RIETI Discussion Paper Series 16-E-062

Problem Solving and Intermediation by Local Public Technology Centers in Regional Innovation Systems: The first report on a branch-level survey on technical consultation

FUKUGAWA Nobuya
Tohoku University

GOTO Akira
RIETI

Research Institute of Economy, Trade & Industry, IAA
The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

RIETI Discussion Paper Series 16-E-062

March 2016

Problem Solving and Intermediation by Local Public Technology Centers in Regional Innovation Systems: The first report on a branch-level survey on technical consultation*

FUKUGAWA Nobuya* (*corresponding author)

Tohoku University

GOTO Akira

National Graduate Institute for Policy Studies

Abstract

Local public technology centers (LPTCs) are technology transfer organizations administrated by local governments in Japan. LPTCs arrange various technology transfer channels mainly for small- and medium-sized enterprises (SMEs) in the region. Although it has been recognized that technical consultation is the most important channel for technology transfer, there are virtually no reliable statistics that define and measure this. This study is the first to investigate such technical consultation, gathering information from surveys conducted at the branch level. The key findings can be summarized as follows. First, LPTCs solve various (technological and non-technological) problems through technical consultation. What is notable is that a non-negligible proportion of the problems have to do with design. Second, these problems are diverse in terms of complexity as well, with design problems requiring a longer time to solve. Third, technical consultation acts as a gateway to further technology transfer activities. Additional technical assistance triggered by technical consultation varies across technological fields. Fourth, LPTCs act as innovation intermediaries that connect SMEs to other sources of knowledge, such as universities, when the problems are too hard to solve internally. Fifth, LPTCs believe that technical consultation contributes to their researchers' better understanding of local firms' technological needs, which is salient for LPTCs that frequently deal with design problems.

Keywords: Technology transfer, Problem solving, Intermediation, Regional innovation systems, Sectoral innovation systems, Small- and medium-sized enterprises, Japan

JEL classification: D83; L26; M13; O31; O32; O33

* This study was conducted as a part of the project "Role of Public Research Institutes in Japan's National Innovation System" undertaken at the Research Institute of Economy, Trade and Industry (RIETI) and based on the "Questionnaire Survey on Technological Consultations by Technical Public Research Institutions", which is provided by the RIETI.

1. Introduction

Problem solving in daily operations and building future capabilities are both sources of productivity growth for firms. Manufacturing firms solve technological problems either by making the most of internal resources or by tapping into external sources of knowledge. The nature of the problems that firms face varies according to the technologies these firms work on and their level of technological capability. Small- and medium-sized enterprises (SMEs) are not only unlikely to have sufficient technological capability to solve their own problems, but they are also likely to face greater difficulties in identifying appropriate sources of consulting knowledge in the market due to a lack of social capital. Local public technology centers (LPTCs) help local firms (mainly SMEs) solve their problems in daily operations and long-term capabilities building through various channels of technology transfer. The technology transfer channels LPTCs offer range from those based on physical assets, such as inspection, to those based on personal interactions, such as technical consultation. Technical consultation has been recognized as the most important technology transfer channel that LPTCs can offer. According to the Japan Association for the Advancement of Research Cooperation (JAREC) (2011), the efforts of the researchers at manufacturing LPTCs have been allocated as follows: to research 35%, to technical assistance based on personal interactions (e.g., technical consultation) 27%, and based on physical assets (e.g., inspection) 24%. The distribution of efforts was 63%, 20%, and 7%, respectively, at agricultural LPTCs, and 30%, 8%, 52%, respectively, at environmental science and public health LPTCs. This suggests that different types of LPTCs engage in different types of activities to help local firms or individuals improve productivity, and the relative importance of technical consultation is highest among the manufacturing LPTCs.

In spite of the abovementioned fact, little is known about the contribution of technical consultation to the regional economy. One of the reasons for this is that technical consultation is difficult to define and measure. Even though it is normally called technical consultation, the problems local SMEs encounter and come to LPTCs for could include non-technological problems. Furthermore, it is known that care should be taken when using extant statistics about technical consultation as different LPTCs employ different definitions for technical consultation and different methods to measure it. A quantitative assessment without such care could lead to biased conclusions, which could negatively affect future design of regional innovation policy. Consequently, this study aims to collect information on technical consultation based on our own definition and measurement method using a questionnaire survey conducted at the branch level.

This survey is new from both a theoretical and empirical perspective and could add to previous literature in the following ways. First, this study defines technical consultation as both a way to solve immediate problems of SMEs and as a gateway to further technology transfer activities. Although the former tends to attract the attention of the policy makers and academics, the latter is just as important. Technical consultation can be understood as a transfer channel with lower levels of personal interactions since the flow of knowledge tends to be unilateral rather than bilateral. However, technical consultation could help clients and LPTCs generate mutual trust, which could eventually lead to a technology transfer channel with a higher level of personal interactions, such as joint research. Second, this study sees LPTCs as innovation intermediaries that not only act as a consultant providing solutions to the problems SMEs face. Moreover, as mediators, LPTCs connect clients to other sources of knowledge, such as universities, when the problem is too hard to solve internally. As such, technical consultation could offer clients opportunities to expand their knowledge networks. Third, this study defines problems SMEs face from the perspective of sectoral innovation systems. This concept suggests that SMEs in different sectors are likely to encounter different types of problems, which require different ways for LPTCs to problem solve. Such understanding of technical consultation could bring out new insights into the efficient design of regional innovation policy. Fourth, this study collects information on technical consultation at the branch level. As noted in the next section, there may be more than one manufacturing LPTC within a prefecture, reflecting the geographical distribution of diversified industrial agglomerations in the prefecture. Collecting information at the branch level makes it possible to demarcate different technology transfer activities undertaken by different branches within the prefecture. This is particularly important when the scant extant quantitative evaluation of LPTCs exclusively had relied on the prefectural level data. Finer information on technical consultation would make it possible to derive more detailed implications for the efficient design of LPTCs.

The remainder of the paper is organized as follows. Sections 2 and 3 provide historical background on LPTCs and the conceptual background of the survey, respectively. Section 4 describes the purpose and design of the questionnaire survey. Section 5 shows the results of the survey and its implications are discussed in Section 6. Section 7 summarizes the contributions of this study and refers to agendas for future research.

2. Historical background of LPTCs

The legal origin of LPTCs can be traced back to “Kogyo Iken”,[2 3] a proposal by the

2 “Kogyo” is part of two major national policies in the late 19th century: “Fukoku Kyohei” (enrichment of the country and strengthening the armed forces) and “Shokusan Kogyo” (promotion of industry).

3 There are two versions in “Kyogo Iken”: official one (teihon) published in 1885 and a draft (miteiko) circulated in 1884 only among senior government executives and soon withdrawn in response to

Ministry of Agriculture and Commerce (Noshomu-sho) for the Meiji Government to promote industries and encourage new businesses at the very beginning of modern economic growth (i.e., industrial revolution) in Japan.[4] The editor of this proposal, Maeda Masana (1850-1921) proposed two directions the government should adopt in the creation and promotion of industry. One was to define legal frameworks where the private sector soundly competes and undertakes research and development (R&D), such as the enactment of the Patent Law, Labor Law, and Factory Law. The other was to provide policy measures to diffuse technologies to conventional industries through installing commercial museums and inspection institutes in chemicals and engineering, which were supposed to be national and located in Tokyo and Osaka.

Maeda studied in France from 1869 to 1876 and appreciated the "Conservatoire National des Arts et Métiers (National Conservatory of Arts and Crafts)," which was established in 1794 in preparation for the first Industrial Exposition in 1798 in Paris. This commercial museum not only exhibited modern industrial machineries and products, but also trained engineers through formal education. It was such elements, human capital development and technology diffusion, that Maeda highly valued in designing public technology transfer organizations after he came back to Japan. Indeed, technology diffusion programs that Maeda envisioned encompassed various elements, not only the education of human resources, but also the incubation of entrepreneurship. First, Maeda proposed dispatching technicians to SMEs that needed technical assistance. Thus, this can be seen as the origin of on-site technical consultation by public technology transfer organizations. Second, Maeda stressed the significance of engineer training so that engineers could respond to the demands of employers and prepare for future entrepreneurial activities. Third, inspection institutes were expected to disseminate new knowledge in the industry by translating the information of foreign inventions.

The technology diffusion programs Maeda proposed focused on traditional industries like brewing (sake), cotton spinning, textiles, ceramics, japan, metal works, paper, leather, indigo dyeing, soda, glass, and hemp spinning. Maeda's attitudes about promoting industry by vitalizing conventional industries came from his being daishokikan (senior position) at Noshomu-sho. At the time, the Ministry of Manufacturing (Kobu-sho) was in charge of most of the industrial policies (particularly those for capital-intensive industries like steel, mining, telegraph, shipyard, and railways), which built on the introduction of cutting-edge technologies from Western countries. Maeda intentionally adopted different strategies from

opposition from the Minister of Finance, Matsukata Masayoshi. For the difference between the two, see Crawcour (1997).

4 According to Ohkawa and Rosovsky (1965), the beginning of modern economic growth in Japan was 1886.

the Ministry of Manufacturing, which were rooted in conflicts in terms of industrial policy design between Kangyo-ryo (predecessor of Noshomu-sho) at the Ministry of Internal Affairs (Naimu-sho) enhancing agriculture through the improvement in domestic species, and the Ministry of Manufacturing pursuing immediate imitation of manufacturing technologies from Western countries, many of which resulted in failures (Kamatani 1985). Indeed, manifesting the "spirit" of the promotion of industry, Maeda stressed that "Manufacturers, as a first step, must be alert to and ready for the research status quo of the industry and to improve the equipment they have now. Only after making such effort can they gradually move forward to large-sized investments into facilities and establishments."[5]

Table 1 shows a list of manufacturing LPTCs established in the late 19th and early 20th century. It is notable that in the initial phase of modern economic growth (i.e., 1886), many of the first LPTCs were established by SME cooperative associations in exporting industries (e.g., silk fabric).[6] SME cooperative associations established inspection institutes on their own out of a need to control product quality, prevent low-quality goods from being exported, and protect brand and reputation in the market. Most of the inspection institutes established by SME cooperatives did not last because of financial difficulties. Although "Kogyo Iken" promoted the establishment of LPTCs, Maeda resigned from Noshomu-sho in opposition to the fiscal policy of Matsukata Masayoshi in 1885.[7] He returned to Noshomu-sho in 1888, after serving as a governor of the Yamanashi Prefecture. After Maeda's return, the Meiji government sent Takayama Jintaro to Germany in 1890 where he learned how to organize national research institutes.[8] After the

5 "Spirit" of "Kogyo Iken" (MOF 1964, p. 436)

6 Yamaoka Jiro (1850-1905), a chemist at the University of Tokyo and government official at Noshomu-sho, was heavily involved in the establishment of textile learning centers in Ashikaga, Isezaki, Kiryu, and Hachioji (Yanagisawa 2005). This suggests that the first upsurge of LPTCs formed by SME cooperative associations was not an independent of the government's plan to promote public technology transfer organizations.

7 Maeda left Noshomu-sho again in 1890 in conflict with Mutsu Munemitsu, the Minister of Agriculture and Commerce. Since 1893, in order to achieve his vision without the help of the government, Maeda devoted himself to "Chosonze Undo (future plans of villages, towns, and counties)", a regional development movement that promoted businesses based on local (traditional, in most cases) products (Soda 1971).

8 Asking for permission to visit Germany, Takayama appealed to the government to address the needs to install inspection institutes as public goods. He argued that despite the increasing demand for testing and analysis of materials and products from various industries, no private companies could invest into this because of the high cost requirements, diversified demand, huge responsibility to guarantee accuracy, and low appropriablity. Having been granted permission, Takayama visited

Japanese-Sino War (1894-1895), the legal infrastructure for public technology transfer organizations was gradually put in place, initially for agriculture, reflecting the fact that agriculture was the most important industry at the time.[9] The enactment of "Fuken Noji Shikenjo Kitei (Rules of Local Public Agricultural Technology Centers)" and "Noji Koshujo Kitei (Rules of Local Public Agricultural Learning Centers)" in 1894 allowed local authorities to establish agricultural centers. Such centers were established as local public organizations because agricultural production significantly varied across regions. However, many local authorities could not afford to install agricultural centers. This led to the enactment of "Fuken Noji Shikenjo Kokko Hojo Ho" (Law on State Aid for Local Public Agricultural Technology Centers) in 1899.

Table 1 here

Following agricultural technology centers, the third Noshoko Koto Kaigi (High Advisory Committee for Agriculture, Commerce, and Manufacturing) of 1898 discussed the establishment of manufacturing technology centers. Of note, there are important differences between "Kogyo Iken" of 1885 and another proposal submitted to the third Noshoko Koto Kaigi.[10] Manufacturing technology centers in the former were organized as national and specialized. These supposedly included a national research institute of spinning located in Osaka,[11] an inspection institute of chemistry and engineering (e.g.,

---

Königlichen Chemisch-Technischen Versuchsanstalt (the Royal Chemical Technology Research Institute). Takayama became the first director of the National Tokyo Manufacturing Technology Center established in 1900.

9 Agriculture-related state aid from Noshomu-sho was 60000 yen, while manufacturing-related state aid was 15000 yen (Ministry of Agriculture 1958, Vol. 2, p. 389).

10 Kamatani (1985 p.39) identifies two reasons behind the difference between the two proposals. One is the phase of economic development. The former was proposed in the very beginning of modern economic growth, which created its need to bail out conventional industries. The latter proposal came about when the industrial revolution had been completed to some extent, which created its aim to enhance global competitiveness and presumably encouraged local authorities to want to share the costs to establish and administrate technology transfer organizations. Another impetus was the government's experiences in the establishment and administration of agricultural research institutes. National agricultural technology centers (agriculture, silk, and fishery) had been established since 1893 and they had been organized hierarchically (headquarters in Tokyo and six branches in Osaka, Miyagi, Ishikawa, Hiroshima, Tokushima, and Kumamoto). Such experience made the latter proposal more financially agreeable and feasible by making the organization more hierarchical (a headquarter in Tokyo and branches in local regions) and reducing the ratio of state aid for branches. These factors appear to be the historical origin of the current LPTCs.

11 Osaka was the largest industrial agglomeration in cotton spinning at the time.

indigo dyeing, japan wax, and leather), a commercial museum (Kanko Reppinjo) in Tokyo or Osaka,[12] an inspection institute of dyeing and patterns, and a model factory for the glass industry. Those in the latter were organized regionally (at the branch level) and for general-purpose. Included as well were a national headquarters of a research institute located in Tokyo and its branches located in Osaka, Kyoto, Nagoya, and other industrial cities. Local authorities were supposed to bear half of the branch's budget and the rest would be state-aided. Each branch was supposed to be able to conduct inspection and analysis in diversified technological fields according to regional characteristics. Based on the latter proposal, "Fukengun Kogyo Shikenjo Oyobi Fukengun Kogyo Koshujo Kitei (Rules of Local Public Manufacturing Centers and Learning Centers)" was enacted in 1901. LPTCs were defined as organizations "established by prefectural or municipal governments" (Article 1) and "engaged in dispatch of technicians for technology diffusion, distribution of samples, inspection of materials and products, testing of production facilities, and technical consultation" (Article 3).[13] Subsequently, "Sangyo Shikenhi Koshuhi Kokko Hojo Ho (Law on State Aid for Local Public Manufacturing Centers and Learning Centers)" was enacted in 1906, followed by an increasing number of manufacturing LPTCs.

Before WWII, almost all the prefectures had manufacturing LPTCs (Japan Society for the Promotion of Science (JSPS) 1935). Most of them were devoted to offering technological support in a specific local industry, such as ceramics and textiles. They engaged in not only technical assistance, but also logo design. However, LPTCs in a metropolitan area, like Osaka, undertook more general roles in assisting local firms by diffusing standards, industrial psychology, and scientific management (Sawai 2002). During WWII, LPTCs were forced to shift their aims to meet the demands of the military, such as the production of weapons and the development of substitute goods. As the war progressed, it became difficult for LPTCs to meet their goals due to a serious lack of physical and human resources, which finally forced many of them to shutdown or significantly decrease their activities. After WWII, an increasing number of manufacturing LPTCs were reestablished

12 The first commercial museum in Japan was Furitsu Osaka Shohin Chinretsujo (Osaka Commercial Museum) established in 1890. It engaged in not only exhibition of modern industrial products but also inspection and research in chemistry. Miyake (2015) makes an inference that Maeda's idea of Kanko Reppinjo in Kogyo Iken was realized as Shohin Chinretsujo with support from Itahara Naokichi (the Chief of the Department of Agriculture and Commerce at Osaka Prefecture and a director of the preliminary committee for this museum) who used to work for Maeda.

13 In 1900, the national manufacturing technology center was established with divisions of chemicals and general analysis. In 1902, the division of ceramics was added and another division of textile dyeing was created in 1906.

in response to the rapid economic recovery in the 1950s.[14] Throughout the high growth era, manufacturing LPTCs became recognized as having made significant contributions to the improvement in SMEs' technological capabilities through prototyping, inspection, analysis, and technical consultation (Small and Medium Enterprise Agency (SMEA) 1964).[15] Meanwhile, in the 1960s, the remarkable economic recovery entailed serious environmental side effects, leading to the creation of LPTCs for environmental science (see Figure 1.).

Figure 1 here

In the 1980s, a number of LPTCs reorganized to strengthen their research functions (see Figure 1.), reflecting changes in business environments, industrial policy, and science and technology policy. First, business environments significantly changed from the high growth era, where economies of scale worked best, to the low growth era, where innovations, symbolized by micro-electronics, numerically controlled machine tools, and factory automation, became more important. This made it necessary for LPTCs to respond to higher level technological needs of local firms, encouraging them to improve research quality. Second, new industrial policies aiming at relocating innovative activities to rural areas, previously heavily concentrated in big cities like Tokyo, were implemented. Examples include the Technopolis Act of 1983 and the Brain Location Act (Law on the Promotion of R&D Agglomerations Contributing to the Sophistication of Local Industries) of 1988. These policies designated innovation intermediaries in regional innovation systems, such as science parks and LPTCs, to act as regional hubs for innovative activities. This encouraged LPTCs to pursue more research-oriented strategies. Table 2 shows that the ratio of LPTCs' expenditures to local government's revenues increased from 1990 (0.69%) to 1995 (0.70%) and internal research expenditures per full time researcher also increased from 16.0 million yen in 1990 to 20.1 million yen in 1995. This suggests that at the time, LPTCs received increasing attention from national and local governments, though the ratio dramatically declined in the 2000s, as described later.

---

14 It is notable that some of LPTCs established in this phase undertook not only technical consultation, but also managerial consultation because most of the SMEs could not afford to ask private companies for advise on managerial issues and such a specialized business service industry was yet to be developed.

15 In the high growth era, the wage disparity between private and public sectors and between national and local public research institutes grew larger. This made it difficult for LPTCs to recruit new researchers and created a high turnover rate of researchers. Furthermore, there was a promotion disparity within local authorities between administrative officers and researchers (Science and Technology Agency (STA) 1958).

Table 2 here

In the 1990s, LPTCs received global attention as they were recognized for having made significant contributions to the rapid economic growth of postwar Japan. With serious concerns at the time over a decreasing competitive advantage in the manufacturing industry, the US government benchmarked LPTCs at Manufacturing Technology Centers (MTC) and Manufacturing Extension Partnerships (MEP) (U.S. Congress, 1990).

Today, LPTCs face two structural changes that force them to redefine their capabilities and responsibilities in regional innovation systems. First, the prolonged economic stagnation since the 1990s has left local authorities with serious financial difficulties.[16] Furthermore, as a result of the central government's structural reform in the 2000s, local authorities have had their subsidies reduced substantially.[17] Consequently, LPTCs budgets have been drastically reduced since then, forcing LPTCs to decrease technical staff who directly engage in technology transfer. Table 2 shows that the ratio of LPTC expenditure to local government's revenue sharply declined between 1995 (0.70%) and 2013 (0.49%), especially in the last three years (from 0.60% in 2010 to 0.49% in 2013). The number of LPTCs has also drastically decreased over time (from 648 in 1990 to 392 in 2013). This is reflected in Figure 1 where although the newly established LPTCs increased after the 1990s, because of reorganization and integration of existing LPTCs, the number of LPTCs in total decreased.[18] Internal research expenditure per full time researcher and the ratio of full time researchers to employees also declined since 1995 and 2000, suggesting greater difficulty for LPTCs in allocating research efforts. In addition, Table 2 shows the decreasing trend since the 1990s in the number of LPTCs and the number of full time researchers, followed by a decline in total budgets, internal research expenditures, and the number of employees, and labor costs. In contrast, research revenue (e.g., income from funded research and grant-in-aid research) per full time researcher increased from 0.5

16 According to Annual Statistics of Local Public Finance Bureau by the Ministry of Internal Affairs and Communications, average growth rate of revenue of local governments is 17.1% in 1960s, 16.6% in 1970s, 5.7% in 1980s, 3.2% in 1990s, and -1.5% in 2000s.

17 According to Annual Statistics of Local Public Finance Bureau by the Ministry of Internal Affairs and Communications, average growth rate of the national treasury disbursements for local governments is 18.5% in 1970s, 0.6% in 1980s, 5.0% in 1990s, and -3.6% in 2000s.

18 It should be noted that only LPTCs closed before 2010 are not in the graph. The enormous upsurge in manufacturing LPTCs in the 1980s and 1990s was affected by frequent administrative reform by local authorities. All the reorganized LPTCs are assumed to be newly established as it was difficult to confirm the continuity of an identical organization. For reference, in 1958, there were 179 agricultural LPTCs, 167 manufacturing LPTCs, 52 environment and public health LPTCs, and 7 LPTCs not classified elsewhere (STA 1958).

million yen in 1990 to 1.4 million yen in 2010, reflecting the intention of local governments to encourage LPTCs to finance research activities on their own. These figures point to the difficult situations LPTCs currently face.

Second, the national system of innovation was fundamentally reformed during and after the 1990s. This was symbolized by the enactment of the Science and Technology Basic Law in 1995, the Technology Licensing Organization Act in 1998, the Law of Special Measures for Industrial Revitalization in 1999, the Law to Strengthen Industrial Technology in 2000, and the incorporation of national universities in 2004. A series of reforms required the national universities in a region to more actively interact with local firms, whereas before the reforms, they were not motivated to get involved in the regional economy. This change marked the national universities' entry into the local market for public technological services, a market that had been initially dominated by LPTCs.

3. Conceptual background of the survey

As stated in Section 1, the empirical novelty of this study lies in the survey that captures information on technical consultation at the branch level, instead of at headquarters or the prefectural level. Regarding the theoretical framework, this survey builds on three concepts pertinent to knowledge spillover and innovation: the evolution of technology transfer channels; innovation intermediaries that expand knowledge networks; and sectoral innovation systems that affect the nature of the problems SMEs face. This section describes each concept's background in detail.

Evolution of technology transfer channels

Examining the relationship between LPTCs and clients, Izushi (2003, 2005) found it to be evolutionary in that the relationship began with technical assistance based on physical asset support, such as inspection, which requires less personal interactions, and developed into highly interactive channels, such as joint research.[19] He highlights that such an evolution of technology transfer is contingent on the generation of mutual trust. Trust, generated through accumulation of communication and recognized benefits from knowledge transfer, is important as it mitigates the uncertainty in knowledge transfer. There are two influential factors in uncertainty in knowledge transfer: the importance of communication between the provider and the user of the knowledge and the time required for the user to evaluate the outcomes of the knowledge transfer.

In the case of technical consultation where LPTCs' researchers provide solutions to the

19 Shapira (1992) argues that the lifetime employment of LPTCs' researchers encourages them to become more involved in the regional economy and to establish stable and long-term relationships with local SMEs, which in turn helps LPTCs build mutual trust with their clients.

SMEs' technological problems, the flow of knowledge tends to be unilateral (i.e., less interactive) and the outcomes of knowledge transfer become visible immediately. Thus, knowledge transfer via technical consultation would entail a lower level of uncertainty. In contrast, joint research requires research partners to retain not only a certain variety of knowledge (i.e., each partner retains diversified and complementary knowledge), but also knowledge disparity under some threshold (i.e., partners should retain a sufficient level of absorptive capacity so that they can match each contribution to the research outcome) (Han et al. 2014). This implies a greater extent of mutual learning and personal interactions than in technical consultation. Furthermore, it normally takes a long time for the direct outcome (e.g., new products) of joint research to be visible, or it is possible that the direct outcome will never be visible, rather, the impact may appear indirectly. Even in the absence of immediate impacts, complementary knowledge acquired by SMEs from research collaborations could be exploited in the firms' other research projects, resulting in improvement in long-term productivity (Fukugawa 2013). Such ambiguity in terms of the timing and type of joint research impact also increases uncertainty around knowledge transfer. Last, research collaborations would entail greater uncertainty when research partners exhibit different codes of behavior, which implies greater cognitive distance. LPTCs as public technology transfer organizations could be considered relatively close to the realm of open science, whereas SMEs are local firms pursuing proprietary technology.

In light of previous studies on the evolutionary relationship between LPTCs and their clients, this study sees technical consultation as a gateway to more interactive technology transfer channels. It examines how technical consultation fosters the generation of trust through regular communication, and how the pattern of evolution is affected by sectoral innovation systems and the presence of mediators, as discussed below.

LPTCs as innovation intermediaries

Innovation intermediaries are individuals or organizations that help knowledge spill over into the economy. They connect actors in national, sectoral, and regional innovation systems, thereby indirectly fostering innovations and, as external sources of knowledge, directly help actors innovate (Stankiewicz 1995; Howells 2006). According to detailed definitions of innovation intermediaries: as consultants, they provide clients with solutions to technological problems; as brokers, they foster market transactions among clients; as mediators, they foster non-market-based, mutually beneficial collaborations among clients; and, as resource providers, they secure access to financial, technological, and physical resources to achieve a collaborative outcome (Howard Partners 2007).

Innovation intermediaries are particularly important for SMEs that tend to suffer from market failure and systemic failure. SMEs often retain insufficient business records, tangible assets, and reputation in the business community, all required to secure financial resources from the financial market. SMEs also are vulnerable to weak appropriation of innovative returns in the product market as they retain insufficient complementary assets. This negatively affects investment in R&D, which hampers firm growth in the long run. Innovation intermediaries can also address the systemic failure that makes it difficult for SMEs with insufficient social capital to identify relevant external sources of knowledge, develop ties to potential partners, and exploit linkages for innovative activities.

A number of developed countries have established innovation intermediaries for SMEs as part of their regional innovation policies. Examples include MTC and MEP in the US, TNO (the Netherlands Organisation for Applied Scientific Research), the Steinbeis Foundation in Germany, the Regional Board for Economic Development (ERVET) in Emilia-Romagna of Italy, and Technology Innovation Centers in the UK (Shapira and Rosenfeld 1996). Previous studies provide econometric evidence that these innovation intermediaries have had a positive impact on their clients' labor productivity growth (Jarmin 1999, examined MEP) and innovations (Ponds et al. 2010, examined TNO; Fukugawa forthcoming a, examined LPTCs). As a source of knowledge, LPTCs help local firms directly improve productivity and indirectly improve it as mediators. Regarding LPTCs as consultants, Shapira (1992), based on interviews with center directors, reports that LPTCs play an important role in improving product quality and in introducing new technology to local SMEs. Based on a questionnaire survey on small firm networks for innovation, Fukugawa (2006) quantitatively examines LPTCs' role as an external source of knowledge and finds evidence of their contribution to the technological success of joint product development. Regarding LPTCs as mediators, Ruth (2006) compares the MEP with LPTCs, and argues that the latter are superior to the former in terms of helping local SMEs establish networks for innovation.

In light of previous studies, this study identifies LPTCs as public innovation intermediaries acting as consultants and mediators in regional innovation systems. It examines how technical consultation is associated with these roles, particularly with linking SMEs to other sources of knowledge, such as universities.

The nature of the problems in the sectoral innovation systems

The nature of the SMEs' problems vary according to the technologies they work with and their level of technological capability. This study captures the nature of these problems from the perspective of sectoral innovation systems. Previous studies on sectoral innovation systems highlight that industrial innovations exhibit distinct sectoral patterns in terms of technological opportunities, appropriability conditions, and spillover channels (Nelson and Winter 1982; Pavitt 1984; Malerba 2002). First, firms innovate not only by exploiting internal resources, but also by using external sources of knowledge, such as feedback from customers, better input from suppliers, reverse engineering of competitors' products, and academic research by universities and public research institutes. It has been recognized that different sectors rely on different external sources of knowledge. Specifically, impacts of academic research on industrial innovations are the greatest in the pharmaceuticals where advancement in life sciences directly boosts drug discovery (Hicks et al., 2001; Huang and Murray, 2009; Furman and Stern, 2011). Second, previous innovation surveys conducted in various countries show that the effectiveness of patents as a means to significantly appropriate the returns to R&D investment varies across industries, which leads to significant variations in patent propensity at the industry level (Levin et al. 1984; Arundel et al. 1995; Goto and Nagata 1997; Cohen et al. 2000; Nagaoka and Walsh 2009). Specifically, patents are the most effective in biotechnology. Biotechnology innovations tend to be standalone as opposed to systemic in that a final product can be clearly defined by specific information in patent documents (e.g., chemical equations), which makes it very difficult for followers to invent around, and makes patents particularly effective as appropriation mechanisms for innovators.[20] Third, previous studies on industrial knowledge bases classify economic activities into three broad categories: analytic (science), synthetic (technology), and symbolic (culture), and argue that different industrial knowledge bases require different modes of transfer in a systematic manner (Asheim and Gertler 2005; Asheim et al. 2007; Martin and Moodysson 2011).

Specifically, previous studies on industrial knowledge bases consider the degree to which tacit knowledge is involved and the significance of personal interactions in knowledge transfer as key components of this framework. First, innovations in science-based sectors, like biotechnology, tend to build on analytical knowledge that can be defined as the knowledge to understand and explain features of the universe (Asheim and Gertler 2005). The production of analytical knowledge refers to encapsulating natural sciences and mathematics where key inputs are the review of scientific articles and the application of scientific principles. Knowledge outputs can be communicated in a universal language like mathematical or chemical equations, which are the least tacit and the most likely to be embodied in codified channels (e.g., scientific articles and patents). Therefore, they tend to be disseminated through channels without geographical constraints like licensing. Second,

20 The appropriability condition is the major issue for agricultural LPTCs because individual farmers are less motivated to invest in R&D because of the potential for greater spillover. The market for agricultural products is characterized by very small price elasticity of demand and supply. In this setting, most of the benefits of innovation (represented as the shift in the supply curve) go to consumers, making producers less motivated to invest in R&D. As this study focuses on manufacturing LPTCs, industrial knowledge bases, rather than appropriability conditions, are used as the key feature of sectoral innovation systems.

innovations in mechanical engineering tend to build on synthetic knowledge that can be defined as knowledge to design something that works as a solution to a practical and more applied problem. Knowledge is created through a heuristic approach (i.e., learning by doing) rather than a deductive process, which makes know how and craft-based skills, both contain more tacit knowledge, more important for innovations of this type. Efficient transfer of tacit knowledge requires face-to-face communications among scientists and engineers, which tend to be more active in industrial clusters (Storper and Venables 2004). Therefore, innovations based on synthetic knowledge tend to be disseminated through personal interactions like technical consultation, which prefers geographical proximity. Third, the production of symbolic knowledge refers to the creation of cultural meanings embodied in shapes, images, words, sounds, experiences, and cultural artifacts. Symbolic knowledge is the most tacit because the means of production is based on learning by doing and observing other creators including artists, musicians, product designers and architects. These characteristics strongly affect the spatial configurations of talents because the nature of valuable knowledge in such occupations particularly prefers the spatial concentration of talents, facilitating frequent personal interactions. This implies that talents located in a cluster would be able to receive greater spillover of locally embedded knowledge from other talents through personal interactions, making them more productive (Gertler 2003; Tether et al. 2012).

Previous studies suggest significant sectoral variations in effective transfer channels from LPTCs (e.g., joint research, technical consultation, and licensing). In fact, a recent study shows that LPTCs located in a region where SMEs concentrate on innovations based on analytical knowledge, such as biotechnology, tend to engage more in licensing, which is less affected by spatial contiguity between the client and provider of knowledge; whereas, those in a region where SMEs concentrate on innovations based on synthetic knowledge, such as mechanical engineering, tend to engage more in technical consultation, which requires more geographical proximity between the two (Fukugawa forthcoming b). If LPTCs are to provide solutions to problems pertinent to design where innovations are based on symbolic knowledge, it is likely that they require face-to-face communications with clients so that valuable knowledge that tends to be tacit can be transferred more efficiently. This also affects the geography between LPTCs and clients. Clients with design problems are predicted to reach out to sources of knowledge located close to them. In contrast, if LPTCs are to provide solutions to problems pertinent to chemicals where innovations are based on analytical knowledge, they may need less personal interactions with clients because such valuable knowledge tends to be codified and suitable for documentation. This also leads to more sparse geographical distribution between the user and provider of knowledge.

In light of the concept of sectoral innovation systems, this study assumes problems LPTCs consult on vary in their nature and it examines how the nature of sectors (or knowledge bases) affects modes of knowledge diffusion, time required for the provision of solutions, and geographical distance between the client and provider of knowledge.

4. Method

This study takes an LPTC branch as the unit of analysis. As shown in Table 3, there are 667 LPTCs headquarters and branches. On average, each prefecture has six or seven LPTCs (319/47).[21] Approximately half of LPTCs were established as branches (348/667). In particular, agricultural LPTCs account for more than three-quarter of the branches (188+52+23. agriculture, forestry and fishery). This is because agricultural LPTCs typically establish branches according to types of agricultural products intensively cultivated in the region, such as strawberries, mushrooms, and cattle. They also establish branches according to agricultural environments (e.g., fishery) including isolated islands, highlands, hilly land, rivers, and the sea. Though not to the same extent as agricultural, manufacturing LPTCs have many branches, accounting for approximately 20% of all branches. This is because manufacturing LPTCs tend to have branches based on the specific technology developed in the region, such as ceramics, foods, and electronics. The technology transfer activities of the manufacturing LPTCs vary even within a prefecture. For instance, a manufacturing LPTCs branch dedicated to biotechnology, such as foods and brewing, may engage more in licensing as patents are very effective in biotechnology, whereas another branch in the same prefecture focusing on mechanical engineering may engage more in technical consultation as synthetic knowledge requires greater personal interactions for efficient transfer. Therefore, if we collect information on LPTCs at a headquarters level or a prefectural level, diversified information would be mixed together, making it difficult to analyze characteristics of technology transfer appropriately.

Table 3 here

This survey targeted all LPTCs branches engaged in technology transfer in manufacturing, foods, and design. Those engaged in agriculture, environment, public health, medicine, civil engineering, and others were excluded, as the goal of the survey was to clarify the roles of technical consultation and those LPTCs were not heavily engaged in technical consultation. Information about LPTCs as of 2015 was collected from the website of the National Institute of Advanced Industrial Science and Technology (AIST), which provided

---

21 A prefecture is a local unit of governance in Japan where there are 47 prefectures. An average prefecture is approximately 8,000 sq km, which is even smaller than an average state in the US (approximately 196,500 sq km) and larger than an average department in metropolitan France (approximately 5,700 sq km).

names, addresses, phone numbers, and zip codes of LPTCs.[22] 161 headquarters and branches active as of September 2015 were selected as potential respondents. Eight headquarters were removed from the list, as they were not engaged in technology transfer activities but exclusively in administration. Questionnaires were sent to 153 headquarters and branches in October 2015 and 111 of them were returned with valid answers by November 2015. The response rate was 72.6%.

The questionnaire consisted of 13 questions. Q1, Q2, and Q13 ask the quantity and quality of human resources, allocation of their efforts, and the occupational background of the director. These are used to control for size of LPTCs (e.g., the number of technical consultation per researcher). Q3 aims to understand the proportion of new and regular clients and their geographical distribution. This also aims to understand how counting method varies across LPTCs. Q4[23] asks how new clients became aware of technical consultation. The purpose of this question is to better understand ways that technology transfer activities could be promoted efficiently. Q5[24] and Q6[25] aim to understand accessibility to technical consultation and efficient reception of new clients. Q7[26] aims to understand how the SMEs' technological problems differ in terms of technological categories even within the same prefecture. Q8[27] aims to understand how SMEs' technological problems differ in terms of complexity. Q9[28] aims to understand the role of LPTCs as innovation intermediaries that help SMEs expand knowledge networks. Q10[29] aims to understand how technical consultation act as a gateway to other technology transfer channels. Q11[30] aims to understand which types of external sources of knowledge

---

22 https://unit.aist.go.jp/rcpd/ci/wholesgk/link/kousetsushi/kousetsushi.html

23 Q4: How did new clients obtain information about technical consultation? Please indicate the source of information that you think is the most important for clients. See Table 8 for choices.

24 Q5: How do you charge for technical consultation? See Table 9 for choices.

25 Q6: Do you employ someone who is in charge of matching clients with a researcher who is the most likely to solve the problem? See Table 10 for choices.

26 Q7: Please indicate the estimated ratio of problems related to each field. If the problem was related to several fields, indicate which field the problem related to most. See Table 12 for choices.

27 Q8: Please indicate the time required to solve the problems. See Table 14 for choices.

28 Q9: Please indicate the estimated ratio of problems being solved (or unsolved) in each way. See Table 16 for choices.

29 Q10: Regarding Choice 1 in Q9, please indicate the estimated ratio of the problems that were solved through additional technical support in each activity. See Table 17 for choices.

30 Q11: Regarding Choice 2 in Q9, which external organizations did you connect the client to for possible solutions? Please indicate the estimated ratio of each external organization. See Table 19 for choices.

are selected when LPTCs mediate clients to other organizations. Q12[31] aims to understand the potential impacts of technical consultation.

Some respondents may not have replied because they were too busy or because they were minimally engaged in technical consultation and unwilling to report that (Armstrong and Overton 1977). Wave analysis was adopted to detect non-response bias (Rogelberg and Stanton 2007). The dataset was divided into 65 respondents with responses before or on the deadline and 46 respondents with responses after the deadline. A t-test was conducted to detect differences between the two. There were no significant differences in variables related to technical consultation (e.g., the total number of problems addressed and problems per researcher) between the two. Therefore, it can be said that non-response bias is absent in the dataset.

5. Results

Table 4 shows that the average LPTC employs 38 people including 30 technical staff who engage in technology transfer activities. Twenty-four percent of the technical staff hold Ph.D.[32] The allocation of efforts is as follows: 28.8% for research (maximum value is 80%), 25.5% for technical consultation (maximum value is 75%), 34.4% for other types of technical assistance (maximum value is 70%), and 12% for administrative task (maximum value is 37%). This is consistent with the results of JAREC (2011), which reported effort allocation of manufacturing LPTCs was 35% for research, 27% for technical consultation, guidance, and technology diffusion, and 24% for inspection and use of equipment.

Table 4 here

Table 5 shows that more than half of LPTCs directors were promoted from within an LPTC; 12% of the directors were from academic institutions. The results of the t-test show that there are no significant differences in the Ph.D. researcher ratio between LPTCs with directors from academic institutions and the rest. About one-fifth of the directors came from local authorities, which allows for local governments to retain greater influence over LPTCs.

Table 5 here

---

31 Q12: Please indicate the estimated ratio of the problems considered to have the following impact on LPTCs or clients by solving them. See Table 21 for choices.

32 STA (1976) reported that only 0.5% of the researchers at LPTCs obtained Ph.D. and 44% of them did not receive a college education. For firms' research arms, the ratio of Ph.D. scientists was 4.1% and the ratio of scientists with college education was approximately 80%.

Table 6 shows that the average number of problems per technical staff was 126. Providing that the technical staff worked 250 days, the result suggests each technical staff solved one problem every other day. The maximum value here is 550, meaning that each technical staff solved more than two problems every working day, which appears very onerous.

It is known that care should be taken when analyzing information about technical consultation to evaluate LPTCs as each LPTCs has its own method of counting the number of problems they address, making comparison difficult. This survey assumed that regardless of the number of technical staff involved, each identical problem was counted as one. However, the respondents reported a great variation in counting methods. Some reported that an identical problem is counted as more than one based on the number of technical staff involved, the number of times the technical staff met with clients, the time required for the problem to be solved, and the number of media (e.g., phone and email) used in making contact. This confirms previously held concerns by LPTCs about the use of technical consultation statistics in order to evaluate their technology transfer activities.[33]

Table 6 shows that the average number of problems per client was 4.6. This means that the same client visited an LPTC seeking solutions to problems four or five times a year on average. The maximum value is 22, meaning that the same client came nearly twice a month.

On average, 92.4% of the clients are firms, whereas 7.5% are individuals. Some LPTCs report that all of their clients are firms, while others report that 90% of their clients are individuals. Regarding the latter, most of the clients engage in traditional craftwork, ceramics, traditional textile (e.g., Tsumugi), and agricultural products.

Eighty-three percent of the clients are local, while 16% of them are from other prefectures. LPTCs in metropolitan areas (e.g., Tokyo, Aichi, and Osaka) exhibit a higher ratio of clients from outside regions, presumably because they have accessible transportation networks and relatively small time distances within the area.

Related to the previous question, the proportion of new clients who visited an LPTC for the first time in 2014 was 17.4%, meaning that most of the clients were regular. The maximum value of the regular client ratio was 96%. LPTCs devoted to design tended to report a higher value here.

---

33 Another factor making technical consultation statistics less reliable is that many LPTCs are currently under intense pressure from the prefectural assembly to justify their raison d'etre, which forces them to adopt different counting methods and dilute the number of problems they have solved through technical consultation.

The most frequent clients consulted 88 times in 2014 with a maximum value of 746, which was incredibly high.

Table 6 here

Table 7 shows share of local and non-local clients by type of problems LPTCs solved most frequently. Implications of the results will be discussed in detail in the next section.

Table 7 here

Table 8 shows that the internet was the most important source of information for new clients to learn about technology transfer channels that LPTCs provide. Word of mouth was important as well. Seventy-five percent of LPTCs believed that non-local new clients relied largely on the internet, with this ratio being only 5% for word of mouth. In contrast, 35% of LPTCs believed that new local clients relied largely on word of mouth. Other sources of information were negligible regardless of the geographical distribution of clients. This means that effective use of the internet could increase the number of potential clients as the range where word of mouth is effective appears geographically constrained.

Table 8 here

Table 9 shows that 86.5% of LPTCs offered technical consultation (excluding dispatch of technical advisors, which is normally fee-based) for free without exception, and only 1% of LPTCs charged for technical consultation. This means that LPTCs act as an important source of technological knowledge freely available to local firms. The potential risks and benefits from offering free technical consultation will be discussed in detail in the next section.

Table 9 here

Table 10 shows that 65.8% of LPTCs do not employ mediators between the technical staff and clients. A typical mediator is a retired member of LPTCs technical staff who understands both the technological needs of local firms and the characteristics of LPTCs. Deploying human resources who can match demand and supply of technological knowledge efficiently would improve technology transfer productivity. This issue will be further discussed in the next section.

Table 10 here

Table 11 shows the presence of a mediator by LPTC type. Implications of the results will be discussed in detail in the next section.

Table 11 here

Table 12 shows that the problems SMEs face come from various technological categories. Problems from food, chemicals, and mechanical engineering represent roughly the same proportion, which ranges from 17.1% to 18.5%. It is notable that design problems are as common as electrical engineering problems, at around 10%. This means that such local firms have needs for design improvement and specific assistance in this area.[34] Although many LPTCs abandoned design divisions in the course of downsizing, as described in Section 2, the results suggest that public sources of knowledge that could help local SMEs improve product design could have a positive impact on productivity growth of local SMEs.

Based on the information in Table 12, the Herfindahl-Hirschman Index (HHI) was computed to measure specialization in terms of technological fields. It is reasonable that the HHI would be high at LPTCs dedicated to leather (86.8) and paper (85.0), while being low at LTPCs dealing with manufacturing in general (34.4). The HHI shows a significantly negative correlation to the number of problems consulted per researcher (-0.189. $p<0.05$) and the ratio of Ph.D. researchers (-0.198. $p<0.05$). This implies that LPTCs dealing with diversified (specialized) technological fields are more (less) frequently engaged in technical consultation and tend to have more (less) qualified human capital.

Table 12 here

Table 13 shows that LPTCs dedicated to ceramics, leather, paper, and textiles tend to address problems in "other" technological fields. These dedicated LPTCs may deal with problems in other highly specific fields, classified into fields other than foods, design, chemicals, and engineering. Indeed, these LPTCs indicate chemicals as the second most important field, which is reasonable considering their technological backgrounds (e.g., synthetic material in the textile industry). LPTCs dedicated to ceramics, design, and textiles tend to address non-technological issues as well.

Table 13 here

34 Problems in design may have related to ergonomics rather than aesthetics, where an engineering approach is typically adopted, and thus would demonstrate a different nature in terms of sectoral innovation systems as discussed in Section 6.

Table 14 shows that 54.4% of the problems dealt with were solved within a day and 83.5% of the problems were solved within a week. This means that most of the clients ask LPTCs for immediate solutions to problems they face in daily operations. Only 1.9% of the problems were really hard and took more than a year to solve. If the problem was hard and it required further interactions between the client and the ultimate provider of the knowledge, technical consultation could transform into other types of technology transfer with higher levels of interactions, such as joint research. Izushi (2003; 2005) argues that such evolution of technology transfer should be accompanied by the formation of mutual trust between clients and LPTCs. This issue will be discussed later in this section.

Table 14 here

Table 15 shows time required for the problem to be solved by type of problems LPTCs solved most frequently. Implications of the results will be discussed in detail in the next section.

Table 15 here

Table 16 shows that almost 90% of the problems have been solved by an LPTC that clients made contact first. Regarding the problems unsolved by the LPTC that clients made contact first, 8.5% of the problems have been transferred to other organizations. Only 1.7% of the problems left neither unsolved nor transferred to other organizations. This means that LPTCs act not only as a source of knowledge, but also as a mediator that indirectly contributes to the promotion of innovation in the region.

Table 16 here

The next question asks what type of technical assistance was additionally provided to solve the problem. Table 17 shows that 41.7% of the respondents reported that no additional support was provided as the problem was solved immediately, which was consistent with the previous result that 54% of the problems were solved within a day. Twenty-eight percent of the respondents reported that inspection was necessary and 20.7% reported that rental equipment was needed. This means that technical consultation is closely associated with technical assistance based on physical assets. Only 2.7% of the problems developed into joint research. This means that it is rare that a relatively unilateral spillover channel develops into an interactive spillover channel.

Table 17 here

Table 18 shows other technology transfer channels triggered by technical consultation by type of problems LPTCs solved most frequently. Implications of the results will be discussed in detail in the next section.

Table 18 here

Regarding the previous question pertinent to Table 16, another question asked which organizations clients were referred to when a problem could not be solved by LPTCs. Table 19 shows that 41.1% of such problems were transferred to other LPTCs. The second most referenced referral source was foundations. Foundations presumably represent organizations that help local firms commercialize innovations. As LPTCs are engaged in the provision of technological assistance, local firms that face difficulties in commercialization, such as the development of distribution channels, were referred to foundations typically established by the local authorities and administered by joint public-private ventures.

Table 19 here

Table 20 shows other sources of knowledge to which LPTCs connected clients with unsolved problems by type of problems LPTCs solved most frequently. Implications of the results will be discussed in detail in the next section.

Table 20 here

Table 21 shows that more than half of the respondents believed that technical consultation contributed to LPTCs staff's better understanding of local firms' technological needs. LPTCs also evaluated technical consultation as a gateway for new clients to become regular clients, which would promote mutual understanding and trust as Izushi (2003; 2005) suggested. Regular clients may positively correlate with the efficient reception of technical consultation clients, thereby improving the matching of clients and LPTCs' researchers. This will be discussed further in the next section.

Table 21 here

Table 22 shows perceived effects of technical consultation by type of problems LPTCs solved most frequently. Implications of the results will be discussed in detail in the next section.

Table 22 here

Table 23 shows perceived effects of technical consultation by the presence of a mediator. Implications of the results will be discussed in detail in the next section.

Table 23 here

6. Discussion

Human capital development to enable more efficient technology transfer

The results show that most of the SMEs' technological problems related to daily operations and were solved immediately. Only 2% of the problems were so hard to solve that they presumably required further interactions with LPTCs or with another organization mediated by LPTCs (Table 14). This implies that the distribution of the problems SMEs face is highly skewed in terms of complexity. One of the reasons why most problems could be readily solved could be that such clients lack the technological capability to solve even elementary problems. However, another important reason could be that LPTCs' researchers have sufficient understanding of backgrounds developing technological problems of local SMEs. This suggests the importance of human capital development so that researchers can readily share knowledge about structures and trends of local economies. Indeed, it has been recognized by LPTCs that technical consultation improves their researchers' understanding of local technological needs (Table 21). Even though LPTCs work to strengthen their research capability by having the researchers obtain Ph.D., the results suggest that the dissertation topics need to be closely associated with the technological needs of local industry (Fukugawa forthcoming b).

This result also suggests that an interface that efficiently matches clients with LPTCs' researchers would improve technology transfer productivity. LPTCs with such an interface tend to recognize that technical consultation is a gateway to higher level of collaborations and possibly to joint inventions (Table 23).[35] In this regard, LPTCs devoted to a specific field, such as ceramics, do not arrange such human capital management, presumably due to their limited internal resources (Table 11). In order to improve the technology transfer productivity of specialized LPTCs, retired technical staff who are knowledgeable about both the technological needs of local industries and the backgrounds of LPTCs' researchers could be re-employed for this matching purpose.

LPTCs as innovation intermediaries

35 This may have resulted from larger LPTCs tend to engage in more joint research projects and arrange full-time staff to match clients with appropriate technical staff at LPTCs. Future research should conduct econometric analysis controlling for other factors.

LPTCs as mediators can connect clients with various other external sources of knowledge. More than 60% of the unsolved problems were transferred to other LPTCs or firms. The transfer ratio to universities was 8.9% and to public research institutes 14.4% (Table 19). This implies that a non-negligible portion of the problems SMEs face required science-based solutions. Specifically, LPTCs that addressed more problems in chemicals tended to connect clients to universities, whereas those that addressed more problems in design tended to link clients to public research institutes or firms (Table 20). This may indicate that universities and public research institutes play different roles as sources of knowledge. The implications here are that the chemical industry is a typical science-based sector where innovations rest mostly on advancement of academic research. On the other hand, SMEs dealing with problems in design seek firms with a division of design or individual designers for new ideas or improvements in design. However, it is not possible for this study to make any further inferences regarding public research institutes.

Unreported results show that the ratio of Ph.D. researchers was positively correlated with LPTCs' linking unsolved problems to universities (r=0.120), whereas the correlation with public research institutes was low (r=0.028). Although both correlation coefficients were statistically insignificant, this suggests the possibility that LPTCs' researchers with higher educational backgrounds have greater advantages in linking clients to universities because they have stronger personal networks within universities. This implies that quality improvements in human capital at LPTCs not only enhances internal research quality, but also upgrades the intermediary function.

Statistics on local authorities show a drastic decrease in budgets and human resources allocated for LPTCs since 2000 (Table 2). Under such circumstances, the intermediary function becomes more significant for LPTCs to continue to contribute to regional economies as providing solutions entirely based on internal capabilities becomes harder. Creating a pool of local firms and individual designers as a potential source of knowledge could enhance LPTCs' capability of addressing clients' unsolved problems, thereby augmenting knowledge flow and innovations.

Incentive structure and its consequences

The predominance of problems that are relatively elementary is considered to relate to the fact that technical consultation is provided basically for free (Table 9). Economic theory suggests a risk of overuse when scarce resources are accessible and available for free. However, providing solutions to elementary problems not only improves the absorptive capacity of SMEs needing technology diffusion, but also acts as a gateway to more interactive channels of technology transfer, which could lead to joint research and joint inventions. Uncertainty in knowledge transfer makes it more difficult to determine the balance between benefits and costs of freely available consulting services. Even though the problem is relatively elementary and a flow of knowledge is unilateral, new clients tend not to understand the process or outcomes of technical consultation. Technical consultation free of charge is considered to lower the threshold for new clients wanting to consult on problems in production and R&D for the first time. Furthermore, it should be noted that nearly half of the problems are solved by using other technology transfer channels, such as inspection and rental equipment, both of which are fee-based (Table 17). This issue also pertains to differences in information sources for potential clients. Regarding local firms, word of mouth is as important as an internet search, while the internet is virtually the only source for non-local firms to gain awareness about technical consultation (Table 8). Offering technical consultation for free would expand opportunities for local firms to tap into LPTCs via technical consultation, thereby increasing new clients through social networking.

The results show the predominance of regular clients for technical consultation (Table 6). Over eighty percent of the clients used technical consultation before. The most frequent clients visited LPTCs almost twice a week, which is incredibly intensive. Izushi (2003; 2005) shows that technology transfer tends to start with technical assistance based on physical assets like inspection and, as communication and benefits from using LPTCs accumulate, mutual trust is generated, allowing a technology transfer channel to develop into a more interactive one, such as joint research. The predominance of regular clients suggests such an evolution of technology transfer, though it is not possible for this study to make further inferences. This issue will be referred to in the last section as an agenda item for future research.

The nature of problems in sectoral innovation systems

Although technical consultation has been recognized as important among LPTCs, the results show that design consulting is non-negligible. The share of problems in design is close to that of electronic engineering (Table 12). LPTCs devoted to ceramics and textiles deal with more problems in design presumably because local SMEs need assistance in pattern development (Table 13). SMEs tend not to have a division of design and may not know appropriate private design consulting firms. Design consulting at LPTCs would be helpful for SMEs with high technological capabilities that face difficulty in commercializing their products due to lack of design capabilities.

The results suggest that the nature of the problems SMEs face demonstrate the sectoral patterns where the innovative activities based on different knowledge exhibit distinct characteristics in terms of spillover channels as well as technological opportunities and appropriation mechanisms (Asheim et al. 2007; Dornbusch and Brenner 2013). First, LPTCs that deal frequently with design tend to deal with problems that require more than a year to provide a solution, whereas those dealing with chemicals tend to deal with problems that can be solved in a day (Table 15). Second, LPTCs that deal frequently with problems in electrical and mechanical engineering tend to solve these through physical asset services (e.g., inspection and rental equipment), whereas those in design tend to do so through personal interactions (e.g., technical guidance and joint research) (Table 18). Third, LPTCs frequently dealing with design are the most likely to agree with the statement that technical consultation promote researchers' understanding of local firms' technological needs (Table 22). These findings imply that problems in design require sharing of symbolic knowledge that tends to be tacit, and thus such problems require more time to find a solution. As tacit knowledge is hard to transfer via documents, solutions to design problems tend to be found through dense personal interactions, which prefer geographical proximity between client and knowledge provider. Indeed, the geographical distribution of clients indicates that geography matters in design, while this is not the case in chemicals (Table 7). In chemicals and engineering, innovative activities tend to build on analytical knowledge relatively easy to be codified and transferred via documentation, such as licensing (Fukugawa forthcoming b). Therefore, in building LPTCs' future strategy, policymakers should be aware of channels of technology transfer most needed by local SMEs, reflecting industrial agglomerations. Since 2000, local authorities have been drastically reducing budget and human resources allocated for LPTCs (Table 2). The results suggest such policy changes made in an uninformed manner could decrease the potential contributions of LPTCs to regional innovation systems, with significant variation based on local industrial structures. Thus, more careful examination is required of the types of resources to be enhanced, reallocated, and abandoned.

7. Conclusion

This study is the first to investigate the characteristics and potential impacts of technical consultation using information from a questionnaire survey conducted at the branch level. The key findings can be summarized as follows. First, LPTCs solve various (technological and non-technological) problems through technical consultation. What is notable is that a non-negligible proportion pertains to design. Second, the problems LPTCs solve are diverse in terms of complexity as well, with problems in design requiring a longer time to solve. Third, technical consultation acts as a gateway to further technology transfer activities. Types of additional technical assistance triggered by technical consultation vary across technological fields. Fourth, LPTCs act as innovation intermediaries that connect SMEs to other sources of knowledge, such as universities, when the problem is hard to solve. Fifth, LPTCs believe that technical consultation contributes to their researchers' better understanding local firms' technological needs, which is salient for LPTCs dealing frequently with problems in design.

As this is the first survey of its kind and the results are preliminary, several limitations are inevitable. First, this study focused on LPTCs and did not collect information from their clients. Therefore, potential impacts of technical consultation were evaluated from the viewpoint of only LPTCs. This makes it difficult for this study to assess the actual impact of technology transfer. Future research should collect information from the SMEs that used the service (and those that did not) along with LPTCs to further examine the productivity effect of technical consultation. Second, regarding the evolution of technology transfer channels, it is likely that frequent users of technical consultation are exposed to greater opportunities to nurture mutual trust and develop a technology transfer channel into a more interactive one (Izushi 2003; 2005). This suggests that frequent users are more likely to conduct joint research with LPTCs. Future research should collect information about frequency of communication and its impact on regular clients' exploitation of LPTCs through more interactive channels. Third, regarding their intermediary function, the results imply that the quality improvement in human capital at LPTCs works to improve the intermediary function with universities. However, the relationship between research quality and intermediary function may not be straightforward. The more qualified LPTCs' researchers are, the less necessary for LPTCs to rely on other sources of knowledge. Future research should estimate the relationship between research quality and intermediary function controlling for other influential factors. Fourth, regarding sectoral patterns and the nature of the problems SMEs face, this study demonstrates that problems in design are typical of symbolic knowledge based problems that require more personal interactions and time to solve. As little is known about the type of design problems and how they have been solved through interactions with LPTCs or other sources of knowledge, future research should collect information about this issue. Similarly, problems related to analytical knowledge need to be investigated so that the results can be compared in terms of the necessity for personal interactions, mediation to universities, and the significance of geographical proximity to the knowledge source.

References

1. Armstrong, J. and Overton, T. (1977) Estimating nonresponse bias in mail surveys, Journal of Marketing Research, 14, 396–402.
2. Arundel, A., van de Paal, G., and Soete, L. (1995) Innovation Strategies of Europe's Largest Industrial Firms: Results of the PACE Survey on Information Sources, Public Research, Protection of Innovations, and Government Programmes, MERIT, Maastricht.
3. Asheim, B. and Gertler, M. (2005) The geography of innovation: Regional innovation systems. In J. Fagerberg, D. Mowery and R. Nelson (Eds.), The Oxford Handbook of Innovation (pp. 291–317). Oxford: Oxford University Press.

4. Asheim, B., Coenen, L., and Vang, J. (2007) Face-to-face, buzz and knowledge bases: Sociospatial implications for learning, innovation and policy. Environment and Planning C: Government and Policy, 25(5), 655–670.
5. Cohen, W., Nelson, R., and Walsh. J. (2000) Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not), NBER Working Paper No. 7552.
6. Crawcour, S. (1997) Kogyo Iken: Maeda Masana and His View of Meiji Economic Development, Journal of Japanese Studies, 23(1), 69–104.
7. Dornbusch, F., and Brenner, T. (2013) Universities as Local Knowledge Hubs under Different Technology Regimes: New Evidence from Academic Patenting, Working Papers Firms and Region, No. R6/2013.
8. Fukugawa, N. (2006) Determining Factors in Innovation of Small Firm Networks: A Case of Cross Industry Groups in Japan, Small Business Economics, 27, 181–193.
9. Fukugawa, N. (2013) University Spillovers into Small Technology-Based Firms: Channel, Mechanism, and Geography, Journal of Technology Transfer, 38(4), 415–431.
10. Fukugawa, N. (forthcoming a) University Spillover before the National Innovation System Reform in Japan, International Journal of Technology Management.
11. Fukugawa, N. (forthcoming b) Knowledge creation and dissemination by local public technology centers in regional and sectoral innovation systems: Insights from patent data, *RIETI Discussion Paper*.
12. Furman, J. and Stern, S. (2011) Climbing atop the shoulders of giants: the impact of institutions on cumulative research, American Economic Review, 101(5), 1933–1963.
13. Gertler, M. (2003) Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there), Journal of Economic Geography, 3(1), 75-99.
14. Goto, A., and Nagata, A. (1997) Technological Opportunities and Appropriating the Returns from Innovation, in Japanese, National Institute of Science and Technology Policy, Tokyo.
15. Han, J., Han, J., and Brass, J. (2014) Human capital diversity in the creation of social capital for team creativity, Journal of Organizational Behavior, 35(1), 54–71.
16. Hicks, D., Breitzman, T., Olivastro, D., and Hamilton, K. (2001) The changing composition of innovative activity in the US: a portrait based on patent analysis. Research Policy, 30(4), 681–703.
17. Howard Partners (2007) Study of the role of intermediaries in support of innovation. http://www.industry.gov.au/innovation/reportsandstudies/Documents/InnovationIntermediariesReport.pdf. Accessed on 7 January 2016.
18. Howells, J. (2006) Intermediation and the role of intermediaries in innovation, Research Policy, 35(5), 715–728.
19. Huang, K. and Murray, F. (2009) Does patent strategy shape the long-run supply of

public knowledge? Evidence from human genetics. Academy of Management Journal, 52(6), 1193–1221.
20. Izushi, H. (2003) Impact of the Length of Relationships upon the Use of Research Institutes by SMEs, Research Policy, 32, 771–788.
21. Izushi, H. (2005) Creation of Relational Assets through the Library of Equipment Model: an Industrial Modernization Approach of Japan's Local Technology Centers, Entrepreneurship and Regional Development, 17, 183–204.
22. Japan Association for the Advancement of Research Cooperation (2011) Survey on Local Public Technology Centers in Regional Innovation Systems, JAREC: Tokyo.
23. Japan Society for the Promotion of Science (1935) Zenkoku Shiken Kenkyu Chosa Kikan Yoran, JSPS: Tokyo.
24. Jarmin R. (1999) Evaluating the Impact of Manufacturing Extension on Productivity Growth, Journal of Policy Analysis and Management, 18, 99–119.
25. Kamatani, C. (1985) Kokka Toshiteno Kenkyu Taisei No Keisei Katei, Tsusho Sangyo Seisakushi Kenkyujo: Tokyo.
26. Levin, R., Klevorick, A., Nelson, R., and Winter, S. (1984) Survey Research on R&D Appropriability and Technological Opportunity, New Haven: Yale University Press.
27. Malerba, F. (2002) Sectoral systems of innovation and production, Research Policy, 31(2), 247–264.
28. Martin, R. and Moodysson, J. (2011) Comparing knowledge bases: on the geography and organization of knowledge sourcing in the regional innovation system of Scania, Sweden European Urban and Regional Studies, 20(2) 170–187.
29. Ministry of Agriculture (1958) Norin Gyoseishi, Norin Kyokai: Tokyo.
30. Ministry of Agriculture and Commerce (1886) Noshomu-sho Hokoku (Report of the Ministry of Agriculture and Commerce), Ministry of Agriculture and Commerce: Tokyo.
31. Ministry of Agriculture and Commerce (1912) Komu-kyoku Chosa Kogyo Ni Kansuru Shisetsu Kogai, Seisan Chosa Kai: Tokyo.
32. Ministry of Finance (MOF) (1964) Meiji Zenki Zaisei Keizai Shiryo Shusei, Volume 18, Meiji Bunken Shiryo Kankokai: Tokyo.
33. Miyake, T. (2015) Kindai Nihon Chinretsujo Kenkyu, Shibunkaku: Kyoto.
34. Nagaoka, S. and Walsh, J. (2009) Commercialization and Other Uses of Patents in Japan and the U.S.: Major Findings from the RIETI-Georgia Tech Inventor Survey, RIETI Discussion Paper 09E011.
35. Nelson, R. and Winter, S. (1982) An Evolutionary Theory of Economic Change, Cambridge: Belknap Press of Harvard University Press.
36. Ohkawa, K. and Rosovsky, H. (1965) A century of Japanese economic growth, in Lockwood, W. (ed.), The state and economic enterprise in Japan: Essays in the political economy of growth, Princeton: Princeton University Press.

37. Pavitt, K. (1984) Sectoral patterns of technical change: Towards a taxonomy and a theory, Research Policy, 13(6), 343–373.
38. Ponds, R., Oort, F., and Frenken, K. (2010) Innovation, spillovers and university-industry collaboration: an extended knowledge production function approach, Journal of Economic Geography, 10(2), 231–255.
39. Rogelberg, S. and Stanton, J. (2007) Understanding and Dealing with Organizational Survey Nonresponse, Organizational Research Methods, 10(2), 195–209.
40. Ruth, K. (2006) Innovation Policy for SME in Japan: The Case of Technology Transfer Centres, in Storz, C. ed., Small Firms and Innovation Policy in Japan, London: Routledge, pp.56–81.
41. Sawai, M. (2002) Kosetsu Shiken Kenkyu Noritsu Kenkyu Kikan No Chusho Kigyo Shien Ikusei Katsudo, Tokyo: University of Tokyo Press.
42. Science and Technology Agency (1958) Koristu Shiken Kenkyu Kikan No Jittai, Tokyo: STA,
43. Science and Technology Agency (1976) Minkan Kigyo No Kenkyu Kikan Ni Okeru Kenkyu Yoin Narabini Kenkyu Katsudo Ni Kansuru Chosa Hokoku, Tokyo: STA.
44. Shapira, P. (1992) Modernizing Small Manufacturers in Japan: the Role of Local Public Technology Centers, Journal of Technology Transfer, 17, 40–57.
45. Shapira, P. and Rosenfeld, S. (1996) An Overview of Technology Diffusion Policies and Programs to Enhance the Technological Absorptive Capabilities of Small and Medium Enterprises. Mimeo.
46. Soda, O. (1971) Chosonze Undo No Tenkai To Sono Keifu, Noringyo Mondai Kenkyu, 25, 14–24.
47. Small and Medium Enterprise Agency (1964) SMEA White Paper, SMEA: Tokyo.
48. Stankiewicz, R. (1995) The role of the science and technology infrastructure in the development and diffusion of industrial automation in Sweden, in Carlsson, B. (Ed.): Technological Systems and Economic Performance: The Case of Factory Automation, pp.165–210, Kluwer, Dordrecht.
49. Storper, M. and Venables, A. (2004) Buzz: Face-to-face contact and the urban economy, Journal of Economic Geography, 4(4), 351-370.
50. Tether, B., Li, Q., and Mina, A. (2012) Knowledge-bases, places, spatial configurations and the performance of knowledge-intensive professional service firms, Journal of Economic Geography, 12(5), 969–1001.
51. U.S. Congress, Office of Technology Assessment, (1990) Making Things Better: Competing in Manufacturing, OTA-ITE-443, Washington D.C.: U.S. Government Printing Office.
52. Yanagisawa, F. (2005) Yamaoka Jiro Kenkyu Noto (1), Fukui Ken Bunshokan Kenkyu Kiyo, 2, 113–121.

Table 1 LPTCs in the early phase

Year	Name	Established by	Technology	Current form
1885	Kyoto Someko (dyeing) Koshujo	Kyoto City	Dyeing	Kyoto City Rakuyo Kogyo High School
1885	Ashikaga Orimono (textile) Koshujo	Ashikaga Koshokai	Textiles	Tochigi Pref. Ashikaga Kogyo High School
1886	Kiryu Orimono Koshujo		Textiles	Abolished
1886	Isezaki Someori (dyeing) Koshujo	Cooperative association	Dyeing	Gunma Pref. Isezaki Kogyo High School
1886	Sakai Jozo (brewery) Kairyo (improvement) Shikenjo	Cooperative association	Sake brewing	
1887	Seishi (paper) Shikenjo	Noshomu-sho, Komu-kyoku	Paper	Abolished in 1889
1887	Hachioji Orimono Senshoku (dyeing) Koshujo	Cooperative association	Dyeing	Tokyo Metropolitan Hachioji Kogyo High School
1888	Kamezaki (Chita-gun) Shiken Jozo Gura	Cooperative association (Rengyo-kai)	Sake brewing	Abolished
1888	Itami Shuzo Kairyo Shikenjo	Cooperative association	Sake brewing	
1891	Iwate-ken Someori Koshujo	Iwate Pref.	Dyeing	Iwate Industrial Research Inst.
1901	Fukushima-ken Kogyo Shikenjo	Fukushima Pref.	Textiles, spinning	
1902	Yamaguchi-ken Someori Koshujo	Yamaguchi Pref.	Dyeing	Yamaguchi Pref. Industrial Technology Inst.
1902	Fukui-ken Kogyo Shikenjo	Fukui Pref.	Textiles	Industrial Technology Center of Fukui Pref.
1903	Ehime-ken Kogyo Shikenjo	Ehime Pref.	Dyeing	
1903	Osaka-fu Kogyo Shikenjo	Osaka Pref.	Inspection in general	
1903	Kyoto-shi Tojiki (ceramic) Shikenjo	Kyoto City	Ceramics	Kyoto Mun. Inst. of Industrial Technology and Culture
1905	Kyoto-fu Orimono Shikenjo	Kyoto Pref.	Dyeing	
1905	Yamanashi-ken Kogyo Shikenjo	Yamanashi Pref.	Dyeing	
1905	Shodo-shima Shoyu Jozo Shikenjo	Cooperative association	Soy sauce brewing	Became prefectural in 1910 (Kagawa Pref. Industrial Technology Center)
1906	Shizuoka-ken Kogyo Shikenjo	Shizuoka Pref.	Japan, paper, dyeing	
1907	Aomori-ken Kogyo Koshujo	Aomori Pref.		Abolished in 1910
1907	Fukui-ken Kogyo Koshujo	Fukui Pref.	Textiles, dyeing	Fukui Pref. Kagaku Gijutsu High School

1907	Hiroshima-ken Kogyo Shikenjo	Hiroshima Pref.	Dyeing	
1908	Ibaraki-ken Kogyo Shikenjo	Ibaraki Pref.		Abolished in 1911
1909	Gifu-ken Kogyo Shikenjo	Gifu Pref.	Dyeing	
1909	Mie-ken Kogyo Shikenjo	Mie Pref.	Dyeing, manufacturing in general	Mie Pref. Industrial Research Inst.
1910	Kagawa-ken Kogyo Shikenjo	Kagawa Pref.	Soy sauce brewing	Kagawa Pref. Industrial Technology Center
1911	Shiga-ken Notogawa Kogyo Shikenjo	Shiga Pref.	Dyeing	
1911	Shiga-ken Nagahama Kogyo Shikenjo	Shiga Pref.	Dyeing	
1912	Akita-ken Kogyo Koshujo	Akita Pref.	Woodwork, japan	

Source: Ministry of Agriculture and Commerce (1886, 1912)

Notes

1. Websites of LPTCs have been used to identify their current forms. Blanks represent those without organizational history information. In case of a discrepancy in the year of establishment, information from the abovementioned source was used.
2. Koshujo=learning center; shikenjo=inspection center; kogyo shikenjo=manufacturing technology center

Table 2 Time series variations in LPTCs allocated resources

	1990	1995	2000	2005	2010	2013
LPTCs expenditure/local government revenue (%)	0.69	**0.70**	0.67	0.60	0.60	0.49
The number of LPTCs	**648**	642	577	498	429	392
Full time researchers/LPTCs employees (%)	47.3	46.0	**47.5**	45.6	41.7	40.1
Internal research expenditure per full time researcher (1 million yen)	16.0	**20.1**	19.5	17.0	16.7	15.9
Research revenue per full time researcher (1 million yen)	0.50	0.66	0.83	0.81	**1.40**	1.07
Growth rate of LPTCs expenditure (%)		26.5	-3.7	**-19.1**	1.8	-16.2
Growth rate of the number of LPTCs (%)		-0.9	-10.1	-13.7	**-13.9**	-8.6
Growth rate of the number of employees (%)		1.8	-4.8	-3.4	-5.9	**-9.1**
Growth rate of the number of full time researchers (%)		-0.9	-1.9	-7.1	**-14.0**	-12.7
Growth rate of labor costs (%)		17.0	0.9	-11.1	**-19.5**	-16.5
Growth rate of internal research expenditure (%)		24.7	-4.7	**-19.4**	-15.0	-17.1

Source

Survey on Science, Technology, and Research by the Ministry of Internal Affairs and Communications

Notes

1. Figures in bold are the maximum or minimum value during the period.
2. Growth rates represent period-to-period changes.

Table 3 Number of LPTCs by division and technology

	Headquarters	Branches	Total	Proportion
Agriculture	78	188	266	40%
Design	5	3	8	1%
Environment and public health	71	7	78	12%
Fishery	43	52	95	14%
Foods	6	13	19	3%
Forestry	22	23	45	7%
Medicine	7	2	9	1%
Manufacturing	81	56	137	21%
Misc	6	4	10	1%
Total	319	348	667	100%

Source

https://unit.aist.go.jp/rcpd/ci/wholesgk/link/kousetsushi/kousetsushi.html. Accessed on 7 January 2016.

Table 4 Employment and effort allocation

Number of employees	38.5
Number of technical staff	30.3
Ph.D. holders/technical staff (%)	24.2
Efforts allocated to research (%)	28.8
Efforts allocated to technical consultation (%)	25.5
Efforts allocated to technical support other than technical consultation (%)	34.4
Efforts allocated to administrative tasks (%)	12.0

Table 5 Previous affiliation of LPTCs' directors as of April 2014 (%)

LPTC	53.2
Firm	8.1
University	3.6
Public research institute	8.1
Local authority	19.8
Technical college	0.9
Chamber of commerce	0.0
Others	6.3

Table 6 Type of clients and frequency of technical consultation

Number of problems consulted on (A)	5356.3
A/technical staff	126.4
Real number of clients (B)	1043.3
A/B	4.6
Share of firms among B	92.4
Share of individuals among B	7.5
Share of local clients among B	83.7
Share of non-local clients among B	16.3
Share of new clients who consulted for the first time as of 2014	17.4
Maximum number of problems consulted on by the most frequent user	88.5

Table 7 Share of local and non-local clients by type of problems LPTCs solved most frequently (%)

	Local	Non-local
Chemicals	78.7	**21.3**
Design	**90.8**	9.3
Engineering	87.2	12.8
Foods	**91.5**	8.5
Misc	79.7	20.3
Total	83.7	16.3

Note

See Table 12 for the definitions of problems LPTCs solved most frequently.

Table 8 The most important information source for new users (%)

	Local clients	Non local clients
Mass media	5	3
Internet	**37**	**75**
Seminars	1	0
Word of mouth	35	5
Scientific presentations and papers	0	4
Patents, trade fairs	3	1
Others	11	5

Table 9 Price of technical consultation (%)

Totally free	86.5
Basically free, could be charged according to the content	12.6
Basically charged, could be free according to the content	0.9
Totally fee-based	0.0

Table 10 The presence of a mediator between technical staff and clients of technical consultation (%)

Full-time staff to match clients with appropriate technical staff	34.2
No full-time staff to match clients with appropriate technical staff	65.8

Table 11 The presence of a mediator by LPTC type (%)

Ceramics	0
Design	33.3
Foods	18.1
Leather	0
Manufacturing in general	44.4
Paper	0
Textiles	28.5
Total	34.2

Note

LPTC type is classified according to the names of LPTCs.

Table 12 Technological fields which the problem is most closely related to (%)

Foods	17.1
Chemicals	18.5
Mechanical engineering	18.5
Electrical engineering	7.7
Design	6.8
Other technological fields	27.1
Not elsewhere classified (e.g., subsidy and IPR)	4.3

Note

This information is used to identify the type of problems LPTCs solved most frequently. Mechanical engineering and electrical engineering are integrated as engineering.

Table 13 Technological fields to which the problem is most related by LPTC type (%)

	Foods	Chemicals	Mechanical engineering	Electrical engineering	Design	Other technological fields	NEC
Ceramics	0.1	**30.5**	0.1	1.2	7.1	54.3	6.7
Design	0.0	1.7	1.7	0.0	**54.5**	34.3	7.8
Foods	**89.0**	1.2	0.9	1.4	1.0	2.1	4.5
Leather	2.0	**45.0**	1.0	0.0	0.0	48.0	4.0
Manufacturing in general	12.4	19.5	**28.2**	11.5	4.3	20.7	3.4
Paper	1.0	34.3	2.0	0.7	0.0	**58.3**	3.7
Textiles	2.2	19.1	0.5	0.3	4.6	**66.3**	7.0
Total	17.1	18.5	18.5	7.7	6.8	**27.1**	4.3

Note

LPTC type is classified according to names of LPTCs.

Table 14 Time required for the problem to be solved (%)

A day	**54.4**
Within a week	29.1
Within a month	10.8
Within a year	4.1
More than a year	1.9

Table 15 Time required for the problem to be solved by type of problems LPTCs solved most frequently (%)

	A day	A week	A month	A year	More than a year
Chemicals	**71.6**	17.6	8.3	1.9	1.1
Design	50.0	21.7	11.7	**13.3**	**3.3**
Engineering	35.7	**43.5**	11.8	6.3	2.9
Foods	58.8	22.5	**14.2**	3.9	0.7
Other technological fields	54.4	31.2	9.3	3.1	2.4
Total	54.4	29.1	10.8	4.1	1.9

Table 16 How the problems were solved (%)

The problem was solved by technical staff.	**89.7**
Clients with unsolved problem were mediated to external organizations.	8.5
Neither of abovementioned	1.7

Table 17 Other technology transfer channels triggered by technical consultation (%)

Inspection	27.8
Use of equipments	20.7
Joint research	2.7
Funded research	2.6
Technical guidance	20.9
Other technical support	6.6
No additional support provided (the problem has been solved immediately)	41.7

Table 18 Other technology transfer channels triggered by technical consultation by type of problems LPTCs solved most frequently (%)

	Inspections	Use of equipment	Joint research	Technical guidance
Chemicals	17.4	20.2	1.2	14.6
Design	4.5	22.0	**6.4**	**30.5**
Engineering	**41.3**	**25.1**	2.2	24.4
Foods	30.4	16.0	2.7	23.1
Other technological fields	25.2	21.1	3.3	20.5
Total	27.8	20.7	2.7	20.9

Table 19 Other sources of knowledge LPTCs connected clients with unsolved problems (%)

Other LPTCs	**41.1**
Universities	8.9
Firms	21.1
Foundations	22.0
Public research institute	14.4
Others	13.2

Table 20 Other sources of knowledge LPTCs connected clients with unsolved problems by type of problems LPTCs solved most frequently (%)

	Other LPTCs	Firms	Universities	PRIs	Foundations
Chemicals	**55.3**	8.8	**12.5**	11.5	26.0
Design	16.7	**42.5**	5.0	**43.3**	15.0
Engineering	45.4	23.7	8.5	10.8	22.2
Foods	31.7	18.1	9.8	15.0	**28.5**
Other technological fields	38.0	25.2	6.8	13.5	16.7
Total	41.1	21.1	8.9	14.4	22.0

Table 21 Perceived effects of technical consultation (%)

Better understanding of needs of local firms	50.3
Training of engineers	29.9
Repetitive use	43.9
Joint inventions	2.9

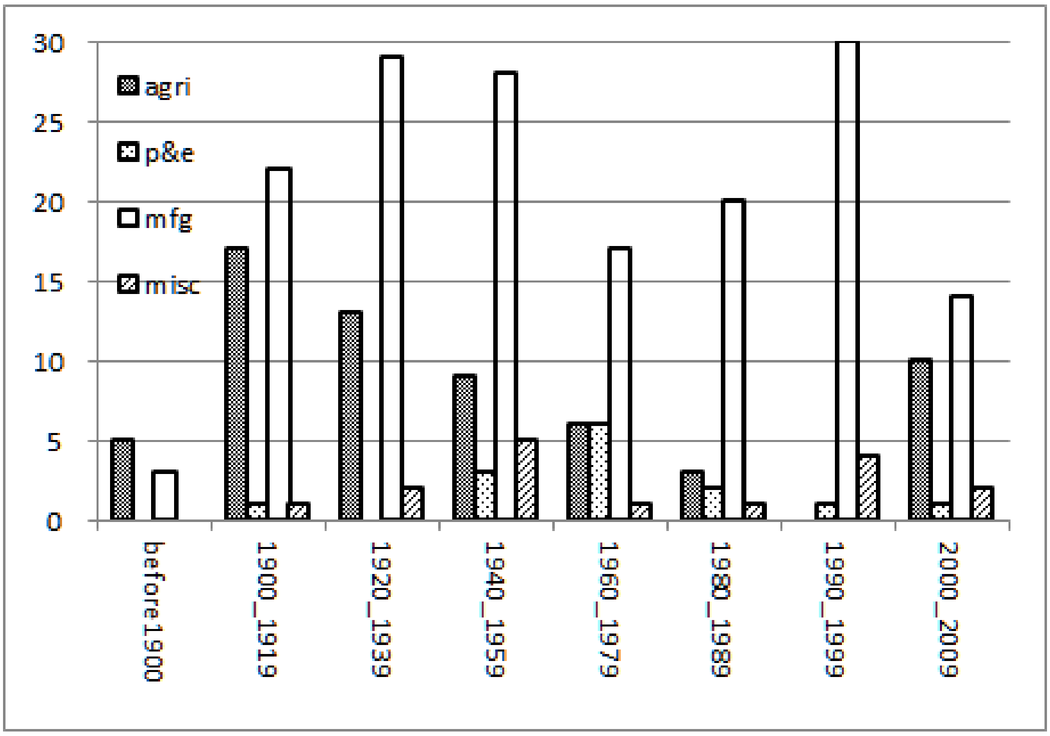
Table 22 Perceived effects of technical consultation by type of problems LPTCs solved most frequently (%)

	Understanding needs of local firms	Training of engineers	Repetitive use	Joint inventions
Chemicals	50.1	24.0	40.4	1.2
Design	**66.7**	18.2	30.0	2.5
Engineering	39.9	28.8	**52.4**	**6.3**
Foods	53.5	33.3	47.4	3.2
Other technological fields	53.5	**34.3**	40.0	1.9
Total	50.3	29.9	43.9	2.9

Table 23 Perceived effects of technical consultation by the presence of a mediator (%)

	Understanding needs	Training	Repetitive use	Joint invention
No full-time staff to match clients with appropriate technical staff	51.8	30.9	45.6	2.4
Full-time staff to match clients with appropriate technical staff	46.2	27.3	39.6	4.1

Figure 1 Distribution of establishment year of LPTCs active as of 2010



Source: AIST "Current Status of Local Public Technology Centers"

Notes

1. agri: agriculture; p&e: public health and environment; mfg: manufacturing; misc: not elsewhere classified.
2. All the reorganized LPTCs are counted as newly established.