitiveness have moved beyond an exclusive focus on technology to address in addition matters of work organization. 3) The concept of manufacturing "extension" suggests only diffusion activities, but in sectors where the pace of change is a competitive factor, a modicum of innovation is often itself part of the diffusion process. 4) The term "innovation" covers all applied research and development while the term "diffusion" suggests the further spread of better practices from whatever source; particular institutes obviously vary in their mix of innovation and diffusion activities. 5) The word “center”, which is increasingly used in the regional development literature to refer to industrial zones, parks, or districts (e.g., “centers of excellence”, “technology and business incubation centers”), has become potentially confusing. Note that the IDI concept is not necessarily restricted to SMEs; for instance, the German Fraunhofer Institutes also serve larger companies.

Table 1 Innovation and Diffusion Institutes in several national & regional economies

NATION (Region)	Number and nature of IDIs (initial year of program)	IDI activities and staffing (1987)	IDI budget and sources of funding
DENMARK	15 local Technology Information Centers (1971), later with EU support (1986-91)	1987: 6,300 field visits by TIC staff; Teknord helps SMEs share technology managers	co-funded by national and local authorities; EU funding to Teknord ended in 1991, but firm contributions have increased
GERMANY	36 Fraunhofer Institutes in western Germany (1949)	contract research for firms of all sizes; 5,000 staff	$334 million (DM600 million), 75% funded by industrial clients since 1973
	63 AIF sector-specific cooperative research (*Gemeinschaftforschung*) programs for 34 sectors (1954)	cooperative research projects; 3,700 staff	$222 million (DM400 million), 25% from public sources
(*Baden-Württemberg*)	80 Steinbeis Foundation branch offices (1971); [13 Fraunhofer institutes are also in this region]	technology transfer 1991: 15,744 projects; 1,873 staff	$23 million (DM42 million) in 1987, of which public funding was less than 10%
ITALY (*Emilia-Romagna*)	12 ERVIT centers created by regional government and 250 National Confederation of Artisans (CNA) trade union offices (1974)	sector-based centers with accounting services, information databases, technical education; CNA helps firms raise capital, make investment decisions; 480 staff at ERVIT centers, 2,500 staff at CNA offices	$24 million ERVIT centers are co-supported by private sector associations, member firms, and user fees.
JAPAN	180 prefectural/municipal Public Testing and Research centers (1874)	industrial programs for firms with fewer than 300 workers: 700,000 test inspections annually, consultations, on-site guidance, equipment loans; 6,780 staff	$447.8 million (¥64.75 billion), nominal fees, publicly supported
NETHERLANDS	19 InnovatieCentra received take-off subsidy from Min. of Economic Affairs (1989)	information broker, technology transfer	must develop into fully independent centers by 1995-96.
US	42 state-level "industrial extension" programs and over 100 university programs (1955)	business assistance, technology transfer, industrial extension; half based at colleges; roughly 1,500 staff	$83 million in 1991 (including for 5 NIST centers); 45% state, 24% federal (6 years of funding for new state programs via STEP since 1988), 11% state universities, 9% user fees, 8% industry
	7 NIST Manufacturing Technology Centers; Manufacturing Outreach Centers (1988)	300 staff	$87 million, 100% federal funding

Sources: Rosenfeld, 1992; Shapira, 1992 and 1993; Hackwood, 1993; Meyer-Krahmer, 1990.

Piore & Sabel suggested that IDIs reinforce flexible specialization networks of SMEs in such places as Baden-Württemberg and Emilia-Romagna. In this view, IDIs were part of an "institutional exoskeleton" (Herrigal, 1990) that supported the rise of industrial districts based on innovating SMEs. Flexible specialization also required institutions supporting the creation, maintenance, and upgrading of a highly skilled labor force as well as fragmented and upscale markets that could be targeted by firms employing these highly skilled workers (Piore and Sabel 1984:223). For the most part, however, industrial districts and networks of individuals, rather than institutions per se, have tended to be the focus of discussion within the flexible specialisation approach. Examination of specific national institutions has often been scant or missing altogether.

Recent work in political economy has suggested that national institutions have played a key role in shaping historically rooted technological trajectories that may differ substantially from country to country (Hall 1986; Zysman 1983, 1994). Institutions, in this sense, have typically included such things as the financial system, vocational education systems, the structure of labor-management relations, and mechanisms of inter-firm bargaining. Since IDIs not only structure relations between regional governments and SMEs, but can also significantly influence the character of LSE-SME relations, IDIs seem to be another important, and potentially variable, institution.

In this paper, we look at the role of one type of IDI, the *Public Testing and Research* (PTR) centers (*kōsetsu shiken kenkyū kikan*) in Japan.[5] Japanese PTR centers began to draw widespread attention in the wake of presidential candidate Clinton's pledges to establish a similar set of institutes in the US (Shapira, 1992).[6] Japanese PTR centers are located in all 48 prefectures, and the oldest center dates back to 1871. Relatively detailed data are available on the PTR centers' budgets and on the nature of their activities, which makes it possible to make historical and nation-wide assessments of their impact. SMEs play a very important role in the Japanese economy: defined in Japan as having fewer than 300 employees, SMEs accounted in the mid-1980s for 52 percent of all manufacturing shipments, 80 percent of all employment, and over 99 percent of all establishments (Small and Medium Enterprise Agency, 1989: 1).

Sections 2 through 4 of this paper position the PTR centers in the overall Japanese S&T context, trace their historical development, and present an overview of their activities. Sections 5

[5] Others have referred to these institutes as "public research institutes" (Saito Masaru in Gonda, Sakauchi, Higgins, 1994: 104) or as "*kohsetsushi*" (cf. Shapira, 1992 and 1993; Nishio, 1993; NISTEP, 1994), a relatively opaque abbreviation for *kōsetsu shiken kenkyū kikan*. Public Testing and Research is a direct translation of this generic Japanese term for the centers. The word "public" distinguishes the centers from purely national (*kokuritsu*) programs (cf. section 2); the words "testing and research" highlight the two very different poles of their activities (cf. section 3).

and 6 focus on the role of the PTR centers in the Japanese car industry. This industry has a large literature on LSE-SME relationships, and detailed information is available on major assembly plants and suppliers. In particular, this part of the paper tries to establish whether and how PTR centers in the vicinity of Japan's five largest car assemblers (Toyota, Nissan, Honda, Mitsubishi and Mazda) have assisted SMEs, and how, if at all, this assistance has affected SMEs' overall relationship with the large car assemblers.

2. Institutions of Japanese Science and Technology Policy

The Japanese central government supports many technology programs at the national and prefectural levels. Almost 75 percent of the national science and technology budget is funnelled to so-called “big science" programs: university research, the Science and Technology Agency's space and nuclear research programs, and the sixteen national industrial labs (*kōgyō gijutsuin*) operating under the supervision of the Agency of Industrial Science and Technology (Science and Technology Agency, 1994:133).[7] The Science and Technology Agency is supervised by the Prime Minister’s Office while the Agency of Industrial Science and Technology is an external branch agency of the Ministry of International Trade and Industry (MITI).

In certain high-tech industries, such as semiconductors or computers, MITI played a major role: it identified core technologies, pushed firms into common research projects, and, at times, even "bullied some companies into compliance" (Kitschelt 1991:489). For the most part MITI’s influence over S&T policies is more indirect. MITI’s 1993 science and technology budget amounted to only ¥281 billion (US$2.52 billion),[8] an amount roughly half that at the Science and Technology Agency (¥582 billion = US$ 5.23 billion) (Science and Technology Agency, 1994:138). Expenditures for regional programs, an area where Japanese technology expenditures have been unusually focused, amounted to almost twice MITI’s formal budget. Regional government expenditures for technology programs in 1992 were estimated by the National Institute for Science and Technology Policy at ¥573 billion (US$4.26 billion), an

[6] The planned number of US institutes, which are to be supervised by the National Institute of Standards and Technology under the Department of Commerce, has since been scaled back from 180 to 100. Once established, the US centers can expect to receive a maximum of six years of federal funding.

[7] Not all Science and Technology Agency activity is “big science”: STA also partially funds the Japan Research and Development Corporation, which is responsible for aiding the transfer of research results from university and government labs to private companies (Best, 1990:194).

[8] These figures refer to the Japanese fiscal year (April 1 to March 31). All exchange rates are based on average annual exchange rates: 1991 ¥134.59 = US$1; 1992 ¥127.31 = US$1; 1993 ¥111.20 = US$1.

amount equivalent to 26 percent of all national-level science and technology expenditures. Almost two thirds of these regional technology expenditures, in turn, went to PTR centers (NISTEP, 1994:30). A highly selective survey of Japanese technology programs appears in Table 2 below.

Table 2 Selected Japanese Science and Technology Programs

Program	Agency / Ministry	Comments
"Big science" programs	Agency for Industrial Science and Technology Science (MITI); and Technology Agency (Prime Minister's Office)	almost 75% of total national budget; covers university research, space and nuclear research programs, 16 national industrial labs
Japan Research and Development Corporation	Science and Technology Agency (Prime Minister's Office)	responsible for aiding transfer of research results from university and government labs to private companies
University-Industry Cooperative Research Centers	Ministry of Education	28 centers established in 26 prefectures during 1987-92 to increase academic collaboration with industry
Science Parks	Japan Regional Development Corporation	operate under administration of prefectural and local governments
Technopolis	MITI	designated areas can claim tax advantages and government support for infrastructure development; at least 17 of the first 19 Technopolis projects were built around a PTR center
Third Sector Institutes	MITI	121 institutes, most of them founded after 1980, carry out projects that are neither purely "government" nor purely "market" activities, but combination of both. Financed partly by local and national governments, partly by consortiums of companies. Some third sector institutes are called PTR centers.
Specific Regional Technology Development System	Agency for Industrial Science and Technology (MITI)	Aims to organize regional networks of universities, PTR centers and local firms; participants pay their own expenses. Between 1992-1993, budget increased 85% to ¥679 million (US$ 6.11 million)
Wide Area Joint-Research System	Small and Medium-Enterprise Agency (MITI)	¥421 million program (US$ 3.79 million) aims to organize regional networks of universities, PTR centers and local firms; participants pay their own expenses
PTR centers	Agency for Industrial Science and Technology (MITI)	provide SMEs services such as research, testing, consultations, individual guidance, equipment usage, and information distribution at no or nominal charge

Sources: NISTEP 1994; Science and Technology Agency, 1994; Best, 1990; Shapira, 1992 and 1993; Junne *et al.*, 1990.

National-level policy initiatives and technological expertise are relayed to the PTR centers by two MITI-affiliated agencies, the *Agency for Industrial Science and Technology* and the *Small and Medium-Enterprise Agency*, both of which also administer a variety of other programs. Other government ministries have also established their own regional programs in support of industry, sometimes overlapping MITI programs (see table 2).[9]

3. Public Testing and Research Centers in Japan: historical backgrounds

The oldest prefectural PTR center still in existence today was established in 1873, just two years after the prefectural system of regional governments was itself inaugurated in 1871. National-level attention to private-sector development began to come into focus a decade later with the creation in 1881 of the Ministry of Agriculture and Commerce, a predecessor to MITI that remained responsible for both agriculture and industry until 1925. Ever since that time, the creation of PTR centers for agriculture, industry, and health has been a continuous feature of modern Japanese history. Altogether, there are some 600 PTR centers spread throughout the 47 prefectures and 10 designated cities in Japan.[10] Although agricultural centers underwent numerous consolidations and declined markedly in number over the last decade, they still account for the majority of all PTR centers. Roughly a quarter of the total, a share that has been rising steadily, are industrial PTR centers, while most of the remainder are divided between health and environment research and testing. In this paper, we are concerned only with industrial PTR centers.[11]

Industrial PTR centers were originally established to support traditional craft industries such as silk spinning-mills, potteries and bamboo processing shops. PTR centers for heavy industry began to appear in the 1930s. During the post-war period they have assisted increasingly sophisticated industries such as electronics and technical ceramics.[12] Although industrial PTR centers are supervised by the Agency for Industrial Science and Technology and the Small and Medium-Enterprise Agency, the actual administration is handled by prefectural and city governments.

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[9] Administrative "sectionalism" has long prevented Japanese R&D activities in different areas from being more closely coordinated (cf. OECD, 1967:22). Consistent with this pattern, PTR centers have apparently had little interaction with the sixteen national (*kokuritsu*) labs engaged in basic research.

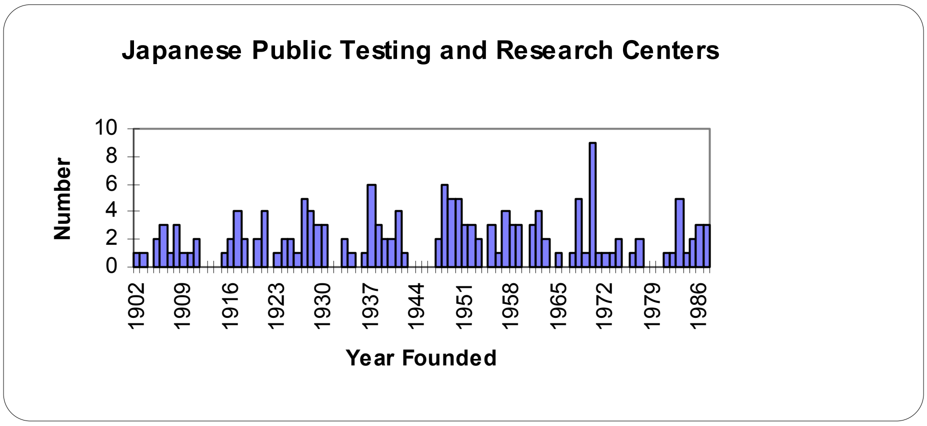
[10] Data combining the several hundred agricultural extension centers with the industrial PTR centers along with several dozen public medical centers, commonly appear under a slightly different label in Japanese (*kōritsu shiken kenkyū kikan*) that in English can also be translated as "public testing and research centers".

[11] The most common name for an industrial PTR center is "[prefecture or city] industrial technology institute" (*kōgyō gijutsu sentaa*").

[12] In addition, 81 regional research institutes more oriented toward leading-edge research have been established since the beginning of the Technopolis project in 1983. The four different legislative programs under which they have been created are the private sector resources utilization law, the bio-oriented technology research

By the end of 1929, Japan had at least fifty industrial PTR centers that are still in existence today. However, as figure 1 shows, the greatest number of PTR center establishments took place during 1937-1941, and during 1948-1952, with the emphasis on the first two years (1937-1938 and 1948-1949). These periods coincide with two major turning points in Japanese industrial history. The build-up of the Japanese military-industrial complex dominated the 1937-1941 period and culminated in the Pacific War. The 1948-1952 period followed the US decision to re-build Japan as an anti-Communist bulwark in the Pacific Basin (the "Reverse Course"), leading to an active re-industrialisation policy. The fact that during these two periods the establishment of new PTR centers peaked in Japan indicates that the Japanese government regarded these centers as effective institutions for rapid industrial development.

Figure 1 Japanese Public Testing and Research Centers (annual establishments)



Source: Data compiled from *Zenkoku Kenkyū Kaihatsu Binran* (Tōkyō: Gyōsei Tosho Shuppan Hambai, 1988), pp. 718-1069

Following the boom in PTR centers for heavy industry during 1937-1941 and 1948-1952, newer PTR centers focused on an increasingly broad range of purposes. In 1955, for example, three centers were founded on Hokkaido, Japan's northernmost island, to deal with underground resources, construction, and industrial arts. In 1970, when nine PTR centers were established, three of these were devoted to earthquake-related testing and research. New centers for industrial testing continued to be established, as well, and a few of these supported the further

advancement law, the key facilities' siting law, and the act on the promotion of multi-polar pattern national land formation (Gonda, Sakauchi, Higgins, 1994: 32, 140).

spread of automotive manufacturing (see section 5).[13] By 1993 Japan had a total of 180 industrial PTR centers.

4. Activities of Japanese Public Testing and Research Centers

Japanese Public Testing and Research centers exist for a wide variety of areas. Table 3 shows a breakdown of those industrial PTR centers whose principal activity is clear from the available data.[14]

Table 3 Japanese PTR industrial centers by type (1986)

General Type	Number of PTR centers
Agriculture, Forestry, Underground Resources	15
Craft and Light Manufacturing	42
Heavy Manufacturing	87
Miscellaneous (health, civil engineering)	12
TOTAL	156

Source: Data compiled from *Zenkoku Kenkyū Kaihatsu Binran* (Tōkyō: Gyōsei Tosho Shuppan Hambai, 1988), pp. 718-1069.

PTR centers perform not merely testing and research activities. Other services include consultations, individual guidance, training seminars, subsidized referrals to outside consultants, usage of center equipment, and information distribution. PTR centers provide only technical assistance; for financial or management support, different organizations are available.[15] Advice programs tend to be free of charge, although the period of advice tends to be limited (5-10 days). PTR centers may also make their lab space available to SMEs as part of the equipment usage program. A closer look at industrial PTR center activities reveals the following (see appendixes A-E):

[13] Some of the apparently "newer" centers, however, have been the result of mergers, or re-founding, of antecedent centers. To take the most prominent example, the main PTR center for Tokyo is listed in the (1986) data as being founded in 1970; actually, that year was merely when two previously separate institutes, both dating back to the 1920's, were merged to form a single center. Between 1986 and 1993, ten PTR centers ceased operation (at least four of the ten through mergers with other existing centers) while 21 new centers were founded.

[14] Note that "Agriculture" in table 3 refers only to centers under MITI supervision specializing in agricultural technology and does not include the hundreds of agricultural extension offices in Japan.

[15] For example, there are 59 SME General Guidance Offices (SMEGGO: chūshō kigyō sōgō shidōjo) scattered around Japan.

1) The amount of time devoted to *research* (meaning applied research into specific industrial problems) varies considerably from center to center. Some PTR centers report spending half their working time on applied research. Some say that a substantial amount of applied research does take place, but in the evenings after official working hours have ended for the day. Other centers claim to spend very little time at all on research problems. At centers where there is significant research, small businesses often dispatch one or two employees to work on specific projects in order to gain technical skills and transfer technology back to the dispatching firm. Centers with large applied research activities are more likely to support flexible specialization types of networks, and may be less likely to support suppliers to the large core firms, since large core firms are likely to require that suppliers keep critical research with the company group.[16]
2) *Test inspections* (*irai bunseki•shiken*) (see appendix C) tend to be inexpensive (e.g., ¥20,000 for two days of equipment analysis) since firms are not billed for labor costs. On the basis of a test inspection, the PTR centers issue a certification of the quality and accuracy of instruments used by an SME. Large firms typically require such certification before dealing with a supplier. Large firms at times also loan personnel to PTR centers to help with the establishment of testing procedures and the development of training seminars. One estimate suggests that PTR centers assist as many as 30 percent of all manufacturing firms in Japan each year (Cooke and Morgan, 1991:23). Except for the distribution of general information materials, the test-inspections programs are by far the most frequently used service offered by PTR centers.
3) *Consultation* programs (see Appendix E) are relatively expensive and time-consuming for centers to provide. The major industrial cities of Tokyo, Osaka, Nagoya, and Yokohama, areas where no single firm or industry dominates the local economy, have the most developed consultation programs. These are the programs most likely to provide assistance to relatively sophisticated SMEs seeking relatively significant technical innovations.
4) *Guidance* programs, which are funded by subsidies from the Small and Medium-Enterprise Agency, appear to cluster in the oldest, or most craft-oriented, centers (see appendix D). Guidance programs last as long as 5-10 days per instance of guidance, yet tend to be free of

[16] Private discussion with Philip Shapira, April 5, 1994. See Shapira (1993: 72).

charge to firms. Guidance programs appear to aim in particular at strengthening traditional craft industries.

5) PTR centers also offer companies the possibility to use of the centers' *equipment*. The extent to which this happens varies according to the center. Mostly smaller and technically less advanced SMEs make use of this service.

6) Each PTR center distributes *general information*, including a magazine and an annual report describing its activities. The centers also provide direct answers to simple inquiries by telephone or fax, and provide advice about available programs.

The next two sections discuss how PTR centers have provided assistance to SMEs in the Japanese automobile industry.

5. The geographical dispersion of the Japanese automobile industry

Japanese vehicle production originally clustered in the southern part of Tokyo, with roughly eighty percent of all vehicles coming from that area until the early 1950s. Traditionally, Nissan and Toyota have dominated the Japanese automobile industry. In the late 1940's, Toyota, under pressure from the Bank of Japan, shed its Tokyo-area operations and concentrated all production activities in Aichi Prefecture, the company's home base. Although the president of the Bank of Japan had argued that supporting a domestic auto industry would be inflationary, the Bank of Japan had an even greater interest in forestalling a collapse of the Nagoya/Aichi regional economy (Cusumano, 1985:15,19). An Aichi PTR center was established in Kariya in September 1949. Toyota's shift southward to Aichi stimulated auto parts production in areas between Tokyo and Aichi, especially in Shizuoka prefecture. In this take-off stage, US army purchases of US$23 million worth of truck, military vehicles and other equipment during the Korean War played a crucial role (Cusumano, 1985:19; Johnson, 1982:200). Early post-war Shizuoka also gave birth to motorcycle makers Honda, Suzuki, and Yamaha.

The erection of trade barriers in the early 1950s encouraged firms from all over Japan to try to enter the auto industry. These new entrants included not only the Shizuoka motorcycle makers but also former aerospace producers like Mitsubishi, Fuji Heavy, as well as makers of precision equipment including Tōyō Kōgyō, Daihatsu and Fuji Seimitsu. Not all of these new entrants were successful.[17]

[17]Only in June 1964 did Mitsubishi become a somewhat major vehicle producer within Japan (Genther, 1990:82-83, see section 6.3). Fuji Heavy, after some experimentation with motor scooters, introduced its first four-wheel

The scarcity and high cost of land in Tokyo pushed Tokyo-based vehicle producers Nissan, Mitsubishi, Isuzu, and Hino to shift final assembly operations from south-central Tokyo to areas just south and north of Tokyo including Kanagawa, Tochigi and Saitama prefectures. Kanagawa and Tochigi PTR centers were established in the vicinity of Nissan's new facilities. A Hiroshima PTR center was established in Kure near Tōyō Kōgyō in November 1949, at a time when Tōyō Kōgyō produced only three-wheel vehicles.

The founding of several newer industrial PTR centers coincides with important dates in the Japanese automobile industry. During the 1950s and 1960s MITI had opposed new entrants in the car industry. For instance, Fuji Heavy, located to the north of Tokyo in Gunma prefecture, benefited from Nissan's activity in nearby Tochigi, yet the Gunma PTR center for heavy industry was apparently established only in the year that Fuji Heavy shares were first sold to Nissan (1968). Likewise, the Saitama PTR center near Honda's first car factory in Sayama in 1965, was established a year after Honda's dramatic entry, despite MITI resistance, into the car business.

As a result of these developments, automobile production presently takes place throughout much of Japan. Some companies have managed to concentrate the bulk of their production within a geographically limited area, but others are more dispersed. These geographical patterns have direct implications for the relationships that car manufacturers may develop with their suppliers *and* with the PTR centers.

6. Japanese Car Makers and the role of PTR centers

In this section we discuss the major features of each car maker's supply structure, local dominance, and apparent use of PTR centers. Table 4 lists the assembly sites of the five large car makers along with nearby PTR centers.

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vehicle in 1958. Fuji Heavy, been better known as Subaru, became a Nissan affiliate in 1968 (Cusumano, 1985:21). Tachikawa Aircraft became Prince Motors in November 1946, absorbed Fuji Seimitsu a few years later, and was eventually taken over by Nissan in 1966 (Sheard, 1983:59; Genther, 1990:47). Daihatsu entered the four-wheel market with mini-cars in 1958, but was unsuccessful in moving into full-size cars. It became a Toyota affiliate in 1967, and it did not succeed in moving into larger cars until it began producing for Toyota in the 1980's (Smitka, p. 66; Genther, p. 47). Precision equipment makers were most successful in the short-lived three-wheel vehicle segment. However, Tōyō Kōgyō (later re-named Mazda) is the only full-line Japanese auto maker to have developed along this path.

6.1 Toyota: champion of test-inspections

Toyota's first automobile assembly plant was located in Koromo (renamed Toyota City in 1959), and many parts factories of what later became the Toyota Group operated in nearby towns. The town where Toyota-related production comes almost as dominant as in Toyota City itself, is Kariya City, where Toyota parts makers have long accounted for almost all the city's industrial output (Takeuchi 1980:161). Not coincidentally, Kariya is also the location of the PTR institute for Aichi Prefecture. Founded in September 1949, the Aichi Prefecture Industrial Technology Institute seems immediately to have become an integral part of the "radical reconstruction plan" (Genther, 1990:58) that the Bank of Japan put together to rescue Toyota.

A major element of Toyota's restructuring during the late 1940s and early 1950s was the establishment of affiliated suppliers. Supplier operations that had once been part of Toyota's in-house activities were moved to newly established first-tier suppliers like Aishin Seiki (June 1949) and Nippondenso (December 1949), both of which were based in Kariya. Many Japanese SMEs emerged in a similar way, not because of entrepreneurship, but as the *deliberate creation of large firms*. Through test-inspections, seminars, and other information programs, the Kariya PTR center gave Toyota a relatively high degree of access to the manufacturing operations of its suppliers. At the same time, use of the PTR center standardized supplier relations in a way that gave suppliers some protection against the worst caprices that might normally result from such a high degree of technical access by a principal customer. As first-tier parts makers like Nippondenso or Toyota Auto Body subsequently grew out of the SME category, they went through a similar process with their own suppliers (firms that were Toyota's "second-tier" suppliers). In short, the evolution of the PTR center provided an *institutional basis* for the high degree of inter-organizational coordination that has made the Toyota group so effective. Writers who characterize Japanese corporate networks in terms of "trust" (e.g. Aoki *et al.*, 1990; Womack *et al.*, 1990) tend to ignore this critical institutional basis for inter-firm behavior.

Toyota's ability to keep all needed parts operations near Toyota City has been far from absolute: 35 percent of Toyota's first tier suppliers in the early 1980's were located on the other side of Aichi prefecture in the city of Nagoya. A final assembly plant was built in the early 1990s on the distant island of Kyūshū. Still, compared to the much greater degree of dispersion evidenced by the other major automobile groups in Japan (with the partial exception of Mazda), Toyota has had a striking degree of industrial concentration. The Toyota supply structure evolved into an even more effective, and less burdensome, method of controlling cost, quality, and time frames than direct ownership of the sources of supply. Toyota is not only the world's third largest auto maker (after General Motors and Ford) it is, perhaps even more significantly, the world's leading producer of automobiles *within one single country*.

The role of the Aichi PTR center in Toyota's success seems neither to have been mentioned by company officials nor to have been examined by researchers. Nonetheless, as Appendix C indicates, the Aichi center in 1986 conducted more test inspections than any other PTR center in Japan. Located in a remote corner of Aichi prefecture dominated by Toyota, the Aichi center appears to have served particularly as a certification institute, thereby keeping the utmost pressure on nearby Toyota suppliers to perform to a given standard. At the same time, the Aichi center provided remarkably little support for services that could have decreased suppliers' dependence on Toyota. In particular, the Aichi center has provided a very small number of consultations — a service that could increase firms' opportunities to improve their production organization or product portfolio.

Toyota's December 1992 opening of a Kyūshū assembly plant (Kurate-gun, Fukuoka prefecture) has been accompanied by the reorganization of three existing PTR centers for heavy industry within Fukuoka prefecture. Furthermore, the Osaka PTR center located close to the main facilities of Daihatsu — which, although an independent car maker, has been financially linked to Toyota since 1967 — ranks third in terms of test inspections. This suggests the possibility that Daihatsu has managed to use its local PTR center in a manner resembling that of its "parent" company Toyota. Further information would be necessary to establish this connection, however, since this center appears to specialize in environmental testing. Moreover, Daihatsu by no means dominates its local economy; major Sharp, Sanyo, and Kawasaki Heavy plants are among those in the same neighborhood.

6.2 Nissan: fewer tests, more consultations

Four of Nissan's facilities and most of its subcontractors are located in the greater Tokyo metropolitan area and nearby Kanagawa and Tochigi prefectures. Cusumano (1985:218) noted the competitive *disadvantage* suffered by Nissan because of the early dispersal of its factories over three prefectures compared with the almost complete concentration of Toyota within Aichi prefecture. This greater dispersion may be partly due to the fact that Nissan relied more on a merger and acquisition strategy. Nissan did — somewhat later, and at greater expense — manage to set up a version of Toyota's JIT system within the Tokyo metropolitan area (Takeuchi, 1991:182; Cusumano, 1985:218). However, Nissan's relationship with its suppliers has generally been more antagonistic than Toyota's, occasionally even involving open conflicts. Nissan also keeps more of its technology in-house (Jones, 1988:7; Takeuchi, 1991:172).

Although Nissan could funnel suppliers through the several PTR centers in Kanagawa and Tochigi, its influence over any one center was necessarily less than Toyota's influence over the Aichi center. Unlike Toyota, which had overwhelming control over the southeastern half of Aichi, Nissan was only one of several contributors to the local economy, and *never reached a dominant local player status*. As shown in table 4, all Nissan factories are located near assembly plants of other major auto makers. Furthermore, many major firms such as Toshiba, NEC, Hitachi and Sony also have their main production facilities in the Tokyo region. Nissan, accordingly, regarded each production location as only part of its overall strategy. For all these reasons, Nissan had less incentive than Toyota to develop local ties and seek influence within local or prefectural institutions.

Perhaps the most striking matter in the figures reported by the PTR centers near Nissan is that the Tokyo Metropolitan center ranked first in terms of consultations. Hence the Tokyo PTR center has played a notably different role than the Aichi PTR center. (This difference is made more striking by the fact that Aichi prefecture is the third leading source of industrial output in all of Japan, trailing only Tokyo and Osaka.) On the basis of the available data, it cannot be established what proportion of these consultations are being provided to Nissan suppliers. In 1977, Nissan further increased its dispersion by establishing a fifth car assembly plant in far-away northern Kyūshū (the southernmost of Japan's four main islands), reportedly to gain access to the region's greater labor potential (Takeuchi, 1991:172). The PTR centers in Tokyo and Fukuoka ranked fourth and fourteenth in terms of test inspections in 1986, but it is not clear how much of this activity can be attributed to Nissan. The Oppama and Zama plants, known for their high levels of automation, have stimulated relatively little testing activity at the nearby Kanagawa PTR center.

Instead of striving for local dominance, Nissan sought influence at the *national* level. Nissan has benefited from close ties with the national government ever since the military expansion into Manchuria during the 1930s (Johnson, 1982:131). Nissan's chair has also traditionally been the head of the Japan Automobile Manufacturers' Association and has generally taken the lead in any national labor arrangements between auto companies and the auto unions.[18] The level of contributions to national political parties gives another indication of the alliance between the Japanese government and former wartime "partner" Nissan (Johnson, 1982:131). During the early 1980s, Nissan's contributions to national political parties, which were 2.7 times larger than those by Toyota, made Nissan the leading corporate donor to political parties in all of Japan. Toyota, by contrast, although at the time Japan's largest industrial company, was not even among the top fifty political contributors to national political parties.[19]

6.3 Mitsubishi: vast internal resources, little use of centers

Mitsubishi's vehicle production, which takes place in Tokyo, Aichi, and Okayama prefectures, has long been more dispersed than that of the other Japanese auto makers. Mitsubishi Heavy, which had been divided into three companies by the American *zaibatsu* dissolution program, was not re-united until 1964. Only in 1970, were the various vehicle-building operations integrated under the name Mitsubishi Motors.[20]

[18] The 1993 appointments of Toyota officials to head the Keidanren employers' association and JAMA mark major breaks with these traditions, reflecting Nissan's serious restructuring problems during the early 1990s as well as Toyota's need for greater influence at the national level.

[19] Even the smaller Japanese auto producers exceeded Toyota's level of contributions: donations to political parties by Mitsubishi Motor and Honda each exceeded Toyota's level by over 60 percent. Tōyō Kōgyō (Mazda), which in the mid- 1970s had struggled away from bankruptcy by means of a bank-led reorganization that attempted to follow Toyotist principles, nonetheless exceeded Toyota's contribution by 30 percent. Toyota, the fifty-fourth largest corporate donor to political parties, contributed 31 million yen ($124,500) in 1982, only slightly more than tiny Isuzu Motors. On the other hand, as the largest Japanese automakers and holders of the largest financial stakes in supplier companies, Nissan and Toyota were similar in giving 25 percent of their contributions to the small-business DSP and only 75 percent to the ruling LDP; on the other hand, Honda, Mitsubishi, Tōyō Kōgyō, Isuzu, and Fuji Heavy (a Nissan group member), all of which rely on Toyota and Nissan group suppliers for a variety of parts, each gave only 15 percent of their political donations to the DSP and gave 85 percent to the LDP. Nihon Keizai Shimbunsha, *Jimintō Seichōkai* [The LDP Policy Affairs Research Council] (Tōkyō: Nihon Keizai Shimbunsha, 1983), p. 233.

[20] Under the Occupation's *zaibatsu* dissolution program, Mitsubishi was divided into three parts, two of which produced vehicles: Central Japan Heavy Industries (Shin-Mitsubishi Jūkōgyō), which produced light vehicles, and Eastern Japan Heavy Industries (Mitsubishi Nihon Jūkōgyō), which produced heavy vehicles. Only in June 1964,

Mitsubishi also has a much more dispersed group of supplier firms than other Japanese auto makers. In 1990, 358 firms were members of the main Mitsubishi supplier association.[21] This larger number of suppliers, however, accounted for a lower percentage of total parts cost than did the supplier associations of the other big Japanese auto makers.[22] . Furthermore, the total number of Mitsubishi suppliers (association members plus non-members), estimated at 600, is also substantially higher than for other auto makers. Both facts indicate Mitsubishi's relatively low level of integration and control over its supply chain

Despite the dispersed production locations and a less tightly integrated supplier group, however, Mitsubishi Motors has long had the advantage of having direct access to the large Mitsubishi conglomerate's supply and engineering base. Mitsubishi Motor (and its predecessors) has long held minority shares in many of the company's first-tier subcontractors. This helps to account for Mitsubishi's smaller reliance upon PTR centers than the other Japanese auto makers. As is shown in table 4, those PTR centers with only Mitsubishi automobile factories nearby (Nagoya and Mizushima) show lower levels of activity, both for test inspections and for consultations, than do centers near any of the other major Japanese auto makers. Although the Aichi center, near Mitsubishi's Okazaki plant, conducted the largest number of inspections of any center in Japan, the low levels of center usage near Mitsubishi's other two plants suggest that the Aichi center's activities have little to do with Mitsubishi compared with Toyota's overwhelming dominance in this part of Aichi. It is possible that Mitsubishi, through its centrally important truck-building operations in Tokyo, may have contributed to the high level of activity at the Tokyo PTR center, but this cannot be determined with the data used in this paper. As far as car manufacturing is concerned, Mitsubishi Motors seems to have stimulated the least significant use of PTR centers of all Japanese automobile producers.

after the three parts were recombined, did Mitsubishi become a somewhat major vehicle producer within Japan (Genther, 1990:82-83).

[21] Japanese car assemblers usually have one or more supplier associations (*kyōryokukai*) of first-tier suppliers, which are used to discuss issues of "general interest". The two Toyota supplier associations have 228 member firms, Nissan's three associations contain 164 members, and Mazda's association has 180 members. Honda does not have a regular supplier association, yet some 300 suppliers convene regularly to discuss matters similar to other supplier associations (Jacot, 1990:103-5; Sako, 1994).

[22] These 358 suppliers accounted for only 85 percent of Mitsubishi's parts costs, compared with 86 percent for the 180 suppliers belonging to the Mazda association, 90 percent for Nissan supplier association, 90-95 percent for the 284 association members supplying Isuzu, and 98 percent for Toyota's supplier association (Sako, 1994).

Table 4 Public Testing and Research centers near the five major Japanese car makers

Car maker (year of establish-ment)	*Major assembly facilities in area (number; year of establishment)*	*Centers in area (year of establishment)*	*Number of inspections (1986)*[1]	*Guid-ance (1986)*	*Consult-ations (1986)*	*Other car assembly plants in the area (parent company)*	*Major electronics and machine tool producers in the area (parent company)*
Toyota (1933)	Toyota City (5: 1938, '59, '66, '70, '79)[2]	Aichi Pref. Ind. Tech. Center (1949)	78,667	2,641	4,830	Mitsubishi	Nippondenso (Toyota), Aishin Seiki (Toyota)
Daihatsu (1933)[3]	Ikeda (Osaka)	Osaka Metropol. Ind. Res. Center (1907)	66,353	0	0	none	Sharp, Sanyo, Kawasaki Heavy
	Otoguni, Kyoto	Kyoto Munic. Inst. of Ind. Res. (1921)	2,760	227	2,938	Mitsubishi	Kyocera (ceramics), Nihon Battery, Morita, Kyoto Machinery
Nissan (1933)	Tokyo (1966)[4]	Tokyo Metropol. Ind. Tech. Center (1970)	61,607	261	34,011	Mitsubishi (trucks); Hino Body (Toyota)	Hitachi, Sony, NEC, Toshiba
	Oppama (1962)[5]; Zama (1964)	Kanagawa Pref. Ind. Res. Inst. (1949)	10,916	435	9,935	Mitsubishi (trucks); Kanto Auto (Toyota); 2 Isuzu	Ishikawajima-Harima, Mitsubishi Heavy, Sumitomo Electric., Toshiba, Fujitsu
	Tochigi	Tochigi Prefect. Ind. Tech. Center (1947)	2,874	90	602	Honda (motor cycles)	Hitachi, JVC, Sanyo, Fujitsu, Matsushita
		Tochigi Pref. Kennan Ind. Res. Inst. (1970)	4,418	106	377		
	Miyakoguni, Fukuoka (1977)	Fukuoka Pref. Kitakyūshū Ind. Res. Inst. (1981)	13,797	227	1,181	Toyota	Yasukawa Electric, Mitsui High Tech, Toshiba, Sumitomo Metal, Matsushita, Mitsubishi Electric
Fuji Heavy Ind. (1953)[6]	Ohta (2)	Gunma Pref. Ind. Res. Center (1968)	14,457	314	5,929	Nissan Diesel; Hino (Toyota); Daihatsu Body	JVC, NEC, Toshiba Battery, Fujitsu, Seiko
Honda (1948)	Suzuka (1960)	Mie Pref. Ind. Tech. Center (1908)	17,485	1,480[7]	1,480	none	Aichi Machine (Nissan)[9]
	Sayama (1964)	Saitama Pref. Ind. Tech. Res. Inst. (1965)	1,729	573	2,249	Nissan Diesel	Nikon, Aichi Rolling Stock
	Hamamatsu (power products)	Shizuoka Pref. Mech. Res. Inst. (1961)	675	108	1,227	3 Suzuki, Yamaha, Nissan	Facom (Fanuc)
	Kikuchi (motor cycles) (1976)	Kumamoto Pref. Ind. Res. Center (1942)	11,694	332	1,409	none	Mitsubishi Electric, Omron
Mitsubishi [1917] (1970/'64)[8]	Nagoya	Nagoya Munic. Ind. Res. Inst. (1937)	3,550	855	5,669	Aichi Machine (Nissan)[9]	Brother, Mitsubishi Electric & Heavy
	Okazaki	Aichi Pref. Ind. Tech. Center (1949)	78,667	2,641	4,830	5 Toyota	Nippondenso (Toyota), Aishin Seiki (Toyota)
	Mizushima	Okayama Pref. Ind. Tech. Center (1918)	3,493	64	826	none	Matsushita, Mori Machinery
	Kyoto (engines)	Kyoto Munic. Inst. of Ind. Res. (1920)	2,760	976	2,938	none	Kyocera (ceramics), Nihon Battery, Morita, Kyoto Machinery
	Shiga (engines)	Shiga Pref. Inst. for Machinery and Metals (1952)	2,068	71	692	Daihatsu	NEC, Sanyo, Matsushita
Mazda (1931)	Hiroshima (2)	Hiroshima Munic. Ind. Tech. Center (1940)	14,113	1,520	2,393	none	Mitsubishi Heavy, Nippon Steel
		Hiroshima Pref. Western Ind. Tech. Center (1949)	3,034	3,744	369		

Source: Compiled from data in *Zenkoku Kenkyū Kaihatsu Binran*, 1988; *Guide to the Motor Industry of Japan*, 1991; Takeuchi, 1991; Comité des Constructeurs Français d'Automobiles, 1989; Dodwell Marketing Consultants (1990).

Notes to Table 4

1. Years of PTR center activities refer to Japanese fiscal year (April 1-March 31).
2. Toyota also operates a Kyushu plant that started production December 1992, which has not been included here for lack of recent PTR center data.
3. Daihatsu was established as an independent car producer, but has been under Toyota management control since 1967.
4. The Tokyo plant was acquired as a result of the 1966 take over of Prince.
5. The Oppama plant will be closed by the year 1995.
6. Fuji Heavy Industries, established as an independent car producer, has been under Nissan management control since 1968.
7. For 1986, the Mie Prefecture Industrial Technology Center reports 1,480 guidance and 1,480 consultation activities. This may indicate that the center does not make this distinction. If there is an error in the reporting, however, the number of 1,480 consultations activities seems more likely to be correct, given the size of the center and the pattern shown by the other centers.
8. Mitsubishi produced a vehicle as early as 1917, but following the American dissolution of the zaibatsu did not become a major vehicle producer until reunited as Mitsubishi Heavy in 1964. Mitsubishi Motors was spun off as a separate company in 1970.
9. In Mie Prefecture (see Honda Suzuka), Aichi Machine is not engaged in assembly activities, whereas it is in Nagoya.

6.4 Honda: limited control over its supply base

Honda was established after the war in Shizuoka prefecture as a motorcycle producer and only began producing four-wheel vehicles in 1963. Consequently, it has had to compromise between striving for local dominance and finding a location near existing networks of other assemblers' suppliers. Honda's solution has been to build automobiles in prefectures adjacent to those where the leading auto makers were located. The Suzuka plant in Mie prefecture, where Honda builds Civics and other high-volume cars, is located next to Aichi prefecture, home of Toyota. No other auto maker builds vehicles in Mie prefecture, moreover, and as table 4 shows, Honda has apparently made good use of testing services at the Mie PTR.

Following a similar rationale, Honda's Sayama plant in Saitama prefecture is located just north of major Nissan production facilities within Tokyo. In Saitama, however, Honda produces more up-scale cars in smaller volumes, and it has a shorter history at this location. Table 4 indicates that relatively little use is being made of the Saitama PTR for testing or consultations. This absence of significant PTR activity is even more striking if one takes into account that Nissan Diesel also has a production location in Saitama prefecture.

To some extent, Honda has been able to profit from the rivalry between Toyota and Nissan. Both of Japan's "Big Two" have encouraged their suppliers to sell to outside companies, including Honda. For instance, Nippondenso sells up to forty or fifty percent of its output to third clients, thereby remaining exposed to outside competitive pressures as well as reaping above-average profits. Thus, in spite of its late entrance into the car business, Honda was able as early as the 1970s to develop a system of localised JIT-supply near its main plants in Sayama and Suzuka (Financial Times, 23 July 1992).

However, Honda never gained the levels of control over its supply base that Toyota or Nissan did. By Japanese standards, Honda has a relatively large number (300) of first-tier component suppliers, indicating that it has always sought to prevent being too dependent on one source. In addition, the number of suppliers directly belonging to the Honda Group, a more tightly clustered subset of first-tier suppliers, has only 35-40 percent as many members as the corresponding Toyota and Nissan Groups (Dodwell, 1988:251-261). Honda's weak domestic supply base has also been one of the reasons to internationalize its car production earlier than Toyota or even Nissan.[23]

6.5 Mazda: an incomplete version of Toyota

Mazda's passenger car and components factories cluster in Hiroshima prefecture as well as, more recently, just across the border in Yamaguchi prefecture; this layout somewhat resembles Toyota in Aichi prefecture. Furthermore, Mazda only has around 180 first-tier components suppliers. Such concentration of facilities and suppliers would appear to make Mazda a suitable candidate to emulate Toyota's strategy of employing PTR centers to control its supply system. However, Mazda has been forced to rely on Toyota and Nissan group suppliers for a significant portion of its components. At two moments in its history, Mazda has suffered from severe financial problems. The first crisis, in the 1970s, triggered a reorganization, as a result of which Mazda became a more integral part of the Sumitomo conglomerate (cf. Pascale & Rohlen, 1983) while allowing Ford to acquire a 25 percent stake in the company. The Sumitomo Group brings Mazda especially strong resources in electronics, but is relatively weak in the areas of engineering and transportation.[24] The second financial crisis, in 1994, though less critical than the first one, led to a management re-shuffle and to the admission of three Ford executives to the Mazda board.

[23] Honda's choice of locations in the US has followed the pattern set earlier in Japan. Its Accord and Civic assembly plants in Marysville (1979 motorcycles; 1982 cars) and East Liberty (1984) and its engine plant in Anna are all located in the state of Ohio, in the periphery of Detroit's sphere of influence; the same is true of the Alliston assembly plant in Ontario. These locations optimize potential local dominance while giving Honda ready access to US component makers as needed (Ruigrok & Van Tulder, 1993:296).

[24] The Sumitomo group's 1987 turnover in the electrical and electronics sector was almost twice that of the Mitsubishi group, yet Mitsubishi's turnover in transportation machinery doubled Sumitomo's turnover (Dodwell, 1990).

Womack *et al.* (1990:237) describe Mazda's Hiroshima production facilities as a "faithful copy" of Toyota's production system, yet due to Mazda's financial crises and its weaker supply base, the effort to imitate Toyota has only been partially successful. Given the relative regional dominance of Mazda's operations but Mazda's smaller size, use of the Hiroshima PTR centers by Mazda suppliers appears roughly proportionate to use by Toyota suppliers in Aichi.

Table 5 summarizes the main features of the Japanese car makers' strategies towards governments and PTR centers.

Table 5: Japanese car makers' strategies towards governments and PTR centers

Car maker	*Geographical concentration of production*	*Control and size of supply base*	*Character of strategies and government relationships*	*Use of Public Testing and Research center*
Toyota	Extremely concentrated (Toyota City); yet new plant in Kyushu	Structural control over very large supply base	Local: structural control; National: distant, at least until 1992 ■ 1936: only T. and Nissan licensed to produce cars ■ WW2: military equipment producer ■ 1949: Bank of Japan saved T. from bankruptcy ■ 1949: defied MITI plans, rebuilt its car operations ■ since 1950's: has developed increasing financial independence ■ does not comply with MITI guidance to reduce JIT, continues 4-year product cycle ■ structural control over local & regional governments	PTR center under structural control: functions as a tool to help subcontractors meet Toyota's stiff demands. Emphasis on test inspections, hence less room for PTR centers to define independent role
Nissan	Becoming more dispersed (three in Tokyo area, one in Kyushu)	High, tending towards more direct control over large supply base	Local: one out of many large firms; National: intimate ■ 1936: only N. and Toyota licensed to produce cars ■ WW2: extremely close ties ■ late 1940s to 1980s: repeated government support ■ 1980s trade polices: Nissan favored over Honda, Mazda, Mitsubishi ■ in Tokyo it never matched Toyota's local dominance (too many other firms)	Regular use of PTR centers, particularly in terms of consultations, possibly also in terms of test inspections and technical guidance
Honda	Suzuka plant in periphery of Toyota sphere of influence; smaller Tochigi plant in Nissan periphery	Controls only small, albeit technologically advanced, supply base. Also relies on Toyota and Nissan supply base	Local: dispersed locations, never full control; National: chilly ■ WW2: military equipment ■ 1950s: independent line ■ 1963: Honda angered MITI by starting to produce cars ■ gained local but not regional dominance ■ 1980s trade policies: MITI "punished" Honda with low VER allocation to US and EC	■ Significant use of PTR centers in Suzuka ■ Little use of PTR centers in Sayama or Tochigi ■ Partly uses Toyota and Nissan supply bases, yet aims to prevent becoming too dependent on either of these
Mitsu-bishi	Dispersed: two Nagoya plants, one Mizushima, one Tokyo (busses, trucks), one in Aichi (near Toyota)	Direct access to Mitsubishi conglomerate's large engineering base	Local: relative control; National: occasional fights: ■ 19th century: strong ties; ■ WW2: military equipment ■ after WW2: loosening ties; ■ late 1960's: defied MITI consolidation plans; ■ little local dominance ■ still a major military producer	Least significant use of PTR centers: ■ Little control over Aichi PTR center, yet benefiting from nearby Toyota supply base and PTR center control ■ Surprisingly little use of Nagoya PTR center
Mazda	Concentrated near Hiroshima	Controls its Hiroshima supply base, but weak control within Sumitomo group	Local: dominance; National: distant but not antagonistic ■ considered a key economic pillar of its regional economy ■ Sumitomo Group more active in other industries and in trading; ■ 1973: MITI supported Mazda restructuring behind the scenes	Significant use of Hiroshima centers ■ Pattern looks like Aichi, yet on a smaller scale with less control

Sources: Cusumano, 1985; Ruigrok and Van Tulder, 1993; Johnson, 1982, Takeuchi, 1991; Womack *et al.*, 1990.

6. Summary and discussion

The literature on SMEs suggests a restructuring is taking place in the division between large enterprises and SMEs throughout the industrialized countries. To stimulate the growth of SMEs and thereby national competitiveness, many countries have established Innovation and Diffusion Institutes. This paper examined the role of one such IDI: the Japanese Public Testing and Research centers.

Japanese PTR centers provide testing and research services, as well as consultations, individual guidance, training seminars, subsidized referrals to outside consultants, equipment loans, and information distribution. These services are markedly different in nature. Testing activities are designed to help SMEs meet *third-party requirements*, i.e. client firms' quality or other technical specifications. The other services help SMEs explore new avenues on their own that can alter their product mix, production organization, or both.

SMEs affiliated with each of the five major Japanese car makers have made use of PTR centers in their vicinity, yet in markedly different manners and degrees. The clearest conclusions about the use of PTR centers can be drawn in the case of Toyota. Toyota suppliers have used the Aichi PTR center's testing services to an extraordinary degree, indicating that Toyota gained additional control, mediated by the PTR center, over its suppliers. Compared to other PTR centers, the Aichi PTR center provided remarkably few consultations, suggesting that Toyota did little to encourage use of this service. This finding is in line with other research suggesting Toyota's solid control over its supply base (Nishiguchi, 1989).

The data on the use of the PTR centers near the other car makers allow less definite conclusions. However, no other Japanese car maker has been able to match Toyota's control over its supply chain, signifying vast differences among Japanese industrial networks. Technical consultations, which tend to help supplier firms gain more independence from client firms, have been more important in PTR centers serving SMEs near the other car makers.[25]

The case of the PTR centers in the Japanese automobile industry shows how public institutions aiming to assist SMEs may be *colonized* (Cawson, 1990) when a large company seeks to *manage its dependence* on SMEs (Ruigrok & Van Tulder, 1995). IDIs may become

[25]More detailed research will be necessary to establish whether and to which extent the conclusions inferred from the aggregate data on the interaction between PTR centers and SMEs can be maintained. However, interviewing PTR center and company staff to determine PTR centers' effect on such sensitive variables as SME (in)dependence, technological level, and overall performance means that this research would require support from the Japanese government as well as the SMEs *and* the LSEs concerned.

caught in a triadic bargaining game between LSEs, SMEs and governments (cf. Stopford & Strange, 1991; Wassenberg, 1995).

The PTR centers in Japan have been proposed as a model of IDIs worth emulating by Western economies. In other countries, however, testing and research services are often handled by a broader array of institutions. In Germany, for example, testing is handled by public bodies such as the Rationalization Board and the *Bundesländer* research establishments, while most publicly-supported industrial research happens at (quasi-) private institutes like Fraunhofer, Steinbeis, and industrial association (AIF) labs. This means that SMEs in the German industrial system are less likely to be subjected to LSE control via an IDI than their Japanese counterparts. On the other hand, it also means that the linkages between industrial testing and technology development, linkages which can lead to higher degrees of incremental innovation, are either weak or absent altogether.

Governments aiming to support an independent SME sector using IDIs modelled after the Japanese PTR centers have more than one type of PTR center to choose from: the Japanese have been experimenting with industrial IDIs for over a century, and different approaches are evident even among the PTR centers that exist today. Underlying this variety, however, the PTR centers suggest, even when they do not themselves embody, the following considerations. 1) Create *linkages between testing and applied research*. These linkages could be developed among different institutes, or they might, more like the Japanese PTR centers, be elaborated within a single institution. 2) Support *consulting and guidance programs aimed specifically at SMEs*. IDIs that include large firms among their <u>indirect</u> clients are more likely to neglect SME innovation. IDIs that include large firms among their <u>direct</u> clients, on the other hand, are more likely to neglect diffusion to the broad mass of SMEs. 3) Develop *safeguards*, whether legal or organizational, to protect SMEs from the risk that large firms will capture control over these institutes.[26]

[26] Earlier versions of this paper were presented at the 3rd Europe Japan Conference "New Frontiers for Regional Economies" at Newcastle, Sunderland, UK (Dec. 13-16, 1994) and the ICCR Euroconference on Costs and Benefits of Europeanization, Hotel Regina, Rooseveltplatz 15, 1090 Vienna (April 5-8, 1995).

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Appendix A: Japanese PTR Centers with Largest Budgets (1986)

Sponsoring GovernmentSS	*Named Speciality*	*Founded*	*Budget '86 (¥1000)*	*Budget '86 (US$)*
Chiba-ken	Agriculture	1949	3,041,050	18,063,855
Tokyo	Industrial	1970	2,366,929	14,059,572
Hokkaido	Forestry	1937	2,155,895	12,806,029
Osaka-shi	Environment	1963	2,066,707	12,276,252
Hiroshima-shi	Industrial Technology	1949	1,979,346	11,757,327
Nagoya-shi	Industrial	1908	1,643,396	9,761,782
Niigata-ken	Industrial Technology	1929	1,475,952	8,767,164
Osaka-fu	Industrial Technology	1916	1,231,404	7,314,547
Kanagawa-ken	Industrial	1906	1,214,306	7,212,985
Fukui-ken	Industrial Technology	1986	1,043,231	6,196,798
Fukuyama-ken	Industrial Technology	1959	984,819	5,849,831
Shizuoka-ken	Industrial Technology	1957	971,601	5,771,316
Hyogo-ken	Industrial	1962	933,074	5,542,465
Ishikawa-ken	Industrial	1902	914,376	5,431,399
Osaka-shi	Industrial Research	1956	898,051	5,334,428
Aichi-ken	Food Industry	1924	860,015	5,108,494
Nagano-ken	Precision Industrial	1958	830,645	4,934,036
Tokyo	Agriculture	1907	823,178	4,889,682
Hokkaido	Industrial	1959	702,947	4,175,509
Osaka-fu (Chuo)	Radiation	1949	679,114	4,033,941
Yamagata-ken	Industrial	1918	656,192	3,897,784

Source: Data compiled from *Zenkoku Kenkyū Kaihatsu Binran* (Tōkyō: Gyōsei Tosho Shuppan Hambai, 1988), pp. 718-1069. US$ 1 = ¥168.35 in 1986. Note that “-ken” or “-fu” means “prefecture” while “-shi”means “city.”

Appendix B: Industrial PTR Centers with Largest Budgets (1986)

Sponsoring GovernmentSS	***Founded***	***Budget '86 (¥1000)***	***Technical Staff***	***Total Staff***	***Special Guidance***	***Consulta-tions***	***Inspections***	***Equipment Use***
Tokyo	1970	2,366,929	173	208	261	34,011	61,607	3,348
Hiroshima-shi	1940	2,206,401	20	26	1,520	2,393	14,113	2,392
Nagoya-shi	1937	2,155,895	107	116	855	5,669	3,550	849
Niigata-ken	1963	2,066,707	91	115	3,142	1,973	3,526	304
Kanagawa-ken	1949	1,979,346	154	200	435	9,935	10,916	98
Osaka-fu	1929	1,475,952	152	177	592	12,843	6,032	853
Osaka-shi	1916	1,231,404	94	121	0	13,480	2,653	355
Fukuyama-ken	1986	1,043,231	60	72	1,687	4,564	5,278	387
Nagano-ken	1957	971,601	35	40	185	2,027	1,808	2,875
Ishikawa-ken	1962	933,074	71	95	136	1,870	3,881	44
Fukui-ken	1902	914,376	91	103	49	9,647	12,533	919
Hyogo-ken	1917	886,215	63	71	3,954	1,738	4,770	244
Hokkaido	1924	860,015	84	114	31	3,625	5,543	193
Shizuoka-ken	1907	823,178	71	82	3,491	1,678	6,546	1,294
Yamagata-ken	1921	749,951	94	110	2,166	5,391	7,208	387
Aichi-ken	1949	679,114	55	66	2,641	4,830	78,667	25
Wakayama-ken	1916	673,396	48	59	8,245	4,539	70,693	584
Okayama-ken	1918	656,192	63	76	64	826	3,493	403
Shiga-ken	1985	616,218	15	22	80	2,080	177	1,209
Ibaraki-ken	1985	597,194	61	70	429	3,289	1,074	295

Source: Data compiled from *Zenkoku Kenkyū Kaihatsu Binran* (Tōkyō: Gyōsei Tosho Shuppan Hambai, 1988), pp. 718-1069. Note that "-ken" or "-fu" means "prefecture" while "-shi"means "city."

Appendix C: Japanese PTR Centers Performing the Largest Number of Test Inspections

Sponsoring GovernmentSSS	***Named Specialty***	***Founded***	***Inspections***	***Share***	***Special Guidance***	***Consulta-tions***
Aichi-ken	Industrial Technology	1949	78,667	9.17%	2,641	4,830
Wakayama-ken	Industrial	1916	70,693	8.24%	8,245	4,539
Osaka-shi	Environment	1906	66,353	7.73%		
Tokyo	Industrial	1970	61,607	7.18%	261	34,011
Gifu-ken	Metals	1937	26,830	3.13%	13	775
Miyazaki-ken	Industrial	1968	17,542	2.04%	31	540
Mie-ken	Industrial	1908	17,485	2.04%	1,480	1,480
Aichi-ken (Mikawa)	Fiber Technology	1927	15,723	1.83%	1,737	4,583
Nagasaki-ken	Industrial	1962	15,291	1.78%	23	386
Aomori-ken	Industrial	1924	15,015	1.75%	378	2,000
Kyoto-fu	Cloth	1905	14,686	1.71%	393	7,782
Gunma-ken	Industrial	1968	14,457	1.68%	314	5,929
Hiroshima-shi	Industrial Technology	1940	14,113	1.64%	1,520	2,393
Fukuoka-ken (Kitakyushu)	Industrial	1981	13,797	1.61%	227	1,181
Chiba-ken	Machinery	1968	13,720	1.60%	78	520
Saga-ken	Industrial	1958	13,110	1.53%	190	927
Saitama	Fiber	1949	12,561	1.46%	693	7,531
Fukui-ken	Industrial Technology	1902	12,533	1.46%	49	9,647
Kumamoto-ken	Industrial Technology	1937	11,694	1.36%	332	1,409
Yamagata-ken	Industrial Technology	1929	11,414	1.33%	251	8,164
Kanagawa-ken	Industrial	1949	10,916	1.27%	435	9,935
Nagano-ken	Industrial	1939	10,751	1.25%	466	3,465
SUBTOTAL (22 centers)			538,958	62.79%	19,757	112,027
TOTAL (169 centers)			858,326	100.00%	93,014	364,708

Source: Data compiled from *Zenkoku Kenkyū Kaihatsu Binran* (Tōkyō: Gyōsei Tosho Shuppan Hambai, 1988), pp. 718-1069.

Appendix D: Japanese PTR Centers Performing the Largest Number of Special Guidance Services

Sponsoring Government (Location)LoLo	***Named Speciality***	***Founded***	***Special Guidance***	***Share***
Kyoto-shi	Dyeing and Weaving	1908	11,656	12.53%
Wakayama-ken	Industrial	1916	8,245	8.86%
Hyogo-ken	Industrial	1917	3,954	4.25%
Shizuoka-ken	Industrial Technology	1907	3,491	3.75%
Niigata-ken	Industrial Technology	1963	3,142	3.38%
Aichi-ken (Owari)	Fiber Technology	1930	2,968	3.19%
Aichi-ken	Industrial Technology	1949	2,641	2.84%
Kanagawa-ken	Industrial Arts	1937	2,547	2.74%
Aichi-ken	Food Industry	1956	2,314	2.49%
Yamagata-ken	Industrial	1921	2,166	2.33%
Ehime-ken	Industrial Technology	1903	1,966	2.11%
Aichi-ken (Mikawa)	Fiber Technology	1927	1,737	1.87%
Fukuyama-ken	Industrial Technology	1986	1,687	1.81%
Tajimi-shi (Gifu-ken)	Pottery	1951	1,650	1.77%
Hiroshima-shi	Industrial Technology	1940	1,520	1.63%
Mie-ken	Industrial	1908	1,480	1.59%
Fukuoka-ken (Fukuoka)	Industrial	1925	1,424	1.53%
Hyogo-ken	Fiber	1920	1,333	1.43%
Oita-ken	Industrial	1921	1,209	1.30%
Hyogo-ken	Machinery and Metals	1917	1,165	1.25%
Kyoto-shi	Industrial	1920	976	1.05%
SUBTOTAL (21 centers)			59,271	63.72%
TOTAL (169 centers)			93,014	100.00%

Source: Data compiled from *Zenkoku Kenkyū Kaihatsu Binran* (Tōkyō: Gyōsei Tosho Shuppan Hambai, 1988), pp. 718-1069. Note that "-ken" or "-fu" means "prefecture" while "-shi"means "city."

Appendix E: Japanese PTR Centers Performing the Largest Number of Consultations

*Sponsoring Government*Location	*Named Speciality*	*Founded*	*Consulta-tions*	*Share*
Tokyo	Industrial	1970	34,011	9.33%
Osaka-shi	Industrial Research	1916	13,480	3.70%
Osaka-fu	Industrial Technology	1929	12,843	3.52%
Aichi-ken	Food Industry	1956	12,545	3.44%
Kanagawa-ken	Industrial	1949	9,935	2.72%
Fukui-ken	Industrial Technology	1902	9,647	2.65%
Tokyo	Textile	1927	8,729	2.39%
Yamagata-ken	Industrial Technology	1929	8,164	2.24%
Kyoto-fu	Cloth	1905	7,782	2.13%
Saitama	Fiber	1949	7,531	2.06%
Chiba-ken	Agriculture	1908	7,481	2.05%
Yamagata-ken (Fuji)	Industrial Technology	1986	6,743	1.85%
Gunma-ken	Industrial	1968	5,929	1.63%
Aichi-ken (Owari)	Fiber Technology	1930	5,726	1.57%
Nagoya-shi	Industrial	1937	5,669	1.55%
Yamagata-ken	Industrial	1921	5,391	1.48%
Aichi-ken	Industrial Technology	1949	4,830	1.32%
Kanagawa-ken	Industrial Arts	1937	4,765	1.31%
Aichi-ken (Mikawa)	Fiber Technology	1927	4,583	1.26%
Fukuyama-ken	Industrial Technology	1986	4,564	1.25%
Wakayama-ken	Industrial	1916	4,539	1.24%
SUBTOTAL (21 centers)			184,887	50.69%
TOTAL (169 centers)			364,708	100.00%

Source: Data compiled from *Zenkoku Kenkyū Kaihatsu Binran* (Tōkyō: Gyōsei Tosho Shuppan Hambai, 1988), pp. 718-1069. Note that "-ken" or "-fu" means "prefecture" while "-shi"means "city."

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1. Years of PTR center activities refer to Japanese fiscal year (April 1-March 31).
2. Toyota also operates a Kyushu plant which started production December 1992, which has not been included here for lack of recent PTR center data.
3. Daihatsu was established as an independent car producer, but has been under Toyota management control since 1967.
4. The Tokyo plant was acquired as a result of the 1966 take over of Prince.
5. The Oppama plant will be closed by the year 1995.
6. Fuji Heavy Industries, established as an independent car producer, has been under Nissan management control since 1968.
7. For 1986, the Mie Prefecture Industrial Technology Center reports 1,480 guidance and 1,480 consultation activities. This may indicate that the center does not make this distinction. If there is an error in the reporting, however, the number of 1,480 consultations activities seems more likely to be correct than the reported number of guidance activities, given the size of the centre and the pattern shown by the other centers.
8. Mitsubishi produced a vehicle as early as 1917, but following the American dissolution of the zaibatsu did not become a major vehicle producer until reunited as Mitsubishi Heavy in 1964. Mitsubishi Motors was spun off as a separate company in 1970.
9. In Mie Prefecture (see Honda Suzuka), Aichi Machine is not engaged in assembly activities, whereas it is in Nagoya.