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Building capabilities for innovation in SMEs: a cross-country comparison of technology extension policies and programmes

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Abstract: There has been a growth of policy attention in many advanced and developing countries to stimulating innovation at the enterprise and establishment level, particularly in small and medium-sized enterprises (SMEs). This paper examines technology extension policies and programmes for building capabilities for innovation in SMEs for a selected set of programmes and countries in the US, Japan, Germany, Canada, Spain, and Argentina. These programmes represent a range that offer best practice insights at the international level and/or which have particular relevance for new sets of countries seeking to implement such systems. The study shows technology extension programme designs and operations are influenced by the innovation systems in which they are embedded. Drawing on our comparison of international examples, implications are discussed for the formulation of national and regional policies for the development of technology extension and related innovation programmes targeted to SMEs.

Keywords: capabilities; innovation; technology extension; small and mid-size enterprise; SMEs; comparison; policies; programmes; regional development.

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1 Introduction

The competitiveness of businesses in advanced and developing economies has experienced challenges in recent years on multiple fronts. Factors underlying these challenges include intensified competitive pressure due to globalisation, industrial restructuring and outsourcing by large companies, developments in technology and management, and policy pressures to maintain higher-wage employment and develop regional innovation systems. While large companies regularly attract much of the attention in debates about competitiveness and globalisation, policies for innovation frequently focus on small and medium-sized enterprises (SMEs). There is a long-held view that SMEs make a central contribution to the innovativeness of an economy (Schumpeter, 1934). The rubric of SMEs and innovation evokes narratives about high-tech startups that emerge from work done in the founder's 'garage' or that are spinoffs from a university laboratory. In the US, SMEs have been termed 'gazelles' when they achieve annual growth rates in sales of 20% or more (Birch, 1979). Another important role model is presented by the 'mittelstand' or medium-sized companies in Germany that succeed through world-class technology and quality in specifically-defined market niches and extensive exporting.

However, not all SMEs are overtly innovative. There is great heterogeneity in enterprise characteristics, resources, motivations, sectoral and regional attributes, and other factors, and concomitant wide variations in orientation towards and capabilities to undertake innovation (Shapira, 2009). Typically, SMEs lack market power (by virtue of their smallness) and can be cautious or even inert in taking innovative actions due to the real risks of business failure and constraints of knowledge, expertise, and finance.

SMEs are numerous, usually comprising upwards of 98% of business establishments in most economies. By share of enterprise employment, SMEs occupy a relatively larger role (70% on average in Europe and in Japan) and a lesser role in the US (under 50%). It should be noted that definitions of SMEs vary by country and industry sector. These definitions are nearly always based on employment size or financial characteristics. In the US and Canada, the threshold for an SME is 500 or fewer employees across most sectors. Japan uses a threshold of 300 or fewer employees to describe an SME. The European Union offers a standard employment-based definition of an SME to include: medium-sized enterprises (50–249 employees); small enterprises (10–49 employees); and very small (micro) enterprises (nine or fewer employees). The upper limit in Argentina's definition of an SME is 200 or fewer employees and there is also a financial based definition (European Commission, 2003; Industry Canada, 2007; METI, 2006; SBA, 2005; UIA, 2007).

Several studies claim that SMEs generate a disproportionate share of net new jobs (Birch, 1979; Observatory of European SMEs, 2004). In addition, the combination of small firms with regions that support flexibility and interfirm linkages has been found to encourage innovation and promote competitive advantage (Piore and Sabel, 1984; Porter, 1990). On the other hand, there is evidence that SME performance lags that of larger corporate counterparts. Indeed, in the US, the manufacturing productivity gap (measured by value-added per employee) between large firms and SMEs has widened over time. On average, value-added per employee in SMEs was about 80% of that of large establishments in the 1960s; by the late 1990s, value-added per employee in SMEs on average was less than 60% of that of large establishments (ModForum, 2003). Moreover, the job growth seen in the SME sector is not entirely independent or due to textbook entrepreneurship. Harrison (1994) argues that large corporations, through mechanisms such as industrial restructuring and corporate outsourcing, have caused many jobs to reappear (rather than grow) in small firms. Additionally, while policy narratives focus on entrepreneurial high-technology firms, these are only a small minority of all SMEs in the economy. Lags in innovation uptake have been noted among the majority of SMEs, typically those which operate in traditional or resource-based industries, at the lower-ends of supply-chains and subcomponent operations, and in 'lifestyle' or family operations lacking the appetite for change (Shapira et al., 2006).

It is this heterogeneity that makes policy responses to assist SMEs so difficult. Perhaps unsurprisingly, multiple policies and programmes targeted towards SMEs are common in most national innovation systems (Hassink, 2002; Shapira, 2009). For instance, Japan has an SME support system that includes some 250 regional SME support centres, 54 prefectural SME support centres, and 8 SME venture business support centres, as well as support organisations in more than 500 local chambers of commerce and industry, thousands of other prefectural and local small business associations and societies, and many new facilities to foster small business exchange, incubation, research, and venture funding (Aoyama, 1999; METI, 2005; Shapira, 2008). These organisations provide an array of services including information supply, business and machinery credit

insurance and loans, tax credits, R&D subsidies, management training, support for new business creation, assistance with technical upgrading and internationalisation, mutual insurance schemes, assistance with succession, mergers, and the avoidance of bankruptcy, and support for SMEs in specific industries (for example, in textiles). In the US, Shapira et al. (1997) identified some 750 organisations with formal relationships to deliver or provide support services to manufacturing SMEs. These organisations included national, state, and local government agencies; non-profit technology or business assistance centres; economic development organisations; universities and community colleges; private consultants; utilities; federal laboratories; and industry associations. This situation of multiple and at times overlapping programmes is found in many other advanced economies.

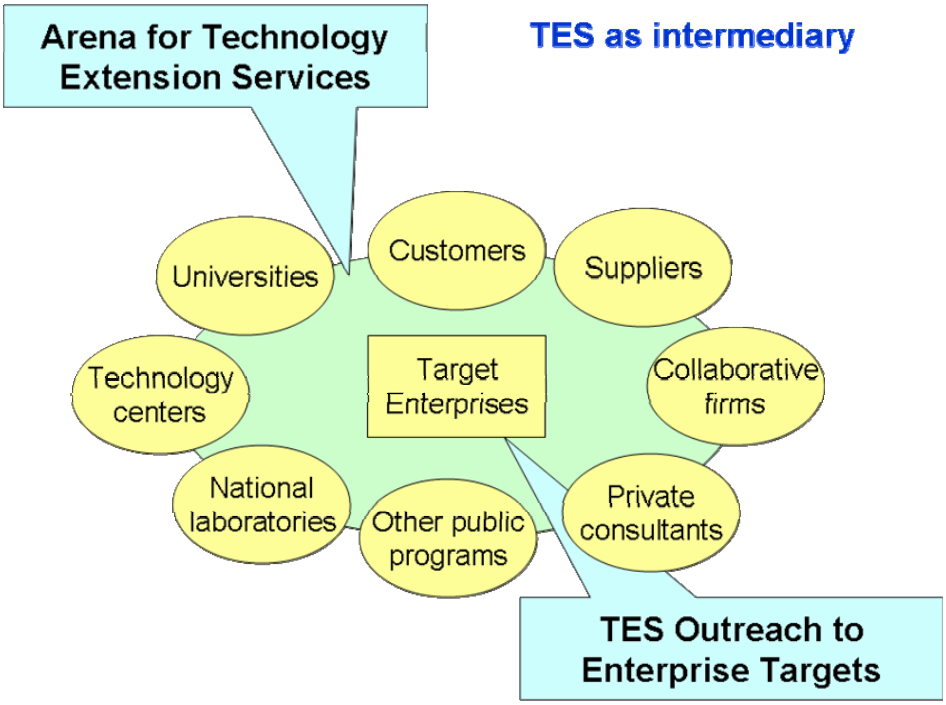
Furthermore, policy responses to foster innovation in SMEs are complicated by the multidimensional nature of the problems encountered by these enterprises. Challenges exist at the firm level, at the industry level, within the context of social infrastructure, and in the innovation environment. There are demand side gaps, with SMEs lacking information, expertise and skills, training, resources, strategy, and confidence to adopt new technologies and techniques. Supply side gaps exist in terms of the costs for vendors, customers, consultants, and other business assistance sources to reach and service SMEs. System-level factors are present in areas such as the limited quantity and sometimes poor quality of education and training services available to SMEs, lack of access for SMEs to universities and national laboratories and technology centres focused on research missions and high-end technologies, and existing government programmes focused on economic development or generic non-technological services. Moreover, the increasing presence of open markets, low-cost but technologically capable competition, shifts from economies of scale to economies of scope, and new open innovation approaches present further challenges in the innovation environment of SMEs (Caputo et al., 2002; Shapira, 2001).

This article explores one policy approach – technology extension service (TES) – for advancing adoption of technologies and encouraging innovation in SMEs. We examine TES programmes in six countries: the USA, Japan, Germany, Canada, Spain and Argentina. We probe the design and operation of these services, as well as their degree of integration with other policies for innovation. These countries have national innovation systems with varying levels of decentralised governance. We posit that the TES service models in each country will share some functional attributes but differ in design and organisation in ways that are influenced by the national innovation system of that country. Hence, we observe that the TES programmes in the six countries share a reliance on the capabilities of personnel who deliver services and fulfil important boundary spanning functions by linking multiple complementary framework policies and direct assistance programmes administered by public and private organisations. They also share characteristics such as the ability to offer customised services to account for differences in regional and national innovation systems, approach to R&D services offerings, methods for reaching customers through distributed delivery systems, and flexibility in funding mechanisms. At the same time, we see differences that reflect the national innovation systems in which these TES programmes are embedded. These differences have to do largely with the relationship between the national and regional innovation systems and the resulting characteristics of the SMEs that operate within these systems.

2 TES roles and features

For the purposes of this study, we define TES as the 'deployment of outreach mechanisms in the field to stimulate companies to acquire or improve their use of technology and stimulate innovation'. This definition presents the TES not only as a service delivery programme but also as an intermediary in the institutional setting in which the firm operates. An important feature of the TES is to encourage multilevel collaboration and involvement across disconnected SME policy arenas in activities to support technology and innovation in firms (Figure 1).

Figure 1 TES as an intermediary intervention in enterprise knowledge sources and relationships (see online version for colours)



The mission of a TES programme characteristically encompasses improvement in firm productivity, quality, product performance, workforce skills, and learning capabilities. Enhanced regional and national competitiveness is a broader goal, while societal returns such as enterprise stability and growth, upgrading of job skills, and sustainability processes are also emphasised.

TES programmes mostly work with existing SMEs, although they may engage with micro-enterprises, supply chains and their branch facilities, and regional clusters and agglomerations. Typical TES services include information provision; benchmarking and assessment; technical assistance or consultancy; training; group or network services; collaborative projects (e.g., R&D, implementation); strategy development; and coaching and mentoring. Some TES programmes undertake applied research. All have strategies and mechanisms to share and diffuse knowledge about innovation and technology to SMEs. These commonly involve the integration of technological and knowledge-based

practices, often of a practical nature, with other enterprise needs and strategies to improve firms' technological performance. TES programmes have recently become more associated with explicitly encouraging innovation in SMEs including product or process innovation, organisational or managerial innovation, innovation in marketing or business models, and skills and capabilities upgrading. Although online computer-accessed services and standard tools are increasingly used, knowledge is most typically transferred through expert staff rather than through codified approaches. TES is not effective as a one-off response to a short-term crisis (such as a plant closure); rather, results from these programmes may take time to materialise and require sustained efforts, and some direct jobs may be lost in the short-term as productivity is increased. Although there is usually a strong public mission and public funding contribution, successful TES programmes stress processes that are driven by industry needs and market opportunities and which leverage other private resources and service suppliers.

We anticipate that TES programmes are influenced by their national innovation systems and their existing business and institutional structures. Hence, we would expect that variations in the specific design of a given country's programme, outreach parameters, targets, and service offerings reflect the specificities of that country's national innovation system. For example, innovation policies and programmes in the US occur within a large federal system comprised of multiple national and state level agencies that target a sizeable and diverse population of SMEs. We thus expect US TES programmes to be flexible and broad-based, reflecting regional characteristics and differences among states with any standardisation aimed at a general level and derived through federally-sponsored approaches. The German innovation system's decentralised governance structure and concentration of narrowly-niched global leaders among its SME population suggests that its TES programmes will also be regionally-oriented with an emphasis on enhancing world-class capabilities and services. Countries with a high degree of regional clustering, such as Spain, would be expected to develop TES programmes that are decentralised and specialised according to the industries in the regions. Table 1 summarises our expectations for how the national innovation system may influence the construction of the TES programme. To probe this relationship, we employ a comparative analysis of seven TES programmes in our six countries [see Kolodny et al. (2001) for an earlier cross-national study]. Summaries of case studies of the programmes are presented in the next section. We then present a cross-case analysis and our findings. The results will show that TES programmes not only reflect the nature of their innovation systems but also go beyond this context to address gaps in embodied knowledge, resources, geographic distance, and learning.

3 Case studies: TES programmes in six countries

3.1 US Manufacturing Extension Partnership

The US Manufacturing Extension Partnership (MEP) is one of the primary federal programmes of industrial services for manufacturing SMEs, organised under the National Institute of Standards and Technology (NIST) in the Department of Commerce. The MEP is a nationwide yet decentralised network of 59 centres,[1] more than 300 local offices, and more than 1,000 professional specialists[2] in all 50 states. Originally, these centres were created to transfer federally sponsored state-of-the-art technology, but later they started

delivering pragmatic assistance, appropriate to state and local conditions, with business services, quality systems, manufacturing systems, information technology, human resources, and engineering and product development ('soft' business practices). Groups of centres collaborate with one other, the NIST national programme, and other organisations to implement shared tools and service offerings to firms.

Table 1 Innovation systems, SMEs, and TES programme features

Country	*Key innovation system and SME characteristics*	*TES features*
Germany	• Middlestand market-niche global leaders • Long-standing commitment to skills training	• Stand alone and highly decentralised • Emphasising high capability
US	• Large population of SMEs • High diversity – from high tech to traditional family	• Flexible and broad-based • Decentralised yet part of national system
Canada	• Large geography, with decentralised clusters of SMEs • High diversity – from high tech to traditional resource-based • Branch plants and supply chains • Links to US	• Similarities to US model • Technical and financial • Not just manufacturers • Use of external experts
Japan	• Numerous very small manufacturers • Traditional hierarchical supply chains • Important role of national and state policymakers and policy consistency	• Consistency and stability • Programme scale and geographical proximity to industry clusters
Spain	• Traditional industries • High degree of regional clustering and industry clustering	• Decentralised and specialised
Argentina	• Traditional industries, relatively under-resourced • Uneven distribution of innovation capabilities (focused on Buenos Aires)	• Fluctuating public funding • More broad-based, less technologically focused • Significant concentration in major population centres

The MEP offers a down-to-earth approach to technology extension – i.e., the programme customises its service offerings to the real and perceived needs of companies, rather than being driven by high-level research targets. The MEP has a focus on manufacturing SMEs; although MEP centres do serve larger companies and supply chains, the bulk of effort is targeted towards small and mid-sized companies (defined as with fewer than 500 employees, but most companies served are smaller). The MEP's decentralised organisation supports this approach by allowing each centre, within certain operational and performance parameters, to customise its organisational model (in-house vs. brokered services), service offerings, and delivery based on the needs of its clients and the institutional capabilities within its service region (Shapira et al., 1995). The MEP also has relatively well-developed evaluation systems which combine conventional activity reporting with systematic client surveys, special studies, and external reviews to promote not just programme justification, but also reflection and learning. The MEP funding

model combines federal, state and company sources. Although federal funding has in recent times been uncertain, this diversified funding model ensures engagement of key stakeholders and combines both public service and private missions. The MEP staffing model typically employs industrially-experienced personnel who often join centres with prior industrial experience and may move back to industry or to other centres after a period of time, ensuring constant refreshing of expertise.

3.2 Kohsetsushi centres, Japan

Japan's long-established and extensive system for small business incorporates a network of more than 180 locally administered Public Industrial Technology Research Institutes (Kohsetsushi centres) for SMEs. Kohsetsushi centres are publicly-sponsored institutions, with large engineering staffs, that offer free or low-cost services to Japanese manufacturers with 300 workers or less. Japan began to establish these industrial research, experiment, and testing institutes at the turn of the 20th century, based in part on the US model of agricultural experiment stations and extension services (Shapira, 1992). Today, there is at least one centre in each of Japan's 47 prefectures and more than 20 centres in the Tokyo metropolitan region. More than 6,000 researchers and engineers are employed in the centres, which are administered and largely funded by prefectural and municipal governments through a system budget exceeding US$ 1 billion (Shapira, 2008). The centres offer a consistent set of services that include applied research and R&D projects with SMEs, testing and instrumentation, technical assistance and training, plus new firm support, internationalisation, and information provision.

The Kohsetsushi programme represents a model of stability and consistency. There are a large number of centres, allowing nationwide geographical coverage within or adjacent to regional industry clusters. There is usually a combination of general centres alongside sector-oriented centres targeted to upgrading particular industries through the adaptation of emerging technologies. Kohsetsushi centres undertake research, technology transfer, and training missions. There are facilities for prototyping and trial industrial production using new machines and technologies at the centres. Centres are dedicated to serving SMEs (with fewer than 300 employees) and staffing is very stable (which ensures good relationships with local SMEs, although makes it harder to rapidly respond to demands for new expertise). Public funding is predominant, with relatively low income from fee generation.

3.3 Fraunhofer Institutes, Germany

The Fraunhofer Society (established in 1949) undertakes applied research and technology transfer through 57 institutes in 40 locations in Germany with about 15,000 staff. Each institute manages its own programme of research and application, marketing, and budget, within overall guidance set by the Society and governing boards. The concentration of institutes is high in key industrial areas of the country. For example, there are 14 Fraunhofer institutes in Baden-Württemberg each with specialisations in focused areas such as solid state physics, solar energy, measurement techniques, materials, chemical technology, industrial engineering, and biotechnology. Overall, these institutes provide joint pre-competitive research, bilateral applied research with individual firms, prototype manufacturing, and pre-production and cooperative technology transfer arrangements

with companies. Customers include large companies, SMEs, and public sector clients, with which customised research projects are undertaken individually or within consortia. In 2006, the total annual research budget (all centres) of the Fraunhofer Society was about €1.2 billion. About one-third of the revenue is derived from core institutional funds from public sources, with the balance from contract research from industry (another one-third) and the public sector (Fraunhofer-Gesellschaft, 2007).

The Fraunhofer institutes focus on applied contract research services. Fraunhofer institutes typically specialise in targeted technologies and are not geographically restricted (i.e., although located in a place, often with excellent partner relationships with universities, a Fraunhofer institute can serve any customer in the country or internationally). Fraunhofer institutes typically offer highly-customised services to their clients; these are often high-value, relatively large projects. The funding model combines core institution funding with contract research. Fraunhofer staff combines a scientific approach with an industrial orientation, seeking publications, patents, research contracts, licenses, and startup companies. There are a relatively high number of students and trainees engaged in Fraunhofer institutes.

3.4 Steinbeis centres, Germany

The Steinbeis Foundation (headquartered in Stuttgart), founded in 1971, operates as a private foundation under state sponsorship. Steinbeis transfers existing know-how in education and industry and helps SMEs to access expertise and new technology through cooperative projects, consulting and technical assistance, and training. Technical services are delivered mainly through semi-autonomous technology centres located primarily at polytechnic universities of applied sciences. The organisational units of the Foundation include transfer centres, research centres, consulting centres, and a university (in Berlin). In all, the Foundation sponsors some 565 centres or units – the vast majority in Baden-Württemberg – involving about 4,600 staff (mostly employed on a part-time or project basis including about 800 university professors, with about 1,200 permanent staff) (Steinbeis Foundation, 2007). Steinbeis centres' budgets are mostly funded through client projects. In 2005, they reported an income of €94.9 million, primarily coming from fees for services from clients (Steinbeis Foundation, 2007).

The Steinbeis centres represent a flexible approach to the ramping up and adapting of a technology extension programme. Steinbeis centres leverage university professors and part-time staff to create localised capabilities. Centres are funded primarily through contract research, from industrial and public sources. If centres fail to attract such revenues, the system allows centres to close, with new centres opened based on predicted demand and revenues. The customer base is not restricted; customers include large companies, SMEs and public sponsors. With centres often directed by professors, there are close relationships with universities (particularly applied universities) and high numbers of students and trainees are engaged in projects. There is a decentralised organisational model with individual institutes pursuing significant autonomy within the overall framework and branding of the Steinbeis Society.

3.5 Industrial Research Assistance Program, Canada

The Industrial Research Assistance Program (IRAP) is administered by the National Research Council and is Canada's main technology support programme for SMEs

(Atkinson-Grosjean et al., 2001). Its mission is 'to stimulate innovation in Canadian small- and medium-sized enterprises' (NRC, 2007). Unlike technological extension programmes in other countries, IRAP provides technical and financial support to firms. IRAP does not target manufacturing SMEs exclusively; its client base – all enterprises with fewer than 500 employees – has increasingly been comprised of service firms. On the other hand, IRAP places more of an emphasis on technology and innovation-oriented SMEs than on SMEs in conventional lines of business through promoting service offerings that have a relatively high technology and innovation content. IRAP services are delivered through a network of some 250 Technology Advisors (ITAs) located in 150 regional offices in 90 cities throughout Canada.

IRAP represents a long-established federal programme, founded in 1962, which leverages existing technology service organisations to serve as local hosts. This allows extensive geographical coverage, important in a physically large country like Canada. Additionally, access to a nationwide technology network, the Canadian Technology Network, contributes to the programme's ability to meet local needs while at the same time offering more technological expertise. The provision of non-reimbursable grant subsidies for private R&D represents a best practice for stimulating this type of activity in SMEs, which often lack the financial wherewithal to pursue emerging areas. IRAP typically engages staff with business expertise, including in industrial laboratories, as well as technical or training specialties. IRAP also undertakes formal and public evaluation of programme performance.

3.6 Federación Española de Entidades de Innovación, Spain

Federación Española de Entidades de Innovación (Spanish Federation of Innovation and Technology Organizations or FEDIT) is a non-profit organisation, which is privately owned and based on membership. The majority of its members are technology centres that are officially registered (CIT). Among the activities developed by FEDIT in its role as an 'umbrella organisation' for the centres are the elaboration of proposals to improve the legal and administrative framework in which the centres operate, and the promotion of cohesion and cooperation among its members (FEDIT, 2005). As of 2004, there were 61 member centres distributed across Spain that employ nearly 4,270 workers, including in-house specialists and consultants contracted to work on a part-time basis. The technology centres are very different in nature as a result of the economic characteristics of the region in which they operate. Typical centre services include R&D project assistance; technical assessment and advice; technology diffusion; standards and quality certification; training; international cooperation; and general information. More than half of the centres' budgets (totalling USD$ 878 million for 2005) comes from private industry, with the remainder coming mostly from regional governments.

FEDIT is an example of the use of an intermediary organisation to build a national programme through networking and linking existing organisations that perform technology extension activities. Established relatively recently (1996), the programme is non-profit in status and allows for differences in local service offerings depending on the needs of area SMEs. The core membership of FEDIT is comprised of industrially-oriented technology centres, which generally have a sector focus related to regional industry characteristics. Staffing in these centres combines research- and industrially-oriented personnel, providing applied research, consulting and training services. Coverage is not geographically uniform in Spain. Constituent centres have a

mix of public and private funding, although there are efforts underway to increase funding from public sources. The system serves a large number of companies, mostly SMEs.

3.7 Instituto Nacional de Tecnología Industrial, Argentina

Created in 1957, the Instituto Nacional de Tecnología Industrial (INTI) is an autonomous entity operating under the jurisdiction of Argentina's Secretary of Industry, Trade, and Small and Medium Enterprise. INTI offers a range of services to SMEs, including value chain and cooperation support. This institute is also concerned with other social aspects of the technology, since it was developed to advance, among other goals, 'collective appropriation of knowledge'. INTI also has a division called Extensión y Desarrollo, which provides training and consulting services to SMEs. The services provided by the INTI centres include training, certification, and technology diffusion. In addition, INTI provides SMEs with access to research laboratories. The centres work with all relevant industrial sectors: meat processing, processing of food products and juices, fishing, wood working, pulp and paper, textiles, chemical, electronics, equipments and machinery, plastics and rubber, leather, and construction.

INTI is a centrally-chartered technology development and transfer institute, under a government ministry. INTI operates a variety of business and technology services, including a technology extension division. The institute supports a system of R&D centres and laboratories in about one-half of Argentina's provinces. Hence, coverage is not geographically uniform but rather is focused in centres of population and industry. INTI centres are mostly sector-focused and provide a range of R&D, training, and certification services. The assisted companies are predominantly SMEs. The funding model combines public sources, donor contributions, and service fee income, with most funds coming from public sources, although year-to-year funding fluctuations have introduced a measure of instability into the programme. INTI has been engaged in recent policy exploration regarding how best to have impact on the competitiveness of its manufacturing base. Multifirm collaborative projects, sponsored by Japanese and European organisations, have been organised among sets of firms in horizontal industries such as metalworking in response.

4 TES programme and innovation system characteristics

The case study programmes offer a series of insights about the design of technology extension programmes. These are highlighted through a cross-national programme analysis, which is reported in this section. Features discussed in this section include geographic distribution, embodied knowledge, funding models, and programme learning and assessment. Across these features, we see the influence of national innovation system context and interrelationships with SME capabilities in the ways in which programmes target and evolve their operations.

Geographic distribution. Notwithstanding the rise of globalisation, the national innovation system continues to define the context within which SMEs operate. One feature of these systems, in our case studies, is the decentralisation of innovation intervention, with states or regions undertaking important roles in programmes of

technological and economic development. In particular, the TES programmes that we examined all report operating with decentralised structures of centres and offices. These decentralised locations perform important place-dependent functions in partnership formation, relationship development, efficient service delivery, and awareness. However, the programmes differ in their approach to geographical distribution of service outlets. For example, in Argentina, INTI has sponsored a greater numbers of centres near high population areas with agglomerations of firms, including half of the 30 INTI centres operating near Buenos Aires. Japan's Kohsetsushi centres are found in all Japanese prefectures, although there is a greater representation of centres in Tokyo, and, in addition to general centres, the system includes centres with a sector focus related to particular local industries, such as textiles or machinery. Kohsetsushi centres generally serve SMEs in their region. Similarly, Canada's IRAP has good geographical coverage with 150 offices in 90 cities, while the US MEP has centres in every state, often with additional local offices situated to enhance efficiency and travel times to customers in geographically isolated rural areas or highly congested urban cities. In the US case, a centre typically serves companies in its own territory (state or substate area), and while there are specialties, companies from any industry can be served. On the other hand, in the German model, Fraunhofer and Steinbeis institutes are mostly targeted to specific technologies, and can serve companies and sponsors without regard to territory (although often there is an important local client base).

Embodied knowledge. Working with SMEs to foster change in strategies, business practices, and innovation requires the capability to impart formal and tacit knowledge over time and in ways that can be customised to the diverse needs and absorptive competencies of the assisted firms. TES programmes embody such capabilities and skills through the engagement of highly qualified staff with technical and business experience to go out and build knowledge-exchange relationships with companies. However, there is a range of staffing models represented in the case study programmes. In some instances, staff is employed directly by the programme; in other examples, staffs are employees of partner organisations or are consultants. The staffing mix also varies between senior (highly-experienced in business) and junior (potentially more up-to-date technologically) workers. The Japanese system could be characterised as the most rigid, with a staffing system that supports early-career entry and lifelong employment. The Fraunhofer centres have developed a core of stable and highly qualified staff coupled with more transient younger workers (including students and trainees) who are attracted to the centres to gain research and project experience. Steinbeis centres tend to be led by professors who operate on a part-time basis outside of their academic duties. About 11% of FEDIT's employees are doctorate degreed specialists. The MEP centres are staffed by industrially experienced specialists hired by their host organisations and the mix of in-house and partnered staff depends on whether a particular centre chooses to deliver most of its services internally or through brokered sets of partner organisations. Most MEP centres that deliver services with internal specialists tend to benefit from a significant movement of specialists coming from industry, although these individuals may subsequently go back into the private sector as well. IRAP's technology advisors include employees that are hired by their host organisations as well as experts at organisations that are part of the Canadian Technology Network and some NRC staff. INTI also uses a mix of in-house specialists and contract workers. With the exception of

the German programmes, use of consultants is common in TESs. Consultants may serve as contractors to complement the capacity of in-house staff, as in FEDIT and INTI (and some MEP centres that primarily employ a brokered service model). Consultants may be used to fulfil specialised needs as in the MEP, IRAP, and Kohsetsushi. They can also serve as a source of employment of students (Steinbeis) and in-house specialists (MEP).

In terms of the type of knowledge shared, there is a significant divergence across the programmes in terms of their service emphasis and mix. For example, Fraunhofer institutes are engaged in world-class R&D, seek to build intellectual property (including through patents), and develop advanced, highly-customised research projects with industrial and public clients. Certain Steinbeis centres also are involved in intellectual property development and technology transfer. The Kohsetsushi centres are also engaged in R&D, although perhaps because of their traditional focus toward SMEs, this R&D sometimes is frequently viewed as 'catch-up' R&D, i.e., replicating locally what has been done elsewhere. However, there is a move to upgrade the quality of R&D in Kohsetsushi centres. At the other end of the spectrum, the US MEPs represent a pragmatic, intermediary approach to technology extension, offering primarily process improvement, innovation and management guidance, and related assistance, with the national system offering standardised programmes in the training, quality, and lean areas. MEP centres do not undertake their own research (under the MEP programme), although they may be frequently housed in institutions that undertake research or have partnerships with universities, national laboratories and other research centres. Hence, MEP staff can call upon research expertise when it is needed by a company. Most FEDIT centres do undertake applied research and can deliver process improvement services in line with the needs in the local SME population. In Canada, the provision of R&D grant subsidies by IRAP is a very highly rated offering. Canadian firms can use these subsidies to undertake the research themselves and/or coordinate with other R&D centres. Most of the other programmes do not offer grants or incentives; however, where centres in other countries do not offer financial subsidies to R&D for SMEs, they are often in close relationship with other programmes that can provide such support (for example, other available small business finance programmes in the Japanese case). In addition to R&D, almost all other programmes offer technical assistance and training services. In some cases, for example in the Kohsetsushi centres, there is assistance for testing and for use of equipment. As a rule, many MEP centres prefer not to serve very small firms because of their instability, inability to cost-share services, and lack of basic business systems. Fraunhofer centres also tend to serve larger companies because much of their offerings are highly customised thereby possessing high transaction costs. Because of the high proportion of micro-enterprises in Japan, Spain, and Argentina, those programmes are more likely to serve smaller companies.

Funding models. A basic premise of TES models is SMEs themselves lack resources of time, expertise, and finance to undertake all aspects of the innovation process, which can lead to suboptimal innovation investments and economic outcomes. TES intervention is a response to correct this market failure. However, the ways in which TES programmes are sponsored varies, from mostly public funding (e.g., Kohsetsushi) to mostly contract fee revenue (e.g., Steinbeis). The contrasts in funding models can be conceptualised by placing the programs in a 'triangle' based on percentages of federal v. regional v. private sector funding. Close to the centroid of the triangle are models that combine different

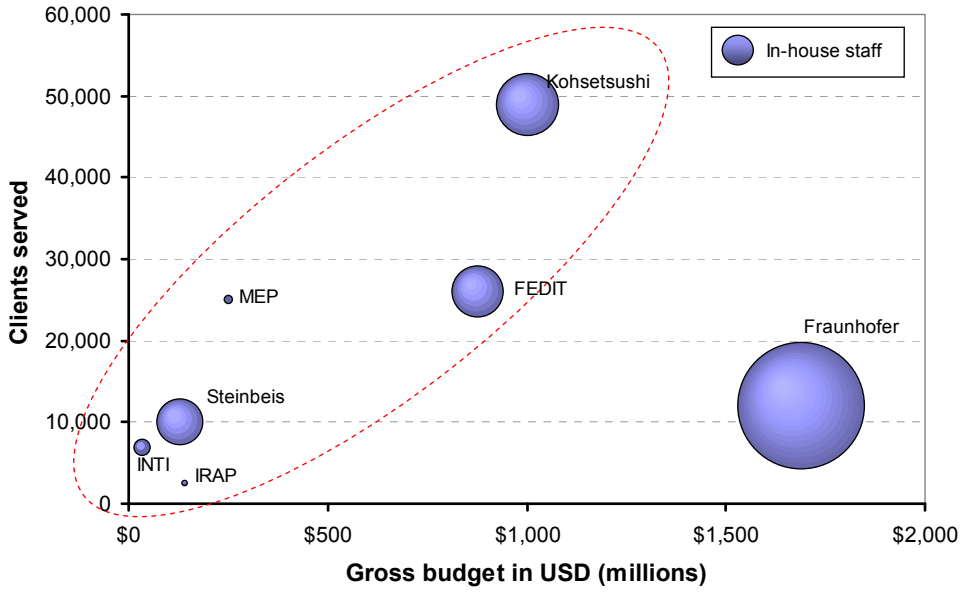
funding sources, for example, the federal-state-private service income model of the US MEP or the core institutional-contract research mix seen in the Fraunhofer institutes. INTI places towards a vertex of mostly national funding, while the Kohsetsushi centres are located towards the corner of mostly regional funding. Significantly, even in programmes which are highly contract fee-driven (e.g., Steinbeis or Fraunhofer), public as well as private sources are used. None of the programmes we examined was exclusively or even predominantly funded from purely private sources. In other words, each of the technology extension programmes we reviewed maintains, and is recognised to maintain, a public service mission. This public service mission varies from undertaking some basic research that industry would not otherwise fund (e.g., the Fraunhofer model) to providing a base for further applied research (which industry may fund), to ensuring that SMEs which might not otherwise be able to afford pure market services are assisted (seen in the state funding in many US MEP centres).

Programme learning and assessment. Engaging in systematic review and learning is an important element of TES programmes as they position themselves within the broader innovation system. Learning is inevitably an ongoing and often informal process, but there are discrete points at which accumulated experience is gathered and assessed through assessment and evaluation exercises. Such activities have both programme justification and service improvement aspects. In general, most of the centres are involved in activity reporting that feeds into justification and legitimisation of the programme for sponsors and stakeholders. Systematic independent evaluation of these programmes is less commonly conducted. Activity reporting, in contrast to evaluation, is often evidenced in annual reports showing numbers of projects, numbers of firms assisted, revenue obtained from client companies, and the like. A few programmes have been subject to formal evaluations that feedback into learning and programme evolution. In the case of IRAP, a large scale formal evaluation employing multiple methodologies was conducted in 2002 by the NRC's Policy, Planning, and Assessment Directorate. The MEP has among the most regularised and developed evaluation systems. In addition to activity reporting, the MEP conducts client surveys (using an outside survey house) to gather information on client satisfaction, impacts, and financial outcomes. The MEP also operates external review panels comprised of centre directors, SME clients, and other knowledgeable observers to review centre practices and performance. The MEP has sponsored special studies from time-to-time to examine certain aspects of programme operations. In the Fraunhofer system, there is often the use of periodic external independent review panels to assess institute performance and make recommendations for future development.

The programmes differ in the use of metrics to measure performance. The MEP is the only programme with a formal metrics-based assessment, one set for individual centres and another for the programme as a whole. Despite the lack of a common metric to measure TES performance, reports of the number of clients assisted are found in annual reports or evaluation studies of four of the programmes, while the Fraunhofer and Kohsetsushi systems do not report overall figures for number of clients served. The number of clients served is often used as a measure of penetration of the service, but it is not without problems. Standardised interactions, brief assessments, and training often yield a larger number of clients served, while highly customised R&D services can result in a smaller number of customers being served relative to budget, even if those customised services may have a greater impact on these customers and the larger

economy. The extent to which there is a relationship between budget and customers served is explored in Figure 2, which arrays estimates of gross budgets (including public and private sources) and number of clients served on the x- and y-axis respectively. This figure focuses on total budget rather than solely on the public budget because of lack of accurate information on what percentage of the budget comes from public funding as well as to facilitate comparability across all the programs profiled here. The size of the bubbles represents estimates of the number of in-house staff, which is another measure of capacity and resources; for example, one might expect highly customised and R&D services could involve more in-house staff relative to budget and clients served. Figure 2 suggests a general relationship between the size of the budget and the number of clients served. The Fraunhofer system is an outlier, likely because of the highly customised nature of the R&D services it offers to its clients, which is further suggested in its larger bubble size (i.e., greater number of in-house staff). Although there appears to be a broadly linear relationship between budget and customers served, there are many caveats to be considered in this representation such as the intensity of the service and its impact on encouraging innovation and technology adoption in SMEs, the details of the budget sources (public versus private/public fee leverage), and staffing model (in-house staff versus use of part-time contractors) impacts any perspective on the relationship among resources and clients served.

Figure 2 TES case study programmes: gross budgets, clients served annually, and in-house staffing (see online version for colours)



Notes: Gross budget figures include all public and private funding sources reported (based exchange rates of 1.35 Euros and .95 Canadian dollars to 1 US dollar). Estimate for firms served by the Fraunhofer system is operationalised as the number of projects in 2005 referenced in the annual report; this likely overstates the actual number of clients served, which is not available.

Source: Author analysis of available programme information (for 2005 or most recent year).

5 Conclusions

Our analysis has examined seven TES programmes in six countries that seek to foster innovation in SMEs through an array of interventions ranging from applied research and technology transfer to training and business mentoring. We find that the design and organisation of these programmes reflects the national innovation systems in which they are embedded. The Fraunhofer institutes and Steinbeis centres mirror the decentralised nature of Germany's innovation system, with expertise and knowledge flows from these programmes tuned to the high-level demands and specific capabilities of German SMEs. The US and Canadian TES programmes are part of national initiatives, which enable consistent sharing of broad-based knowledge. These North American programmes are also decentralised and flexible in delivery arrangements to leverage local differences and resources; they also use reflexive evaluation and learning approaches to stimulate programme adaptation and improvement. The Japanese Kohsetsushi centres exhibit a high level of consistency and stability in programme structure and also seek to develop specialised knowledge capabilities to meet the needs of relatively capable SMEs. There is a long-established public service orientation, with little of the emphasis on contracting and income-generation seen, for example, in German counterparts. Spain and Argentina illustrate models that focus on the needs of traditional industries within the innovation systems, significant levels of clustering around population centres, less availability of public resources, and the need for less technologically-advanced and more regionally specialised knowledge.

The analysis has shown that staffing and human resources are central to these programmes because of the emphasis on tacit knowledge exchanged via face-to-face interaction. To attain this knowledge, programmes focus on specialists with a certain expertise profile comprised of technology and business experience plus good interpersonal capabilities. To identify and hire staff with the requisite expertise profile, different models of staffing are used based on local human resource availability. In some cases, such as the MEP, Kohsetsushi, and Fraunhofer institutes, there are sufficient pools of expertise to support in-house hiring. However, other programmes – particularly Steinbeis centres and IRAP – involve external consultants and partnerships with public and private organisations to provide specialised services. In some cases, as in the example of the MEP which offers staff workshops and online-training, TES programmes provide opportunities to specialists to upgrade and update skills and capabilities. Mostly, however, staff training is of an 'on-the-job' nature.

Geographical coverage and service points are also important. Imperfections in the training and consulting markets suggest that high transaction costs and information asymmetries make it difficult for private consultants to serve SMEs and for SMEs to identify, hire, and manage consultants (Oldsman, 1997). TES programmes link SMEs to service delivery providers, public and private. The importance of decentralisation for awareness-building, relationship development, service delivery, and partnerships underscores the ability of the TES programme to span disparities in SME policies and programmes. On the other hand, building a decentralised network can be costly, hence the need for identification of and proximity to agglomerations of companies and targeting of service offerings to the specific needs of these companies. Moreover, exploitation of

agglomerations of firms should be leveraged through targeting of value-added services to groups of firms and networks in addition to provision of core services delivered on a one-on-one basis.

TES programmes are supported through different models of funding, but public funding is always present to maintain the programmes' 'public-service mission'. Invariably, there is a funding tradeoff in that more pressure for private funding (fees) or 'self-sufficiency' usually means services that move up-market to target larger firms. In addition, there are tradeoffs between the coverage and impact aspects of these programmes. A core of public funding thus appears to be important in ensuring that TES programmes maintain a focus on serving SMEs at the base of the market. We also observe that pressure to increase coverage (i.e., serve more firms) usually leads to standardised services, which in turn typically have less impact than customised services. Alternatively, customised services generally require more staff time and lead to less coverage of SMEs but often have greater impacts on these companies in terms of stimulating innovation in products and processes. One of the major management challenges of TES programmes is to balance such competing demands, although we see that individual TES programmes come to different solutions, depending in part on the scale and stability of their core public funding and what levels of fee income are feasibly generated from assisted enterprises.

Systematic evaluation of TES programmes is not common, but still important. There is an evaluation tradeoff between activities promoting programme justification versus those promoting learning and improvement. It is much more usual for TES programmes to engage in activity reporting, which demonstrates to sponsors and customers their breadth of engagement. Systematic independent evaluations are rare, yet they are more apt to provide reliable and independent results to support programme justification, in addition to supporting ongoing change and enhancement of the programme. This tradeoff highlights the defining orientation of TES programmes, which is their flexibility through experimentation, local customisation, learning, and incentives for improvement.

The case study programmes offer examples of the evolution of knowledge-based strategies for fostering innovation in regional and national innovation systems. The strategies suggested in these programmes underscore the extent to which innovation systems still pose challenges to SMEs' abilities to maintain competitiveness through innovation. The decentralised nature of SMEs' operations emphasises the need for programmes that can reach out to these facilities in their regional context. Knowledge gaps continue to be important and underscore the importance of tacit exchanges by expert individuals or highly experienced industry specialists. These two factors imply that addressing the innovation needs of SMEs requires some level of public resources, and we see evidence of TES programmes seeking to leverage multiple sources of funding to attain sufficient resource bases. Finally, although TES programmes need to evolve along with the innovation systems in which they are situated, we observe that only a few of these programmes – especially the US MEP and the Canadian IRAP programmes – use formal methods for assessment, feedback and learning. This ability to engage in evaluation and learning, while not formally practiced in most TES programmes, nevertheless will become ever more important to TES programmes as national and regional innovation policies seek to address the heterogeneity of circumstances found among SMEs and in different regions.

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Notes

1 Some centres are organised as private non-profit entities; some as part of state agencies (such as the state Department of Commerce or Science and Technology Office); and some are embedded in or associated with universities or community or technical colleges.

2 Most with prior industrial experience (in-house specialists) plus consultants used to provide specialised services or supplement capacity in high demand service areas.