IDB
Inter-American Development Bank

Institutions for Technology Diffusion

Philip Shapira
Jan Youtie
Debbie Cox
Elvira Uyarra
Abullah Gök
Juan Rogers
Chris Downing

Institutions for Development Sector

Competitiveness and Innovation Division

TECHNICAL NOTE Nº IDB-TN-832

June 2015

Institutions for Technology Diffusion

Philip Shapira
Jan Youtie
Debbie Cox
Elvira Uyarra
Abullah Gök
Juan Rogers
Chris Downing

Manchester Institute of Innovation Research, Manchester Business School, University of Manchester

Program In Science, Technology, and Innovation Policy, Georgia Institute of Technology

June 2015

IDB
Inter-American Development Bank

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Institutions for technology diffusion / Philip Shapira, Jan Youtie, Debbie Cox, Elvira Uyarra, Abullah Gök, Juan Rogers, Chris Downing
p. cm. — (IDB Technical Note ; 832)
Includes bibliographic references.
1. Technological innovations—Canada. 2. Technological innovations—Europe. 3. Technological innovations—Latin America. 4. Diffusion of innovations—Canada. 5. Diffusion of innovations—Europe. 6. Diffusion of innovations—Latin America. 7. Technology transfer—Canada. 8. Technology transfer—Europe. 9. Technology transfer—Latin America. I. Shapira, Philip. II. Youtie, Jan. III. Cox, Debbie. IV. Uyarra, Elvira. V. Gök, Abullah. VI. Rogers, Juan. VII. Downing, Chris. VIII. Inter-American Development Bank. Competitiveness and Innovation Division. IX. Series.
IDB-TN-832

http://www.iadb.org

Contact: Gustavo Crespi, gcrespi@iadb.org.

Abstract*

This technical note analyzes international experiences and practices of public technology extension service programs. Technology extension services comprise varied forms of assistance provided directly to enterprises to foster technological modernization and improvement, with a focus on established small and mid-sized enterprises. The note discusses the definitions, rationales, and characteristics of selected technology extension service programs, drawing on examples from Europe, North America, and other regions. It presents four detailed case studies: the U.S. Manufacturing Extension Partnership; the National Research Council-Industrial Research Assistance Program in Canada; England's Manufacturing Advisory Service; and Tecnalia, an applied technology organization in Spain. The case studies address several program elements including the history and evolution of the program, structure, program scale, financing structure, services and clients, governance, personnel, monitoring, and evaluation. The analysis highlights common and distinctive characteristics as well as program strengths, weaknesses, and key practices. The note provides a framework for positioning technology extension services within the broader mix of policies for technology transfer, business upgrading, and innovation, and offers conclusions and insights to support efforts to strengthen technology extension services in Latin America.

JEL codes: L6, O2, P5
Keywords: technology extension; technology diffusion; industrial extension; technology centers; small and medium-size enterprise; SMEs; institutions; policies; programs

* The project team gratefully acknowledges the time and assistance provided to by program staff and agents associated with the U.S. Manufacturing Extension Partnership, the National Research Council-Industrial Research Assistance Program, the Manufacturing Advisory Service, and Tecnalia. The team has also benefited from comments and suggestions offered by colleagues from the Inter-American Development Bank (IDB) throughout the project and by participants at the IDB Technology Extension Regional Workshop in Buenos Aires, Argentina, March 6–7, 2014.

Contents

1. Introduction

The objective of this technical note is to analyze the international experiences and good practices of public technology extension service (TES) programs. The note begins with a discussion of the definition of TES, addressing key perspectives on providing services to small and medium-sized enterprises (SMEs), rationales for TES intervention, and selected characteristics of TES programs. The note explicitly gives a definition of TES and distinguishes it from other services (i.e., what TES is not), and draws on examples of programs from Europe, North America, and other regions.

This project provides detailed studies of four programs: the U.S. Manufacturing Extension Partnership (MEP); the National Research Council-Industrial Research Assistance Program (IRAP) in Canada; England's Manufacturing Advisory Service (MAS); and Spain's Tecnalia, an applied technology organization that includes some TES-like services in its portfolio. Each of the programs was chosen to highlight particular aspects of TES and the variety of organizational formats. The detailed case studies address several program elements including the history and evolution of the program, structure, program scale, financing structure, services and clients, governance, personnel, monitoring, and evaluation.

The technical note provides a framework for positioning TES within the broader mix of policies for technology transfer, business upgrading, and innovation, and considers the range of activities and services typically associated with TES programs, as well as the rationale and justification for the public support of TES services. Following an in-depth discussion of the four selected TES cases, an analysis highlights common and distinctive characteristics, and identifies strengths and weaknesses of the programs. The work closes with conclusions and insights, which will be useful for efforts to strengthen TES in Latin American countries.

2. Technology Extension Services

This section reviews the scope, justification, and characteristics of technology extension services (TES), drawing on available literature and documentation. The review addresses four key areas: (i) scope and definition, (ii) rationale and market failures, (iii) basic program characteristics, and (iv) policy mix and institutional setting. It draws on selected key literature with relevance to TES from diverse global perspectives.

2.1. Defining TES

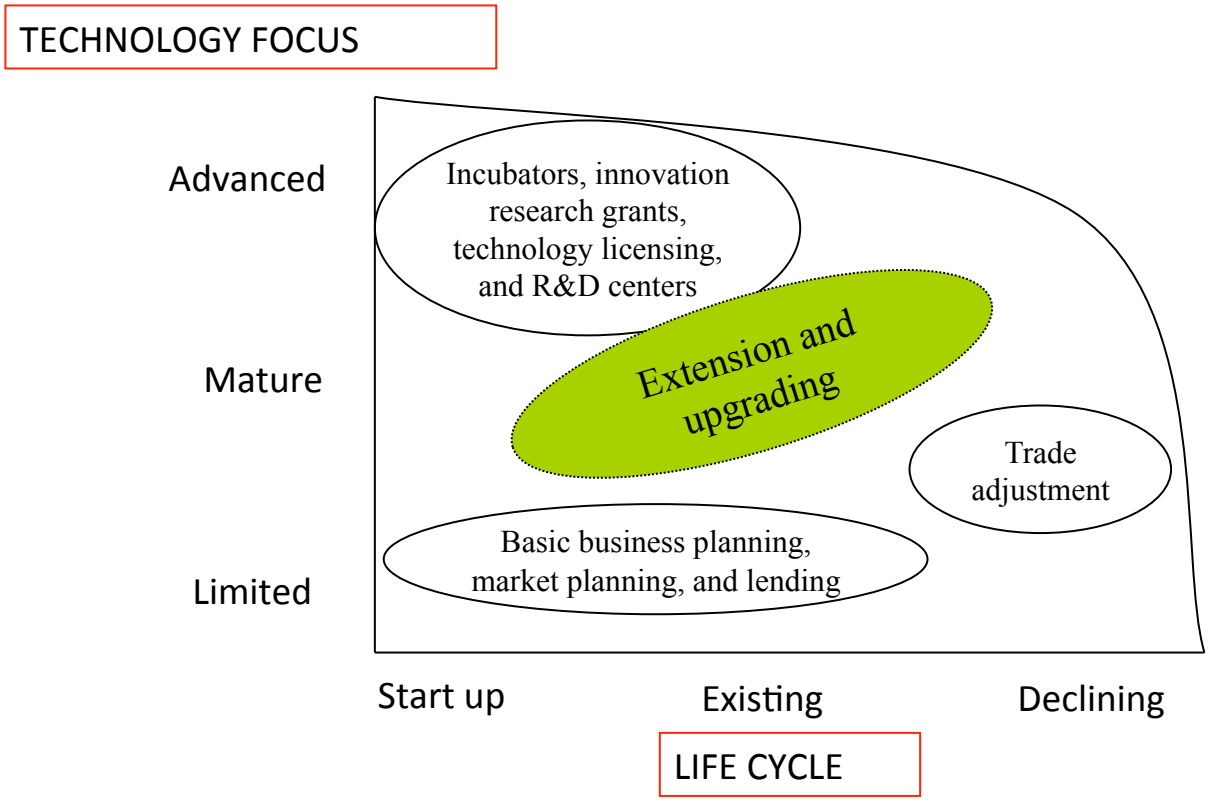
Technology extension service (TES) is defined as assistance provided directly to enterprises to foster technological modernization and improvement, with a focus on established SMEs. Although the literature on small business assistance is extensive, the literature on TES programs is more specific and bounded. Bellini (2003) refers to a diversity of potentially relevant terms for the former, which include but go beyond TES: business support services, business development services, industrial and manufacturing assistance services, external assistance or external advice. Bellini distinguishes these as “real services” in that they engage in activities directly with companies that transfer knowledge and stimulate learning using nonfinancial means, enabling innovation and economic development. In contrast, indirect assistance—such as tax credits—supports firms but does not directly engage with them.

Technology diffusion and absorption related policies and interventions, including TES, are an important part of the mix of research and development (R&D), technology, business support, human capital, and related policies that economies at national and regional levels can apply to stimulate and bolster economic development and innovation. For example, interactions between the upgrading of skills, technological change, and learning have been identified as major factors underlying productivity growth (De Ferranti, 2003). Approaches to technology diffusion and absorption, however, have evolved over the past few decades. Supply-push technology approaches (forming part of what has been termed the linear model) were highlighted in the 1950s to1960s. This model follows the notion that policy can publicly support research and technology development, in the hope that diffusion and adoption by firms will occur further down the line. Despite critiques that the linear model overlooks feedback loops, market signals, and learning, it is still prevalent in contemporary innovation policy. In contrast, more recent demand-pull models reflect the idea that companies have certain problems or needs for which technologies can be engaged to provide solutions. Demand–pull approaches, while beneficial in terms of considering user or market demand, have also been challenged for being too narrow and at times backward

looking, and for focusing on the immediate rather than longer-term opportunities. TES straddles these two idealized models. On the one hand, unlike supply-push, TES reaches out to businesses to ensure a connection between technology and the needs of business. On the other hand, it also gives importance to strategic trends in both hard and soft technologies and techniques to encourage and support businesses, especially SMEs, to have sufficient confidence and capacity to adopt these practices.

Technology extension services can be positioned within a framework that places them in the overall policy system for innovation. A general example of such a framework organizes TES relative to other services for small businesses along a continuum comprised of technology focus and firm lifecycle (Figure 1). The y-axis shows a range of firms from those with a very limited focus on technology to those dealing with mature technologies and those dealing with advanced technologies. The x-axis displays firms along a life cycle from new start-up firms to existing industries to declining companies. The services are shown in the area under the curve. Technology extension spans the market from post start-up to pre-declining firms and from firms with more than limited use of technology to those with a relatively advanced technology focus (though not necessarily technologies at basic science or speculative levels). It thus complements services for advanced high technology firms (such as incubators, technology licensing offices, and university R&D centers), traditional services for entrepreneurs and very small businesses (such as the review of business plans and small business loans), and services for declining firms (such as trade adjustment assistance). Policy intervention is very common in the top left quadrant associated with advanced high technology firms, under the assumption that these investments will have a propulsive effect on the economy. Likewise, interventions associated with basic entrepreneurship are common among policy interventions. Moreover, when a firm declines and risks dissolution, urgent bailouts and adjustment assistance may be pursued, and this is generally not the time for longer-term technological assistance. Services to help regular mature SMEs to adopt technologies fit within these axes. Typically, however, such services are not emphasized in the policy mix.

Figure 1. Positioning of Technology Extension Services



Source: Authors' elaboration.

The differentiation of technological extension is not necessarily cut and dried around a particular set of services. By way of illustration, some of the excellent TES programs have found it best practice to link shop floor productivity services (which are at the core of TES) to business and marketing efforts (which are at the core of basic business assistance). The framework included in the study indicates that technology extension falls between basic business assistance (i.e., basic business planning and basic marketing) and sales planning and high-end R&D (i.e., startup incubators, technology transfer offices, and science centers of excellence). In short, TES should be situated in a middle position as they are aimed at improving the performance of the companies.

In considering the scope of TES, it is important to bear in mind what technology extension is not. TES is not just about technology transfer from labs to firms but rather about systemic measures to improve firms' technological performance. It is not just about advanced technology but rather about pragmatic improvements in operations and practices, usually with commercially proven technologies. It is not a short-term jobs program as results will take time to materialize and require sustained efforts and some direct jobs may even be lost as productivity increases. It is not just a government program but rather a process that is driven by industry needs and market opportunities and leverages existing resources. It is not

a resolution to crisis or radical economic transition, as it requires a reasonably stable industrial base (Shapira, 2001).

TES also may be characterized in terms of a set of service offerings (Box 1). These services can be grouped into the following categories:

- Providing information to an SME in response to a problem
- Sharing and comparing of practices within an industry or across industries
- Engaging in in-depth projects through technical assistance or consultancy to address problems
- Helping SMEs identify and utilize third party providers (i.e., brokering) for certain types of services, including financing resources
- Leading training programs to disseminate knowledge mostly to company managers but also to nonmanagerial employees
- Working with groups of companies from different industries or within a given supply chain
- Linking and coordinating collaborative projects involving multiple firms
- Giving ongoing coaching and mentoring for strategy development
- Encouraging the take-up of growth services that will eventually lead to new or improved product and market development

There are other services that can complement typical TES offerings; these services are frequently focused on infrastructure such as for testing and machining on nontechnological needs related to human resources, accounting, and financing assistance.

Not all TES services focus on manufacturing. Manufacturing is at the core of TES services because it is an important trade sector. Maintaining the manufacturing base is not a given, and is not easily replaceable if it is lost. Many developed countries focused on post-industrial sectors in the 1990s and 2000s, but have since reemphasized policies and programs to promote advanced manufacturing.

Box 1. Typical and Related TES Services

TYPICAL TES SERVICES	RELATED SERVICES
• Information provision • Benchmarking and assessment • Technical assistance or consultancy • Referral, links with finance • Training • Group or network services; supply chain development • Collaborative projects (R&D, implementation) • Strategy development; coaching and mentoring • Growth services	• Testing, finite element analysis • Machining • Modeling and simulation • Rapid prototyping, additive manufacturing, 3D printing • Machine and equipment design • Computer-aided design • Bar coding, RFID • Incubator, accelerator • Technology transfer • Intellectual property searching • Human resource programs (basic, technical skills training) • Recruitment • Accounting, business valuation, trusts • Funding for technology, capital, training, etc. • Export assistance • Computer hardware/network systems (e.g., operating systems, LAN, communications, computer networks) • Website, e-commerce (e.g., search engine optimization, traffic monitoring, site mapping, re-design)

Source: Authors' elaboration.

Technology extension service is incompletely defined by a particular set of services alone. It can also be viewed as a set of activities that leverages tacit knowledge built up throughout the careers of TES professionals. This tacit knowledge is made available to SMEs through a locally distributed network and has the ability to address particular problems brought to the program by the local manufacturing facility in a demand-pull fashion (although the program may use follow-on project opportunities to encourage the adoption of the aforementioned services).

2.2. Rationale

The rationale for TES programs is typically based on market failures that are endemic to SME operations (see, for example, National Academies, 2013). There are market failures on both the demand and supply sides. Market failures on the demand side deal with SMEs lacking information, expertise and skills, training, resources, strategy, and confidence to adopt new technologies and techniques. Market failures on the supply side involve the costs for vendors, customers, consultants, and other business assistance sources to reach and service SMEs. System level failures 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, national laboratories and technology centers focused on research missions and high-end technologies, and existing government programs focused on economic development or generic nontechnological services.

TES programs vary in the ways in which they link the broad market and system level failure concerns with their particular program objectives. For instance, field service programs such as the Manufacturing Extension Partnership (MEP) in the United States and the Manufacturing Advisory Service (MAS) in the United Kingdom exemplify services, which address the information and market failures in markets for technology related services. Other programs such as the Industrial Research Assistance Program (IRAP) in Canada also use this justification but further address market failures related to underinvestment in innovation by firms.

There are also strategic concerns associated with economic competitiveness. Many countries have de-emphasized manufacturing, as their large corporations focused on core competencies, particularly in financial services. The economic downturn of the late 2000s demonstrated the need for rebalancing, a greater focus on manufacturing, and more of an emphasis on exporting. As a result, many developed countries have initiated major efforts to enhance the manufacturing ecosystem and increase support for advanced manufacturing. Furthermore, new rounds of technological growth are anticipated around supply chains and regional clusters to foster local and regional economic development.

Finally, recent technological and systemic trends create challenges as well as opportunities for SMEs. These trends include vertical disintegration; flexible specialization; the increasing presence of open markets; globalization and offshoring to low-cost but technologically capable competition; shifts from economies of scale to economies of scope; and new, open approaches to innovation (Caputo et al., 2002; López-Estornell et al. 2012; Mas-Verdu, Vaviera-Puig, and Martinez-Gomez, 2008; Shapira, 2001).

2.3. Organizing TES

There are a range of approaches for organizing TES around the common theme of providing direct services to enterprises, fostering technological modernization and improvement. These various approaches reflect differences among countries in industrial structure, the landscape of existing services, institutional capabilities, and policies. While every program has some distinctive elements, we can identify three primary broad ways through which TES is organized and delivered: (i) dedicated field services, (ii) technology-oriented business services, and (iii) applied technology centers (see also Table 1).

Dedicated field services provide TES to enterprises through discrete or free-standing programs which are primarily organized for this purpose and which have their own

management structures, staffing, funding, and branding. The underlying rationale for establishing such programs typically relates to market and other system failures, including lack of enterprise awareness of new technologies, access to tacit knowledge, and weaknesses in other private and other public services (as discussed in Section 2.2). Dedicated field services usually provide referrals to other programs and services where, for example, enterprises can obtain financial, applied research, or further private consulting assistance.

Table 1. Approaches to Organizing Technology Extension Services (TES)

	Dedicated Field Services (DFS)	Technology-oriented Business Services	Applied Technology Center Services
TES organization and delivery	• Discrete TES field services program	• TES organized in association with other business support and financial services	• TES is one component of a portfolio of applied technology and contract research services
Rationale	• Lack of awareness, access to tacit knowledge, weaknesses in private and other public services	• As for DFS *plus* weak business–technology linkages (including finance)	• As for DFS *plus* under-investment in and exploitation of applied R&D
Selected TES operational features	• Core set of highly experienced field staff • Small and mid-size manufacturing business orientation • Delivery of a set of technology and management advisory services • Referrals to other business and technology services • Decentralized networks of offices	• Core set of top managers • Small business orientation • Range of small business needs, including technology and management advisory, entrepreneurship, finance, business assistance • Decentralized networks of offices	• Mix of in-house staff, consultants, students • Range of government, large and small business clients • Primarily contract applied R&D, testing, material analysis, instrumentation as well as TES services • Physical technology centers, may be organized in networks of institutes

Source: Authors' elaboration.

A variation on this approach is technology-oriented business services where TES is provided in association with other business support and financial services. In this approach, the program provides enterprise services to address a range of small business needs, including technology and management advice, entrepreneurship, and finance. Technology-

oriented business services may provide start-up assistance to new ventures as well as working with established SMEs.

A third approach is to provide TES in the context of an applied technology center. In this organizational format, TES is one component of a portfolio of applied technology and contract research services that the center offers. Applied technology and research centers have physical facilities that may include laboratories and equipment, and their staff profile will include researchers as well as staff (who may or may not be research active) who provide TES advice and consultancy directly to firms. Technology-oriented business services and applied technology centers each have their own particular rationales, but the TES components of each of these two broader services have rationales that are similar to those of dedicated field services.

2.3.1. Dedicated Field Services

A dedicated field services approach uses experienced technology specialists, often with engineering and industrial expertise, to work with SMEs. This work is usually accomplished in a decentralized manner, including through direct engagement at the company location, to address its technical and business needs. Dedicated field services programs have their own identities, management, funding, and staff, although they coordinate with and refer to other business, applied research, training, and consultancy programs and services. Two examples of this approach are the MEP in the United States and the MAS in the United Kingdom (Table 2).

The U.S. MEP is a decentralized program delivering TES to manufacturing SMEs through a system of 60 centers. The National Institute of Standards and Technology (NIST) administers the program. NIST provides one-third of the funding for these centers, which they must match with two-thirds from with nonfederal sources. The centers provide a pragmatic set of services related to process improvement, product development, marketing, energy, environmental, and human resources. Most also connect manufacturing SMEs with other private and public assistance sources.

The MAS is a government program providing business support to manufacturers in England.[1] The program is overseen by the UK Department for Business, Innovation and Skills and is managed by a consortium of private consulting firms in four large English regions. At the heart of the program are 120 highly experienced field specialists who offer strategic support, process efficiency, and commercialization services to manufacturers.

[1] Economic development and business support are among the devolved functions within the UK. In Scotland, the Scottish Manufacturing Advisory Service is administered by Scottish Enterprise (the agency responsible for supporting business and fostering growth and investment in Scotland). Separate programs to provide technology advisory services and innovation assistance are also offered by development agencies in Wales and Northern Ireland. In this study, the Manufacturing Advisory Service in England is examined, which is the largest program of its kind in the UK.

Justifications for a dedicated field services approach include concerns about the lack of awareness of pragmatic technologies and techniques and the importance of tacit knowledge to adopt these practices. In addition to these market failures, a dedicated field services approach to TES is likely to emerge where there are concerns about public or system failures by existing institutions (such as universities or established small business programs) to support technological upgrading in SMEs.

The MEP and MAS share several operational characteristics: a core set of highly experienced field staff, a manufacturing orientation, delivery of a set of services that resonate with manufacturing SMEs, and a decentralized network of offices. The MEP is a partnership between federal and state governments whereas the MAS is centrally funded by the national government. The MAS has an explicit structure to involve the private sector in the management of its centers and in making referrals to clients, whereas the MEP uses a flexible range of approaches for service delivery.

Table 2. Selected Programs Using Dedicated Field Services

Characteristics	**Manufacturing Extension Partnership** (MEP, United States)	**Manufacturing Advisory Service** (MAS, England)
Orientation	Pragmatic manufacturing services, dedicated field agents	Pragmatic manufacturing services, dedicated field agents
National governing agency	National Institute of Standards and Technology	Department for Business, Innovation and Skills
Service operation	Cooperative agreements with state and local MEP centers with varied organization including private, nonprofit, university, and state government	Contract with privately-administered service delivery consortium
Geographic scope	50 U.S. states	Four regional divisions in England
Service delivery	60 Centers	10 Offices (in England)
Staff	1,300	120
Annual funding	US$300m federal, state, and fee income (including US$123m federal funding)	US$48.2m (government funding)

Source: Authors' elaboration.

2.3.2. Technology-oriented Business Support

Technology-oriented business support programs address a range of small business needs including entrepreneurship, finance, and business assistance. These programs address weaknesses in business technology linkages, including the ability to obtain financial capital to support the adoption of technology. Within this category, our work focuses on the IRAP because of its integration of TES, and finance and entrepreneurship services. The IRAP is a centrally run program with a decentralized network of field offices and is administered by the National Research Council of Canada (Table 3). It uses highly experienced specialists to

work with companies, offers funding for applied R&D projects to SME clients and collaborates with partner organizations to provide services to entrepreneurs.

Table 3. Selected Technology-oriented Business Support Program

Characteristics	**Industrial Research Assistance Program** (IRAP, Canada)
Orientation	Business support, applied R&D, technology extension
National governing agency	National Research Council
Form of entity	Public
Geographic scope	Distributed across Canada
Number of offices	120
Staff	240
Annual "core" government funding	US$292.8m

Source: Authors' elaboration.

2.3.3. Applied Technology Centers

Applied technology centers perform contract R&D for companies and other types of organizations; general manufacturing and advisory services are also provided to complement this R&D support. These TES services might be offered under a contract with a state or local government to SMEs in the region. Public support for applied technology centers usually aims to address underinvestment in, and exploitation, of applied R&D. Five examples of applied technology centers are: the Fraunhofer-Gesellschaft (Germany), the Industrial Technology Research Institute (ITRI) (Taiwan), Public Industrial Technology Research Institutes also known as Kohsetsushi centers (Japan), Carnot Institutes (France), and Tecnalia (Basque region, Spain) (Table 4).

The Fraunhofer-Gesellschaft is comprised of about 60 research institutes that carry out contract research for government (at national and state levels) and business organizations. A mix of in-house researchers and students perform most of the R&D at each institute. Each Fraunhofer Institute has a particular R&D specialization. The ITRI is a private nonprofit institute administered by the Taiwanese Ministry of Economic Affairs to perform advanced R&D primarily for large multinational companies in emerging electronics and related areas. It has had several very successful spinoffs including the United Microelectronics Company and the Taiwan Semiconductor Manufacturing Corporation. The ITRI has a single location supplied with state-of-the-art equipment for prototyping and testing. The Kohsetsushi centers in Japan are one of the oldest TES service networks. This publicly sponsored network uses a stable set of specialists to offer free or low cost TES services to Japanese SMEs. The centers offer a set of standardized services that include applied R&D, testing and instrumentation, technical assistance, and information provision. The Carnot Institutes in France are public research institutes designed to bridge the space

between France's basic research capabilities and industrial needs. The Carnot Institutes share some features of the Fraunhofer program in that Carnot emphasizes contract research with industry. Tecnalia is another Fraunhofer-style program that offers technology services, collaborative R&D, exploitation of research through licensing and spinoffs, and services for organizational innovation and business diversification through 10 centers located throughout the region.

Across these programs, the ITRI performs the most high-end research oriented toward the creation of new industries. Tecnalia and Kosetsushi tend to do more basic applied R&D in areas such as testing and materials analysis and Kosetsushi incorporates field specialists who meet with SMEs across their program. Fraunhofer has a strong customized R&D track record that is contract research driven. Carnot is more focused on developing linkages between research and industry. Within this category, our work focuses on Tecnalia because of its potential comparability to Latin American situations.

Table 4. Selected Programs Supporting Applied Technology Centers

Characteristics	**Fraunhofer Institutes** (FhG, Germany)	**Industrial Technology Research Institute** (ITRI, Taiwan)	**Public Industrial Technology Research Institutes** (Kohsetsushi, Japan)	**Carnot Institutes (**France)	**Tecnalia** (Basque Country, Spain)
Orientation	Applied R&D	Advanced and Applied R&D	R&D and technology assistance for SMEs	Applied R&D	Applied R&D
National governing agency	Fraunhofer Society	Ministry of Economic Affairs	Ministry of Economy, Trade and Industry	National Agency for Research	Tecnalia Corporation
Form of entity	Private not-for-profit	Government-owned	Public (local government)	Public research institutions	Private not-for-profit
Geographic scope	Distributed across Germany	Main site in Hsinchu (beta site in Tainan)	All prefectures in Japan	Distributed across France	Distributed across the Basque country
Number of institutes	60	1	180+	34	10
Staff	20,000	5,730	c. 7,000+	19,000	1470
Annual funding	US$723m (core government)	US$300m	~US$1,000m	US$2,540m (consolidated budget)	US$70m

Source: National Academies (2013); Shapira, Youtie, and Kay (2010).

2.3.5. Other Examples of TES-like Services

Other countries, including medium-income and developing economies, also offer technology-oriented business support services. For example the Small and Medium Industry

Development Organization (KOSGEB), an agency of the Ministry of Industry and Technology of Turkey established in 1990, runs a number of overlapping programs to support SME capacity development in Turkey. KOSGEB does not generally provide consultancy services itself except for the TEKMER program (an incubator program for start-up and microfirms physically located in collaborating host universities) but it provides money for firms to buy this service from the open market. In some programs, SMEs are allowed to use the facilities of KOSGEB (office, machinery, etc.) and obtain subsidized laboratory services for SMEs. If the firms benefit from certain other KOSGEB programs, these laboratory services are free.

Labs are located within 11 regional offices and 12 TEKMERs are located within university campuses (KOSGEB, 2010, 2012). Thirty-five percent of KOSGEB's more than 1,000 staff resides in the Ankara headquarters facility with the remainder distributed across 75 regional service centers. The 2010 budget amounted to around US$160 million, of which about two-thirds was used directly for service provision (KOSGEB, 2012). In 2009 KOSGEB's mandate was extended to cover nonmanufacturing SMEs as well. KOSGEB support used to be more in-kind in nature, including in-house consultancy, but in the last five years there has been a trend towards providing financial support to SMEs to obtain these services from the open market (KOSGEB, 2010).

In China, there are a number of programs aimed at increasing the manufacturing capacity of SMEs. One of the main priorities of China's 12th S&T Five Year Plan is innovation in manufacturing. Technology-oriented business services and applied technology centers are used to offer TES-like services in China. The Spark program is one of the longest-established examples of programs focusing on SME capacity building. Since the 1980s, the program has helped Chinese rural enterprises (i.e. town and village owned enterprises) to use science and technology with the ultimate goal of fostering rural economic development. Besides affording funding to large impact and key projects, the Spark program has provided guidance for projects receiving technical assistance. Spark's science and technology correspondents visit rural areas to offer technical and entrepreneurial assistance to rural enterprises. While the Ministry of Science and Technology (MOST) administers this program, much of the program management is done at subnational levels including province, prefecture and county (Li, 2012c). Cumulative investment in the program by the Chinese government reached roughly US$1.9 billion by 2006 (Yan, 2006)

Another relevant program is the Chinese National Engineering Research Center (NERC) program established in 1992 with the aim of promoting industrialization and upgrading traditional industries through the use of engineering research and investment in human resources and laboratory infrastructures. NERCs are considered one of the main instruments for providing technical assistance (Li, 2012a). They specialize in particular areas of technology and operate by engaging in research contracts for firms, conducting joint

research projects with industry and providing consultancy and technical services in the form of product prototyping, turnkey engineering, process development and laboratory services. Roughly half of the 264 NERCs (by 2010) were established by the private sector while the rest represent collaborations with universities and public research organizations. MOST provides financial resources for the initial setup of the NERCs, but they are financially independent by charging for their services (annual revenue for this is around US$10.4 billion), receiving income from research contracts and in rare instances receiving grants from MOST for special projects. The World Bank also provided financial support for a number of NERCs. Since the National S&T Infrastructure Construction Plan in 2004, NERCs have gained importance in providing services to industry. NERCS employed over 65,000 staff by 2010 and MOST invested around US$16 million in them that year (Li, 2012b).

Finally, the InnoFund program, established in 1999, is a funding instrument to support Chinese SME manufacturing efforts through grants, loans and equity investment. The budget for this program was about US$288 million in 2012.

In Thailand the National Science and Technology Development Agency (NSTDA) has been operating the Industrial Technology Assistance Program (ITAP) since 2001. The program aims to increase competitiveness of industrial SMEs, facilitate technology transfer and operate a national network of qualified staff. ITAP's activities include information services, feasibility studies, technology acquisition, techno-business matching, networking, technical consultancy, industrial needs assessments, and various other consultancy and dissemination activities (Supattaraprateep, 2010). The program supported 2,820 projects between 2006 and 2011 based on a public investment of US$56 million, matched two-to-one by beneficiary SMEs. It has 10 regional nodes employing around 50 project managers and 45 other staff. Most of the ITAP projects are focused on the food and agriculture, wood and furniture, and health sectors; although there is a wide variety of industrial coverage. (Supattaraprateep, 2010; Wanichkorn, 2013). A UNIDO study (Dhanani and Scholtès, 2002) reports that ITAP advisers were inexperienced and the program was concentrated in the Bangkok area. The NSTDA has received technical assistance from the Canadian Industrial Research Assistance Program (IRAP) in reforming ITAP and increasing staff capacity. Besides the NSTDA's ITAP Program, Thailand's National Innovation Agency also runs the Innovation Coupon program and the SME promotion agency runs a Consultancy Fund. The latter underwrites the cost of services for commercial production as opposed to ITAP's coverage of a wider range of services for R&D and laboratory testing, proof of concept, prototype, pilot and commercial production.

2.3.5. Approaches to Organizing Technology Extension Services

This overview highlights the variations evident in different countries' approaches. Each approach has its advantages and limitations. Applied technology centers are usually most appropriate in regions with advanced technology ecosystems and SME customers willing and able to pay for contract assistance with advanced technological issues as well as pragmatic service adoption. Technology-oriented business services are particularly relevant to markets with a large set of microenterprises or other types of SMEs with a need for integrated financial and technological assistance services. A dedicated field staff approach requires a relatively stable base of SMEs, but otherwise offers the flexibility of working with a broad set of customers and in environments with multiple private sector suppliers (in which case the field staff acts as a broker) as well as in local environments with few alternative sources of knowledge and assistance. All three approaches can accommodate various combinations of collaborations and alliances to provide program support (e.g., manufacturing associations), specialized services not resident within the program (e.g., incubators and other startup services or specialized machining and prototyping), and add capacity when necessary.

2.4. Policy Mix

TES programs differ not only in objectives and approach (as our three-part categorization indicates), but also operate within the context of particular national and regional innovation systems and capabilities, each with their own strengths, weaknesses, and dynamics. In these innovation systems, other complementary policies and actions are required to make TES programs really effective. Policy and programmatic actions to upgrade SME capabilities include labor market (e.g. vocational and technical training), fiscal (e.g. grants, loans, tax credits), legislative and regulatory (e.g. the cost of regulation) initiatives. There are considerable country-level differences in SME policy mix emphasis. The U.S. policy framework places less emphasis on vocational training and upgrading (because education tends to be primarily operated at the state and local levels), while cost and regulatory issues are of primary emphasis. In contrast, Japan takes a more centralized approach to labor, fiscal, legislative, and regulatory policies while there are structural constraints on flexibility and innovation (Shapira, Youtie, and Kay, 2010).

Ideally, TES programs should operate within well-integrated policy and institutional settings (Molina-Morales and Mas-Verdu, 2008). However, in most cases, the policy and institutional setting is not very well connected. Hence, one important role of TES is as a gateway to other fragmented services, including private consulting services and public programs. The innovation systems and institutional context, such as where the program is

located in the innovation system and how it relates to other actors, deserve commentary. Some programs (such as the MEP) reside in the standards laboratories within the commerce function while others (such as the IRAP) reside in the research function. There are often complex historical reasons for programs being situated in particular institutions, including the lack of an ideal organizational setting. The most important emphasis of the different cases is how the programs operate, with appropriate attention given to the institutional context within which the programs reside (Shapira, 2001; Shapira Youtie, and Kay, 2010).

2.5. TES Assessment and Evaluation Models

There are variations in approaches to assessing and evaluating TES. Countries with the most extensive assessment and formal evaluation approaches include the United States, the United Kingdom and Canada where assessment and evaluation are often guided by a program logic model (Shapira and Youtie, 2013). The model begins with program intervention. Program interventions are the easiest to measure and are typically captured through monitoring and tracking systems that count instances of assistance provided and customers served. Ideally, a customer and activity reporting system is used to track program interventions (although sometimes self-reported information is relied upon). A program-wide reporting system would have the capacity for the decentralized input of information, standardized definitions of customer and assistance characteristics, and periodic reporting capabilities.

An intervention leads to several successive changes within the SME and beyond. This model reflects the contribution of private sector firms in terms of human and financial capital resources, which is much greater than the value of a day of TES assistance received from the program in the same terms. Subsequent effects begin with changes in intermediate outputs; including capacity for change; adoption of new practices; and improved firm capabilities. Examples of intermediate output measured include enhanced knowledge about business, scientific, or technical areas; improved use of existing equipment; increased investment in skills; improved just-in-time manufacturing practices; better utilization of space; attainment of certifications (e.g., ISO 9000); and increased capital investment. Firm-level business outcomes often result from these intermediate outputs; in this regard, labor productivity (e.g., value-added per employee) is a common measure of business performance resulting from TES, although measures such as increased/retained sales and cost savings are also gauged. These types of outputs require customer surveys and, to address rival explanations such as selection bias, comparative econometric approaches showing results for nonbeneficiary and beneficiary firms. Broader economic impacts typically focus on job benefits, although sometimes TES can result in fewer jobs in the short run as

the client becomes more productive and may not need certain low skilled workers but is able to retain most workers as a result of these productivity gains. Typically business outcomes are run through an input-output model to extend direct benefits to other parts of the economy. Case studies are commonly used to draw out linkages between the assistance and these types of outputs, outcomes, and broader impacts.

To conclude, multiple methods are required to capture the full logic model associated with TES interventions. There is, however, a paradox associated with evaluating these types of programs. While TES evaluations seek to measure the impact of the program on client firms, they tend to ignore the situation of firms within value chains and networks (including technology centers, manufacturers, services providers, entrepreneurs, investors). Thus the key role of convening and connecting, which goes beyond the specific client firm to the broader ecosystem is usually not well captured in a typical TES evaluation. Special studies of the role of partnerships or global value chains must be conducted to capture the convening and connecting role of TES.

2.6. Summary

TES represent important measures for providing assistance to the typically underserved existing industry base of a country. Although TES can overlap with other services, several characteristics are central to the concept: an orientation toward established businesses, the use of expert specialists, and decentralized service provision. TES may be organized through a dedicated field staff, technology-oriented business support or R&D center approach. Many of the differences between TES-like programs lie in the distinctive policy frameworks of particular countries.

Several debates about the service orientation of TES support are ongoing. First, there is a debate about the relevance of TES for manufacturing versus nonmanufacturing sectors. This consideration is appropriate given the extensive literature on innovation in the services sector in Latin America (Aboal and Garda, 2012; Alvarez, Zahler, and Bravo-Ortega, 2012; Tacsir, 2011) as well as in OECD countries (Garcia-Quevedo and Mas-Verdu, 2008; Mas-Verdu, 2007). Most TES programs either target manufacturing; or they target other industries that are related to manufacturing; or they are trade sectors that provide value through sales outside the local economy. TES programs are either oriented to manufacturing (e.g., the MEP) or they have a manufacturing-plus orientation (e.g., the IRAP). Logistics/distribution is one such manufacturing-plus industry. On the other hand, high-end service sectors such as information and communications technology (ITC) tend to be less relevant for TES services and more relevant for advanced services such as incubators and R&D centers.

Second, there is a debate in the literature about whether services should have a focus on technology, sector, or region. Different countries take different approaches to these orientations. In Japan, every prefecture has one general center and the rest are sector focused. In Spain, services such as the Federación Española de Entidades de Innovación (Spanish Federation of Innovation and Technology Organizations or FEDIT) or Tecnalia have a sector focus. For FEDIT, this helps to secure corporate membership. Additionally, Spain has many geographically clustered industries, rendering a focus on sector more logical. The Fraunhofer Institutes have a highly technological orientation, reflecting the needs of its highly specialized base of firms, but this orientation requires closures and openings of new institutes every few years to keep pace with technological advances. These approaches are not necessarily mutually exclusive; rather they reflect the broader needs and makeup of a country's industrial base.

Finally, there are debates about how to design TES programs. These debates include whether or not to focus on dynamic firms with growth potential, SMEs in strategic positions in global value chains, specific sectors or technologies, or to broadly service the SME base. Likewise, designs will have to determine how to prioritize the types of market failures or problems experienced by the SMEs in the market. For example, while most programs focus on problems SMEs have in acquiring information, knowledge, and resources to adopt pragmatic technologies and techniques, SMEs also face supply-side issues. Large customers, vendors, and consultants find it too costly to support SMEs and trade associations are lacking. The role of TES is not to crowd out these suppliers by offering publicly subsidized services that compete with these private sector providers. Rather TES serves a brokering role by reducing the high cost of marketing that these suppliers would experience in their efforts to reach SMEs, as well as a coaching and mentoring role to provide ongoing contact with SMEs that would be too costly and outside the scope of a typical private sector engagement. These supply-side gaps mean that TES programs must also help coordinate these potential service suppliers and balance these efforts with the delivery of assistance to SMEs.

3. Overview of Case Studies

To probe TES operations and institutional contexts, and to provide in-depth understanding, this section presents four operational case studies. These TES and TES-like programs were selected based on their relevance for drawing lessons applicable to Latin American countries. The experiences of these programs are primarily oriented around public TES programs that target firms, either directly or through private operators. This section

discusses the rationale for case selection, the methods used to develop the cases, and highlights of cross-case findings.

3.1. Case Selection

Four case studies were developed:

- The U.S. Manufacturing Extension Partnership (MEP)
- The Manufacturing Advisory Service (MAS) in England
- The Industrial Research Assistance Program (IRAP) in Canada
- Tecnalia, based in Spain's Basque Region

The criteria used to select these case studies considered the need to incorporate a sectoral and / or territorial focus in the provision of services, the extent of diversity and clustering in the customer base, the quality and availability of program specialists, the types of services offered, use of evaluation for program improvement, and role of public funding. The programs chosen for case studies were found to offer insights applicable to a diverse range of companies, flexible and decentralized, and providing services with more of an application orientation than a research orientation. Each case represents a different TES organizational approach. Most importantly, they all have manufacturing bases with some stability. In addition, these cases have applicability to middle-income countries, as well as advanced economies.

The U.S. MEP and the MAS in England are two programs that most clearly fit the definition of technology extension (as discussed in Section 2). However, their institutional context and program operations differ. The U.S. MEP is larger, with a broad variety of centers and range of services; and significant involvement of state government and other partners. It serves a broad base of manufacturers through a decentralized field service delivery system. The MAS program is a smaller, centrally funded service delivered through private delivery organizations. It offers experienced field service assistance offering structured services. The Canadian IRAP is an example of a centrally run technology-oriented business services program; it offers a wide range of services, works with nonmanufacturers, and combines technical assistance, field service, and financial support to companies in one program with a network of decentralized service delivery locations. Tecnalia is an example of an applied R&D center network that also offers TES-like services. Headquartered in the Basque region of Spain, Tecnalia also presents a regional perspective. All four case studies can be applied in the Latin American context. The previous section offers initial introductions to these cases. The remainder of this report provides substantive detail and analysis of the four cases beginning with an explanation of the case study approach.

3.2. Case Study Approach

Key probes were developed to analyze TES programs and case studies (see Box 2). With regard to the case studies, information was obtained through a review of websites and reports about the program, interviews with program managers, an analysis of budget and other financial information and evaluation documents.

Box 2. Key Probes for Analyzing TES Programs and Case Studies

TES programs and case studies are examined using the following set of probes:

- **History and evolution:** how the program was started, relevant pre-history, and how/why the TES was housed in the particular institution.
- **Structure:** key partners; budget for TES versus other types of services (advanced and basic); major service providing organizations; structure at agency level, program level, and provider level; how coordination takes place.
- **Program scale**: annual budget–overall and normalized by number of manufacturers; number and type of institutions involved; number of offices overall and per state; number of staff; changes over recent period (last 3 to 5 years) in terms of budget and service orientation.
- **Financing**: financing structure; funding mechanisms; degree of financial sustainability; incentives for firms and institutions involved in the program; recent changes; any performance-based financing schemes.
- **Services and clients**: core TES services (e.g., needs assessments); and range of services provided, including whether or not there is a planned progression of services; marketing/outreach methods; provision of specialized services not available in-house; provision of adjacent services; industry segments served (if any); pricing structure and whether it varies by company size or location (urban vs. rural); evolutions and challenges in service provision; linkages to labs, equipment, other infrastructure.
- **Governance**: how does the TES make decisions about opening or closing centers; how the TES combines flexibility and oversight; who sets goals for the program; examples of a cooperative agreement with changes highlighted; incentives for involvement of institutions and staff; governance of the program and or institution(s) involved, private sector participation in the design and monitoring of the program, and composition and selection of advisory board members for the program; and what types of decisions are made at the central program level versus the regional level.
- **Personnel:** educational, experience, and certification qualifications of staff; the program's policies for attracting, hiring and retaining highly qualified staff; training activities; certification programs; key specialization(s) of extension program staff; use of performance-based incentives.
- **Monitoring and evaluation**: various evaluation methods and metrics used for monitoring and evaluation methods used; and impact of the programs in the beneficiary firms; challenges in measuring impacts and implementing frameworks and methodologies; evolution of evaluation methods over time.

Source: Authors' elaboration.

Each case includes at least one state or provincial level example. The funding, services, and operation of the Georgia MEP (a university-based extension service) and the South Carolina MEP (a private nonprofit MEP service) have been profiled in the context of the U.S. MEP. For the IRAP, the largest region, Ontario, is presented. With regard to the MAS, the West Midlands and Northwest and Northeast regions are profiled because these regions account for nearly one-third of all manufacturing employment in the UK. Tecnalia in Spain already represents a regional focus. Because the IRAP and MAS are centralized programs, the regional profiles provide a window into central program operations rather than a distinctive management approach to TES. In contrast, the MEP is decentralized, so the

two regional examples were carefully selected to illustrate a diverse range of operations. The South Carolina MEP was one of the first three centers established by the program in 1989. It is a private nonprofit center with a long history of developing assessment tools and operates in an economy with a diverse range of potential clients. The Georgia MEP is one of the two oldest university-based programs in the United States and is very well regarded for its management, the flexible use of industrially experienced personnel, and its ability to leverage and manage resources from the university (including faculty and students) and other related federal and state programs.

Case studies of the four programs were conducted over the four-month period of July to November of 2013. The case studies were guided by an inception report; a review of literature, definitions, and frameworks; discussions at a project kickoff meeting in Washington, DC, in June of 2013; and feedback from IDB, including in-depth comments on early drafts of the MEP and IRAP cases. Additional feedback was obtained through an IDB workshop on technology extension in Buenos Aires in March of 2014. The cases include information about the program at national level as well as state, provincial or regional examples.

In each case write-up financial amounts are presented in the country's home currency. In the cross-case analysis current budgets are presented in U.S. dollars at current exchange rates.[2] Detailed accounts of each of the four TES programs follow in the next four sections.

4. U.S. Manufacturing Extension Partnership

The Manufacturing Extension Partnership (MEP) is a national network of manufacturing specialists with centers in all 50 U.S. states. The federal government portion of the financing is matched by centers with funds from state, private sector, and other sources. The objective of the MEP is to enhance the competitiveness of the U.S. manufacturing sector through working with manufacturing SMEs. The program allows for flexibility in the structure and operation of centers, enabling states to take advantage of local historical conditions and assets in the configuration of their centers, while maintaining robust governance and extensive monitoring and evaluation.[3]

[2] US$ 1 = 0.613 GBP, 0.727 EUR, and 1.0582 CAD.
[3] This case study is based on personal interviews with managers at NIST MEP, SCMEP, and GaMEP performed in July and August, 2013, and reviews of websites, and program and center reports.

4.1. History and Evolution

The creation of the MEP arose from concerns about the competitiveness of U.S. manufacturing in the 1980s (OTA, 1990). These concerns reflected the ascendancy of strong European and Japanese manufacturers, which relied on advanced technology and techniques rather than lower costs. U.S. manufacturers were confronting heightened competition in both domestic and export markets and the nation's former trade surplus became a deficit. Not only were there challenges in mature industries such as textile and steel, but also in complex subsectors such as the automobile, machine tool, and semiconductors and electronics industries. Warnings about the prospects for U.S. manufacturing led to several major policy reports, activities and initiatives. In 1986, the National Research Council's Manufacturing Studies Board published "Toward a New Era in U.S. Manufacturing" about key transformational manufacturing technologies and policies to address these changes (1986). That same year, the Council on Competitiveness was founded by the former head of Hewlett Packard and chairman of President Reagan's Commission on Industrial Competitiveness to provide a forum for leaders from business, university, and government to raise topical national competitiveness issues in the manufacturing sector in the U.S. policy arena.

The Omnibus Trade and Competitiveness Act was signed into law in 1988 primarily to address industrial competitiveness concerns and the expanding U.S. trade deficit.[4] Part of it dealt with technology challenges and established regional manufacturing technology transfer centers within the newly renamed and reoriented National Institute of Standards and Technology (NIST) in the U.S. Department of Commerce. In 1989, three manufacturing technology centers were selected in an initial start-up phase: the Great Lakes Manufacturing Technology Center at the Cleveland Advanced Manufacturing Program in Ohio (now called MAGNET, the Manufacturing Growth and Advocacy Network); the Northeast Manufacturing Technology Center at Rensselaer Polytechnic Institute in Troy, New York (now part of the New York Manufacturing Extension Partnership); and the South Carolina Technology Transfer Cooperative based at the University of South Carolina in Columbia (now the private nonprofit South Carolina Manufacturing Extension Partnership). Two additional centers were established in 1990 in Michigan and Kansas and two more in 1991 in Minnesota and California. These new manufacturing technology centers built upon a history of prior state and federal initiatives in manufacturing extension (see Appendix 1). Georgia, Iowa, Maryland, Michigan, North Carolina, Ohio, Tennessee, Texas, and Pennsylvania had industrial extension services in their states and the Department of Commerce's State

[4] PL 100-418. http://www.gpo.gov/fdsys/pkg/STATUTE-102/pdf/STATUTE-102-Pg1107.pdf.

Technical Services (STS) funded pilot manufacturing technology transfer programs in the 1960s and early 1970s (Shapira, 1990). While these centers were not the first experiences with technology extension in the United States, they did represent the beginning of a nationwide system.

Expansion to other states came through the Department of Defense's Technology Reinvestment Project (TRP), created in 1993 to foster dual use commercialization. A further 27 manufacturing technology centers were created through TRP. These centers were all managed by the U.S. Department of Commerce, and transitioned to Department of Commerce funding by 1997, after which they were integrated into what became the Manufacturing Extension Partnership. By the middle of the 1990s there were MEP centers in all 50 U.S. states and Puerto Rico.

The founding legislation in 1988 did not envision an ongoing role of federal funding for TES services, although this was subsequently changed. Originally, it was anticipated that the federal co-funding share would ramp down from 50 percent of the center's budget in the initial years to 33 percent after the third year. A sunset provision stated that the federal match would cease after the sixth year as the centers became self-sustaining. This was found to be unworkable (i.e., precipitating center closure) and in 1998, the Technology Administration Act eliminated the six-year sunset clause, allowing for an ongoing federal role.

The program's strategic orientation has evolved since its inception. The initial design called for centers that would transfer federal laboratory technologies to small and medium-sized manufacturers; however, a 1993 National Academies study observed that besides technology services small and medium-sized manufacturers needed a broader range of management and training services (National Research Council, 1993). This finding led to a reorientation of the program toward off-the-shelf proven technologies and techniques rather than laboratory technology transfer. In the early to mid-1990s the MEP engaged in the building of a program to achieve national coverage, establish local service partnerships, and create an evaluation system to demonstrate business and economic impact. By the early 2000s, the direction of the program advanced toward system-wide initiatives. Offers of standardized services were put into place across the MEP system (e.g., tools for companywide assessments and delivery of quality system services such as ISO 9000 and lean manufacturing).

National efforts to train MEP specialists were extended through the MEP University, which provided training in manufacturing services. The program explored ways to provide services in the context of national and global supply chains. The 2000s was a period of shoring up support for the program in the face of efforts to reduce or eliminate its federal funding. The late 2000s placed an emphasis on growth strategies. During the Obama

administration, efforts have been made to build up the manufacturing ecosystem through multi-agency solicitations around manufacturing and cluster development and through a new Advanced Manufacturing Partnership guiding a series of initiatives. These include a National Network for Manufacturing Innovation, comprised of regional manufacturing technology centers fostering the development and adoption of leading edge technologies.[5] By early 2014 four manufacturing innovation institutes had been established and additional institutes are planned. Within the framework of U.S. manufacturing programs these institutes undertake advanced technology development and demonstration activities, generally with consortia of research organizations, selected larger companies and sophisticated smaller firms. The MEP continues to work downstream, offering pragmatic technology deployment and other TES services targeting the broad base of manufacturing SMEs.

4.2. Structure

4.2.1. Federal Agency Organization

The MEP's national office is situated in the NIST facilities in Gaithersburg, Maryland and houses 45 staff members (National Academies, 2013). It reports to the NIST Associate Director for Innovation and Industry Services. At the program level, the MEP's organization includes a director, deputy director, and managers for systems operations, center operations, program development, and policy and research (Figure 2). The MEP has had three directors over its nearly 25-year history, all of whom emerged from management positions in government laboratories. The regional account managers are accountable to the systems operations manager and are responsible for overseeing a set of centers in a given region. The program development manager is responsible for new service delivery initiatives. The operations manager oversees the financials and cooperative agreements for each of the centers. The manager of policy and research designs, collects, and analyzes center-reporting metrics. The Gaithersburg office does not house any MEP center specialists.

[5] www.manufacturing.gov

Figure 2. NIST MEP Organization Chart, June 2013

Source: National Academies (2013).

4.2.2. State Structures

The MEP is a decentralized and flexibly structured system that allows individual centers to develop strategies and services suited to local conditions. The structure of centers varies according to the history of programs for manufacturers in each state or region but is required by law to be affiliated with a nonprofit organization.[6] Nearly two-thirds of the centers are structured as nonprofit organizations (under section 501(c)(3) of the Internal Revenue Service code which allows exemption from federal income taxes for designated public purposes); 17 centers are based in universities or community colleges; and state governments, usually commerce departments, run four centers. 501(c)(3) centers are typically set up as standalone private nonprofit organizations with independent boards. University centers are organized as a separate unit or embedded in the engineering college, school or university. Programs run by state government take in federal funds, centrally manage reporting and contractual requirements, and usually set up or use universities or separate 501(c)(3) organizations to deliver services.

The national program specifies that each center should have a director, a board of directors, and field specialists, but no other organizational arrangement is required. There is

[6] Regional Centers for the Transfer of Manufacturing Technology, 15 U.S.C. 278k, 2012. http://www.gpo.gov/fdsys/granule/CFR-2012-title15-vol1/CFR-2012-title15-vol1-part290. See also http://www.nist.gov/mep/legislative-history.cfm.

often a manager responsible for the field specialists and regional offices. Some centers divide their staff into account managers who develop projects and technical specialists who deliver services and some have managers of key service areas such as continuous improvement or growth services (i.e., services that lead to increased sales such as product design and development assistance). Because many centers work with third party providers and partners, there may be managers responsible for partnerships and subcontractors. There is also usually someone responsible for reporting and metrics information. While centers may manage other federal, state, or local programs (e.g., a center may provide training for small businesses in how to respond to government contracts as one of the Defense Logistics Agency's Procurement Assistance Centers), all work with manufacturing SMEs is subject to reporting and metrics requirements of the MEP program.

The MEP does not have a requirement at the federal or center level to work with any particular partner organization. A range of partner organizations are involved with the MEP. One study found more than 700 partners formally listed in the MEP reporting system (Shapira, Kingsley, and Youtie, 1997). The federal program has formal partnerships with the U.S. Patent and Trademark Office, Economic Development Association, Association of Procurement Assistance Centers, E3-Energy, Economy and Environment (initiative of the Department of Commerce, Environmental Protection Agency, Small Business Administration (SBA), Department of Labor, Department of Energy, Department of Agriculture), American Association of Community Colleges, Economic Development Administration, International Trade Administration, and Department of Transportation.[7] The program also has a cooperative agreement with private nonprofit intermediary organizations such as the State Science and Technology Institute (SSTI) and, through SSTI, the National Governors Association (NGA), and as well as with private firms. At the center level, diverse organizations have been involved, including universities, colleges, economic development organizations, technology centers, federal labs, utilities, and different kinds of private sector consultants. Some states require that certain partners work together at the regional level but no national requirement for local partnership collaboration exists.

Some of these partnerships provide matching funds for new initiatives. The following two federal-level partnership examples are illustrative. In 2013, the MEP collaborated with the Economic Development Administration of the Department of Commerce and the Department of Labor's Employment and Training Administration to write and jointly issue a multi-agency federal funding opportunity (FFO) announcement entitled "Make it in America Challenge" to award up to US$40 million from the national program budget for a maximum of 15 projects in distressed regions. The FFO promoted projects that encouraged re-shoring by

[7] http://www.nist.gov/mep/partners/partnershipagreements.cfm

constructing or rehabilitating physical infrastructure, providing technical assistance, and offering workforce training. The MEP offered US$6 million or US$125,000 per project out of the national program budget to MEP centers serving the distressed regions.[8] In 2011 the MEP granted US$300,000 to co-sponsor a manufacturing innovation policy academy with the NGA to work with governors' administrations in eight states—Colorado, Connecticut, Illinois, Kansas, Massachusetts, New York, and Pennsylvania. The academy agenda exposed the states to progressive practices, cutting edge research, and peer-to-peer learning for state issues increasing the economic development orientation of universities, cluster strategies, manufacturing roadmapping, and various workforce needs. The academy hosted three meetings during the year, which brought in speakers and consultants.

Some partnerships extend the operational capabilities and offerings of the program. For example, the E3 partnership furnishes assessment tool capabilities enabling MEP centers without these capabilities to provide sustainable manufacturing services to their clients. Partnerships with the SBA enable MEP centers to provide services to small microenterprises, usually through referrals to Small Business Development Centers for business plan development and through referrals to various SBA financing programs.

These types of programs are not usually evaluated separately in the MEP's monitoring and tracking system, because the system is primarily focused on the performance of a client firm and center but special studies have been undertaken to assess the effectiveness of these partnerships. For example, one such study by Yin, Merchlinsky and Adams-Kennedy (1998) found that a special program at the national level providing funds to selected centers to encourage partnerships between MEPs and SBDCs—where the MEP would provide technical services and the SBDC would provide business and market planning services—was not more effective than partnerships that emerged organically at the center level without the planned federal effort.

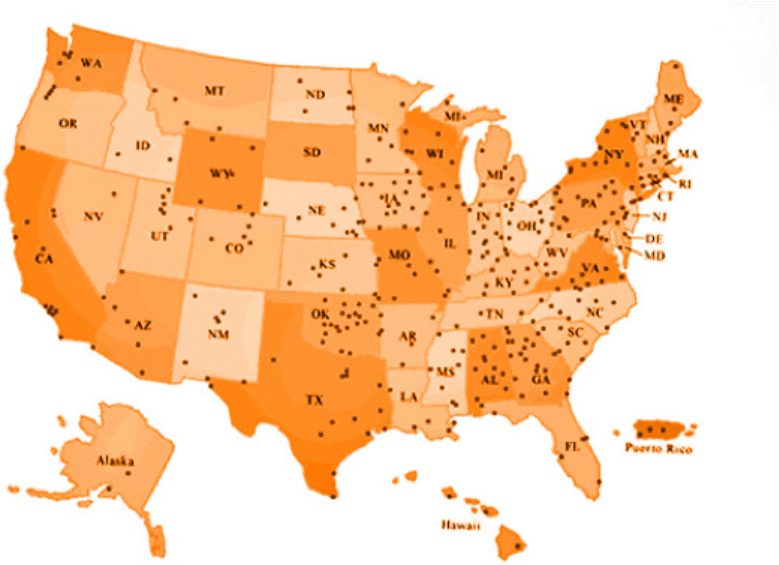
4.3. Program Scale

The MEP has 60 centers that operate 370 offices (Map) staffed with 1,450 specialists (National Academies, 2013). The average center employs 27 full-time equivalent staff members of which two-thirds are professional and technical staff.[9] In the mid-1990s, there were 75 centers because a few states (e.g., New York, California, Ohio) had multiple centers; these centers have since merged into a single statewide network with the former centers becoming offices in the statewide system. Pennsylvania remains a multicenter state. At one point, the MEP had several super centers comprised of multiple states, which were

[8] http://www.manufacturing.gov/make_it_in_america.html
[9] According to data from MEP's quarterly reporting system.

expedient for states without infrastructure for the program. However, they have all since dissolved as the directors of these super centers retired and individual states sought to have more control.

Map 1. MEP Office Locations (MEP, 2006)



Source: MEP (2006).

4.4. Financing

The overall annual budget for the MEP is about US$300 million, including federal, state, and private sources (National Academies, 2013). An estimated US$123 million is sourced from the federal budget (in the financial year (FY) 2013) and roughly 80 percent of these federal funds financed the basic operations of the centers (Table 5).

Table 5. NIST MEP Federal Budget (FY 2013)

Item	Millions of Dollars	Percent of Total
Center Renewal Funding	93.5	76.0
Strategic Competitions	3.9	3.2
Support for Centers	11.4	9.3
Programmatic Requirement/Administration	3.2	2.6
Centralized MEP System Support	8.2	6.7
NIST MEP Labor + Benefits	7.8	6.3
Other Objects	0.9	0.7
NIST Overhead	5.5	4.5
Total	123.0	100.0

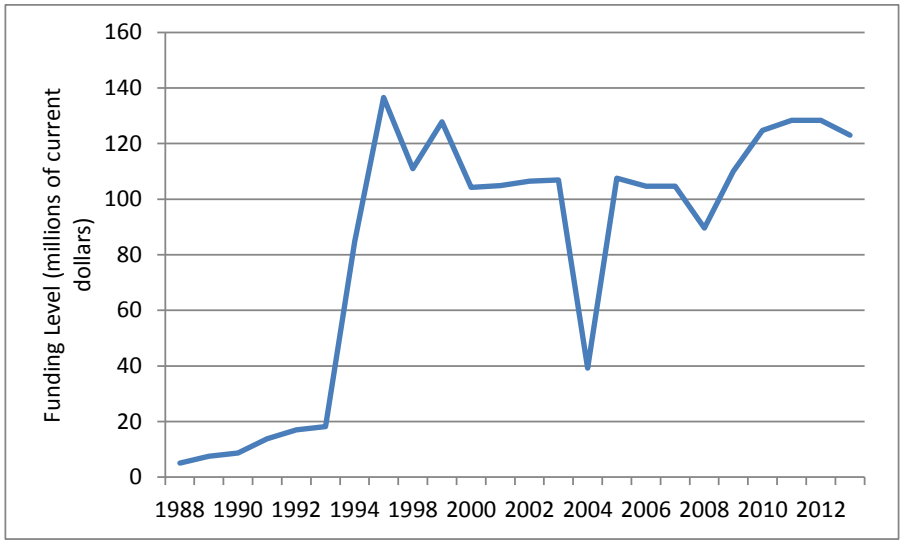
Source: National Academies (2013).

The funding model for the MEP is that centers receive one-third of their budget from NIST and match the other two-thirds themselves. Allowable matching contributions are:

funds from state and local government sources, fees for services performed, revenue from licensing and royalties, and in-kind contributions of personnel; although the latter cannot account for more of half of the cost share (National Institute of Standards and Technology, 2013). The funding model sought by NIST is: one-third federal (NIST), one-third state government and one-third fees charged to manufacturing SME clients. The state government share has been less reliable in recent years as some have cut their program match in the wake of financial shortfalls. Raising cost sharing dollar requirements have led to more fee-based services, larger more sophisticated firms and those in highly urbanized areas (GAO, 2011).

The MEP has also experienced considerable fluctuations in its federal budget. The initial budget for the MEP was US$5 million in 1989 (three centers for US$1.5 million each plus program administration). The budget rose as centers were added: US$7.5 million in 1990, US$12 million in 1991, US$15 million in 1992, US$17 million in 1993, US$40 million in 1994. Through the transition from the Department of Commerce and TRP (Department of Defense) funds, the MEP appropriation rose to US$95 million by 1997 (Hallacher, 2005) plus some supplements for Y2K (Year 2000 information technology) assistance. In the 2000s, the federal budget for the MEP fluctuated from around US$100 million to US$130 million. It was at the lower end of this range in the early 2000s (indeed its budget was reduced to around US$40 million in 2004), but has incrementally grown in the period from 2010 to 2013. The MEP budget grew by nearly 3 percent from 2010 (US$124.7 million) to 2011 (US$128.4 million), but dropped back to US$123 million by 2013 (Figure 3). Efforts to maintain support for the program have been coordinated by the Modernization Forum and the American Small Manufacturers Coalition advocacy associations.

Figure 3. MEP Federal Funding, By Year



Source: National Academies (2013).

Given that the MEP is the primary federal technological service for small and medium-sized manufacturers, its budget is relatively small in comparison to the budget for general assistance to small businesses and R&D. Its budget is 75 percent of the Small Business Administration's noncredit budget line (based on an average of the budget for fiscal years 2012–14), 0.1 percent of the federal R&D budget and 7 percent of the budget for the Small Business Innovation Research and Technology Transfer (SBIR/STTR) programs. The U.S. investment in the MEP as a percentage of GDP was around 0.0009 percent in 2012. Ezell and Atkinson (2011) reported that, notwithstanding issues of comparability, in 2009 the overall budget for Canada's extension program was 10 times larger than that of the MEP as a share of GDP, Germany's was 20 times larger, and Japan's was 30 times larger. In 2011 (the most recent year of manufacturing data available), the MEP federal budget amounted to US$436 per manufacturing establishment.[10]

The average center receives US$1.5 million from the federal government, but there is a wide range: allocations run from less than US$500,000 for smaller states (Delaware, Hawaii, South Dakota, West Virginia) to more than US$5 million for larger states (California, Texas, New York). The federal sponsor does not offer performance-based financial schemes.

4.5. Services

Two basic service delivery models exist in the MEP system. This first is the in-house specialist model whereby the majority of services are delivered by internal staff. The second is the broker model whereby consultants provide specialized services or capacity and the MEP brokers the services by qualifying external consultants and managing relationships between these consultants and manufacturing clients. Nearly all centers provide some form of a mix of these two models. The Georgia MEP is among the centers that provide almost all services in-house; the Oklahoma Manufacturing Alliance is among those that are primarily marketing and project management organizations with nearly all services provided through third party consultants.

Most MEP centers deliver assistance through a range of services including lean process, energy management, quality systems, business process and supply chain management, product and market development, information technology, and human resource development (Table 6). There is no natural progression of services, rather services are dependent on client needs; and services are not standard. They vary widely in terms of description of services, number of hours involved, milestones, and costs. Likewise, centers

[10] Based on 295,643 manufacturing establishments with at least one employee from County Business Patterns in 2011 and a fiscal year 2011 MEP federal budget of US$129 million.

usually charge for these services based on the effort required not on the type of service provided. Prices are subsidized but no specific formula is used.

One of NIST's federal roles is to signal strategic changes in direction for the overall MEP system. For example, in 2008, NIST developed a Next Generation Strategies (NGS) document to guide center services. NGS emphasizes the need to address "five key critical areas in concert": (i) continuous improvement, (ii) technology acceleration, (iii) workforce, (iv) supply chain, and (v) sustainable manufacturing (NIST, 2008). In the last five years, the MEP has placed greater emphasis on growth services including product development, marketing, and technology acceleration.

Table 6. MEP Services and Next Generation Strategies

Core service	Elaboration
Continuous Improvement	Lean manufacturing
	Process improvement
	Quality systems
	Standards training
Technology Acceleration/Growth Services	Product design and development
	Marketing assistance
	Commercialization assistance
Supplier Development	Markets
	Integration
	Costing
Sustainability	Energy assessments and management
	Environmental, health and safety
	Environmentally friendly materials
Workforce	Training
	Leadership development, executive coaching

Source: NIST (2008).

The national program has provided resources for the development of tools to support exporting, product development, technology scouting, and business continuity services.[11] Over several years, the MEP has engaged with various private organizations and public agencies to develop tools and service approaches, for example:

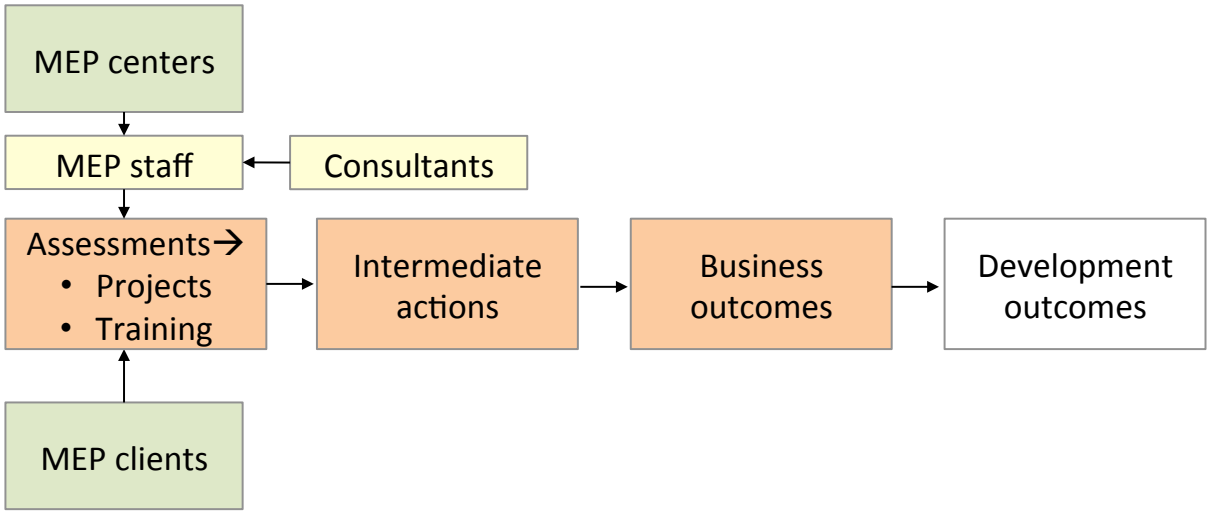
- USNet (training and capacity building for network-based delivery of services), Supply America Corporation (a supplier development approach)
- 360vu (a national branding program to facilitate work with supply chains)
- Eureka! Winning Ways (product and market development process)
- Make it in America (re-shoring initiative including total cost of ownership tools)
- E3 (partnership with the aforementioned five federal agencies to use a review and assessment process to reduce energy, production, and environmental waste).

[11] http://www.nist.gov/mep/manufacturers/

In 2010 the MEP funded 22 projects expanding capacity or developing new tools and services. One of these contracts was with five MEPs to develop a set of supply chain management simulation and optimization tools and services. Centers are also given flexibility to develop their own services and tools and product development is a common activity, although it tends to be self-financed. The South Carolina MEP's creation of an initial plant assessment tool called Competitiveness Review (CR), which is licensed to other centers, is an example of this approach.

Many TES services with individual enterprises begin with an assessment or a brief engagement designed to identify problems and match services to a firm's needs. A second approach originates from manufacturers calling the center to solve a particular shop-floor or other problem; once the initial problem is addressed, known as a point solution, other services with greater companywide effects are encouraged. Projects usually involve provision of business and process improvement advice, pilot examples of good practice, and linkage to other solution providers (Figure 4).

Figure 4. Typical MEP Client Service Model



Source: Authors' elaboration.

The MEP frequently delivers TES services on a one-on-one basis with the manufacturing establishments. Group engagements–including quality circles, lean consortia, CEO forums and virtual groups using readily available applications such as LinkedIn–offer peer-to-peer learning, through benchmarking one another's practices, and training; participating firms are usually geographically close and not direct competitors. Most centers offer open enrollment training courses to multiple manufacturers on a particular topic such as

value stream mapping, as well as customized training to employees and managers of a given client manufacturer.

MEP centers often work with, or refer to, private sector consultants of which there are many in the U.S. The strength and diversity of private consultants varies by area (urban and rural). The MEP is aware of the need to work with this consulting community and not crowd it out. Many state programs use private consultants in delivering services and all make referrals to them. The MEP's involvement is helpful for outreach and diagnosis in reducing the transaction costs for private consultants serving SMEs.

Aside from the national program website, the MEP does not have a major countrywide marketing effort to manufacturers. Each center is responsible for its own marketing. Some have technical specialists who are also responsible for business development and others have separate sales/account managers. Most centers use formal marketing approaches such as direct mail to manufacturers, telemarketing, electronic newsletters, introductory visits, and road show presentations. Open enrollment courses typically lead to more intensive projects with manufacturing participants. Field specialists are encouraged to become embedded in their communities through participation in chamber of commerce activities, civic clubs, economic development groups, and other local-based efforts to obtain referrals. Partnering with state and local economic development and manufacturing organizations is another avenue for reaching new clients.

4.6. Clients

The MEP served more than 31,000 clients in the fiscal year 2012 and has provided 490,000 project engagements since the late 1990s (Manufacturing Extension Partnership, 2013). MEP services target managers and employees of small and medium-sized manufacturing establishments. Local centers may provide services outside of this target, for example to nonmanufacturers, but cannot use federal dollars for this. Some centers have used targeted marketing approaches designed to serve important industries in their regions; the national program encourages targeted marketing and cluster-based strategies, but these are not required.

MEP centers typically operate within their own states or sub-state regions. While there is no contractual restriction on working in other regions, common practice for doing so involves notification to the home center and inclusion of its staff if warranted. Product development or supply chain efforts are among those services that may lead to working with out-of-state manufacturers.

There is currently no national pricing structure for most services to clients, although some of the more recent innovation services are leaning in that direction. The MEP highly

encourages that some of the nonfederal funds come from fees from client firms, as the willingness of the firms to pay for the service is an indicator of its relevance to the company. Centers often vary pricing structures based on the size of the firm.

4.7. Governance

The core governance mechanism for the MEP is the cooperative agreement (National Institute of Standards and Technology, 2013). A cooperative agreement allows for substantial involvement of both the federal government partner (NIST MEP) and the center. This contrasts with regular contracts, which have an orientation toward outsourcing and less ongoing involvement of the sponsor. The topics covered in a MEP cooperative agreement are presented below (see Box 3).

Box 3. NIST MEP Center Cooperative Agreement: Main Elements

The **Cooperative Agreement** is the core document used by NIST to partner with individual MEP centers. An MEP cooperative agreement typically covers the following items:

- Development of plans, startup-up plans, operating plans
- Reporting of surveys, studies, manuals
- Substantial involvement of the MEP national office through assistance and guidelines, linkages to the national system, guidelines for performance data collection and evaluation, timely response requirement, assistance to address technical and managerial problems, framework for high performance standards, participation in activities of center's host organization to address any issues
- Center obligation to develop and submit plans and budgets, complete tasks in a timely manner, review national system products prior to in-house tool development, participate in MEP meetings and conferences, submit technical and financial reports, participate in program reviews
- Submission of modifications to work, plans, management in writing
- Establishment of and regular meetings with a board of directors or trustees
- Participation in multi-center and national meetings and activities
- Engagement with NIST MEP in continuous improvement of program
- Record-keeping of administrative and financial information
- Approval of key personnel changes by NIST MEP
- Reporting on tools, systems, resources, and equipment with a value of US$10,000 or more
- Approval of sub-awards over US$100,000
- Submission of detailed financial and technical reports to the NIST MEP management information reporting system as specified by reporting guidelines
- Participation in statutory merit panel reviews
- Termination of center
- Contribution and documentation of cost sharing and matching
- Audit requirement
- Post-client project follow-up

Source: Authors' elaboration.

All centers must abide by the rules of the cooperative agreement. The MEP assigns a regional manager and a federal program officer (FPO) to monitor compliance and cooperate with each center toward its success. Center leadership communicates with the regional manager on a regular basis. The manager participates in group or advisory board

meetings. The FPO is the principal link between the center's financial and reporting staff and the NIST Grants Office that oversees the cooperative agreement.

The advisory board is another governance mechanism. This may be a fiduciary board to guide management on the running of the center or an advisory board to provide input on the wants and needs of manufacturers; some boards serve both functions. The frequency of advisory board meetings varies by center. The MEP requires that a majority of board members be manufacturers.

All centers are required to participate in a review process. Centers in good standing are on a two-year panel review cycle, with a mini-review undertaken every other year by the regional manager, and those undergoing transition are on an annual cycle. Centers must submit a progress report 120 days prior to the review. A committee consisting of center directors and other knowledgeable individuals, and chaired by a NIST MEP official, conducts the panel review. In the early history of the MEP, panel reviews were done in person at the center's site. Today they are done through conference calls, visits to the NIST campus, or site visits to the center. The committee then provides feedback to the center on its successes and where there is room for improvement. The center may provide a formal response to these recommendations but needs to take appropriate action on them prior to the next review. The recommendations and responses become part of the center's progress report for the coming year.

The MEP cooperative agreement is renewed annually for up to five years, with awards based on funding availability and performance. After five years a new cooperative agreement is awarded (National Institute of Standards and Technology, 2013). The MEP or the center may decide to terminate the award in which case the center will be re-competed. Typically centers are closed/restructured/re-competed because of the departure of a center director or because matching funds are no longer available at the host organization. The re-competes are initiated by a published request for proposals in the Federal Register. Organizations submit proposals, which are assessed according to several criteria: demonstrated understanding of target firms in the region, existing technology resources and delivery mechanisms, and a management and financial plan (Department of Commerce, 2012).

4.8. Personnel

The MEP does not have any formal education, experience or certification requirements for center personnel. A widespread practice is that MEP technical personnel should have a mix of engineering and/or business education. Several years of industry experience is usually

necessary, but no specific industries are targeted (although personnel often reflect the industrial make-up of their region).

No national compensation structure is in place for center personnel; each center has its own pay scale. Some centers do not pay incentives nor have indicators tied to compensation; others do, primarily based on revenue generation, impact, and coverage but the exact metrics used are difficult to generalize across the program. Private nonprofit organizations tend to have more flexibility to apply performance-based incentives. Most centers pay competitive salaries. Centers stress the flexibility that specialists have and the broad range of interesting work they do as intangible incentives for attracting and retaining specialists.

Training has been an evolving area. In the early part of the program, the MEP had several mechanisms such as the National Technology Transfer Center and the MEP University, where courses relevant to providing services to manufacturers were available to new and existing specialists. The MEP University was discontinued in 2012 in favor of training specific to new services (e.g., engineering or exporting of innovation). In the past the MEP has held a national conference every year with workshops, networking, themed presentations, and roundtable discussions to enable training, but the conference was canceled for 2013 and 2014. Orientation programs for new center directors are offered through its regional managers. In 2009, the MEP started the Emerging Leaders Program in which a center specialist engages in a yearlong program of leadership and management training and peer-to-peer knowledge exchange from centers across the system.

4.9. Infrastructure

The MEP does not require that particular facilities, laboratories, or prototyping and testing equipment is available. Some centers are situated in technology centers, universities or other locations where certain types of equipment are accessible. However, it is more common for centers to have partnerships with public and private organizations with laboratory and specialized equipment capabilities.

Housing and maintaining equipment at MEP centers was more common in the 1990s when some centers acquired computer-aided manufacturing systems for demonstration and training. Additionally, during this period, the MEP placed greater emphasis on manufacturing information technology as a separate service line in response to demand for Y2K and enterprise resource planning assistance. Centers acquired a range of IT equipment and software. However, many of these in-house IT oriented services ended in the early 2000s as other sources of information technology support became more common and less emphasis was placed on these services by the national program.

In-house equipment has its own challenges. A refreshment funding resource is necessary to ensure that the equipment does not become obsolete. Finding the right people to operate and provide training on this equipment can be a challenge. Another issue is the relevance of the equipment to client manufacturing processes; equipment that is lab-oriented, experimental or untested may have limited applicability for most small manufacturers.

4.10. Monitoring and Evaluation

The MEP has a system-wide evaluation process, which includes reporting, performance criteria, client output reports, success stories, and external review. The federal review process aims to understand and improve the quality of program delivery and the extent to which goals are met, and to help justify the program. MEP center metrics balance coverage, revenue, and impact. These three goals are often not complementary. For example, service to a large number of firms is often less deep and thus produces lower impacts and less revenue.

A third party surveys all clients for whom project work is done (using an Internet web site) six months to one year after completion of the initial project, satisfying a requirement of the cooperative agreement. Furthermore, participants are expected to report quantitative impacts. The NIST has used various evaluation systems to provide information for program justification, as well as to guide program learning. The 1990s allowed for state-level experimentation with evaluation studies and center-specific professional evaluators. In 2001, MEP standardized evaluation through the introduction of a third party survey-based system and Minimally Acceptable Impact Measures (MAIM) (although qualitative success stories were also requested) to gauge center performance and report program wide metrics to the U.S. Office of Management and Budget in compliance with the Government Performance and Results Act. Quarterly impact reports are produced from these data. The early 2000s saw a period of uncertainty in federal support for MEP and the national program responded in part through this investment in the evaluation system. In 2012, MAIM was replaced with the Center Operations Review and Evaluation (CORE) system. CORE uses a scorecard approach drawing from survey data on:

- New sales: services received directly leading to an increase in sales at the establishment over the past 12 months
- Retained sales: services received directly leading to retaining sales that would have otherwise been lost
- New jobs per million dollars in federal funding: services received directly leading to creation of jobs over the past 12 months

- New investment: services leading to an increase in investment over the past 12 months in plant or equipment
- Cost savings: services received directly resulting in cost savings in labor, materials, energy, overhead, or other areas over what would otherwise have been spent in the past 12 months
- Clients per million dollars in federal funding: total number of clients receiving services
- New clients per million dollars in federal funding: new clients served in the past 12 months

Survey data is balanced along with NIST management ratings in six diagnostic areas:

1. Strategic alignment with the MEP's emphasis on innovative growth services: The center has a plan and/or has shown progress on the execution of the plan to transition from a focus on process improvement to development and implementation of an innovation practice and has trained its leadership and delivery staff.
2. Strategic alignment with the NGS: The center has an actionable and measurable strategy that is built with purposeful alignment to MEP NGS, maintains a balanced portfolio of services, is willing to experiment with services and provides success stories.
3. Market understanding: The center strategy is aligned with industry targets of their service area and serves a mix of clients based on number of employees, industry and geographic location.
4. Business model: The center's business model is aligned with strategic intent balancing internal delivery and brokerage with subrecipients / contractors; mix of sales and service representation in key staff; long-term client engagement and the need to increase market penetration; a pipeline of revenue-generating projects; work with manufacturing leaders in the state; documented succession plans.
5. Partnerships: The center has a documented plan to identify, work with, and evaluate partner organizations; center partners are in alignment with federal, state, and economic development strategies.
6. Financial viability: The center has the financial flexibility to reinvest in itself in accordance with the MEP mission; and diverse and stable nonfederal funds, including growth in client revenue.

In 2012, MEP centers together served 31,373 manufacturers through more than 490,000 project engagements. Of these customers, 7,000 received a more intense level of service (i.e., at least eight hours) (National Academies, 2013) and more than 6,000 of these customers were surveyed. The survey queried impacts resulting from MEP assistance. The MEP reported that across all centers, respondents collectively achieved US$2.5 billion in new sales; US$4.1 billion in retained sales; 61,139 in new or retained jobs; US$900 million in

cost savings; and US$2.5 billion in new client investments (Manufacturing Extension Partnership, 2013). These figures for the previous reporting year were 33,838 manufacturers served through more than 460,000 project engagements. Again more than 6,000 of these manufacturers were surveyed and these respondents had collectively achieved US$3.6 billion in new sales; US$4.6 billion in retained sales; 60,497 in new or retained jobs; US$1.3 billion in cost savings; and US$1.9 billion in new client investments. These differences are primarily due to a lack of stability in client reporting between periods rather than any substantive differences in impact.

This system does not use a quasi-experimental design or comparison group. However, the MEP has from time to time commissioned special studies to assess program effects. It sponsored a comparative study of assisted and unassisted firms from 1987 to 1992 using longitudinal research databases from the U.S. Census Bureau and customer data from eight MEP centers. The study found that manufacturing extension clients had 4 to 16 percent higher growth in value-added per worker than nonclients (Jarmin, 1999). This study has been repeated, with less definitive results (Ordowich et al., 2012).[12]

The MEP has also sponsored several program wide reviews. In 2003–2004, it sponsored a study conducted by the National Academy of Public Administration (NAPA) which found that the program to be well run and effective. However, it judged the MEP to be too oriented toward cost savings and lacking in sufficient services fostering innovation (National Academy of Public Administration, 2004). The National Academies recently completed an external panel review of the program, "21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program of the National Institute of Standards and Technology" (National Academies, 2013) which included a review of 65 program evaluations, including 15 that use comparison groups. All 15 found some positive and significant effect of the MEP on firm outcomes relative to those of nonclients after controlling for size, industry, and other factors; most studies show the MEP to be valuable despite the fact that six of the 15 also found negative effects (e.g., on wage levels, adoption of multiple technologies). The National Academies study concluded that the program is important in efforts to advance U.S. manufacturing but its funding is not commensurate with the importance of the manufacturing sector, its evaluation system should allow for more analysis and external studies, and there should be more sharing of best practices across the centers and about international technology extension programs.

[12] Two methods were used to model the effect of MEP on firm productivity: a Difference in Difference (DiD) model (which found significant negative effects) and a lagged dependent variable model (which found significant positive effects). The DiD model can only control for time-invariant establishment characteristics. It cannot account for baseline differences in productivity between the treatment and control group (beyond those explained by time invariant characteristics), nor can it control for the possibility that the outcome variable is correlated over time, hence the inclusion of a lagged dependent variable model. These results can be used to bound the impact estimates.

The MEP does not directly assess its effectiveness compared to other organizations (including in other countries) that provide TES services. Nevertheless, such comparisons have been undertaken indirectly in other independent studies. The aforementioned program wide reviews do foster comparisons based on budgets and service orientation; for example, the most recent National Academies review pointed out that the MEP's budget is below that of comparable programs in the other countries. Relative to private sector suppliers of TES services, Oldsman (1997) found that the MEP served more as a broker facilitating the creation of more business opportunities for private sector providers than as a competitor.

4.11. South Carolina MEP (SCMEP)

As one of the program's original three centers, the South Carolina MEP (SCMEP) has undergone many changes. The initial cooperative agreement was with the University of South Carolina but eventually the center was transferred to the 501(c)(3) which operates SCMEP to enable improved market penetration. In addition, its manufacturing base, comprised of 3,900 manufacturing establishments with at least one employee in 2011, has shifted from the textile industry to more technology intensive transportation manufacturing with the location of BMW's production facility in Greenville, South Carolina, and the subsequent establishment of automobile and aerospace related plants. This restructuring has placed ever more emphasis on the importance of the center.

The SCMEP received US$2.3 million from the federal government and another US$682,000 from the state government in 2012, with the remaining 56 percent of its budget coming from client fees. The program worked with 250 companies in 2012 on 530 projects. Internal staff conducts about 60 percent of projects, with 40 percent served through third party providers. Workload assignments give first priority to internal specialists then the work is outsourced to its network of 90 to 100 mostly small subcontractors. These firms are vetted through an initial trial project that is closely managed by an SCMEP specialist. SCMEP services mirror those indicated by the national NGS. A core service of the center is its Competitiveness Review performed with client manufacturing firms (see Box 4).

Box 4. SCMEP Competitiveness Review

The Competitiveness Review is a core service of the South Carolina Manufacturing Extension Partnership (SCMEP). This is a companywide assessment tool developed by the SCMEP 20 years ago to ensure recommendations have a broad-based perspective. The assessment tool begins with three-hour onsite client meeting and plant tour. The meeting is structured to gather information from documented sources and interviews. Key aspects of the tool are:

- Company overview: founder/founding information, original business of the company, growth information, primary products, sales volume and projects, number of customers and suppliers, repeat business
- Employee information: number of shop floor employees, pay structure
- Plant information: size, shifts
- Operational levels: capacity, production schedules, scrap rate
- Lead time: customer service/order entry, design, schedule, manufacturing, warehouse, distribution/shipping, total lead time, major bottleneck, investment prioritization
- Costs: raw material, direct labor, overhead
- Inventory: raw material, work in process, finished
- Characteristics of the operation: share that is make-to-stock, make-to-order, engineer-to-order, assemble-to-order; volume
- Leadership: written business plan, extent of alignment with customer desires, extent of knowledge of the plan, frequency of review of progress toward achieving goals, diffusion of goals to individual employees and progress reviewed relative to goals
- Culture: reward system, team-based improvement, systems for management receipt of improvement ideas, employee satisfaction measures (e.g., turnover of employees, time off for vacation and professional development, formal employee satisfaction measures)
- Environmental, health, and safety (EHS): workers compensation rating, EHS management position, awareness of new regulations, environmental management systems (e.g., ISO 14000)
- Order fulfillment: pace of work, elimination of non-value-added activities, accuracy of inventory, inventory turn measurement, visual management techniques, use of expediting, batch size reductions, supplier evaluation system, information sharing with suppliers, teams with suppliers for collaborative improvement, formal documented quality program, use of final inspections for defects, scrap rate reduction program, nonconforming goods identification, process for corrective action, preventive maintenance, equipment efficiency tracking, identification of large energy using equipment, evaluation of hazardous v. nonhazardous waste streams
- Sales: organization of sales responsibility, method to track sales process, documentation of service standards, quoting system, sales growth measurement, information on primary competitors, strategic marketing plan, target market, information in marketing materials, market share tracking system, financial measurement system, results by product family, performance to the business plan, lead time for monthly financial closing, employee development plans, cross-training systems, certified on-the-job trainers, formal evaluations, health care benefits, documented job descriptions
- Internal results: trends in scrap rates, rework costs, customer complaints, inventory turns, manufacturing lead time, labor productivity, product cost reduction, equipment efficiency, on-time shipments, customer lead time, premium freight use, shipping errors, share of sales concentrated in a few customers, market growth
- Business results: trends in market share, repeat business, sales, warranty claims, operating income, cash flow, net income, profits.

After this meeting, the field specialists return to the office to input information into the Competitiveness Review software. Observations and recommendations are written up. Results are printed out and, the following day, taken back to the client in a follow-up meeting. Usually the client and SCMEP will agree to one or more project engagements to address key areas highlighted in the Competitiveness Review. SCMEP does not charge in-state clients for the assessment. However, it does offer annual licenses of the tool to other MEPs along with training. For every 10 assessments, SCMEP gets 9.2 follow-on projects with customers. The last two years have seen a threefold rise in revenue from growth services. In addition, workforce development projects have increased as the state has asked the SCMEP to provide rapid response training to troubled manufacturers; for these manufacturers to access state funds, their application must include an assessment such as the SCMEP Competitiveness Review. SCMEP charges US$1,000 to US$1,200 a day for services to small and medium-sized manufacturers, with up to 50 percent paid by larger companies.

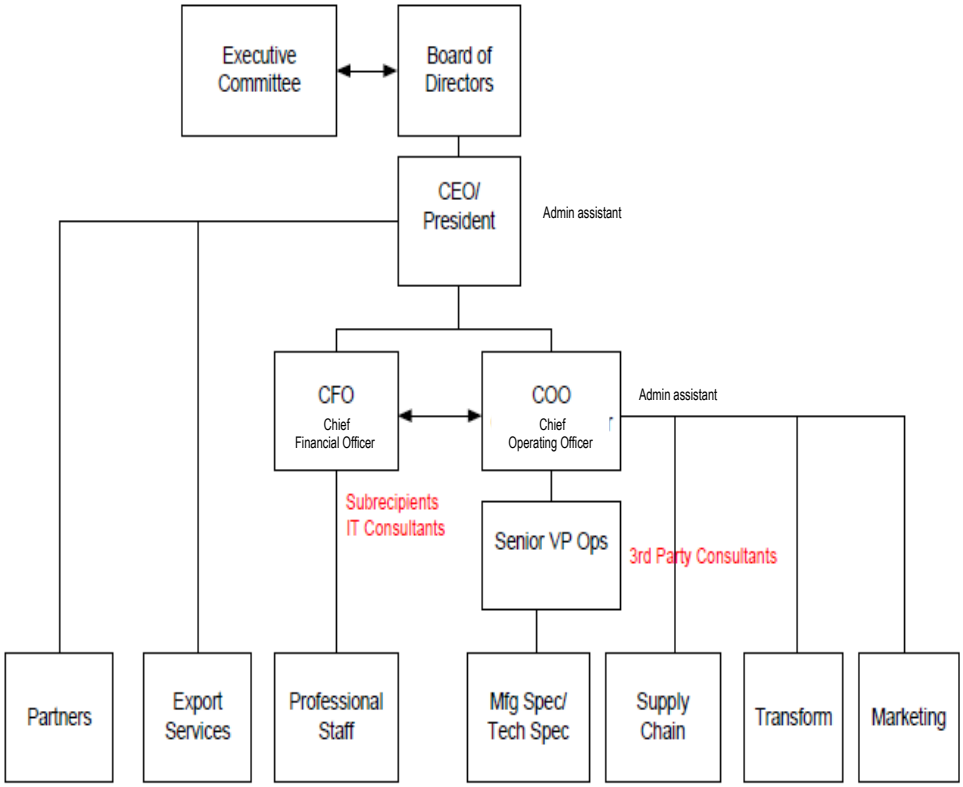
Source: South Carolina MEP Case Study.

South Carolina manufacturers are served through seven regions. The main office is in Columbia. Greenville, with the largest concentration of manufacturers in the state, is the location of SCMEP's second office, which includes a set of training rooms. Other manufacturing specialists work from home and are responsible for specific sets of counties.

The center employs an extensive marketing program. This program is broad-based rather than targeting particular industries. SCMEP employed targeted marketing in the past (e.g., metalworking and plastics) but the approach did not allow for sufficient revenue generation and client penetration goals. A successful partnership from a marketing perspective is with the South Carolina Department of Commerce. The Department hired a full-time employee to work with the SCMEP on marketing. As a result, an extensive mail and telephone marketing program and schedule of joint visits has been implemented to enhance market penetration and outreach to new clients. The SCMEP also works with a call center, sends out e-newsletters, and holds roadshows in various communities around the state to strengthen awareness and use of the program.

The SCMEP is headed by a chief executive officer, who reports to the board of directors (Figure 5). Board members represent small and large manufacturers, the South Carolina Department of Commerce, higher education, and a human resources recruiting firm. Meeting quarterly, the board of directors has fiduciary responsibilities. The board's executive committee reviews plans and financials and its finance committee reviews detailed fiscal data. The center's books receive an annual external audit.

Figure 5. SCMEP Organization Chart, 2012



Source: South Carolina MEP Case Study (2013).

A chief operating officer in charge of planning, revenue generation, product development, and technical service provision reports to the chief executive officer. Under the chief operating officer is the senior vice president of operations, who runs the field network. This network is composed of manufacturing specialists responsible for business development and technical specialists who conduct projects. The center also has managers of different product lines such as supply chain and marketing.

The SCMEP employs nearly 20 full-time staff members. The average base salary is about US$90,000. Compensation includes a substantial bonus and matching funds into a retirement plan. The center also supplies apparel, smart phones, computers, and tablets. Center specialists are given considerable flexibility to meet their goals with minimal administrative responsibilities to the extent possible. The ideal background for a center specialist is a college degree, particularly in engineering (which 70 percent of employees have). The preferred manufacturing experience is 10 years in at least two different industries to ensure a broader perspective. Certifications depend on the position: for lean manufacturing specialists six sigma and greenbelt certifications are common but in general,

certifications are not required. More weight is given to the level of familiarity with, knowledge of, and past results in the area in which the specialist works.

The SCMEP engages in partnerships with federal, state, higher education, and private sector institutions to enhance the manufacturing ecosystem in South Carolina. These include the University of South Carolina, Clemson University, the South Carolina Technical College System, South Carolina Workforce and Employment, Workforce Development Boards, and various federal, state, and local partners (e.g., the Chamber of Commerce, Department of Commerce, South Carolina Economic Developers Association, Small Business Development Center, and Service Corps of Retired Executives or SCORE). The center has several energy-related partnerships including the U.S. Department of Energy, South Carolina Energy Office, and the South Carolina Electric and Gas Utilities. It is the coordinator of Lean Alliance networks in five regions of the state and has a collaborative arrangement with the South Carolina Manufacturer's Alliance. The center also partners with South Carolina Launch, for assisting with start-ups, and its parent organization SCRA, a private nonprofit that coordinates applied R&D and the construction of research facilities in the state.

In terms of cooperation with other centers, the SCMEP is involved with four other MEP centers to develop a tool for improving supply chain management. The project draws from several different concepts including the Theory of Constraints to assess supply chain maturity and resilience. One component is a cloud-based software that pulls information from different supply chain systems.

4.12. Georgia Manufacturing Extension Partnership (GaMEP)

Georgia has a long history of university-based industrial extension. This history stems from the establishment of Georgia Institute of Technology (Georgia Tech) to serve the state's burgeoning manufacturing sector and the creation in 1934 of an engineering experiment station similar to the model for agriculture at the state's land grant university, created in the wake of the Hatch Act and Smith-Lever Act. The first industrial extension office was opened in 1960 in Rome, Georgia with US$30,000 from the Governor's office and US$75,000 from the local regional development commission. From 1964 to 1966, six other industrial extension offices were established with funding from what now is the U.S. Economic Development Administration and a seventh office was added in 1979 (Combes, 1992). The early (pre-MEP) industrial extension service had a rural flavor, based on the notion that outlying towns had few private vendors readily available to their manufacturers.

The Georgia Industrial Extension Service became part of the national MEP in 1993 as part of the wave of TRP-funded centers. The federal money was used to expand the network, in particular to metropolitan Atlanta where half the state's manufacturers are

located. It expanded the range of services from a traditional focus on manufacturing technology, operations and plant layout to marketing, quality, information technology, energy, and environmental and occupational safety and health areas. It also created a more integrated service network by formalizing partnerships with small business development centers, the technical college system, and the public utility company as well as through hiring a specialist to connect the center to R&D resources in the Georgia Tech faculty and federal laboratories (Georgia Tech Research Corporation, 1993).

The GaMEP gets US$2.55 million from the NIST MEP (Table 7). The other two-thirds of the GaMEP budget are comprised of program income from client fees (25 percent of the budget) and an allocation from the state government (just over 40 percent of the program budget). The GaMEP serves 800 companies in a given year, 300 of which receive more intensive assistance. In-house specialists deliver nearly all of the center's engagements. Third party providers are used at times to address capacity and expertise gaps; currently the center is working with several energy standards specialists as part of its energy management standards initiative. These specialists are brought in as temporary employees of Georgia Tech or Tech Temps.

Table 7. Georgia MEP Financial Summary

US$ millions	Prior year FY 2011 actual	Current year FY 2012 budget	Next year FY 2013 budget
Income			
NIST MEP funds	2.55	2.55	2.55
State/local funds	3.44	4.30	3.70
Project/service fees	1.19	1.30	1.40
Total income	7.19	8.15	7.66
Major expenditure items			
Personnel	3.93	4.31	3.88
Fringe benefits	0.98	1.12	0.97
Travel	0.18	0.37	0.39
Supplies	0.19	0.40	0.42
Contractual	0.05	0.03	0.03

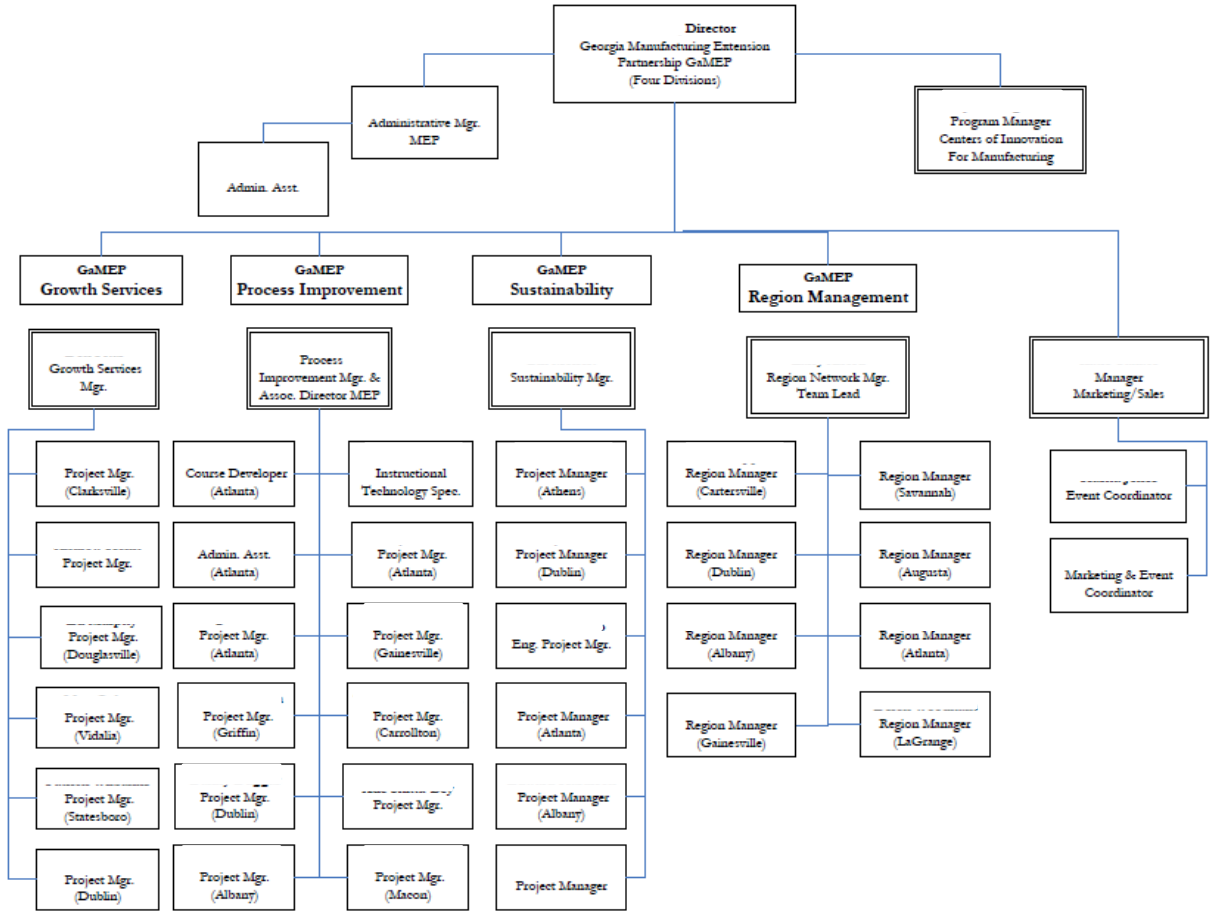
Source: GaMEP Case Study (2013).

The center is housed in the Enterprise Innovation institute (EI2) at Georgia Tech. EI2 addresses the service mission of the university by including science, technology and innovation in its outreach to companies, entrepreneurs, government, economic developers and communities. EI2 houses and operates various complementary federal, state and local programs that support business and industry. These programs are provided seamlessly through joint visits to companies and joint projects involving MEP specialists and staff from

the other complementary programs. For example, the state's Minority Business Development Agency center will bring in MEP specialists as part of the team providing services to minority owned manufacturers. The MEP will refer manufacturers operating in industries that have been adversely impacted by import competition to the Southeastern Trade Adjustment Assistance Center (SETAAC) also administered by EI2 so that marketing assessments can be provided free of charge by SETAAC as specified by their sponsor (the U.S. Department of Commerce's Trade Adjustment Assistance program). The GaMEP's energy group leverages state and federal programs to conduct energy and environmental assessments to reduce energy costs and air or water pollutants. There are no particular standard or common program combinations. The program does not track this metric (indeed, each sponsor has its own separate metrics requirements). What can be reliably concluded is that these combinations and collaborations within EI2 vary depending on client needs and enable the program to address more of their needs in a synergistic manner.

A center director heads the GaMEP, and three service line managers and a regional network manager report to the center director (Figure 6). Each region has a manager. The center has a three-person marketing and event group, and it has a manager who handles MEP reporting and administration. In 2006, the GaMEP established an industry advisory board, which meets two to three times a year to review marketing, product development and delivery plans. Board members are drawn from small and medium-sized manufacturers and public and private sector service providers.

Figure 6. GaMEP Organization Chart



Source: GaMEP (2013).

The GaMEP has three service lines: (i) growth services including ideation, product and market development, and executive coaching; (ii) process improvement including lean enterprise and quality systems; (iii) and energy and sustainability. It has developed several lean and quality tools that have transferred into the MEP system at no cost (e.g., Buzz Electronics lean 101 course). The GaMEP has been awarded grants from the Department of Energy to develop and pilot the Superior Energy Performance certification program including implementation of the ISO 50001 Energy Management Standard. The cost of developing other new services is handled out of the center's overhead budget and grants from federal agencies.

Prior to joining the MEP, Georgia Tech did not commonly charge for industrial extension services. An informal five-day rule offered free service for smaller projects. Since becoming part of the national program, the GaMEP is more engaged in fee and revenue services. Pricing is based on the size of the company with fully loaded daily costs in the range of US$1,300–US$1,700. The center matches two-thirds of the service cost to firms

with fewer than 25 employees; this ramps down to 30 to 50 percent for medium-sized companies and 20 percent for large companies; no cost share is provided for service to out-of-state companies nor for firms outside the state lacking Georgia operations. The pricing model is applied equally to rural and urban manufacturers. Georgia Tech's sponsored programs unit processes contracts and the university's professional education unit processes training services. Invoicing, billing and collection are handled by these units.

The center delivers services through a network of field agents. The field agents typically have an industrial or mechanical engineering undergraduate specialization and an MBA or graduate engineering degree. The center looks for people who have more than five years of industry experience in both operations and cross-facility project work. Knowing how to interface with a client, use appropriate tools, work in teams, and implement projects are preferred skills. Most agents have been with the center for more than two decades (some have worked with clients through multiple ownership changes). Salaries are competitive and compensation includes Georgia Tech benefits. The program's field agents are organized in nine regions in the state of Georgia. Two regions serve Atlanta: north and south Atlanta. Some regions have multiple physical offices shared with other business assistance providers such as the Department of Economic Development and/or the small business development center, and some field agents are home-based. Box 5 describes GaMEP services.

Box 5. Georgia MEP Services

Georgia Manufacturing Extension Partnership (GaMEP) services include assessment, technical assistance, training courses (both open enrollment and on-site), and coaching for implementation. The center does not have a standardized companywide assessment tool for all initial engagements. The majority of the assessments are based on knowledge and experience of the field engineer, although various service specific tools such as the Lean 101 guide, energy audit and assessment tools, and innovation engineering tools are sometimes employed. Most services are prompted by client initiated requests to help resolve a problem, with the center aiming to extend to company wide follow-on projects. GaMEP field agents primarily offer services with clients in a one-on-one setting. However, the center also uses lean consortium groups to deliver these services throughout the state. The consortium groups offer benchmarking, training, networking, leadership development and information access to help Georgia manufacturers (as well as those in certain service, government, and healthcare sectors) develop strategies for lean in their facilities and implement lean projects.

The primary way the GaMEP markets its service is through relationship building and networking in the local community using the program's regional offices. The offices enable field engineers to gain a foothold with regional economic developers and leaders and to obtain referrals. At least 50 percent of GaMEP business is repeat business. A small in-house group coordinates marketing in electronic and printed media. This group sends emails to Georgia manufacturers to join newsletters, working groups, and classes. Open enrollment courses are an important source of new business and the center markets project services to attendees.

The center does not have a separate sales or account management team; everyone is regarded as a business development person. Individual goals have been established for project managers to have new clients in line with MEP's new metrics for customer penetration. The center created an in-house lead system to support these new business development goals. It uses a proactive approach, including an estimation tool similar to the one developed by the North Carolina MEP, "to discover and communicate the impact/value [of its work] to sponsors, stakeholders, and clients" (Georgia Tech Enterprise Innovation Institute, 2010).

Source: GaMEP Case Study.

Georgia has 9,000 manufacturing establishments from diverse industries, 40 percent of which are branch facilities. Just over 2,000 manufacturers are in the target 20–250 employee range although the MEP considers the entire manufacturing base when evaluating market penetration. The state's manufacturing base has declined by 1,000 establishments since the mid-2000s. As a result, the GaMEP has placed greater emphasis on growth services and gives some funds to its sister incubator program, the Advanced Technology Development Center (ATDC), to encourage manufacturing startups. The GaMEP's state sponsor is more broad-based in how it defines the center's customer-base, including distribution and any type of manufacturing large or small, while the national program is focused on small and medium-sized manufacturers.

The GaMEP used to operate infrastructure through the Center for Manufacturing Information Technology (CMIT). CMIT was founded on October 31, 1995 with US$500,000 funding for equipment from the state lottery and MEP funds covering personnel. Vendors provided software. The center offered training and project-based assistance. It took great care in reflecting the manufacturing situation by developing a product, machining parts, and creating inventory so customers could relate to how production information feeds into an enterprise resource planning system. The center closed in 2003 as a result of changes in the national program.

Partnerships exist with other parts of Georgia Tech for testing and applied R&D. The center is engaged in a state funded cooperative agreement with the small business development center to extend and customize MEP services to the needs of very small manufacturers in rural Georgia. It gets referrals from technical college system institutes and the Georgia Department of Economic Development and works with them to open manufacturing facilities in the state. The GaMEP participates in manufacturing associations and state manufacturing initiatives such as the Made in Georgia campaign or the Next Generation group. The center also provides thought leadership through testimony to state and federal manufacturing committees and since 1994 through co-sponsorship of the Georgia Manufacturing Survey, which provides data on the needs and use of manufacturing technologies and techniques. Survey results are widely cited by the national program.

As with other MEP centers, both the SCMEP and GaMEP produce client impact data for the NIST. Client survey results are shown in Table 8. The results indicate difficulties in comparability and fluctuations in the quantitative totals. Issues have long been raised about fluctuations and lack of reliability in these impact numbers (National Academies, 2013).

Table 8. NIST MEP Survey Results for the SCMEP and GaMEP

Impacts from NIST MEP	SCMEP		GaMEP	
Survey of Customers	2011	2010	2011	2010
Manufacturers served	846	798	1,770	710
Operating cost savings	$16.6 m	$22.1 m	$36 m	$35 m
Increased sales	$59.8 m	$98 m	$191 m	$243 m
Jobs created or retained	1,410	1,269	950	1,350

Source: NIST MEP Survey of Customers for SCMEP and GaMEP, 2011 and 2010.

4.13. Conclusions

The MEP program has several strengths as well as ongoing challenges. Its major strength is its focus on the needs of manufacturing SMEs across the United States. The program's successful approach to building a national infrastructure and set of services for these SMEs, mostly focused on process improvement and lean manufacturing, is also notable. Nevertheless, the program continues to face challenges with its funding. The MEP's funding has been unstable throughout its history both at the federal level, with threats of budget cuts and program elimination occurring at various points in the program's history, and at the state level, with certain states withdrawing support for the program in their budgets. Another challenge lies in the MEP's efforts to build up innovation services, such as product development and design, as part of its "Next Generation Strategy," which have been tested by issues such as operating with too many single source contracts rather than sharing best practices across state and regional centers. Likewise, although the MEP has allocated a consistent set of resources for program evaluation, issues remain about what is collected, how reliable the quantitative impacts are, what can be learned from the results, and how they can be used for program improvement.

A recent comprehensive review of the MEP by the National Academies (2013) found that the MEP program provides valuable help to small manufacturers, but recommended a series of enhancements to further improve MEP performance and its contribution to supporting U.S. manufacturing. In total, 37 detailed recommendations were offered, along the following themes: greater flexibility and experimentation for MEP centers, more facilitation to share best practices across MEP centers and from foreign programs, and further attention to rolling out more effective innovation-oriented programs. The Academies also highlighted the need to improve data collection of program outcomes and to ensure that the MEP was integrated into the evolving U.S. national manufacturing strategy.

5. The Industrial Research Assistance Program in Canada

5.1. Introduction

The Industrial Research Assistance Program (IRAP) is a business R&D enhancement program that delivers funding, technical and business advice, and networking services to Canadian SMEs. The National Research Council (NRC), an agency of the Government of Canada, manages IRAP. The objective is to encourage applied R&D in Canadian SMEs by providing financial support and advisory services. The IRAP program operates offices at its own and partner organizations in five regions on a budget of more than C$280 million[13], 42 percent of which is focused on technology extension services; the rest is used to deliver applied research and development funding. Results of independent evaluations of the program performed every five years report a cost to benefits ratio of 1:11.[14]

5.2. History and Evolution

The IRAP was born out of concerns about the lack of industrial R&D in the Canadian economy in the early-to-mid 1900s. The Canadian government established the National Research Council (NRC) in 1916 to advance industrial R&D through the creation of laboratories and scholarships. The NRC created several predecessor programs to IRAP. In 1930, the Research Information Services (RIS) was set up to respond to general technical questions. RIS was reconstituted as the Technical Information Services (TIS) in 1945 and expanded through a network of field offices in the Provincial Research Organizations (PROs). PROs are councils, foundations, and centers set up to promote technology based economic development in a particular region. The function of the TIS was to advise small firms on science and technology questions as part of an effort to facilitate these firms' adjustment to economic changes following World War II (Coderre, 2011).

The IRAP was voted into being in 1961 and received its first pilot funding allocation in the 1962/1963 fiscal year. It was charged with providing awards to private companies to perform industrial R&D. The program created a Committee on Industrial Research Assistance to issue awards called contributions, for R&D projects. The Committee had authority to grant awards up to C$100,000 to firms. The pilot budget was extended as issues arose around whether contributions would be given to one-time versus ongoing projects; in-house R&D staff only versus subcontractors; all industrial projects versus those of

[13] Canadian dollars (C$) are used throughout this section. C$1 = US$0.945.
[14] Based in part on interviews conducted with the Vice President of the NRC-IRAP, the current and former regional director of the Ontario region, and a former director general at the NRC.

importance to the domestic economy; those from large versus those from small firms; those from domestic and multinational firms with a strong R&D Canadian presence; and funding to associations and consultants that performed R&D. These contributions were managed through Industry Technology Advisors (ITAs) (Coderre, 2011).

A major turning point in the program came in 1977 with the appointment of Keith Glegg, previously with the Canadian Marconi Company, to Vice President of Industry and Technology Transfer at the NRC. Glegg expanded the IRAP, starting with the merger of the TIS and the ITAs in the first half of the 1980s. The merger was furthered through a C$20 million allocation, which allowed for 60 new ITAs—half employees of the NRC and half contracted through the PROs—situated throughout the country in proportion to each region's population. This expansion brought the total number of ITAs and managers above 200. This set of ITAs would have up to C$100,000 signing authority for awards to industry (which has since been ended). They underwent formal training and participated in monthly meetings (Coderre, 2011).

The mid 1970s also saw the emergence of IRAP's Youth Employment Program. This was preceded by the Youth Internship Program (under the Youth Employment Strategy of the Human Resource Development Council) and, before that, the Science and Engineering Student Program. The premise behind this program was to enhance industry's capacity to perform R&D. Initially the program supported student internships but eventually it included internship support for new scientist and engineering graduates and, more recently, support for post-secondary science, engineering, technology and trade, business and liberal arts graduates (Coderre, 2011; Goss Gilroy Inc., 2012). The program had a phase in the 1970s and early 1980s in which several IRAP letters of the alphabet programs evolved:

- IRAP-M: contributions for small projects up to C$25,000
- IRAP-P, IRAP-R: contributions for large projects
- IRAP-H: the Science and Engineering Student Program (now the Youth Employment Program)
- IRAP-L: support for the use of laboratories for feasibility testing for companies lacking the appropriate equipment (no longer offered)
- IRAP-C: the field advisory sub-function of TIS known as the Industry Technology Advisors (ITAs)
- IRAP-F: the technical information sub-function (no longer in existence as a separate function)

Industry Canada (formerly the Department of Industry and Technology) was asked to transfer several programs targeting SMEs to the IRAP in the 1980s and 1990s. These programs included the Manufacturing Assistance Program and Technology Partnerships

Canada funding programs and the Canadian Technology Network, the latter being a system of organizations and business advisors for SMEs. New loans through the Technology Partnerships Canada program ended in 2006 and loan repayments management reverted back to Industry Canada in 2012–2013 (Goss Gilroy Inc., 2012). The Canadian Technology Network was absorbed into the IRAP in 2004. Other than these programs, there is no substantial overlap between services offered by the IRAP and Industry Canada, although Industry Canada remains a key stakeholder. Indeed the program review performed by Goss Gilroy found that of the services currently offered in Canada, none were found to provide the same level of advisory services as those provided by the NRC-IRAP. The IRAP also operated international technology transfer efforts for the Department of Foreign Affairs and International Trade during the 1980s (Coderre, 2011).

In the most recent economic downturn, the IRAP received C$100 million for a two-year period through Canada's Economic Action Plan. These additional economic recovery moneys went mostly to fund more contributions to SMEs for R&D projects. Fifteen percent of this budget was allocated to assist companies in hiring recent post-secondary graduates (Goss Gilroy Inc., 2012). The Jenkins report, which was commissioned to review Canadian R&D policy, recommended reductions in the Scientific Research & Experimental Development (SR&ED) tax credit and reallocation of some of these funds to the IRAP (Jenkins, 2011). The IRAP subsequently received an additional C$110 million of which more than 85 percent was allocated to contributions. (See also Appendix 2 for a chronology of major IRAP program milestones.)

5.3. Structure

IRAP is administered as one of four divisions of the NRC. There has been a debate over where it is administratively best situated. Concerns about the fit between the technology assistance mission of the IRAP and the NRC's laboratory orientation have been raised. Some see a better fit between the program and Industry Canada (which has an economic development mission). Today, the program is widely valued within the NRC, although there are challenges in the ability of NRC's research to leverage the IRAP's technology transfer and market intelligence capabilities (Coderre 2011; personal interview). The program itself is organized into five regions:

1. The Atlantic/Nunavut (Newfoundland and Labrador, Nunavut, Nova Scotia, Prince Edward Island, and New Brunswick)
2. Quebec
3. Ontario
4. West (Alberta, Northwest Territories, Manitoba, Saskatchewan)

5. Pacific (British Columbia and Yukon)

In the 1980s, there were 10 regions and in the 1990s there were seven. Each region has an IRAP head office (

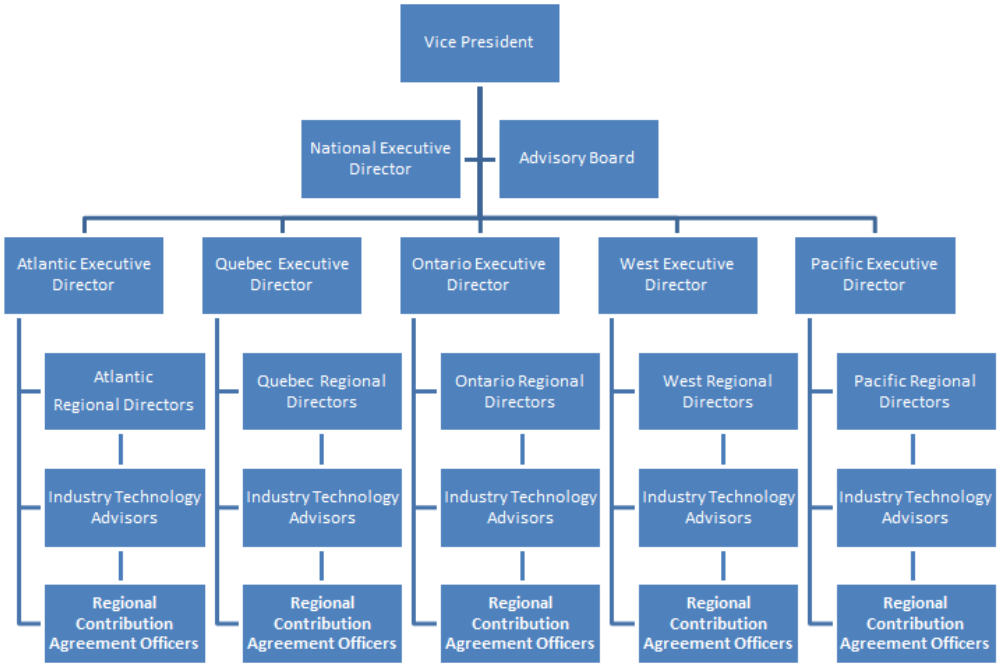
Map 2). Most ITAs work out of partner organization offices throughout the region, many of which house a single ITA. The national office in Ottawa provides support for the program but does not house ITAs.

Map 2. NRC-IRAP Locations

Source: Ciobanu (2010).

A vice president heads the IRAP. Senior leadership is comprised of five regional executive directors and a national office executive director (Figure 7). Each of the five executive directors has two to five regional directors reporting to them. Prior to the 2000s, the program had fewer directors but came to realize that additional support was needed to manage ITAs and process applications for contributions (i.e., delegate signing authority). In addition, each region has Regional Contribution Agreement Officers (RCAOs) to process contribution documents. The IRAP established an advisory board in 1986 comprised of industrial officers, industry association executives, and other organizations. This board has strategic and consultative, as opposed to fiduciary, responsibilities.

Figure 7. IRAP Organizational Chart



Source: IRAP.

5.4. Program Scale and Financing

The IRAP's budget has steadily increased from a pilot allocation of C$1 million in 1962. The program's budget rose to C$6 million in 1967, C$6.8 million in 1969/70 and C$13.8 million in 1972–1975, at which time it represented 22 percent of the NRC's overall budget. In 1986, the budget nearly quadrupled to C$54 million. It grew again by 50 percent to C$83 million in 1991/92 and by more than 60 percent to C$135.8 million by the mid 1990s. The budget more than doubled from 2008 to 2009 due primarily to an influx of moneys from Canada's Economic Action Plan (Table 9). It dropped back in 2011/12 to below C$140 million, then grew again in the 2012/13 fiscal year by C$110 million to nearly C$280 million as part of the SR&ED reallocation. The IRAP also gets about C$1 million from the Gates Foundation for Canadian HIV Technology Development and Vaccine Initiative and another C$25 million/year under the three-year pilot Digital Technology Adoption Program. The 2013 core budget was C$137.6 million. The total 2013 budget was reported to be about C$280 million due to the additional moneys from the SR&ED for applied R&D projects.

Table 9. IRAP Budgetary Resources, 2007/8–2011/12 *(in millions of C$)*

	2007 – 2008	2008 – 2009	2009 – 2010	2010 – 2011	2011 – 2012	Total
IRAP core funding for ITAs, administration						
Personnel	32.1	33	37.7	35.4	38.9	177.1
Operating and maintenance	9.2	11.1	8.3	9.3	7.8	45.6
TOTAL IRAP core operating expenditures	41.3	44.1	46	44.7	46.7	222.7
IRAP core funding for grants and contributions						
IRAP contributions to organizations	12	11	10.7	11.4	11	56
IRAP contributions to youth employment (Non-TES)	5	4.8	5.3	8.6	5.6	29.2
IRAP contributions to firms (Non-TES)	69.1	70.7	74.2	72.6	72.7	359.2
TOTAL IRAP core grants and contributions	86.1	86.5	90.2	92.6	89.3	444.4
TOTAL IRAP Core funding	127.4	130.6	136.2	137.3	136	667.1
Special Non-TES Funding Programs (Non-TES)*						
Contributions to youth employment			9.6	19.4		29
Contributions to organizations			5.9	5.2		11.1
Contributions to firms			125.4	115.6	1.2	242.2
Personnel associated with these programs			1.2	1.2		2.4
Operating expenses associated with these programs			0.8	0.8	0.6	2.2
TOTAL IRAP special funding programs (Non-TES)			142.9	142.2	1.8	286.9
Total IRAP Budget	127.4	130.6	279.1	279.5	137.8	954

Source: Goss Gilroy (2012).

Based on the budget in Table 8, roughly 42 percent of the IRAP core budget is estimated to be for technology extension functions such as the ITAs or contributions to organizations, which in turn perform technology extension-like services. The rest of the budget is for non-TES contributions. The total C$280 million budget is equivalent to nearly 0.015 percent of Canada's GDP and a little over C$250 per establishment (all sectors). The program does not involve matching funds from the provincial government or from third party organizations.

5.5. Services

The IRAP offers four main services.

1. **Nonrepayable contributions to firms**. These awards cover 50–80 percent of personnel or subcontractor costs in R&D projects in SMEs (non-TES service)
2. **Nonrepayable contributions to organizations**. This comprises funding to support specialists to provide advisory services in local organizations in the provinces

3. **Youth employment program**. This provides funds to employ technical and business graduates as interns in SMEs (non-TES service)
4. **Advisory service**. This is a core TES-service, which can provide direct assistance to companies on aspects such as business advice, strategic planning, market assessment, strategic information, competitive technology intelligence, intellectual property searching, technology validation and technical engineering.

The first service listed above is funding SME R&D projects through nonrepayable contributions. While this is not a TES, it is useful to understand how TES can be integrated into R&D project funding to enhance the effectiveness of such funding. More than 2,000 SMEs a year benefit from these contributions. They are awarded to SMEs to conduct R&D projects not affordable with in-house resources alone. The awards are called contributions because per Canada's Treasury Board Transfer Payment Policy certain conditions are attached, in contrast to grants or contracts which require that specific deliverables be provided at the end of the award period.[15]

The award process stems from ongoing contact that a lead IRAP ITA has with a client firm. An application, residing in an online template on the NRC-IRAP Innovation Portal requires that the client provide an overview of its business, a project description, measurable objectives, budget, and other financial resources. Each application has to have a technical assessment as well as a business and financial assessment, neither of which can be performed by the lead ITA. The business and financial assessment is required to show that the firm has the finances to provide resources to complement the IRAP contribution, which does not cover the full cost of the project. Contributions cover up to 80 percent of personnel costs and up to 50 percent of subcontractor costs, and average 42 percent of the project. The contribution cannot be used for capital or other kinds of nonpersonnel expenditures. Finalized applications go to a regional director. Regional directors have approval authority up to C$350,000, executive directors to C$500,000, and the vice president has full authority. All paperwork associated with nonrepayable contributions is processed within the regions by the RCAO. Continuous efforts have been made to increase audit and quality control while balancing the burden on the SME client. Box 6 presents further details about the four main IRAP services.

[15] "Contribution (*contribution*) is a transfer payment subject to performance conditions specified in a funding agreement. A contribution is to be accounted for and is subject to audit. Grant (*subvention*) is a transfer payment subject to preestablished eligibility and other entitlement criteria. A grant is not subject to being accounted for by a recipient nor normally subject to audit by the department. The recipient may be required to report on results achieved." Source: Treasury Board of Canada Secretariat, http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=13525&section=text#appA

The IRAP does not charge for ITA advisory services, nor do its organizational partners charge for these services. In addition, there is no standard length of time associated with advisory services. ITAs provide ongoing advisory services as needed to their portfolio of clients. The program does not deliver in-depth implementation services; rather it relies on the public and private sector community for these services. However, in some cases, especially in Northern Canada, private sector firms are not prevalent, so the IRAP subsidizes (through contributions to organizations) public sector organizations to fill this gap. There is no formal certification of consultants and quality of service from third party providers is maintained by the ongoing involvement of the ITA. Infrastructure services are not offered. If clients have an infrastructure need, the ITA will refer the client to an NRC laboratory, another public research organization, or another partner, such as a university.

Box 6. IRAP Services

Canada's Industrial Research Assistance Program (IRA) offers four major program services:

Support for R&D Projects (nonrepayable contribution of 50–80 percent of personnel or subcontractor costs in R&D projects in SMEs). One example of project type funding through this service is technology validation. A technology validation project may involve establishing the measurable value of a technological solution or working with an early adopter to test the benefits of the technological solution. The SME must present a project plan describing the technological solution, the tasks involved in the project, and the approach for measuring the solution's value. The plan must also indicate how the results will be fed back into commercialization. The IRAP will provide nonrepayable contributions for one to three months of the SME client's technical staff salaries (NRC, 2010).

Funding to organizations providing assistance to SMEs. This is not a direct service to firms, but its embedding in a TES context enhances the effectiveness of organizational funding. The IRAP has formal relationships with approximately 125 organizations (changing each year) including business and industry associations, universities and colleges, economic development organizations, and other types of institutions. The objective of arrangements with these organizations is to reach and serve additional SMEs in the regions and facilitate knowledge transfer to existing SME clients. Many of these organizations house ITAs. Goss Gilroy's 2012 review of the program found that their capabilities are complimentary to those of the IRAP in that they tend to serve early-stage firms. Contributions to these organizations cover the cost of expert services plus, in some cases, a modest fee to cover processing costs (but not fully loaded overhead rates).

Youth employment. This program, which again is a funding rather than a TES type offering, enables recent graduates to do paid internships in SMEs. The graduates obtain work experience and the SMEs obtain increased technical or business capability. Participants must be aged 15 to 30 to qualify and be a recent graduate who is unemployed, or underemployed. The program will pay up to C$30,000 or 50 percent of the intern's costs for a maximum duration of 12 months (Goss Gilroy Inc., 2012). The duration of the IRAP's Youth Employment Program internship must be a minimum of six months and a maximum of 12 months.

Advisory services. Included in this category are business advice, strategic planning, market assessment, strategic information, competitive technology intelligence, intellectual property searching, technology validation, and technical engineering. These services are delivered one-on-one through a network of Industrial Technology Advisors (ITAs) and also through a brokering arrangement whereby the ITA links the SME to multiple experts and they choose the service provider. The ITA will also link companies with other companies within and outside of Canada to address technology or business needs. These services are based around the ITAs' inherent capabilities and knowledge of best practices rather than involving for example formal assessment tools. Advisory services do not include implementation (such as lean manufacturing kaizen events or preaudit assessments for standards certification); these types of services are provided through partner organizations.

Source: Authors' elaboration.

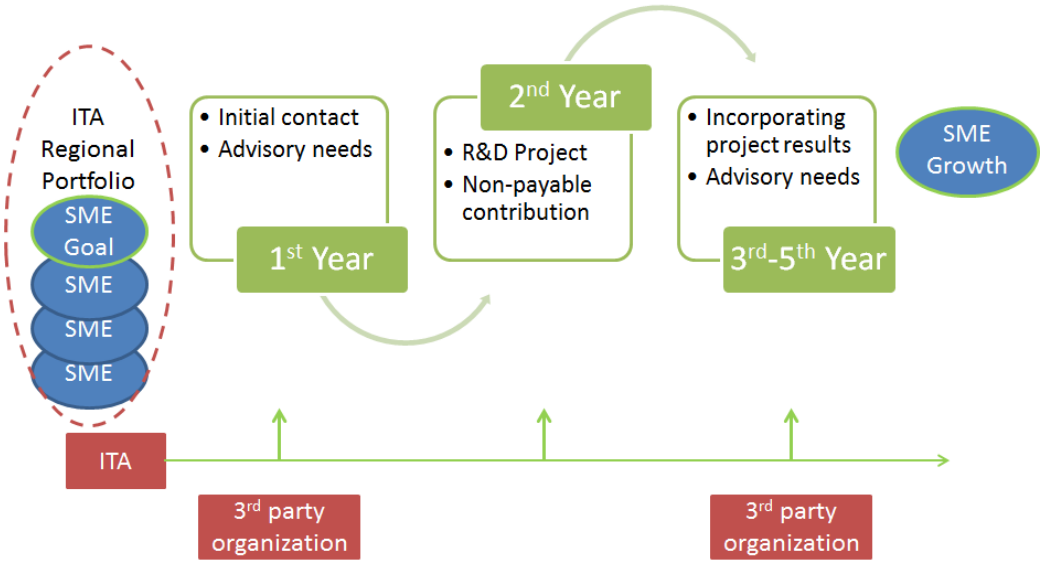
5.6. Clients

IRAP services are open to all companies with fewer than 500 employees. Canada has 2.4 million establishments, of which 1.2 million have employees; 99.8 percent of these firms have fewer than 500 employees. Firms in certain North American Industrial Classification System (NAICS) codes defined by the program as being product oriented are the primary targets. Manufacturing clients were more prevalent early in the program's history. The current composition of clients by industry indicates that one-third of the firms are in information and communication technologies and nearly 20 percent are in materials and manufacturing; about 10 percent are in each of construction, agriculture and food, energy and environment, and life sciences (Goss Gilroy Inc., 2012).

The IRAP reaches about 10,000 firms a year, roughly 15 percent of potential clients. Approximately one-third of these firms receive contributions. Nearly 60 percent of firms served through contributions are in Ontario or Quebec. In contrast, the Atlantic region, which has fewer R&D-intensive industries, receives a higher share of funding to support organizations, which in turn provide services to firms.

There is no mass marketing of the program other than the IRAP website (http://www.nrc-cnrc.gc.ca/eng/NRC-IRAP/index.html). Marketing is conducted primarily through one-on-one relationships between the ITA and the SME client in its region. The IRAP takes a portfolio approach to the economy in a given region and the SMEs within it. Each ITA works from a portfolio of SMEs and is responsible for following their economic progress over a multi-year period (collecting data for up to 5 years after the project). A typical client cycle is initiated through discussions to understand a company's business and strategy and continues with advisory assistance provided by ITAs. When the company is ready for a major innovation project, the ITA will help structure the project, secure the necessary resources and prepare the application for IRAP funding. After the due diligence process undertaken by IRAP personnel, the appropriate level of IRAP manager is provided with a recommendation for approval or rejection of an SME's request for funding. The ITA closely follows an approved project and the implementation of results and impact on the company's growth are monitored in the subsequent years (Figure 8). Customer relationships are managed through a customer relationship management (CRM) software called SONAR, which was introduced in 1998 and completely renewed in 2013.

Figure 8. IRAP Client Service Model



Source: Authors' elaboration.

5.7. Governance

The IRAP is governed by NRC rules and regulations. The NRC is an agency of the Canadian government and oversight is provided by Parliament through the Ministry of Industry. The NRC has a council of appointees from the client community to provide strategic direction. A president, an executive vice-president, and secretary general head the NRC. Amongst four vice presidents one heads the IRAP. In addition, the IRAP has a program-specific advisory board. The advisory board is comprised of 11 members: seven of whom are from industry, two from the financial sector, one from a national drug and development center, and the vice president of IRAP. The advisory board provides guidance on strategic as opposed to fiduciary affairs.

ITAs have long been given oversight flexibility. However, in recent years, their activities have become systemized. Indeed, a field manual was created in the late 2000s. The field manual resides online to accommodate the evolution and variety of situations encountered. It complies with Federal Finance Administration Act (FAA) regulations and is used primarily as a reference document. Conformance with procedures as outlined in the manual is standard. Directors can override these procedures but a written justification is required and must be stored in SONAR.

One longstanding governance issue for the program is the oversight of contribution agreements with client firms and partner organizations. A set of conditions is used to govern contribution agreements with firms and organizations. These include (NRC, 2013):

- Responsible conduct of research if the project uses human or animal subjects (firms only)
- Adequate financial records
- Evidence of personal service and contractor efforts such as time records, payroll ledgers, invoices, SR&ED claims or cancelled checks (firms only)
- Written notice of any changes to the project or relationships with subcontractors
- Acknowledgement of the financial contribution of the Government of Canada on company marketing materials
- Agreement to exploit the intellectual property developed through the project to create economic and social benefits to Canada (firms only)

If these conditions are breached, the firm or organization is given written notice. A breach may result in a modification of the contribution or at the worst, termination and requirement that the company refund the program. The firm can request release from the agreement and, through an exit payment, be freed from further obligations. The NRC finance branch performs post-contribution audits on approximately 10 percent of the contributions; these are selected at random. The post-project audit can include holding a meeting with the client to determine the status of the project and what was achieved.

5.8. Personnel

As of 2011, the Program employed 30 managers/directors, 236 ITAs, 6 analysts, 39 RCAOs and 71 administrative support employees. The typical IRAP ITA has an engineering or science background and 20 years business experience. Young engineers or scientists are not considered for this type of position, while candidates with prior positions such as director of manufacturing, vice president of R&D, general manager, entrepreneur, or CEO are preferred. ITAs as a whole are probably among the most highly qualified and experienced of any group of extension specialists in any country and the program relies on this high level of embodied knowledge in order to provide services to client firms (rather than relying on an assessment tool, for example). ITAs are hired so as to be located close to the territory in which they work so that they can drive to client meetings. Their backgrounds should allow them to be conversant with the prevalent industries in their regions; if textile manufacturers

dominate a given region, for example, ITAs are not necessarily required to have worked in the textile industry as long as they have sufficient capabilities to serve the industry.

The program does not see much turnover among its ITAs, for several reasons. The ITAs are unionized, they earn competitive salaries (within the compensation framework, i.e., pay levels of the NRC[16], which does not include incentive pay or bonuses for example), they have some freedom to meet program goals, they do interesting work and they contribute to the success of SMEs. At one point in the IRAP's history, there were two classes of ITAs: NRC ITAs and network member ITAs. Network ITAs outnumbered NRC ITAs by four to one. As of April 1, 2003 the network member ITAs were converted to NRC employees.

The IRAP has an on-boarding process for new ITAs. Orientation sessions are held at the Ottawa headquarters, in part to gain familiarity with other NRC divisions. New ITAs are teamed with veterans to call on clients and learn to use program tools. The program also has supported internal training in various soft skills and business areas such as in client engagement, marketing, and finance. More recently, Stage-Gate training has been piloted on a trial basis to support ideation capabilities. The ITAs have sector teams and informal special interest groups to enable information sharing and updating about sectoral trends, key players in the sector, and their needs.

5.9. Monitoring and Evaluation

IRAP has two main monitoring and evaluation processes. As of 2010, clients receiving nonrepayable contributions are required to complete three post-project instruments: a status of the instrument administered yearly for five years, a post project assessment administered at the end of the project, and an impact assessment also administered yearly (at the end of the project) for five years. Clients receiving advisory services only do not complete these instruments. Four gross client-level metrics are monitored:

- Revenue: total sales, money received from sales of products, gross receipts, turnover
- Income: revenues minus expenses, cost of goods sold
- Number of employees: gross number of employees
- Investments in R&D: budget lines or allocations for other R&D projects

This monitoring does not directly tie these four metrics to IRAP related assistance per se, rather it is designed to provide an overall picture of the financial health of the client after receipt of program assistance. Customer satisfaction is addressed separately. Clients can

[16] See for example, http://www.nrc-cnrc.gc.ca/eng/careers/collective_agreements/technical_category.html

share comments, recommendations and complaints concerning the service with the vice president.

The IRAP is legislatively required to undergo an evaluation every five years in which the program is reviewed for its efficiency and effectiveness. The NRC performed early evaluations, but external evaluators have been used to conduct more recent assessments. These evaluations use mixed methods approaches including document review, stakeholder interviews, surveys of ITAs, surveys of clients (firms, organizations), and cost-benefit analysis. Quasi-experimental designs and comparison groups are not used, with the exception of a couple of special studies in partnership with Statistics Canada, which enabled a comparison of clients and nonclients. The most recent of these was performed in 2007, when the performance of 700 clients in British Columbia was compared with that of 370,000 matching nonclients (NRC, 2007); this study found that IRAP clients had five times the shareholder equity of nonclients and four times the growth in average shareholder equity from 1998–2002. The most recent external evaluation used the following measures (Goss Gilroy Inc., 2012):

- Number of companies and organizations served (typically about 10 percent of target clientele base of SMEs): program reach, either companies or organizations receiving contributions or companies or organizations receiving advisory services
- Number of R&D projects funded: number of companies receiving contributions for R&D projects
- Satisfaction with service: timeliness in funding decisions, receipt of awards, receipt of payments, quality of referrals
- Intermediate measures of increased technical and business capacity: measured by a series of survey questions eliciting the percentage of IRAP clients agreeing that the program helped increase the firm's business skills and knowledge and scientific and technical knowledge, that it led to enhanced technical knowledge or capabilities, enhanced ability to perform R&D, and enhanced business knowledge/capabilities.
- Intermediate measures of employment: jobs created or retained in the firm, and the percentage that are in R&D related positions
- Intermediate measures of R&D: extent to which the program helped the client develop intellectual property, increase overall productivity, and create new or improved products or processes
- Intermediate measures of commercialization: the extent to which the program increased a firm's production or service provision capacity, product or technology commercialization, domestic or international market share

- Rival explanation: Share of clients for which the project would not have succeeded without funding
- Company value: shareholder equity of clients versus nonclients (NRC, 2007)
- Social benefits: effect of the funded project on environmental, health, safety, and security for Canadians, including reducing negative environmental effects.
- Benefit cost ratio: the ratio of benefits to costs of clients served as measured by the national budget allocation; recent evaluations have estimated this ratio at more than 11:1 (Kijek, 2010).

The IRAP does not distinguish results associated with grants and contributions from those associated with advisory services. For the most part, any client that received a contribution also received advisory services. Nevertheless, several of the indicators from the Goss Gilroy assessment have a more direct association with advisory services and the results for these indicators are:

- Quality of referrals (83 percent of clients satisfied or very satisfied)
- The program helped increase the firm's business skills and knowledge (70 percent of clients agree)
- The program helped increase the firm's scientific and technical knowledge (90 percent of clients agree)
- The program led to enhanced technical knowledge or capabilities (90 percent of clients agree)
- The program led to enhanced ability to conduct R&D (62 percent of clients agree)
- The program led to enhanced business knowledge/capabilities (68 percent of clients agree).

Several recommendations have been made in these evaluations. These recommendations concern (i) the need for more inclusive monitoring systems (across all services provided), (ii) a greater role for the ITAs in initial client selection, (iii) improved costing of contribution program management, (iv) more systematic mechanisms for client feedback, (v) greater integration of the program with other NRC offerings, and (vi) more comprehensive ongoing feedback on all aspects of the program. The IRAP-NRC is required to respond to each of these recommendations in writing. It has, for example, developed a formal monitoring system (SONAR) in response to a prior set of recommendations.

5.10. IRAP Regional Case: Province of Ontario

The IRAP operates through a national program framework so each region operates the same way (albeit some regions have more offices and ITAs because they are larger). This case study profiles the Province of Ontario because of its size and its representativeness of how the program operates. Ontario is the largest province in Canada by population and number of establishments and accounts for nearly 40 percent of Canada's GDP. More than one-third of all employer establishments with fewer than 500 employees operate out of Ontario. It is the fourth largest province in square miles, comprising 10 percent of the country's land area. The automotive industry is strong in the southwestern part of the province. Information and communication technology is also prevalent in part a result of Waterloo-based Blackberry LTD (formerly Research in Motion) as is agribusiness and life sciences. Northern Ontario has nodes of activity in the technology and life sciences domains as well as traditional manufacturing and agribusiness.

The Ontario provincial government has developed an active innovation support system. The province has supported the creation of industry/academic cooperative programs, centers of excellence, research fellowships, networking associations, regional innovation centers, business incubators and accelerators, and venture funds (Ontario Ministry of Research and Innovation, 2013). IRAP seeks to complement these offerings.

Ontario has roughly 100,000 small and medium-sized establishments that are product or service based and interested in growing through innovation. The IRAP regional office in Ontario, as is the case with each region, conducts an analysis of the landscape to identify trends, gaps, and challenges. The program is responsible for following the longitudinal progress of SMEs in the region.

Seventy ITAs located in 35 offices in the region serve these SMEs. The ITAs reside in the Ontario regional headquarters in Toronto, three additional Toronto locations (Seneca College in Markham, MaRS in downtown Toronto, and in the Oakville Corporate Centre in Oakville), the Communication Research Centre in Ottawa, the Accelerator Centre at the University of Waterloo near Blackberry LTD and various partner organizations distributed throughout the province such as the Northwestern Ontario Innovation Centre in Thunder Bay. These ITAs are managed by one of five regional directors.

The budget of the Ontario region is about C$65 million for contributions and C$3 to C$4 million for salaries and operations. The operations category includes a travel budget, which is allotted to each territory and through which travel claims are submitted. In 2009 and 2010, the region received additional funds in part to provide support for the downturn in the automotive sector in southwestern Ontario. This sector has since experienced an upswing in business activity.

The typical ITA in Ontario manages a portfolio of 60 SMEs in his or her territory. Of these, the ITA typically works with 40 a year, providing primarily advisory services. One quarter of these firms may receive contributions, which are staged throughout the year depending on client progress. The Ontario region issues awards to roughly 1,000–1,200 SMEs a year and provides contributions to another 50 organizations for service delivery.

Nonrepayable contributions are processed within each region. The procedure begins with client projects that have received recommendations from the lead ITA and the two other ITAs who have performed technical and business assessments. The final decision is made by the director or, depending on the project's size, the executive director or vice president. The contract is let and signed by all parties. Client companies then work on the project and submit a claim to indicate this work. Claims are submitted electronically along with backup documentation. The RCAO administers all the electronic paperwork processing the claim, followed by a review and authorization by the ITA. The Ontario region has six RCAOs each managing roughly 150 nonrepayable contributions a year. Progress reports are processed alongside each claim and final reports are produced at the end of a project.

5.11. Conclusions

The IRAP is a well-established program that continues to be held in high regard in Canada and attracts increasing funding to expand into new areas of service delivery. One of the program's strengths is its ability to combine technology extension and R&D project funding in SMEs, which produces tangible benefits and returns to the Canadian economy. On the other hand, the program lacks a robust system to capture what its ITAs do on the nonfunding side of program services. As such, many of the expanded initiatives are focused on the R&D project funding side rather than the technology extension side of the program. Likewise, the program provides funding to organizations, which in turn deliver services to SMEs, but there is limited information on the performance of these organizations. The lack of a robust monitoring and evaluation system, apart from the five-year legislatively mandated evaluations, lies at the core of these challenges.

6. The Manufacturing Advisory Service in England

6.1. Introduction

The MAS (Manufacturing Advisory Service) provides manufacturing business support for companies based in England with the objective of helping manufacturing businesses to

improve and grow. The MAS is wholly owned by the UK Department of Business Innovation and Skills (BIS) and is financed almost entirely by BIS.[17] It is currently operated under contract to BIS by the Manufacturing Advisory Consortium (MAC) for three years (2012–15). The MAS represents a significant government intervention to support the manufacturing sector and in particular SMEs in this sector.

The manufacturing industry in the UK employs around 2.6 million people and in 2013 accounted for 11 percent of UK gross value added (GVA)[18] and 54 percent of UK exports.[19] In the global landscape, the UK is the 11th largest manufacturer in the world[20] and manufacturing accounts for the largest part of UK exports. Output in the sector declined particularly sharply during the 2008/2009 recession, but recovered by 2010 and has grown modestly since then. More than 70 percent of business research and development goes into the manufacturing sector and goods produced in the sector account for nearly half of all UK exports (Maer and Rhodes, 2013). Manufacturing is vital to the economic prosperity of the UK and accordingly the current government has included advanced manufacturing in the first stage of a process entitled the Growth Review. The HM Treasury (2013) report stated that the sector would benefit from a range of measures, including bringing forward the launch of an enhanced Manufacturing Advisory Service (House of Commons Library, 2013).

From January, 2012, as a result of the Growth Review, the MAS was given an additional specific focus on strategic and technical support for SMEs developing advanced manufacturing capabilities and creating high value jobs. Support was also targeted toward enabling business improvement for manufacturers operating in global supply chains and linking SMEs with an apprenticeship program facilitating a minimum of 1,250 engineering and manufacturing apprenticeships annually.

Manufacturing business support (along with other economic development and business assistance activities) is a devolved function in the current UK system of administrative governance. In Scotland, manufacturing advisory services (SMAS) are offered through Scottish Enterprise.[21] During the period 2007/2008–2009/2010, expenditure on SMAS was £5.06m.[22,23] In Northern Ireland and Wales, existing manufacturers can receive support respectively from Invest Northern Ireland and Business Wales. The MAS is the

[17] Some additional funding has been secured through European Commission ERDF scheme.
[18] Gross value added (GVA) is a measure in economics of the value of goods and services produced in an economy or in area, industry or sector.
[19] EEF, UK Manufacturing 2014 the FACTS - http://www.eef.org.uk/NR/rdonlyres/1EC00841-E738-44A3-A837-DFBEC00DF99B/23672/1402EEFFactCard_NB.pdf
[20] The UK's world ranking is from the UN national accounts and refers to 2012
[21] In 2012, Scottish Enterprise evaluated its Efficiency Support and this included an evaluation of SMAS. Strategic Evaluation of SE Efficiency Support (including the Scottish Manufacturing Advisory Service)
[22] British pounds (£) are used this case. £1 = US$1.631.
[23] The total expenditure on the efficiency program over the period 2007/08 to 2009/10 was £13.2m, most of which was spent on the BE (non-SMAS) strand of support (£8.1m or 62 percent). Expenditure on SMAS was £5.06m (38 percent). The BE element was fully funded by SE whilst the SMAS element was partly funded via ERDF (£501,400, 10 percent) and company income (£807,400, 16 percent).

national manufacturing advisory service for England. Although larger companies can receive services (at cost), SMEs in England are the main focus of MAS publicly sponsored services. There are about 97,700 active manufacturing firms with 250 or fewer employees in England, representing more than four-fifths of all manufacturing SMEs firms in the UK About 93,000 English SMEs employ fewer than 50 employees.[24]

6.2. Evolution of the Manufacturing Advisory Service

The history of the MAS dates back to 1977. Interim studies of the service were carried out during 1978–81. Encouraging results were instrumental in securing a marked expansion of the MAS in 1983.[25] Since this time the service has been much reorganized and changed. It was re-launched in 2002 by the then Department of Trade and Industry. From 2002 to 2011 the MAS was organized on a regional basis and was designed to offer technical and strategic advice to SMEs. The regional offices were titled as Centres of Manufacturing Excellence. Under this regional model, regional development agencies and the BIS funded the regional centers and they were run by separate organizations in each region; for example in the North West of England the Manufacturing Institute based in Trafford Park, Manchester, ran the service from 2002–2011.[26]

In December 2010[27] and again in January 2011[28] the BIS organized two MAS stakeholder events to inform MAS policy decisions going forward from April 2012. Topics discussed and reported on included the possible leveraging of European Regional Development Funding (ERDF) for the MAS to reach out to more manufacturers and tailor the service to local needs and priorities: to not only maintain funding levels but to actually increase funding.

In 2011 a decision was made by the government to reacquire the service and, effective January 1, 2012, the MAS became a national service. This revision of arrangements was linked to the abolition of the Regional Development Agencies and to the austerity program in the UK as the revised service would be subject to a 25 percent budget

[24] FAME database, accessed November 2013, enterprises in SIC 2007 codes 10–32 (manufacturing).
[25] In 1987 the DTI "closed the productivity element of the Business and Technical Advisory Service (the successor to MAS) to allow BTAS assistance to concentrate on helping small and medium-sized firms put more effort into design, quality management and marketing." http://webarchive.nationalarchives.gov.uk/+/http://www.dti.gov.uk/iese/aurep01.html
[26] http://www.manufacturinginstitute.co.uk/
[27] http://webarchive.nationalarchives.gov.uk/20110614205941/http:/www.mas.bis.gov.uk/news/slides-MAS-policy-workshop.pdf and http://webarchive.nationalarchives.gov.uk/20110614205941/http://www.mas.bis.gov.uk/news/MAS-policy-workshop-report.pdf
[28] http://webarchive.nationalarchives.gov.uk/20110614205941/http://www.mas.bis.gov.uk/news/stakeholder-meeting-slides-27jan.pdf and http://webarchive.nationalarchives.gov.uk/20110614205941/http://www.mas.bis.gov.uk/news/stakeholder-meeting-report-27jan.pdf

cut. The Manufacturing Advisory Consortium (MAC) now delivers the national program. This consortium comprises the accounting and business advisory firm Grant Thornton UK LLP, Pera Consulting Ltd., the West Midlands Manufacturing Consortium Ltd. (WMMC) and the South West Manufacturing Advisory Service Ltd. (SWIMAS). Grant Thornton leads the contract and subcontracts the three other organizations to run regional MAS operations.

The BIS ran a competitive process to appoint the consortium to run the service and selected the Manufacturing Advisory Consortium from the contenders. This consortium has a three-year contract run the service. The situation will then be reviewed and either the contract renewed or a further competition launched. Other consortia that bid to run MAS included the Manufacturing Institute. Although its consortium was unsuccessful, the Manufacturing Institute is still involved in the delivery of the MAS in the North West of England.

The various stages of the development of the service are identified as MAS I through MAS IV. At the outset in 2002, the MAS was created in recognition of underperforming manufacturing companies in England and designed as a response to productivity issues. The first two contracts for the MAS (MAS I and MAS II) were much focused on productivity improvement. For the third contract (MAS III) the Regional Development Agencies were tasked to deliver services and it evolved more as a brokerage service, a one-stop shop for manufacturers. Under the latest contract (MAS IV) the service offers comprehensive manufacturing assistance for manufacturers. Under MAS IV, everything from strategy to people development to productivity improvement and new product development is provided as a much stronger feature than it was in earlier bids.

Although the MAS has evolved over time (see Table 10), from a national policy perspective it is one of the few programs to survive the restructuring of the UK business and innovation support landscape. It sits centrally in the business support structure of the Department of Business, Innovation and Skills and is one of the few direct delivery schemes, along with the Growth Accelerator and UK Trade and Investment (UKTI) services that are available to businesses in the UK. From the BIS viewpoint, MAS is part of the core enterprise delivery that they provide and is a very specific service for manufacturing. The policy support team for the MAS is located in the advanced manufacturing and supply section of the BIS.

Table 10. MAS Timeline, 2002–2015

MAS Phase	Period
MAS I	2002–2005
MAS II	2005–2007
MAS III	2007–2011[29]
MAS IV	2012–2015

Source: Authors' elaboration from MAS reports and interviews.

The evolution of MAS IV delivered by the MAC, and the introduction of a national consortium to lead the service, represent significant change to the program. Prior to 2012 and the MAS IV contract, the Regional Development Agency (RDA) led the service. Until March 31, 2012, there were nine RDAs, nondepartmental bodies in the UK. RDAs were originally established in 1998 to enhance economic development and one RDA existed for each of the Nomenclature of Units for Territorial Statistics (NUTS) level 1 regions of England.[30] The decision to abolish them was taken in 2010 as part of the austerity agenda, with a view to reducing the government deficit. There was no direct replacement for the RDAs as the newly formed Local Economic Partnerships (LEP) tasked to take on some of the responsibilities of the former RDAs do not receive any funding from central government and local councils have not received an equivalent injection of income from central funds. The UK Central Government Treasury funded RDAs[31] and the budget for the RDAs was £1.76 billion in 2010/2011.

The MAS core contracts were issued centrally from the BIS but to the RDAs who delivered the service. The RDAs complemented the service with additional funding and individual initiatives and activities within each region. This meant that each RDA led contract for the delivery of the MAS actually evolved and became quite different and that there was no unique and common set of indicators emerging from delivery of the MAS. All RDAs delivering the MAS did have to use GVA as an indicator but they measured it slightly differently and the variation in indicators across the various RDAs made it quite difficult to compare and contrast different ways of running the service. The indicators that the MAC now use emerged from the review process conducted by BIS when the decision was made to bring the MAS back into a national delivery model and to procure the service.

[29] http://webarchive.nationalarchives.gov.uk/20110614205941/mas.bis.gov.uk/

[30] Similar activities were carried out in Wales by the Welsh Government Department of Economy and Transport, in Northern Ireland by the Department of Enterprise, Trade and Investment and in Scotland by Scottish Enterprise and Highlands and Islands Enterprise.

[31] Funded from HM Treasury via six different central government departments: Department for Business, Innovation and Skills; Department for Communities and Local Government; Department for Energy and Climate Change; Department for Environment, Food and Rural Affairs; Department for Culture, Media and Sport; and UK Trade and Investment.

This new model (MAS IV) emerged from the best operational practices elsewhere but also allowed it to be cross compared with other support delivery for which the BIS is responsible to create fairly common indicators and to standardize outcome measures across the other business support services.[32] From the BIS perspective they are now more able to evaluate and understand which elements of service are working well and which are not.

6.3. Structure and Operational Model

Via the national consortium led by Grant Thornton, the MAS draws on private sector expertise and national sector specialists to provide services to local businesses through a consistent delivery framework. The decision to change the operational model arose due to the abolition of the RDAs. The MAS is now delivered through a single organization, with the aim of delivering national consistency in service provision and ensuring that all services are available to companies throughout England. It has been suggested that this single organization model allows better sharing of best practice, although regional differences continue.

The role of the lead private operator Grant Thornton is in part to deliver the service in the South East of England. It has also taken on the role of lead contractor for the consortium and deals directly with the MAS on behalf of the consortium in all matters related to the contract. In essence there are two parts to the government's relationship with the appointed service delivery team. On the one hand there are management board meetings every month for all the consortium members to discuss aspects of service delivery. On the other hand, there is a quarterly contract review session, which is between the BIS and Grant Thornton as lead contractor. This effectively means there is a separation of the issues of practical delivery, where the BIS engages with the whole consortium, and contractual issues where the BIS speaks solely to Grant Thornton.

Although a national service, the MAS is delivered in England through four regional operations, and these can be viewed as regional based centers. The advisors are managed through one of the four regional areas and operate out of one of the regional centers only. Regions have different practices and advisors may work differently in each. The four areas are London and the South East, the South West of England, the North and West of England, and the East of England (Map 3). The West Midlands Manufacturing Consortium (WMMC), one of the regional delivery partners of the MAS in the North and West of England, is profiled in Box 7.

[32] Towards the end of 2014, MAS became part of the UK Government's Business Growth Service – a gateway to a range of business services for SMEs (see: http://www.greatbusiness.gov.uk/businessgrowthservice/).

Map 3. MAS Regions (England)

Source: Manufacturing Advisory Service (Regional designations as of 2013).

Box 7. The West Midlands Manufacturing Consortium

The West Midlands, and the North East and North West regions of England have long had a strong manufacturing presence, particularly the automotive industry in the West Midlands, but this industry has experienced declines in recent years. Conversely, new and developing technology is flourishing and a good proportion of the UK's pharmaceutical, medical and process engineering production is carried out in the North West. Nearly one-third of all manufacturing employment in England is in these two combined regions.

One of the regional delivery partners of the MAS in England is the West Midlands Manufacturing Consortium (WMMC). WMMC was established in 2002 as a special purpose vehicle to deliver the MAS in the West Midlands. WMMC Ltd. was set up as a not-for-profit company by three member organizations, Warwick Manufacturing Group, the Engineering Employment Federation (EEF) and Business Link West Midlands. Since its creation it reports that it has worked with nearly 17,000 manufacturers, delivered 5,484 in-depth interventions and generated around £100m of Quality Cost and Delivery (QCD) improvements per year. In addition to the MAS, WMMC delivers sector support programs for Rail (Rail Alliance), Aerospace (SC21) and Automotive and has also run the Inside Manufacturing Enterprise which worked with local businesses and schools to encourage 14-17 year olds to work in the manufacturing sector.

WMMC is currently contracted to Grant Thornton to deliver the MAS in the North East and North West regions of England in addition to the West Midlands. This is a three-year contract in the first instance. It may be renewed for one further year or may be put out to competitive tender again; this has yet to be decided. There is a board for the regional delivery of the MAS that comprises two members each from the Warwick Manufacturing Group, the EEF and the delivery team–Area Manager MAS and Finance Director Area MAS–plus two people who are independent appointments, both of whom used to work for the car manufacturing company Rover. The composition of the board was designed to ensure a good representation of the manufacturing community, although it does seem mainly representative of the West Midlands element of the region.

Source: Authors' elaboration from MAS interviews and reports.

The MAS also maintains multiple strategic partnerships, including with Growth Accelerator, UK Trade & Investment (UKTI), the Technology Strategy Board and Local Enterprise Partnerships (LEPs). These agencies offer a range of mentoring, growth, export, technology, and other business support services. The UK Government expects these various agencies to collaborate to deliver a connected approach to business support. The MAS, for example, refers manufacturing companies to the relevant partner agencies; a company with a growth strategy including exports would be referred to UKTI and if a company has a problem with leadership, the MAS would refer that company to the Growth Accelerator which offers a management and leadership program.

The MAS has evolved over time and it is one of the few facilities that has survived the revamps and changes to the structure of service support from a national policy point of view. From the BIS perspective it sits centrally as part of the business support structure. The BIS supports few direct delivery schemes at present and when considering business support services Growth Accelerator[33] and UKTI[34] are always included because they are the key direct delivery end services BIS currently have in place. The BIS funds the rest of the investment in services supporting business, but the delivery is at arm's length, not directly by BIS. These include the Advanced Manufacturing Supply Chain Initiative,[35] which is more reliant on other partners in delivering its particular objectives. The MAS is a central part of the core enterprise delivery services of the BIS but is distinctive because of the specific services provided and its focus on manufacturing.

6.4. Program Scale and Financing

The annual funding available to the MAS from the BIS was reduced from £20m in 2010 to £15m in 2011, as part of the government's austerity drive to reduce public expenditures following the global financial crisis. Subsequently, as the government has shifted more towards a growth agenda, additional funding has been made available to the MAS. The UK government has committed £50 million over three years commencing in April 2012 to provide what they describe as an enhanced service through the MAS, tailored to suit the needs of the individual business and the local economic environment. The annual budget for 2013 was £19m ($30.7m). Additional funding came in 2014 in the form of E.U. European Regional Development Funding (EDRF) and providing an additional £10–12m. Two MAS regions—the South West and the North and West areas—have now secured ERDF funding. The South West MAS received ERDF funding for two specific projects, whereas the

[33] Note both Grant Thornton and Pera are also involved in delivery of this service.
[34] See https://www.gov.uk/government/organisations/uk-trade-investment.
[35] See http://centreofenterprise.com/amsci/.

North/West MAS secured ERDF funding to extend the service. The other two regions have not yet applied for ERDF. This is likely to lead to a mixed picture of funding across the various MAS regions, and related regional differences in service scale and scope.

The national dimensions of the service that are increasingly important are the sector and the supply chain offers as these do not respect regional boundaries constructed from historical or administrative convenience. The MAS is seeking national focus and coordination in both of these dimensions. Yet, although the framework is set nationally, there are different providers, varying needs to respond to different sectoral and local circumstances and differences in the availability of and access to ERDF funding across the four regions.

MAS (2013) (covering the period January 1, 2012 to March 31, 2013) offers some insight into performance and the number of firms that received MAS support and provides a comparison against targets (Manufacturing Advisory Service, 2013).

- 12,093 business reviews delivered to manufacturers (target 10,294)
- 2,341 in -depth support projects completed (target 2,064)
- 3,965 in -depth support projects currently in progress (target 3,329)
- 7,277 new jobs forecast by manufacturers (target 4,955)
- 19,985 jobs safeguarded
- £619.6 m of Gross Value Added (GVA) for the English economy (target £301.4m)[36]
- MAS reports delivering over a return on investment that is over twentyfold (target 14:1)

Since the MAS IV contract began in 2012 the MAS has undertaken the following:

- 25,000 enquiries (Level 1)
- 19,500 manufacturing diagnostics (Level 2), 13,100 of which were individual companies
- 600 (Level 3) events and best practice visits
- 4,800 intensive interventions (Level 4) with a further 1,900 active currently

From the BIS perspective the contract is national and run on identical lines in all regions. It is managed by the MAC, which is made up of four partners with a regional presence. These regions are aligned to old Government Office (GO) boundaries[37] and bid for ERDF funds within these boundaries. The BIS is most definite that this is a national contract and should be seen as one; the resource flexes across boundaries when necessary and the staffing is aligned with the manufacturing base.

[36] The GVA data is from the Blue Book (ONS, 2013). The data refer to 2012.
[37] Government Offices for the Regions were established across England in 1994 and closed in March 2011 http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/administrative/england/government-office-regions/index.html

6.5. Services

The MAS provides companies with direct access to expert advisors, who work with them to identify and implement productivity and innovation improvements to their business. The MAS states their service is driven by strategic insights gained through a continuous feedback loop with industry. There are 800 plus strategic reviews with companies performed each month. Critical research from the MAS National Barometer is also used to guide service offerings. Core services provided by the MAS are focused on its stated aim to help manufacturers streamline their processes, reduce waste, become more energy efficient and generally improve and grow the business (Table 11).

Table 11. Core Services Offered by MAS

MAS Core Service	Elaboration
Strategic support	Performance benchmarking Business model development Finance Expert program for manufacturing SMEs Leadership training and workforces development Market analysis and sales planning
Achieving manufacturing efficiencies	Applying lean techniques across the whole business Improving quality and delivery performance Implementing 5S and visual management Building effective teams Value stream mapping and process mapping Waste reduction
Commercialization of ideas	Assistance with produce idea generation Using automation and design for manufacture and assembly Intellectual property review audits Sourcing prototyping partners Assistance with conformance and compliance Identifying routes to market

Source: http://www.mas.bis.gov.uk.

The delivery model for the MAS services has a five-level structure (see Box 8). A telephone helpline is available to companies and it can conduct a free manufacturing review for SME manufacturers, offer subsidized consultancy (up to 50 percent), and organize appropriate local events for manufacturing companies. The final level of the service provision is referral to other organizations (i.e., the brokerage element of the MAS).

Box 8. MAS Services: Five Levels

The MAS offers a five-level service model to manufacturing companies delivered or coordinated by its expert advisors. The levels are not necessarily followed by companies in a linear fashion, but are used by MAS to categorize the types and intensity of its service offerings.

Level 1 Enquiries	Experienced advisors who are geographically dispersed around the country provide support at the Level 1 stage. Advisors provide local support to address initial requests from companies and to suggest appropriate next steps. Online support packages are also available to companies who access the service via the MAS website.
Level 2 Manufacturing Review	At Level 2, the MAS provides an onsite specialist manufacturing diagnostic review. This is usually one day, but may be two days for more complex businesses. A diagnostic process based on the principles of Manufacturing Excellence is used. This has been developed in conjunction with the Warwick Manufacturing Group and includes comparisons against best-in-class performance. In addition, a Fast Track telephone Level 2 review is used for common, well-understood issues. The Level 2 review usually results in a series of business improvement actions for the client.
Level 3 Events	Level 3 involves training and networking events, including best practice visits. This is an integral part of delivering the business improvement actions identified in Level 2. It is complemented by a sustainable improvement community using best practice social networking procedures to provide peer-led best practice examples and less costly forms of self-help.
Level 4 Consultancy	Level 4 services provide support for additional consultancy, with a three-tier menu of project support options. (i) MAS Foundation Service: Funding up to £1,000 (or a maximum of 50 percent) toward an improvement project, targeted at companies who need basic low-level help. (ii) MAS Step Change Service: Funding of up to £3,000 (or 5 percent maximum) toward a more significant improvement program. (iii) MAS Transformation Service: Funding of up to £10,000 (or 50 percent maximum) for a strategic change to the business.
Level 5 Referrals	Under Level 5 referrals, MAS advisors are responsible for identifying partner organization support. The advisors retain responsibility for the referral until it is demonstrated and confirmed by the client that the partner organization has addressed the client need.

Source: http://www.mas.bis.gov.uk.

The MAS also offers supply chain support. This includes helping SMEs diversify into advanced manufacturing supply chains, aiding original equipment manufacturers and their supply chains to develop better relationships and greater efficiency, and assisting groups of SMEs in supply chains or clusters to interact more effectively. MAS supply chain projects use the processes available through Levels 1–5 with custom implementation packages assembled to suit client needs, delivered by a team of dedicated supply chain experts. The way in which the MAS operates avoids unfair competition with private sector providers; MAS primarily acts a broker and, like other field services such as the U.S. MEP, reduces

transaction costs, opens up new market opportunities, and ensures quality control in linking SMEs with private sector consultants.

6.6. Clients

A dedicated approach has been developed by the MAS to support the key sectors highlighted in the government's Industrial Strategy (BIS, 2012). The BIS has selected these sectors as offering the best opportunities for growth and where UK manufacturers have a particular strength or competitive advantage. The focus areas are a mix of established and new industries and include the automotive, nuclear, oil and gas, aerospace, offshore wind, and chemical sectors.

Any manufacturing company can avail itself of MAS support.[38] While any size of business can apply for MAS assistance, funded (subsidized) support is available only to SMEs (fewer than 250 employees, annual turnover under £40m, and not part of a group which exceeds these criteria). Additionally, in practice, the MAS indicates that there is an emphasis on working with more capable larger SMEs. There is no differentiation in terms of the key performance indicators (KPIs) but the MAS prefers to focus on the larger SMEs, these are categorized as companies with 30 people plus with £5–10m in annual sales. A challenge is that the majority of British manufacturing companies employ fewer than 30 people and have annual sales under £2m (90 percent of the manufacturing companies in the UK are SMEs and 90 percent of them employ less than 25 people).

6.7. Personnel

The MAS has four area directors. Each area director has responsibility for a region of England. The four areas are London and the South East, the South West of England, the North and West of England and the East of England. Each sub-region has from 4 to 12 manufacturing advisors (Table 12).[39]

[38] The MAS defines a manufacturer as an enterprise involved in the process of "getting raw materials to goods and their associated services." Even if a company outsourced its production, it would still be included as a manufacturer in the MAS definition. http://www.mymas.org/manufacturing-support/who-we-can-help.
[39] Source: MAS website (accessed August 2013); North West region validated by interview with NW MAS advisor.

Table 12. MAS Personnel, 2013

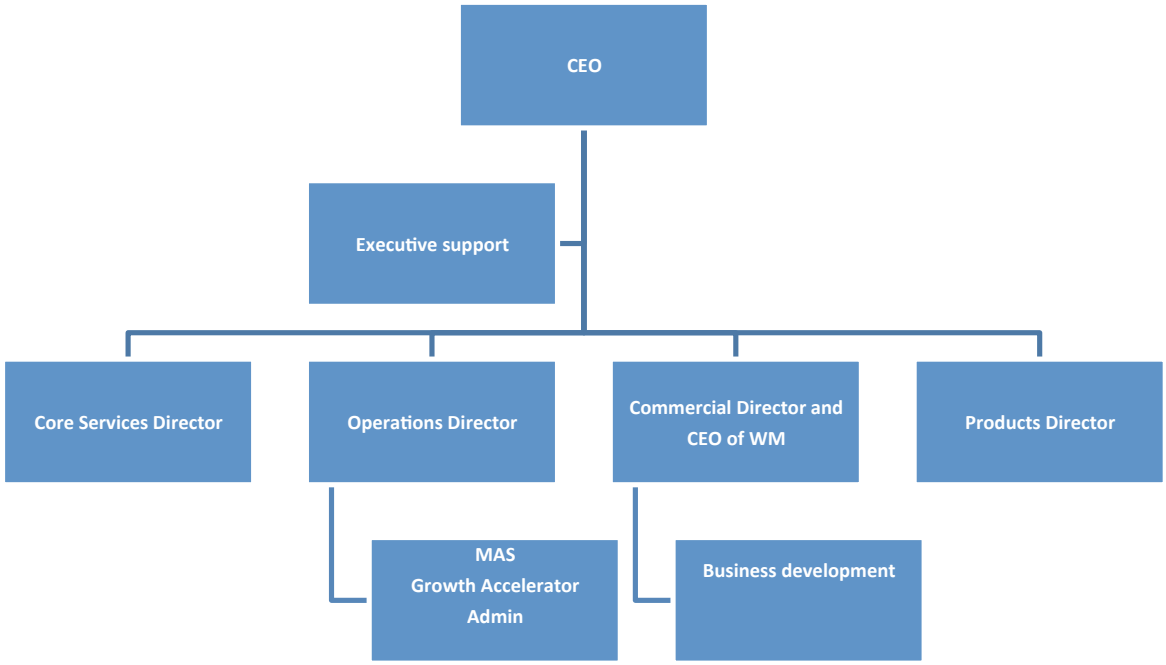
Area director	Region and Sub-region	Manufacturing advisors
Director for London and SE	London	4
	South East	9
Director for South West	South West	18
Director for East of England	East Midlands	7
	Yorkshire and Humber	7
	East of England	12
Director for the North and West of England	West Midlands	12
	North East	4
	North West	8

Source: MAS interviews, 2013.

MAS advisors typically have an engineering background. Most have worked in industry (e.g., as production managers) or have other hands-on manufacturing experience. Examples of MAS advisor experience and expertise are summarized in Table 13. Using this experience as the foundation for the job requirements, the MAS then trains and develops advisory skills. The advisory staff benefit from a performance related pay structure. For the advisors, performance measures are linked closely to the contract measures that the MAS has to deliver. An element of the non-client facing staff is linked to overall performance of contractual targets plus their own performance measures geared to the role of the individual.

Figure 9 presents the organizational chart for the North and West of England MAS region. The MAS core advisors for this region report directly to the operations director. In addition to the core advisors (shown in Table 13), there are sector specific advisors. There is only one at present for the automotive sector in the North and West of England MAS and one for the South of England for offshore wind but further specialist advisors are being recruited.

Figure 9. MAS North and West of England, Organization Chart



Source: Authors' elaboration from MAS interviews, 2013.

Table 13. Examples of MAS Advisor Expertise, MAS NW Region

Background	Experience	Skills	Sectors
Experienced manager with a background in engineering, design and change management	Highly experienced in production engineering activities with a broad knowledge of issues related to implementing and sustaining lean manufacturing	Manufacturing process Design Production End of life recycling	Electronics Refrigeration Mechanical assembly
Held a number of senior positions in the manufacturing sector	As director of a manufacturing operation, led team of 180 people, grew turnover, and reduced operational costs through the implementation of lean business principles	Operational Improvement Lean Office Lean Manufacturing Benchmarking	Furniture General manufacturing Aerospace Healthcare
Experienced manager with laboratory experience. Held posts as operational excellence manager, logistics manager and consultant	Manufacturing and supply chain experience in blue chip companies	Efficiency Strategy Planning and scheduling Performance measurement Supply chain Logistics Process improvement	Food Automotive Continuous Manufacturing

Source: MAS interviews, 2013.

6.8. Infrastructure

Infrastructure provision (including use of equipment, laboratories, or testing) is not provided directly within the MAS program. However, the MAS provides brokerage support for clients who have infrastructure requirements. For example, the WMMC (West Midlands) MAS would take clients to Warwick University (with its internationally recognized Warwick Manufacturing Centre). This is part of the MAS role: to know where appropriate facilities and equipment are available for businesses and broker the clients with that infrastructure

6.9. Monitoring and Evaluation

The Department for Business Innovation and Skills sets targets for the MAS. The targets are set out in the main contract with the lead contractor, Grant Thornton, and reflected in the subcontracts with the regional MAS delivery teams. The MAS (2013) identifies several KPIs used to assess MAS performance. These are essentially quantitative indicators and include the following:

- Business reviews delivered to manufacturers
- In-depth support projects completed
- In-depth support projects underway
- New jobs forecast by SME manufacturers
- Jobs safeguarded
- GVA for the English economy
- Days of in-depth consultancy provided
- Value of media coverage secured
- Number of followers on Twitter

In practice, the two key measures for a business supported with a grant by MAS are related to GVA and jobs. The business is asked at the beginning of the process how they believe the grant will improve their GVA and how many jobs it will safeguard or create. The MAS subsequently monitors that original assessment. These figures are reported through the Business Activity Tracker (BAT).

Importantly, the current indicators have emerged from the process that the BIS underwent when the decision was made to bring MAS back into a national delivery model and to procure the service. This reorganization allowed the BIS to select performance indicators that allow cross comparison with other support delivery under its remit. Thus when the BIS is evaluating they have a better chance of understanding what is working and what

is not across all their business support delivery services. There is, however, an element of performance measurement that is specific to MAS and these are the related to the MAS levels of service provided (1–5).

The regional monitoring process registers volume of activity across the various levels of service provision, for example the numbers of Level 1 enquiries are recorded. At the start of every business intervention the MAS conducts a Level 2 business review. If at this stage a need emerges and the MAS believes it can support the business financially then the business will be asked: if you receive MAS support how will that improve your GVA, by how much will it improve your GVA; will it create new jobs and if so how many? Subsequently the MAS will revisit and conduct a further Level 2 Business Review to reassess the initial answers provided and then record the results. The MAS establishes the baseline figures in the first review and also collects the metrics to work that out in the first Level 2 review; a year later the MAS will conduct another review to monitor what actually happened to the business versus what was predicted to happen. Using this process the MAS gathers the required indicators for monitoring and assessment of the program achievements. This monitoring is repeated in subsequent years.

The reporting process allows advisors to record their activity at the local level on their laptops or tablets. Material is scanned in and the advisor automatically generates documents and this input is available directly to BIS through its computer network. This allows BIS to generate reports easily and analyze in depth the regional and sectoral MAS activity. The monitoring system is a usable Customer Relationship Management (CRM) system. This is a recording tool at service provider end and advisors have access to it on their laptops or iPads/tablets and into which they can enter information, for example the customer satisfaction questionnaires (see appendices 3 and 4). It is a practical solution for data collection that allows the advisors to scan or enter material and run the automatic generation of documents. The data input goes directly into the central computer system managed by SWMAS, which the BIS can directly access and in turn easily generate reports and look at regional and sectoral activity on a day to day basis. The BIS can use this data to consider how the evolving MAS will look in the future by using past data and assessing successes and failures.

The following three-way relationship is a further re-elaboration of the monitoring process. The MAS client undergoes a Level 2 review. This involves meeting with a MAS advisor from one of the regional bases for example, the West Midlands. The MAS advisor reviews the client's needs and requirements and this process will identify a specific requirement such as a business plan. The MAS advisor then locates the appropriate person from the supplier registry to carry out this requirement activity. The client contracts with that supplier. The supplier undertakes the work and the client, if satisfied, will pay the invoice.

The client then goes back to MAS to be reimbursed for example, 50 percent of the cost (if that is what they have been awarded) from the MAS. At that point the MAS advisor revisits the client and collects data around the growth projections and asks a number of key questions such as: Did it happen? Did it not? Were they happy? Were they unhappy? The MAS will not approve the payment of the grant until that information is pulled together. By this process the advisor directly gathers the information and inputs the data directly into the monitoring system.

Monitoring of the qualitative experience for MAS customers is conducted through a customer satisfaction survey. Questions are related to the level of service received by the client (see Appendix). A separate private company is subcontracted to draw samples monthly from the businesses, which have received support at the different MAS levels. The survey comprises standard questions with options to distinguish whether it has been useful and beneficial; if are there are other elements of service the company would prefer; if there are elements of the service that could be improved. At the other end of the scale, the BIS has access to complaints that come in either directly or to the MAS. These two aspects of customer input cover the full spectrum of the business experience of the Manufacturing Advisory Service.

The MAS is also subject to formal program-wide assessments. The current Manufacturing Advisory Service is operating under a restructured delivery model, with a new contract and delivery consortium and has not yet been formerly evaluated in its current format (Phase IV, see Table 9). Previous phases of the MAS were evaluated in 2010 (DIUS, 2010) and 2007 (DTZ, 2007). The 2007 review concluded that the scheme worked well and was well received by the sector and its target market. A good and long-term relationship is valued highly by businesses. A main weakness identified was the patchy performance data collected, which posed significant challenges for monitoring and review of the scheme. This weakness has clearly been addressed in later years with a more robust system of performance measurement now in place nationally.

Box 9. Summary of the 2007 Evaluation

DTZ Consulting & Research (London) reviewed the 2002–2005 MAS program (MAS I) in 2006, and their report was published in 2007. The aim of the evaluation was to provide an independent review of the achievements of the MAS, its effectiveness and impact in the first three years of its operation (2002–2005), and to make recommendations to inform policy and delivery of this intervention in the future. The evaluation focused on the most significant MAS support packages Level 2 diagnostic and Level 4 consultancy.

A combination of qualitative and quantitative research methods was deployed. These included: interviews with key staff in the Regional Development Agencies and the MAS regional centers; a telephone survey of 946 firms that received Level 2 and/or Level 4 assistance from the MAS between June 2002 and June 2005; a survey of a control group of 401 firms that did not receive support from the MAS (referred to as nonusers); case studies of 20 beneficiary companies that received Level 4 support; and econometric analysis to identify the characteristics of MAS users and explore attribution and impact of the MAS intervention in quantitative terms.

Main Findings

- SMEs in the manufacturing sector that were in need of practical assistance for best practice manufacturing techniques and improvement of productivity had been targeted.
- The main market for MAS consisted of small enterprises (employing 10–49 employees) and in general, of SMEs.
- MAS served businesses across all size bands. A typical MAS user was an established small/medium size business in manufacturing (Tier 1 or below, rather than an Original Equipment Manufacturer), and likely to be exporting.
- The MAS outperformed its original key objectives by nearly 50 percent in terms of numbers of diagnostic visits (Level 2 support) and by 100 percent in terms of consultancy support (Level 4 support).
- The ten MAS regional centers ran nearly 1,300 events across the country in the first three years of the operation of the program.
- Companies that received Level 4 consultancy were significantly more likely to experience higher productivity and additional intermediate benefits than companies that received only Level 2 assistance.
- In comparison with other forms of business advice the MAS program was rated highly by businesses. A relationship of trust has been built between the MAS and its client base.
- On average, two in three businesses claimed clearly that they would not have achieved all/part of the improvements they have achieved and as quickly without MAS support.
- Overall, the evaluation evidence concluded the scheme worked and was well received by the sector and its target market. Regional variations in delivery and performance existed but these were justified by demand, supply and infrastructure, sector and region related issues.
- In the absence of the scheme, there were strong indications that no other form of business support would be sought by many businesses that used the MAS to improve aspects of their operations.
- The nature of benefits also varied by size of business. For example, more microbusinesses than other businesses reported increased turnover/sales as benefit yielded by MAS support. On the other hand larger SME businesses (50+) were more likely than other businesses to have benefited from improved just-in-time (JIT) practices.
- The MAS addressed two of the key underlying reasons for public sector intervention: introducing manufacturing firms to external business advice and providing them with access to affordable and tangible manufacturing advice, which they had not experienced before or from other sources, possibly leading them to buy further external support at the commercial rate.[a]
- Value for Money (VFM): £1 of public funding allocated to the provision of MAS Level 4 support generated approximately £1.4-£1.8 of economic benefit for firms supported between 2002 and 2005. [b]

[a] Nearly one-third of MAS users had either not accessed any other form of business advice, or had not accessed a comparable service. In addition, 70 percent of manufacturers that did not access MAS did not appear to be accessing external expertise that is of a similar nature to MAS.

[b] The evaluation could not isolate the exact cost of Level 2 and Level 4, or the benefits of providing Level 1 enquiry handling and Level 3 assistance (training and seminars), and could not establish whether the MAS could be in principle self-sustaining without subsidy.

Source: DTZ (2007).

Box 10. Summary of the 2010 Evaluation

In 2010, BIS and the RDAs commissioned a review was commissioned by to determine if there was a case for the continuation of funding for MAS beyond April 2011 and to provide lessons for future MAS design, management and delivery. DTZ Consulting conducted the evaluation, in partnership with the Cambridge Institute for Manufacturing. The methodology adopted to meet the objectives of the evaluation included both primary and secondary research. The primary research consisted of 31 interviews with key stakeholders in the MAS centers, RDAs, the CBI and commercial providers and 200 interviews with manufacturers in the UK. Secondary research included a desk-based review of relevant documentation, trends and indicators. Specifically the review looked at past performance and achievements of the MAS program at national and regional levels drawing upon review of relevant evaluation reports produced by the BIS and RDAs; the UK policy context for the manufacturing sector and headline indicators for the sector (business by size and employment); and relevant global trends, strategic analysis and identification of implications for the UK manufacturing. Some of the key findings and conclusions from this work are summarized below.

- The evidence suggests that MAS has played a significant role in helping businesses to grow and the more in-depth the intervention, the higher the impact.
- The service is also highly valued by manufacturers.
- If the MAS did not exist, no other service/product in the market could currently deal with the very technical nature of many requests from manufacturers currently dealt with by MAS.
- With additionality on the in-depth intervention work shown to be 90 percent and with satisfaction rate above 80 percent the service offers significant impact and satisfaction to manufacturers.
- The service can demonstrate a wide range of benefits for UK manufacturers to date and has proved very responsive to the needs of the sector.
- The MAS offering includes lean, strategy, leadership, and new process innovation and introduction. MAS practitioners possess both technical expertise and generic skills of team building, problem solving methods, facilitation, mentoring and coaching that are applicable to all levels of a manufacturing company from the shop floor to the boardroom.
- Estimates of value for money suggest that the return on public investment/spending on the MAS since 2002 is approximately £6.2 of additional GVA for every £1 of public spending allocated to the provision of the MAS for firms supported between 2002 and 2009.
- Most importantly, the evidence to date also suggests that the MAS has addressed a number of the original market failures. For example: With Level 2 support, MAS reaches companies where the culture of getting external advice has been traditionally limited.
- Public funding to alleviate the costs of assistance made available by the MAS also enables companies that would not have undertaken the program and/or would not pay for external advice to participate and be prepared to pay for advice in the future.
- It also triggers the appetite for further advice with over two thirds of businesses stating that they would now seek advice in the future following the positive experience from MAS.
- A review of key manufacturing trends indicates that although the manufacturing sector in the UK has been quite resilient to global changes and economic recession, a number of global drivers currently emerging would change radically the landscape for manufacturing and industry in general.
- Overall, it could be argued that key market failures that led to the establishment of MAS in the first place are still present.
- Furthermore, all manufacturers continue to need practical advice on both standard production processes and new sectors/areas such as resource efficiency, environmental technologies and recycling.
- All manufacturers, not just SMEs, will need support to be able to understand and then implement changes affecting the sector at global level in order for their businesses to remain competitive. For example: It is likely that manufacturing businesses will to need to restructure and this requires sector specialist knowledge. This is an area where the MAS has traditionally added value and could continue to do so in a fast changing business environment where the speed of adoption of new production techniques and/or new products is competitive.
- It also appears that the core MAS offering of lean thinking and operational efficiency will remain important, as cost reduction remains an issue for UK companies. This, however, goes beyond production and would require implementation of lean thinking across the entire organization.

Designing the future MAS:

- For the way forward, for the MAS to increase its Strategic Added Value it would also need to address the emerging requirements of manufacturing businesses by offering strategic advice in areas that matter to the UK competitive position as a whole, including servitization, value chains, sustainability and strategic interventions aligned to sectors/technologies.

Source: DTZ (2007).

6.10. Conclusions

The Manufacturing Advisory Service in England is a constantly evolving service that engages with many actors in the area of business support. This variety of actors offers the various elements of what could be a more systematized and coherent package of business support. The existing system has evolved in response to government objectives but also to targets of the time, for example a focus on poor productivity in the first decade of the century moving to more focus on GVA and securing jobs at the present time.

The MAS literature states that the move to a national MAS model was undertaken to ensure a consistent quality of service across England. However, in losing the input of the RDAs, the additional funding and individual activities each RDA offered, an external reviewer might consider if there has also been some valuable regional diversity lost in the system.

Nonetheless, despite the various evolutions of this technology extension service, many of the same actors (e.g., advisors, third party providers) are involved in the delivery of the service and in the business support landscape of England although the configurations and branding may differ over time. The focus of UK government intervention on business support now is the growth agenda and job creation, and targeting growth oriented companies.

Several positive lessons can be derived from the MAS case. First, the MAS does have a clear measurement system, as has been described, for monitoring and evaluating the service. This is an essential prerequisite for any successful TES. It needs to be established at the outset who will execute the measurement system, what to measure, and how to measure in line with the identified aims and objectives of the service. Second, the MAS has appropriately qualified expert advisors from engineering backgrounds who can speak the language of the manufacturing business and who can easily establish a rapport with the companies with which they are working. Third, a TES service should ensure that the process of receiving advice and being referred to other appropriate agencies for support not directly delivered by the TES is as easy and clear as possible for the companies.

The MAS has identified strengths but the organization of the service presents a number of challenges. The organization of service delivery is complicated for outside observers and for those working within the system to understand. This is a national service but is delivered by regional based organizations that are made up of different member organizations, as in the WMMC example. The configuration of the delivery model, however, is probably in practice not that important to the recipients of the service, provided the service they receive is appropriate and accessible and that there is some degree of consistency. This message of consistent branding should be emphasized, and if there is a lesson to be learnt from the MAS case study it is that there is strength in maintaining a common brand

and trying to preserve a common theme. The service can be tweaked around the edges, but the bureaucracy surrounding service provision and the complexity of the system should not change. These beneficiaries essentially require a quick, clean, professional, and easy way to access service.

7. Tecnalia, Basque Region, Spain

7.1. Introduction

The Tecnalia Corporation is a strategic partnership between Tecnalia Research and Innovation, Neiker-Tecnalia and AZTI-Tecnalia.[40] Tecnalia Research and Innovation was set up in 2011 with the merger of six technology centers: CIDEMCO, ESI, FATRONIK, INASMET, LABEIN, and ROBOTIKER. Tecnalia highlights its key objectives to offer technological solutions to help its business clients grow.[41] Tecnalia's activities include research and technical development (RTD) and demonstration projects, technical services, exploitation of research through licensing and spin-offs, and services for organizational innovation and business diversification. Tecnalia's fields of activity are sustainable construction, energy and environment, information and communication technology (ICT), industry and transport, and health. Tecnalia has a total staff of around 1,470 people, and a turnover of €110 million.[42]

7.2. History and Evolution

The Basque Country, in Northern Spain, has a population of 2.1 million (4.7 percent of Spain's total population) and contributes 6 percent of the Spanish GDP. The region is characterized by having strong political autonomy and its own fiscal system, a complex governance (with a multitier system of regional government, three provincial governments, twenty counties and over 200 municipalities). The current Basque regional innovation system is dense and complex, comprising a multitude of organizations for scientific research, technological development, training and intermediation.

The Basque technology centers have been the cornerstone of the regional innovation system. However many of the technology centers (LABEIN, INASMET, IKERLAN, CEIT, and TEKNIKER) predate the creation of the Basque Autonomous Community 1978, and some of

[40] This case draws from secondary sources and interviews with experts and stakeholders, including Edurne Magro and Mikel Navarro (Orkestra, Instituto Vasco de Competitividad), Arantza Zubiaurre (University of Deusto), Jaime del Castillo (University of the Basque Country), Iñaki San Sebastian (Tecnalia), and Rogelio Pozo (Azti-Tecnalia).
[41] www.tecnalia.com
[42] Euros (€) are used throughout this case. €1 = US$1.376.

them even date back to the 1950s and 1960s. These centers were mainly testing labs created by local industrialists or engineering schools. The first technology centers had diverse origins, governance and focus, generally with a private legal status and organized around sectoral lines of business (Table 14) (Rico Castro, 2007). The Engineering School of Bilbao set up LABEIN in 1955, initially with a focus on construction, mechanical engineering, machinery and the environment. INASMET, formed in 1962 by industrialists in Guipuzcoa, focused on quality certification, testing, chemistry and technological marketing. The Mondragon Cooperative group, with private funding and a focus on electronics, mechanics, IT and thermodynamics set up IKERLAN in 1974. The University of Navarra as CIT formed CEIT in 1963 with a specialization in materials, mechanics, electricity, informatics and the environment.

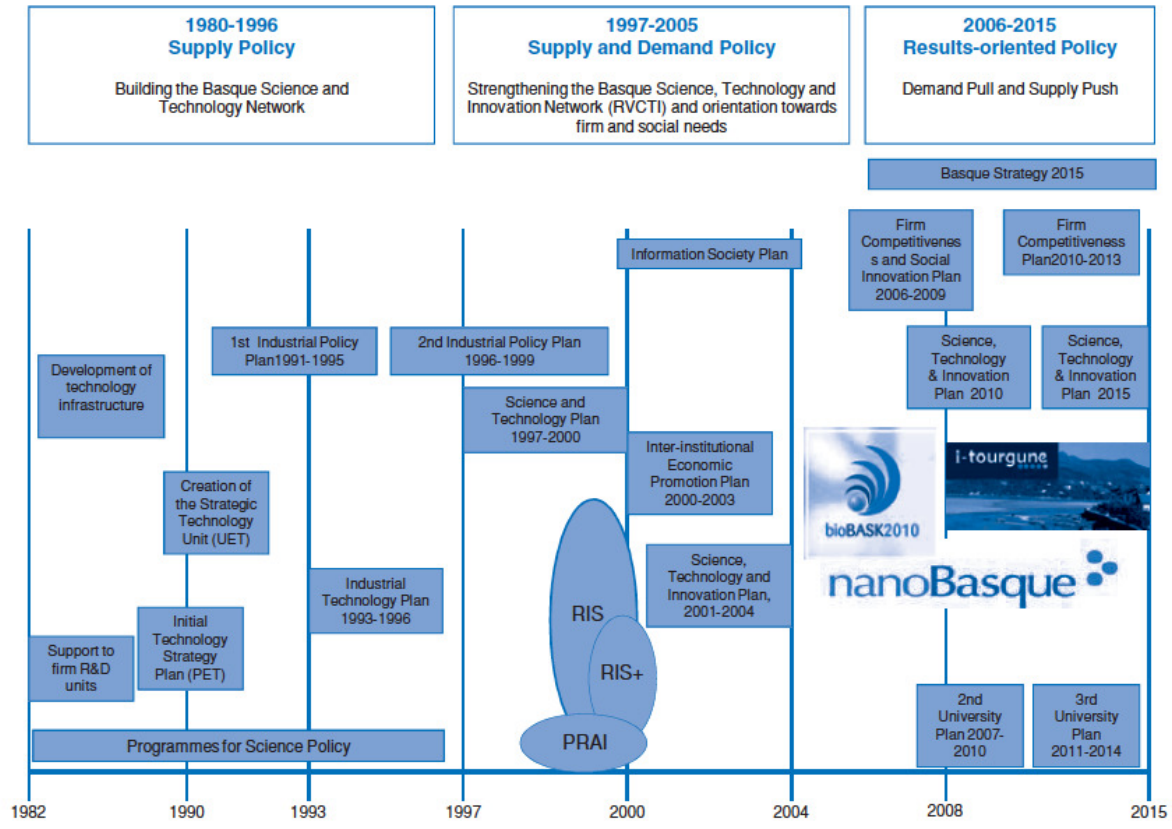
Table 14. Origin of Selected Basque Technology Centers

Name	Year formed	Origin (and formation)	Sectors
LABEIN	1955	Engineering school of Bilbao (bottom up)	Construction, mechanical engineering, environment, nuclear technology, mechanics, hydraulics and machinery
INASMET	1962	Business association in Guipuzcoa (bottom up)	Processes, quality control, technical trials
CEIT- C	1963	University of Navarra (bottom-up)	Materials, mechanics, electricity, IT, environment
IKERLAN	1974	Mondragon cooperative group	Electronics, mechanics, IT, thermodynamics
TEKNIKER	1981	Armery School of Eibar (bottom-up)	Mechanical trials, chemical analysis, metalography and chemical treatment
GAIKER	1985	Vizcaya provincial government (top-down)	Plastics and composites, environment and recycling
ROBOTIKER	1985	Vizcaya provincial government (top-down)	Electronics, IT, engineering equipment goods, automotive and aerospace, energy
LEIA	1989	Alava provincial government (top-down)	Environment, recycling and waste management; new materials
ESI- European Software Institute	1993	European Commission, Basque Government (top-down)	Software process improvement

Source: Rico Castro (2007).

Science, technology, and innovation policy in the Basque region has moved through several key stages (Aranguren et al, 2012). A first stage in the 1980s was oriented towards capacity building, mainly dedicated towards the development of a technological infrastructure. A second stage, particularly after the latter part of the 1990s, focused on consolidating the Basque network of science, technology, and innovation; the setting up of specific technology and innovation priorities; and responding to the needs of the industrial and social stakeholders of the region. A third period, in effect since the mid-2000s, is more results-oriented and looks toward diversifying the industrial fabric (see Figure 10). During this 30-year period the number of technology centers more than doubled and their role and orientation has changed considerably.

Figure 10. Key Milestones of Basque Science and Technology Policy



Source: OECD (2011).

The 2000s witnessed further changes in the regional institutional landscape for science, technology, and innovation in the Basque Country. In terms of infrastructure, the Basque network of technology parks was expanded.[43] Additionally, more support was given to

[43] The Basque Country had been a pioneer with the creation of the Bizkaia Technology Park in 1985, one of the first in Spain. In the 1990s additional parks were created in Alava and San Sebastian. In 2005, the Garaia

scientific research through the creation of Cooperative Research Centers (CICs) and Basic Excellence Research Centers (BERCs), and the creation of the science agency Ikerbasque. The Basque Council for Science, Technology and Innovation (CVCTI), led by the president of the region, was created to provide strategic orientation and coordination. The Basque Innovation Agency, set up in 2007 as a nonprofit making private–public partnership to coordinate and stimulate innovation in the public and social sectors as well as the private sector, supports the council.

Since these changes in the 2000s, technology centers have also undergone restructuring and integration. As a result of this integration, two main groups have emerged: Tecnalia and the IK4 Research Alliance. These groups were set up to address international technology competitiveness challenges, exploit synergies across the centers and find alternative funding sources to compensate for the reduction of regional funds.

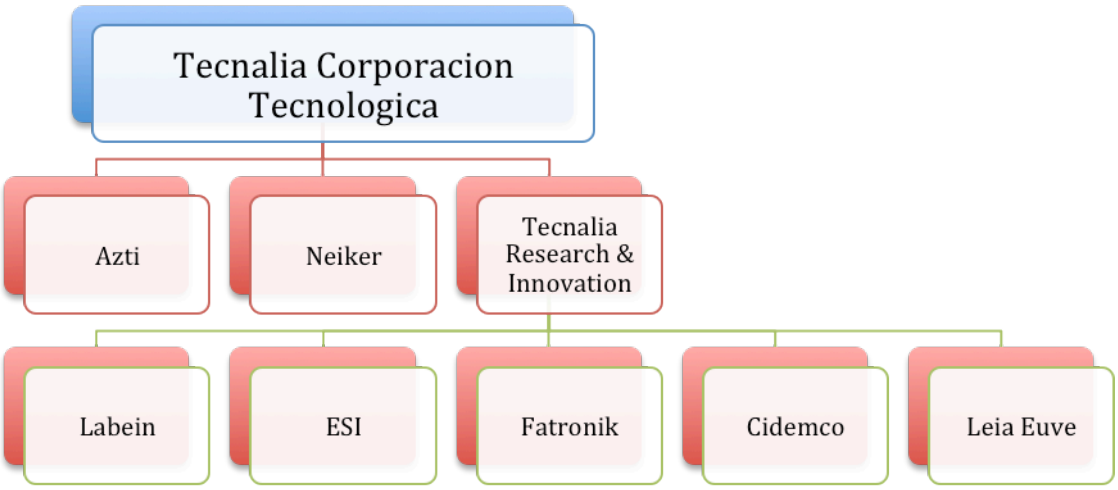
In the case of Tecnalia, the integration of the centers started in 2001 and continued for almost a decade until a full merger became effective in 2011. IK4 was created in 2005 as a network of 9 centers (AZTERLAN, CEIT, CIDETEC, GAIKER, IDEKO, IKERLAN, LORTEK, TEKNIKER and VICOMTech), not so much to achieve critical mass and joint presence in international markets, but to achieve greater complementarities. These centers employ 1,162 people. The other difference between Tecnalia and IK4 is that Tecnalia is a nonprofit private foundation, while some of the centers in the IK4 group are foundations, whereas others are associations or cooperatives. Unlike Tecnalia, all these centers have kept their autonomy and governance structures.

7.2. Tecnalia: Current Structure

Tecnalia Corporation is a strategic partnership between Tecnalia Research and Innovation, Neiker-Tecnalia and AZTI-Tecnalia. Tecnalia Research and Innovation was set up in 2011 as the merger of six technology centers: CIDEMCO, ESI, FATRONIK, INASMET, LABEIN, and ROBOTIKER. AZTI, focusing on the fisheries sector, and NEIKER, dedicated to agricultural research, maintain a different status because they are public centers, dependent on the Department of Environment of the Basque Government. They are not as fully integrated as the other centers but form part of the broader strategic partnership (Figure 11).

Innovation Center (headed by the Mondragon Cooperative Corporation and with the support of Mondragon University and Ikerlan) was set up.

Figure 11. Tecnalia Corporacion Tecnologica, Organization Chart, 2013



Source: Montero (2011).

This strategic alliance was motivated by the small scale of Basque technology centers compared with most of their European counterparts (such as the Fraunhofer centers, see section 2 of this report, TNO in the Netherlands and VTT in Finland).[44] Greater scale was deemed necessary in order to exploit synergies, achieve greater specialization and be better positioned to access and lead international research projects in a context of diminishing regional government funds. Integration was initially motivated from the bottom up by the centers involved, however delays and coordination difficulties led the government to eventually drive the merger from the top down.

Tecnalia research and innovation brought together organizations with different activities, orientation and client base. Most centers were created as testing labs to cater to the needs of industrial clusters (by groups of firms or engineering centers). The oldest centers such as LABEIN combined traditional service activities, related to the assessment of conformity, diagnosis, maintenance, etc., with applied R&D projects, whereas the activity of the newest centers such as CIDEMCO was more centered on applied R&D projects with firms. Some had a more sector-based orientation (for instance AZTI) whereas others specialized in a particular technology (e.g., INASMET's focus on materials technology) and operated across sectors.

The operating business model of Tecnalia is now based on sector oriented business divisions targeting key markets. There are seven divisions, made up of multidisciplinary and multicenter teams that coordinate their technology offer to different strategic sectors. Five of

[44] TNO was previously the Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (Netherlands Organisation for Applied Scientific Research). VTT was previously the Valtion Teknillinen Tutkimuskeskus (State Technical Research Center) of Finland.

these divisions relate to the different R&D markets, namely: sustainable construction, energy and environment, ICT, industry and transport, and health. The other two divisions are technology services and innovation strategies. Each division has a director, a business development director, a market director, and a trading account. This means in practice that each unit tends to involve several centers in different locations. The integration has not involved any closing of the centers, or relocation of staff from one center to another. However over time, a number of people have relocated between the different sites to improve the critical mass of some sites and enable specialization in service provision.

7.3. Scale

Tecnalia is the largest private research, development, and innovation organization in Spain and the fifth largest in Europe. In 2012, 1,473 people were employed across its 29 offices in 21 locations worldwide (in the Basque Country, the rest of Spain, France, Italy, and Mexico) and its turnover was €110 million. Tecnalia grew considerably between 2008 and 2010, only to reduce its activity and staff in 2011 and 2012 (Table 15). It has an increasing patent portfolio, and an increased interest in the creation of new technology based firms. Of the new technology based firms created by Tecnalia, around 25 are operating today employing 132 people. Tecnalia maintains an equity stake in 17 of these firms.

Table 15. Tecnalia, Personnel and Revenues, 2007–2012

	2007	2008	2009	2010	2011	2012
Personnel	1,322	1,378	1,636	1,819	1,475	1,473
Revenues (€m)	111	128	142	153	116	110

Source: Tecnalia annual reports, various years, including Tecnalia (2012).

Of the total number of Tecnalia employees, around 250 staff (about 17 percent of the total) are dedicated to technological services such as certification, conformity assessment, and calibration.

7.4. Financing

Tecnalia has three sources of funding: core (noncompetitive) public funding, competitive public funding and private funding. Although the funding model of Tecnalia and IK4 was inspired by the German Fraunhofer system of technology centers, the share of public sources in total funding has diminished over time, which has translated into increased

pressure to find new funding sources. Both Tecnalia and IK4 have lower shares of institutional funding in their total budgets when compared with Germany's Fraunhofer Institute and Finland's VTT Centers (Table 16).

Table 16. Funding of Tecnalia and IK4 in International Comparison

Funding (EUR millions)	Fraunhofer	VTT	Tecnalia	IK4
Government base funding	621.4	85	15.3	12.3
Own activities	940.5	184	106.3	81.8
Government funding (research projects)	391		21.4	15.3
Government contracts	15			
Business contracts	427.8		74.5	57.2
External research funding institutions	106.7	37	10.4	9.2
Other	88.9			
Total government funding	1,027.4		36.7	
TOTAL	1,650.8	269	121.6	94.1
Share base funding (public)	38%	31%	13%	13%
Share total public funding (includes base funding)	62%		30%	29%
Share own resources	62%	69%	87%	87%

Source: OECD (2011).

Currently, around 30 percent of Tecnalia funding comes from competitive R&D programs (at EU, national or regional levels) and around 15 percent is institutional funding from the Basque Government. Noncompetitive core funding received from the government has decreased considerably in the last few years (e.g., from 21 percent in 2007). In terms of competitive public funding, one of the growing sources of funding for Tecnalia is participation in EU projects. It has seen a dramatic increase in participation including a near doubling from 2008 to 2009. Tecnalia participated in 353 Seventh Framework (2007-2011) projects, leading 76 of them, which places Tecnalia high in the worldwide ranking of private organizations participating in the Seventh Framework in terms of projects and economic returns.

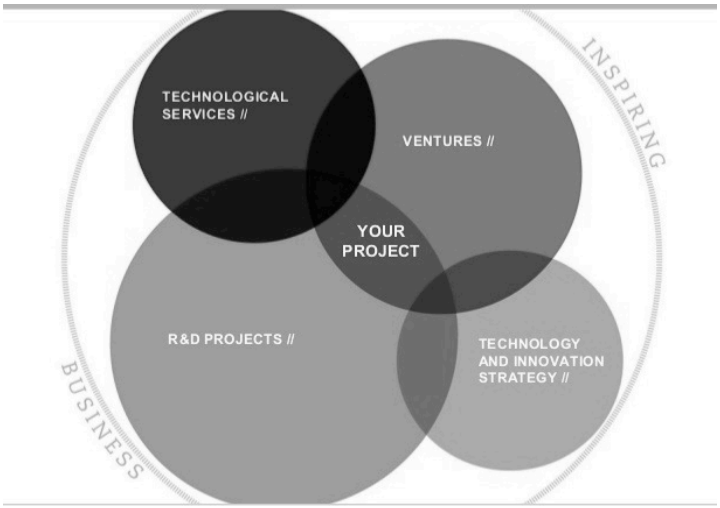
Over 50 percent of Tecnalia's income is derived from services and technology projects with firms. It is important to differentiate, however, between the income associated with the provision of technology services and the income from technology projects. Some of the reported private funding from applied R&D projects is actually supported by public

programs for collaborative R&D (see next section). The provision of technical services, on the other hand, is not supported by any public funding program and undertaken purely on a market basis.

7.5. Services

Tecnalia's business model is nowadays oriented towards the provision of integrated support to companies serving all their innovation needs. More specifically Tecnalia's activities are articulated around four key services or activities: (i) technology services, (ii) collaborative R&D, (iii) exploitation of research through licensing and spin-offs, and (iv) services for organizational innovation and business diversification (Figure 12). Tecnalia's activities thus include market services that are closer to the original activities of the technology centers, and research oriented activities that involve greater technological risks and are supported by public funds.

Figure 12. Tecnalia's Service Model for Working with Companies



Source: www.tecnalia.es.

Collaborative projects are the core of Tecnalia's activity, followed by the provision of technical services. Recently, there has been an increased focus toward the exploitation of research through licensing and spin-off on the one hand and the provision of strategic advice for business development on the other. This shift has responded to both an increasing technological sophistication of the centers (resulting from their increasing scale and specialization and exposure to international research networks) and changing demand of firms toward more added value services. The potential of gaining additional revenues through licensing and increasing the portfolio of services offered to firms is an additional factor (Box 11).

Box 11. Tecnalia's Services to Companies

Tecnalia offers four major services to companies.

Technical Services. The provision of technical services accounts for around 16-18 percent of total turnover. These are similar to the original services of the Basque Country technology centers, which included testing, calibrations, inspections, audits, and certifications, but now the broader portfolio provided by different labs in different centers is integrated under a single division. These vary widely depending on the markets served, which include construction, health, energy, chemicals, transport, casting and steelmaking, and mechanical welding. These are often one-off contracts and are used by a larger number of firms (about 3,500).

Collaborative Projects with industry (contract R&D) represent Tecnalia's largest service category, accounting for some 60 percent of its total turnover. These are long-term applied research projects. Collaborative contracts with firms are supported by funding schemes for collaborative R&D by the Basque and Spanish Governments. The regional government's INTEK program, launched in 1997, has long been the main instrument fostering such collaborations between the technology centers and industry. The program aimed to support R&D in firms and foster systemic links between firms and the technology centers (and other members of the RVCTI). INTEK would fund up to 50 percent of cooperative or individual projects in firms on a competitive basis. Eligible projects would include at least two firms and at least one member of the RVCTI. Individual projects funded by INTEK could also include subcontracting to a member of RVCTI. As Magro (2011) notes "although the only direct type of beneficiary of the program is firms, agents from the Basque Network are the indirect beneficiaries of the program." Since 2009 and under the program Aukera, Tecnalia has started to offer a new modality of risk-sharing contract, whereby Tecnalia would share part of the cost of the collaborative research project and in return also share part of the benefits should they occur. These are more flexible contracts, which aim to encourage greater exploitation of results, as well as generate incentives for firms to contract the services of Tecnalia during times of economic uncertainty.

Knowledge Exploitation and Spin-Off Firms. An emerging activity is the exploitation of knowledge via licensing or spin-off firms, which since 2012 has been developed through the Tecnalia Ventures division. In the past, there has been little tradition of spin-off creation among the Basque technology centers, with some exceptions (e.g., CEIT). Tecnalia Ventures S.L. is a separate legal entity fully owned by Tecnalia. Its objective is to evaluate Tecnalia's in-house R&D activity (that is not contract research with firms) to maximize its commercial exploitation. It assesses the potential market interest of different technological assets and projects and decides whether to support their development or discard them. It is staffed with around 12 people with technical and business profiles. Around 4 percent of turnover is currently obtained from this activity.

Innovation Strategy. A further mechanism used by Tecnalia to support firms is via the innovation strategy division, the objective of which is to help companies articulate their innovation strategies for growth and diversification. By helping firms to design their innovation strategy, their needs in terms of projects and technology services are identified along the innovation life cycle and Tecnalia is able to provide an integrated portfolio of activities that are fine-tuned to those needs and challenges, including technical services, R&D contracts, or licensing opportunities.

Source: Authors' elaboration from Tecnalia interviews and reports.

The provision of technical services consists of three main activities:

1. Legal requirements and standards (for instance, in relation to health and safety or environmental standards). This may involve conformity assessment of electrical equipment or construction materials to ensure compliance with national and international standards.
2. Process quality controls to help firms to improve their production processes and efficiency and reduce waste. This may involve the calibration of technical equipment to ensure the reliability of their measurements.

3. The reduction of time-to-market of new products, for instance through testing and certification.

The technical service portfolio offered to firms therefore includes calibration services, conformity assessment, studies and analysis, technical guidance, certification, diagnosis, inspection, and technical training. These are provided in Tecnalia's variously accredited labs (see section 7.9) to a range of sectors and markets. These sectors are slightly different to the target markets for R&D projects and include: construction, electrical energy, materials, metrology, health and quality of life, and sustainability.

Tecnalia seeks to maintain a balanced portfolio of activities between services that are relatively more profitable and stable (such as technical services) with other activities of a more exploratory nature, and to exploit synergies between these more market oriented and more research oriented activities. An example of these synergies is the introduction of new technical services as a result of R&D activities. For instance, the services that Tecnalia provides in smart meters and smart grids equipment testing is the result of advanced research activities that it has been developing in the area of electrical systems. Conversely, there is often a sequencing or progression of activities from more routine to more advanced services. Many companies that benefit from Tecnalia's technical services progressively demand other, more advanced activities, such as business strategy advice and R&D projects. It is very common that repeat customers of technology services start demanding technologically more advanced activities.

Clients are targeted through market segmentation and technical services are advertised through formal marketing channels, such as commercial visits to companies, mailings, pamphlets, etc. The marketing of these services has intensified as a result of the economic crisis, which has affected some industrial clients, particularly in the construction sector.

Unlike the R&D projects with firms supported by public funding, Tecnalia competes with other private providers in the provision of technical services. The price of these services is therefore not subsidized but set by the market.

Tecnalia does address some market failure weaknesses in the provision of private consulting services to SMEs. However, in the area of contract technical services, Tecnalia competes not only with other private sector providers, including multinationals such as Applus+ and SGS, but also with IK4. An internal reflection is taking place with regard to the activities that Tecnalia should focus on as a technology center, and those it should stop providing or provide through third parties.

7.6. Clients

Tecnalia serves both public and private sector clients. The work with public sector organizations lies mainly within the innovation strategies division, through for instance the provision of advice to organizations (mainly at the regional and local level) on the use of technology or on the definition and implementation of innovation policies and programs for technology-based competitiveness. The target clients, as emphasized by Tecnalia, are "those firms whose needs coincide with the solutions that we can provide." Size is not a criterion, rather the criteria used when targeting firms is alignment with their services and the growth potential of the firm.

According to Tecnalia's annual reports, the group has a client base of around 4,000 companies (Table 17). Technical services are provided to a large proportion of these clients (about 3,500).

Table 17. Tecnalia's Client Base: 2007–2012

	2007	2008	2009	2010	2011	2012
Companies assisted	3,235	3,800	4,059	4,700	n.a.	4,000

Source: Tecnalia annual reports, various years, including, Tecnalia (2012).

In terms of size and intensity of research, the main client base of Tecnalia is SMEs (primarily medium sized firms) undertaking R&D. This is partly due to the structure of Basque industry, mainly SMEs employing between 50 and 200 people, often family run and with a productive specialization in sectors such as machine tools, automotive, white goods, electronics, aerospace and wind energy. However, different types of clients benefit from different types of services. In the case of applied research projects, links are dominantly with more technologically advanced medium to large firms. In the case of technical services, the size and technological intensity of the firm decreases.

Geographically, around 70 percent of Tecnalia's clients are Basque firms, 20 percent Spanish and 10 percent foreign. The client base of IK4 is slightly more regional and less international. In the case of technical services, the geographical spread of clients varies greatly according to the services because some, such as certain testing activities, are more sensitive to distance, whereas others can be provided globally. Around 20 percent of the technical service clients are international. Much of the demand for these services is linked to access to international markets, for instance by firms seeking certification in EU markets or Spanish or Basque firms seeking to expand their international markets.

Another characteristic of Tecnalia's client base is that it is relatively stable, particularly in the case of advanced technology services. Many current clients are longstanding clients of Tecnalia. Often relationships leading to firms seeking services have been forged through mobility of personnel. In the past, engineers working on collaborative research projects may have been subsequently employed with the partner company, thus increasing links with the centers.

Tecnalia is increasingly developing collaborations with third parties (such as universities and private firms) for the provision of services and the development of new services, for instance through the sharing of infrastructure and equipment, strategic alliances and the setting up of joint ventures. They are also leveraging relationships with business associations, local development agencies, cluster associations, Chambers of Commerce and vocational training centers in order to expand the client base and reach out to these smaller firms. In Spain Basque vocational training centers are pioneers in the provision of innovation support services. These centers have greater employment orientation, more extensive links to firms, and recent public support for new equipment that allows them to provide specialist services (certification, testing, etc.) to firms (Navarro et al, 2013). This does, however, remain a challenge.

7.7. Governance

In order to understand Tecnalia's present governance arrangements it is important to recall how technology centers were governed before Tecnalia was constituted. Until the 1990s different technology centers had different legal statuses, but generally they were nonprofit associations or cooperatives. Since the 1990s, most centers have changed their legal status to that of a foundation allowing for greater private sector involvement. This is in line with the Science and Technology Plan 1997–2000 policy priorities calling for a shift from a mainly supply-side to a demand side orientation (Rico Castro, 2007). The governing bodies (board of trustees) of the technology centers were composed mainly of representatives of firms but the different administrations (regional and provincial) were also represented. There were exceptions where the public sector was dominant, for instance in NEIKER (public research center), CEIT, IKERLAN and AZTI. The participation of organizations from the scientific sector in the governing structures of the Basque technology centers has traditionally been small. Participation by private trustees was generally firms belonging to the particular area or sectoral specialization of the center. Navarro (2010) questions whether this greater presence of firms in the governance of the centers actually translated into greater ownership of firms and involvement in shaping priorities for the centers.

Tecnalia is a nonprofit private foundation. The board of trustees has representatives from firms, business organizations, public administrations (provincial and regional) and the research system (University of the Basque Country). Business members play an active role in organizational decision-making and in the definition of research priorities. Additionally, it could be argued that the regional government has a relatively more involved approach in relation to the strategic priorities and orientation of Tecnalia than was the case with the individual technology centers. This is reflected by the role of the government in the merger process and the fact that the director general of Tecnalia is the former Technology Director of the Basque Government.

Tecnalia has several business units: sustainable construction, energy and environment, ICT, industry and transport, health, technology services, and innovation strategies. In addition to the board of trustees, the different business units in Tecnalia have advisory groups from the private sector that provide specialist advice for the definition of market and technological priorities. Overall, it is estimated that around 150 firms are present in the various governance structures of Tecnalia (board of trustees, advisory groups, etc.).

Tecnalia also participates in the governing structures of business associations (Adegui, Confebask), cluster associations, vocational training centers, and chambers of commerce. However it is not clear whether cluster associations are active in the advisory groups of Tecnalia. Similarly, while Tecnalia is represented in the governing bodies of the CIC, the reverse is not true. The CICs, and the research system generally are underrepresented in Tecnalia's governing structures (Navarro et al, 2013). Internationally, Tecnalia is a member of the EARTO Executive Committee and its Board of Directors, together with organizations such as TNO and Fraunhofer.

7.8. Personnel

As of 2013, Tecnalia employed 1,473 people (with an average age of 39). Of these, 192 have doctoral degrees (a relatively low proportion compared with research universities, confirming Tecnalia's orientation to applied development and consulting rather than basic research). Around 250 people work in the division of technology services. Their profile is more technical compared to the rest of Tecnalia. They have a lower proportion of PhD holders (only 4 or 5 members of staff), and the rest of the staff have a mixture of university degrees (40 percent) or technical/vocational training (around 60 percent). Generally, no additional educational experience is required; instead Tecnalia prefers to provide in-house training tailored to the specific lab and person. Remuneration of technical personnel is fixed, while performance incentives related for instance to sales apply to staff in sales and management activities.

Tecnalia has not hitherto encountered difficulties in finding the right personnel for the technology services division, although finding staff with commercial skills to market the services is proving more of a challenge. In the other divisions of Tecnalia, management and business skills are becoming more valued, as a result of the shift toward added value in the provision of services, including those for business innovation. This is manifested in retraining (to improve management and business skills among staff) and requiring new skills of potential recruits.

In the past, the technology centers ran an internship program for graduates. After their internship many of the beneficiaries of this program would find employment in one of the firms of the technology centers. This had the positive effect of improved links between the centers and industry. The internship program was discontinued as a result of a dispute with the unions with the effect of increasing the cost of services, already an issue for client firms. Navarro (2010) argues that the government should reinstitute a sound internship program in the technology centers with well-defined objectives.

7.9. Infrastructure

Tecnalia maintains a range of laboratories across nine sites to provide technical services, including trials, quality control, calibration and inspections. The labs' different locations sometimes pose coordination problems. On a different note, the merger has enabled greater specialization of these labs and there is a progressive movement of personnel from one location to another to support this specialization, reduce duplication and improve critical mass.

Technical services are tied to specialized equipment maintained by the centers and are formally accredited by the Entidad Nacional de Acreditación (ENAC).[45]. Tecnalia invests heavily in maintaining this infrastructure. For instance, of the €141.5 million of total income that Tecnalia obtained in 2009, around €10.5 million was invested back in technological equipment and infrastructure.

7.10. Monitoring and Evaluation

Tecnalia operates a balanced scorecard that defines clear baselines and targets and includes indicators related to value added (income from R&D contracts in new technologies), demand (projects with clusters), productivity (patent applications and patents granted), entrepreneurship (creation of new technology-based firms), networking (leading and

[45] ENAC is the body designated by the government to assess technical competence in accordance with international standards.

participating in European projects, European projects with Basque firms), scientific excellence (number of publications), and economic results (total income from R&D contracts, economic returns from European R&D projects). These data are collected by Tecnalia and are related in its annual report.[46]

More specifically, in the technical services division, customer satisfaction surveys are carried out regularly to improve relationships with customers and move the activities of the division closer to the market. Customer satisfaction metrics are the most valued for Tecnalia, with an important emphasis on the improvement of lead times, quality and customer satisfaction. In particular, one of the most important metrics is customer retention, namely whether customers make repeat demands of these services rather than one-off engagements. As a result of the economic crisis, Tecnalia has made additional efforts to increase flexibility and responsiveness to client needs, which has translated into significantly improved customer satisfaction.

7.11. Conclusions

The creation of Tecnalia is relatively recent, and as a result it is difficult to fully assess its strategic orientation and performance. The strategic process of the merger is not fully completed and Tecnalia is undergoing a process of reflection about the types of activities it should focus on moving forward. Nonetheless, despite being a relatively new organization, Tecnalia builds on over 50 years of experience in supporting Basque firms in their technological and innovation needs. Its activities are a product of this legacy and advanced R&D activities with concrete services to firms.

Tecnalia has several strengths but also a number of challenges. Over time, the mandate of the Basque technology centers has evolved from a focus on technical service provision to small firms to an R&D focus. This has to a large extent been driven by the need to secure income from R&D projects in response to the reduction in their core funding but also by the policy orientation of the Basque Government, more geared towards R&D funding. The priorities of the Basque policy led to an increasing scale, specialization and technological sophistication of the centers in terms of applied research capacities in strategic areas.

Major strengths of Tecnalia lie in its applied research capabilities, the quality of its facilities and the skills of its personnel. Tecnalia is able to recruit qualified personnel thanks to the high quality of engineering and technical training in the region. The translation of the

[46] See, for example, Tecnalia's 2012 Annual Report, at http://www.tecnalia.com/images/stories/Informes_anuales/TECNALIA-Report2012.pdf

Tecnalia model elsewhere would require working closely with engineering faculties and technical colleges.

A challenge for Tecnalia is finding out where they can add more value and where their activities respond to a perceived market failure. For technical services that are closer to the market, they are competing with other private sector businesses that provide similar services (and other technology centers such as those within IK4). Even though Tecnalia is a private organization, since it is partly supported by public funding their provision of TES could be perceived as unfair competition by other providers.

Finally, questions remain about whether the needs of the traditional industrial SME base in the Basque country are sufficiently addressed. Most of the public funding to support innovation in the Basque Country takes the form of collaborative R&D subsidies, yet there are no public programs supporting the use of technical services or technology extension services by SMEs. There is not a perceived shortage of private sector providers for technology extension services in the Basque Country; there is already a functioning market in place. However, the demand of these services by the least innovative firms could be stimulated through additional public funding vehicles. The needs of these firms could be further channeled via other actors in the system, such as technical colleges, local development agencies or chambers of commerce, which could act as brokers between SMEs and technical service providers.

8. Lessons and Insights

This concluding section presents lessons and insights based on the four primary case studies. There is a discussion of crosscutting insights related to the evolution, structure, scale, financing, services, targeted clients, governance, personnel, and evaluation of technology extension services and their associated institutions.

8.1. Lessons from the Case Studies

Multiple insights are offered through the case studies of the U.S. Manufacturing Extension Partnership, the Manufacturing Advisory Service (England), Industrial Research and Assistance Program (Canada), and Tecnalia (Basque Country). Key points emerging from each program are discussed below.

8.1.1. U.S. Manufacturing Extension Partnership

The first insight from the MEP is the role of private sector organizations in raising the need for the program and their significance in the creation of the MEP. Another lesson lies in the ability of the MEP to ramp up the program to all 50 states by leveraging other funding sources at the state and client levels to match federal program funds. With regard to infrastructure, it is interesting to note that if states did not have sufficient infrastructure to implement an MEP center, interim multistate infrastructures were useful, although no longer needed today. The ability of the program to evolve its orientation in response to customer and sector needs provides a lesson in showing how the MEP stays relevant to manufacturing customers. Likewise, both the SCMEP and the GaMEP show how local centers can evolve with the national program. The SCMEP changed from a new university based center with limited capacity to reach out to the state's manufacturers to a private nonprofit center able to serve the state's manufacturing base through a combination of in-house field specialists and consulting firms.

The GaMEP changed from a state industrial extension program offering mostly free basic process improvement services to a member of the national MEP network that offers growth services as well as process improvement and energy and environmental services of value to private manufacturers based on fee revenue from these firms. Insights into the governance structure illustrate how the MEP's use of cooperative agreements rather than contracts is important in enabling both the national program and the center to be jointly involved in designing the service. The cooperative agreement also enables the MEP to allow for flexibility in the operation of state centers that fit into the historical and structural framework of the state. Finally, the resources that the program expends on its monitoring and evaluation system have played a role in providing justification for ongoing federal investment, although issues with the evaluation system, use of indicators, and lack of systematic sharing of best practices across centers remain ongoing.

8.1.2. Manufacturing Advisory Services (England)

The MAS case offers several key program elements that are useful to consider for the design of a TES program. First, the MAS has a clear measurement system for monitoring and evaluating the service. It is an essential prerequisite for any successful TES to establish at the outset who will measure, what to measure and how to measure in line with the identified aims and objectives of the service. Second, the MAS has appropriately qualified expert advisors from engineering backgrounds who speak the language of manufacturing business and can easily establish a rapport with the companies with which they are working.

Third, the service has established a clear process for referring other appropriate agencies and private sector firms for support not directly delivered by in-house advisors. Moreover, the program has made this process as easy and straightforward as possible for clients.

8.1.3. Industrial Research Assistance Program (Canada)

The IRAP presents an example of the integration of TES into a nonextension service offer of funding for applied R&D projects, to make this type of funding more effective at the firm level. Another lesson to be learned from this case study is how to integrate TES into funding for organizations to provide assistance to SMEs. Important insights are gleaned from the ways the program is able to leverage extremely experienced and capable specialists (the ITAs) for the benefit of SMEs. Although the program does not have a rigorous ongoing evaluation system, it does make use of monitoring and independent evaluation for program improvement as well as program justification. A further lesson is the longevity of the program, which reflects its ability to learn and adapt and from time to time be used as a delivery mechanism for other Canadian technology-based economic development programs.

8.1.4. Tecnalia (Basque Country, Spain)

The main insight from Tecnalia is that it is the product of contingent decisions and events, in particular the need to rationalize a dense technology infrastructure and increase the critical mass and international competitiveness of the technology centers. Thus, it is important not to lose sight of the origins of the technology centers, namely as locally embedded, bottom up initiatives designed to cater to the technology needs of companies in the local clusters. The Tecnalia case also offers a lesson concerning the role of public funding. The precursory centers to Tecnalia were generously supported by the public sector, particularly during the 1980s and 1990s, and these moneys, enabled the center to address a perceived gap in technology service provision for SMEs. The private sector has had a dominant role in the governance and orientation of the technology centers. A number of these centers are now absorbed into Tecnalia. Driven in part by the funding model, with limited public support and the need to secure private and European project revenues, Tecnalia's services are moving up market, focusing more on medium-sized and larger companies. Direct TES to SMEs appear to be declining in importance, as Tecnalia develops its R&D capabilities and seeks a wider reach. Another aspect of the reduced role of public support is that Tecnalia conducts performance measurement, but without significant external formal evaluation. On the plus side, Tecnalia's new orientation to add value to firms, share risks and capitalize on

intellectual capital presents a promising orientation for an applied research system that is also seeking to be relevant to, and linked with, business.

8.2 Insights for Implementation

In the following section, we compare and contrast the four cases, drawing out insights organized around the key probes which were identified for the study (see Box 2).

8.2.1. Historical Evolution

Three key factors in launching a TES program are: (i) establishing pilot centers or activities, (ii) obtaining private sector support for the program, and (iii) planning for evolutionary phases. Each program has a distinctive historical evolution, generally developing from a prior base or pilot program. Having an initial pilot effort or single center/set of centers is important for starting the program. The MEP was built on an earlier model of state programs and a small set of federally sponsored centers. The IRAP developed from a small pilot initiative. The MAS evolved from earlier rounds of existing business assistance programs. Tecnalia is the result of a merger of a prior set of technology centers. In each of the cases, we have noted the pre-history, chronology, and changing institutional arrangements, which framed the development of the current programs. This pre-history highlights the importance of activities that indicate the need for assistance to manufacturers (MEP), stronger innovation institutions (Tecnalia), or more industrial R&D (IRAP).

Support from the private sector and broader policy efforts to foster economic competitiveness were important in the creation of these pilot efforts. For example, the MEP was able to leverage broader concerns of private sector leaders about manufacturing competitiveness to obtain initial legislative support for its creation. In addition, program priorities have shifted with different phases of development and this change in emphasis, should figure in program planning. The MEP moved from an initial emphasis on scaling up a national program from a base of three technology centers to focusing on system wide services to the current stress on growth services (e.g., product and marketing development). The MAS likewise moved through initial stages emphasizing productivity improvement services to stages emphasizing brokerage of third party providers to the current more comprehensive company-wide service approach. Tecnalia is progressively moving from a traditional collaborative technology project model towards adding more value through commercialization of IP and business innovation services.

8.2.2. Structure and Governance

What is the appropriate organizational context for TES? Each sponsoring organization has its strengths and weaknesses. A basic research organization is too science oriented to be the appropriate home for TES. On the other hand, an organization with a purely commerce function may lack sufficient technological gravitas to be the best host. The four programs profiled here represent efforts to balance these structural characteristics. All of them are structured under the authority of a government agency (national or regional). Often the organizational situation and management structure reflect the history of the program and its mission. The IRAP was established to enhance industrial R&D in SMEs, hence it was situated in an applied research unit in the National Research Council. The MEP was placed under the National Institute of Standards and Technology because of its initial intent to transfer industrially relevant advanced technologies. The MAS fell within the remit of the UK Department for Business, Innovation and Skills because of its business and innovation orientation. In the British case, there has been significant high-level reorganization of agencies. In 2007 the current Department for Business, Innovation and Skills replaced separate agencies for Business, Enterprise and Regulatory Reform and for Innovation, Universities and Skills. Regional Development Agencies have been abolished, and regional devolution has resulted in separate structures for business support in England as well as in Scotland, Wales and Northern Ireland.

The MAS has been maintained throughout these changes, now targeted at a national level in England and operated under an outsourced arrangement with a private consultancy consortium. Tecnalia was created under the auspices of the Basque regional government as a stand-alone private nonprofit organization and as a result of the merger of several technology centers patterned after the Fraunhofer Institutes to add greater institutional capabilities to the Basque region's innovation system and to rationalize an arguably overly complex configuration of multiple individual technology centers. The use of flexible contracting mechanisms is evidenced in these case studies, with both the MEP and the IRAP using cooperative agreements rather than contracts to enable ongoing involvement and experimentation. Although government plays a major role in oversight, if not governance, of these TES programs, the programs also include private clients in their governance structure, usually through advisory board participation.

8.2.3. Program Scale

The ideal TES program should have sufficient program scale including field specialists and offices located close to clusters of companies. Likewise, plans should consider that, because TES relies on a decentralized service delivery, the larger the region, the greater the program costs. The differences in the economic scope (and number of potential companies) of the nations and regions covered by the four cases and in the scale of each program illustrate these divergent costs. They are apparent in the comparative program scale metrics that have been developed for the individual programs (Table 18). The most recent year available is presented (2012-13 for budgetary and center information, 2011 for customer information). The number of manufacturing SME's and customers per TES staff are lowest for Tecnalia, highest for the MAS, with the MEP and the IRAP falling in the middle. The budget per client served is higher for the MEP and the IRAP than for MAS (no budgetary information for TES alone is available for Tecnalia). These ratios suggest that the MAS, with its outsourced administration of TES, is relatively efficient. However, differences in actual services provided suggest that all such comparisons should be viewed with caution. Additionally, the extent to which all costs are captured is unclear. These numbers are primarily input and service measures and do not assess the benefits achieved relative to cost (value for money). Despite these limitations, it can be concluded from these metrics that TES has minimal scale economies. Fewer, bigger centers are not better than multiple, smaller locations in integrated TES systems.

8.2.4. Financing

Core public funding is essential to maintain the public mission of TES. Without it TES programs have a tendency to charge the same as private consultants, which drives service to larger and repeat clients and fundraising outside the service region. Moreover, if core funding is unstable, SMEs come to distrust the program and take-up is significantly reduced. In light of the importance of core public funding, each of the four programs has developed a different financing model. The MEP requires two dollars of matching funding (from clients, state governments, or other nonfederal sources) for every dollar of federal funding. The IRAP is fully funded by the national government. The MAS is also funded by the national government with some moneys coming from the European Union.

The IRAP and the MAS require companies to either contribute fund matches or cover the full costs for follow-up program activities or customized projects. Tecnalia receives 43 percent of its funding from public sources and only 15 percent via core, noncompetitive public funding (although it could be argued that some of the income derived from R&D

projects with firms is partly subsidized by other government programs), with the rest coming from contracts and other sources; sometimes these fundraising efforts are outside of the public mission of the organization. In sum, a common thread is that core government funding is critical to the ability of these programs to serve the public mission. The lower the level of core public funding, the greater the propensity for a program to move up market to serve medium size or larger firms in order to raise private revenues with lower transaction costs.

Table 18. TES Comparative Program Metrics

Comparative Program Metrics		MEP	MAS	IRAP	Tecnalia
Total budget	US$m	300.0	48.2	292.8	148.1
National (federal) contribution to the budget	US$m	123.0	48.2	292.8	70.0
Budget devoted to TES	US$m	300.0	48.2	60.8	25
Manufacturers in country*	x 000	334.8	109.2	52.8	13.5
Manufacturing SMEs in country*	x 000	332.0	97.7	52.5	12.6
Companies served (total, all services)	x 000	31.4	13.1	1.8	4.0
Companies served by TES services	x 000	7.0	13.1	1.8	3.5
TES customers that are SMEs	x 000	7.0	13.1	1.8	
TES customers that are manufacturing SMEs	x 000	7.0	13.1	0.2	
States, provinces, or regional areas in program		50	4	13	3
Centers in program		60		5	10
Offices, field locations in program		370	10	120	21
Total staff in program		1,300	120	397	1,473
Number of field agents in program		926	82	240	
Number of TES projects or engagements completed	x 000	49.0	13.1	1.8	
Scale Ratios					
Manufacturing SMEs /Staff		258	910	133	9
TES customers / Staff		5.4	109.5	4.5	2.7
TES $ / customer (all)	US$ x 000	9.6	3.7	163.8	37.0
TES $ / TES service customers	US $ x 000	42.9	3.7	34.0	

Source: Authors' elaboration from available program reports
Notes: Annual data, for most recent year (generally 2012–2013 for budget data, 2011 for customer information). Comparative numbers and ratio should be interpreted cautiously given the differences in program operations.
* For Tecnalia, figures relate to the Basque region rather than the country.

8.2.5. Clients

TES broadly serves SMEs with a manufacturing or product oriented nonmanufacturing emphasis. Target sectors are given consideration but usually not rigidly applied. Tecnalia is the most sector-focused program, building on the orientations and expertise of its constituent centers. The MAS has certain priority sectors designated as such by the government, but in

practice it serves all manufacturers. The MEP is designed to serve small and medium-sized establishments across all manufacturing industries, but federal funding can only be used to serve SMEs in manufacturing industry classifications. The IRAP serves manufacturing and nonmanufacturing SMEs that generate some type of product based on a diverse range of industry classifications. If the program charges for service, it should recognize the diversity of client capacity to pay for services and reduce fees (i.e., apply more subsidy) accordingly for smaller clients.

8.2.6. Services

TES uses a pragmatic approach to providing services to client firms. As a result of monitoring of company needs services on offer tend to be driven by demand. At the same time they can be guided by broader strategic issues such as the case of the MEP with its inclusion of growth services or the enhanced consideration given by the MAS to strategic support services. Accessing TES services should be easy, without requiring much form filling and red tape on the part of the business client. Multiple points of entry should be possible, including point solutions (i.e., undertaking initial work with the company to solve a particular technological or business problem that the company has today), companywide assessments, and through group processes such as open training programs and peer-to-peer networks. By way of example, services offered by the case study programs range from R&D oriented (Tecnalia and, to some extent the IRAP) to off-the-shelf manufacturing technologies and techniques (the MAS and MEP). Typical TES services can be seen in the MAS three-pronged categorization of strategic support, process efficiencies, and commercialization of ideas, or the MEP five-pronged categorization: continuous improvement, technology acceleration, supply chain, sustainability, and workforce.

Most of the IRAP's budget goes toward non-TES applied R&D funding, with TES advisory services viewed as having the ability to lead to and improve applied R&D projects in SMEs. Third party providers are commonly used, but their use should be easy for the company and quality should be maintained through the certification of providers and ongoing involvement of the TES specialist. Indeed, most of the case study programs use some combination of in-house expertise and third party providers to deliver TES services.

8.2.7. Infrastructure

In-house laboratory or equipment infrastructure is not an element in TES services offered by the IRAP, MEP and MAS; if infrastructure is required these programs will usually refer the client to another organization. Core TES services in product and process improvement areas do not require infrastructure, but TES services can be offered to complement infrastructure. Tecnalia maintains some in-house infrastructure for testing and certification in delivering non-TES services. The high cost of acquisition, customization, maintenance, upgrading, and operation of infrastructure precludes considerable investment, with TES programs preferring instead to put these moneys toward investing in capable personnel.

8.2.8. Personnel

A key factor in these TES programs is the expertise of extension professionals. The IRAP, MAS, and MEP emphasize the importance of decades of industry experience (often with multiple industries) in its extension professionals. In contrast, Tecnalia focuses on research capability (e.g., staff with PhDs), and is said to be weaker in terms of proven industrial expertise. Programs with targeted sectors do not require that the extension professionals have long experience in one of these particular sectors, rather they should be broadly conversant with the services needed. Extension professionals should be able to fill any of three roles common to TES services: (i) account manager performing outreach and client management functions; (ii) general extension professional performing assessments and basic services; and (iii) specialized extension professional providing in-depth information and advice in a given service area. Any given extension professional may perform more than one of these TES roles. For example, the GaMEP has field engineers that perform account management and basic general extension services and each field engineer is also assigned an area in which to provide specialized services; in contrast the SCMEP has separate staff members for account management, general extension, and specialized extension services (with some general extension staff also engaged in specialized service provision). Programs should plan to provide funding for training and certification of TES professionals. Monetary incentives are not always possible, particularly if the program is housed in a public organization, so other benefits are emphasized. Program managers in the IRAP, MAS, and MEP emphasized the lack of turnover and satisfaction with giving back to the region and its smaller industries by private sector managers after having had a successful career in industry.

8.2.9. Evaluation

TES programs typically use monitoring and tracking systems to capture information on companies served, services provided, hours of service, fee income, immediate outputs, and other metrics. These metrics may be collected by program staff or by third-party organizations, and often involve post-project customer surveys and/or questionnaires. Some programs openly publish aggregated summaries of these metrics, for example the MEP's performance metrics or in the MAS Quarterly Manufacturing Barometer. TES programs are also subject to a range of formal evaluations. These generally take a longer perspective to allow full benefits and costs to materialize or focus on measuring results against particular goals (such as increasing gross value added in England). Evaluation methods vary, but can include surveys, controlled studies, and case studies. Examples of findings of evaluations for intermediate outputs, business outcomes, and broader economic impacts are reported in Table 19. A full review of studies of the impacts of TES services is provided in Shapira and Youtie (2013).

Overall, the case studies emphasize that effective monitoring and assessment through a robust evaluation system is important not only for justifying the program to sponsors but also for ongoing learning. Measuring client impacts should be the primary goal of this system. For example, the MEP has an extensive monitoring system built around a survey of all clients receiving a level of intense services (usually at least eight hours of service). National administrators use this survey, along with national program ratings of centers and review of operating plans, to oversee center performance. The MEP complements its monitoring system with special studies and reviews. The MAS also has a set of indicators that it tracks in its annual report and the program has sponsored detailed econometric evaluations of program performance based on a comparison of client and nonclient outcomes. The MAS, however, uses a sampling approach for surveying clients rather than the census approach used by the MEP.

The MAS in particular and, to some extent the MEP, emphasize the importance of having an effect on value added per employee, even though this is a difficult measure to estimate and it is of marginal usefulness in program improvement efforts. Optimal measurement of value added per employee requires comparison group studies and efforts to account for selection bias in this type of measurement. In contrast, the IRAP primarily relies on legislatively mandated reviews performed every five years (the MAS also has this requirement). The IRAP uses due diligence in monitoring its applied R&D projects, but not much is captured about the program's advisory services. Tecnalia has a relatively narrow set of output indicators that are mandated by the Government and reported in their annual review, but no extensive monitoring or evaluation system is in place to assess the impact of

their services. It should be noted that even the MEP and the MAS have evolved their evaluation approaches to better align them with changes in the program mission. Thus TES programs should plan for changes in their indicators over time and include multiple qualitative and quantitative approaches in their evaluation systems.[47]

Table 19. Examples of Selected TES Evaluation Results

Intermediate outputs Capacity for change, changes in practice, improved firm capabilities	**MAS Clients, 2002–2005 (DTZ Consultancy evaluation, 2007)** Survey of clients, percent of clients reporting output	
	Improved productive use of equipment	47%
	Increased investment in skills	37%
	Improved just-in-time manufacturing practices	35%
	Better stock turns/stock holding/delivery	33%
	Increased space utilization, and	30%
	Increased investment in capital equipment	20%
	IRAP clients (Goss Gilroy, 2012)	
	Increase in firm's business skills and knowledge	70%
	Increase in scientific and technical knowledge	82%
	Enhanced technical knowledge or capabilities	90%
	Enhanced ability to perform R&D	62%
	Enhanced business knowledge/capabilities	68%
Business outcomes Performance changes for clients	**Findings from selected MEP evaluations**	
	Customized services in product development and marketing lead to bigger benefits, routine services for quality and process improvement lead to more modest firm effects. (Oldsman and Heye, 1998; Thomson, 1998; Youtie and Shapira, 1997)	
	Compared with nonclients, growth in labor productivity of MEP clients over a 5-year period in the late 1980s and early 1990s [2]	3.4%–16% greater growth
	An update to Jarmin (1999) using a comparable control group method, found mixed results for the MEP's overall net productivity impacts on assisted firms for the period 1997 to 2002, but did find that MEP services were associated with significant productivity improvements for smaller firms and certain types of services (Ordowich et al,. 2012).	
Broader economic outputs Economic returns generated	**MAS evaluation, 2002–2005 services (DTZ Consultancy, 2007)**	
	Economic benefit received by firms, on average, for each £1 of public funding (Level 4 consultancy services)	£1.40–£1.80
	Estimated internal rate of return of over a five-year period.	15%–17%
	Additional Gross Value Added through Level 4 and quantified Level 2 services between 2002-2005.	£155m
	IRAP (NRC and Goss Gilroy, 2007; Goss Gilroy 2012)	
	Benefits relative to public sector costs–based on multipliers derived from input-output models.	More than 10 to 1

Source: Programs reports as referenced in table.

[47] For more on TES evaluation and impacts, see Shapira and Youtie (2013).

8.3. Insights for Evolving TES Programs

The case studies offer a series of insights for evolving TES programs including programs in other countries, for example in Latin America, seeking to benchmark, improve, or establish new TES programs. The direct transfer of program approaches is probably not viable, given the unique institutional and industrial contexts of program countries and those developing new initiatives. A comparative review of key insights and practices is however instructive and useful, particularly if combined with initiatives to adapt those practices to new contexts. The following are among the key insights and practices highlighted by the analysis of the cases described in this report:

- **An evolutionary approach to development**. Startup of TES programs can be usefully tested through initial pilot efforts, particularly where significant changes are proposed to existing structures. Private sector firms should be involved in helping to make the case for TES programs. In terms of their evolution, these programs should plan on a national build-up phase and subsequent phases designed to hone offers of service.
- **An appropriate organizational context**. TES programs can be established in organizations ranging from economic development agencies to research agencies. Structures that emphasize a dedicated field staff, R&D centers, and technology-oriented business support can be used. Leveraging key partners is important for providing a full complement of services to meet the needs of SMEs. These partnerships should involve agreements that enable a review of performance and other changes (including ending the partnership) in response to changes in the program. Centralized structures are particularly useful for covering smaller regions whereas larger regions can consider decentralized approaches depending on the extent to which these regions have diverse existing TES-oriented organizations.
- **Sufficient program scale**. TES programs should have sufficient scale to provide services across the region. Scale should be primarily focused on having sufficient field specialists and decentralized offices. Because the decentralized network constitutes the lion's share of the program, TES has limited economies of scale.
- **Core public funding**. A base of sufficient public core funding is required for the financial sustainability of centers. A lack of core funding can lead TES programs to move away from their SME service mission and more toward larger companies (including outside the service region) who can fully cover service costs. It also

can lead to program instability hampering client confidence and trust in the service.

- **Broad client base**. TES requires a stable base of SMEs around which services should be designed. Manufacturing can be considered a core clientele for these services. However, as economies become more service oriented, service industries with a product orientation (such as software firms) can be considered. While setting out target industries can be useful in addressing economic development goals to strengthen regional economies, it can also add administrative complications to service provision and thus is to be implemented with considerable flexibility. Most TES programs do not rigidly apply target industry approaches in practice.
- **Structured approach to services**. TES should have a strong element of being demand driven—that is they should respond to needs prioritized by potential SME clientele. These needs will change over time, so programs should monitor and keep ahead of these changes. Several points of entry for initial work with SME clients should be permitted, including the ability to address technological problems encountered by an SME and follow up with more comprehensive services, as well as the ability to perform companywide assessments (either informally or through assessment tools). The range of services should not only emphasize cost savings and operational improvements but also cover and aim for strategic assistance. Technological and marketing needs to bring in new sales should also be a part of the TES portfolio. Formal or informal processes for referring partners providing access to specialized equipment or to private sector firms should include a prequalification or vetting process of these third party providers and, some level of management of the third party engagement (rather than a complete handoff of the client to the third party). Service pricing should allow for subsidies that decrease according to company size. While most TES should be delivered in a one-on-one manner, programs should also consider group approaches for the delivery of noncompetitive TES such as adoption of operational efficiencies; these types of services allow for effective peer-to-peer learning among companies in a region.
- **Links to equipment and infrastructure**. TES is not an infrastructure program. Because of the high cost of acquiring, operating, maintaining, and upgrading equipment and infrastructure, programs should link with partner organizations to provide equipment and infrastructure related services rather than devoting TES resources to equipment and infrastructure acquisition and maintenance.

- **Public-private governance that incorporates flexibility and experimentation**. Private sector participation is a requirement of program governance. Such participation is most optimally accomplished through advisory board mechanisms, in which private sector firms can provide strategic guidance in current and future offers of service. Where there is sufficient governance capacity in the central public agency, the agency should use cooperative agreements to combine flexibility (in terms of being able to make changes to the program as needed) with oversight.
- **Industrially experienced personnel**. Highly qualified TES specialists are at the core of the service. A significant length of experience in one or more industries is the most important criterion for hiring TES specialists. Also important is the ability of the specialist to perform at least one, if not more than one, of the three common TES specialist roles: account management, general TES provision, and specialized TES provision. Programs should plan on allocating a portion of the TES budget to training and certification so that TES specialists can maintain their expertise. Hiring in certain target industries is not as important as the ability of the specialist to be broadly conversant in process improvement, product development/marketing, strategic planning, and human resource needs of SME clients. Performance based incentives can be useful but are not always possible in a public agency environment; hence the ability to give back or do good should be emphasized along with a degree of latitude (subject to a level of oversight) in serving SME clients.
- **Effective monitoring and robust evaluation**. A strong evaluation system that provides information for program learning as well as program justification should be implemented. While geographic coverage should be a consideration, client impact should be given precedence in any evaluation system. Client surveys should be a core methodology in TES evaluation systems. However, because of the multidimensional, demand driven nature of TES programs, multiple methods should be used to capture impacts, including qualitative logic base case studies, peer-to-peer learning, and special studies of new initiatives. Comparison group approaches that gauge the effects of client firms relative to nonclient firms should be implemented from time-to-time and should take into account predispositions of higher performing SMEs to use the service (self-selection bias). Performance indicators should be monitored over time but changes in some of these indicators should be planned as the program evolves.

8.4. Good Practices and Debates

In starting or developing a TES program, stakeholders agree that there is a set of good practices evident in other programs that should be considered (with the usual caveat that good practices often need to be interpreted in context and adjusted to fit particular local conditions). First, TES should represent a pragmatic approach to the diffusion of technologies, focusing on the adoption of proven technologies. Second, while TES may begin with solving a particular company problem, the long-term goal should be to build up client capabilities. Third, TES should be designed to be flexible in delivering assistance to companies, offer services that are customized to the needs of the client, and aim for intensive engagements that will make a difference to company performance. Fourth, expert-led, long-term relationships with businesses are critical to developing trust. Fifth, the program requires a long-term perspective to boost its scale and reach to clients in the region. Sixth, the program is not just about direct relationships with customers but also involves coordinating and developing linkages with other service providers and financial resources. And seventh, TES should seek to combine good governance with flexibility and experimentation to be able to respond to changing business needs.

In recognizing these good practices, debates still exist about the best way to design and offer TES. The first debate is whether to focus on high growth potential firms rather than blanket support; it is recommended that intensive services be provided to the former firms while light touch services (such as open training) be offered to serve the larger population of potential clients. Second, the effectiveness of general strategic versus specialized demand driven diffusion is debated; it is observed that specialized support should be integrated with broader companywide strategic concerns to significantly affect business performance. Third, the debate as to whether it is better to target the program to a given region or industry cluster or broadly serve all firms depends on the composition of the industries in the region. Fourth, there is a debate as to whether online methods can be used or whether face-to-face approaches are required. In the current context, face-to-face delivery, usually at the company site, is more effective than online databases, although this face-to-face advantage may diminish in future generations. Fifth, there is a debate about what should count in measuring the program. While business performance indicators are at the core of TES, the work that these programs do in coordinating and linking service providers is critically important but difficult to measure. Sixth, debates about whether TES programs can be self-sustaining stand in contrast to the dependence on public funds to maintain the public mission. Finally, it is important to consider perspectives on TES as a stand-alone program versus one that exists in a broader ecosystem. While the start-up of a TES program is a major effort, careful attention should be paid to how the program is integrated into national and regional innovation strategies.

References

Aboal, D. and P. Garda. 2012. Technological and Non-technological Innovation and Productivity in Services vis a vis Manufacturing in Uruguay. IDB Discussion Paper No. IDB-DP-264. Washington, DC: Inter-American Development Bank.

Alvarez, R., A. Zahler, and C. Bravo-Ortega. 2012. Innovation and Productivity in Services: Evidence from Chile. IDB Discussion Paper No. IDB-DP-263. Washington, DC: Inter-American Development Bank.

Aranguren, M. J, E. Magro, M. Navarro, and J. Valdaliso. 2012. *Estrategias para la construccion de ventajas competitivas regionals: El caso del pais vasco*. Madrid, Spain: Marcial Pons.

Bellini, N. 2003. *Business Support Services: Marketing and the Practice of Regional Innovation Policy*. Cork: Oak Tree Press.

BIS (UK Department of Business Innovation and Skills). 2012. Industrial Strategy: UK Sector Analysis. BIS Economics Paper No. 18. London, UK: UK Government, Department for Business, Innovation and Skills.

Caputo, A., F. Cucchiella, L. Fratocchi, P. Pelagagge, and F. Scacchia. 2002. A Methodological Framework for Innovation Transfer to SMEs. *Industrial Management and Data Systems* 102(5): 271–83.

Cheney, D., C. Ordowich, J. Youtie, A. Fernández-Ribas, and P. Shapira. 2009. Evaluating the Impact of MEP Services on Establishment Performance: A Preliminary Empirical Investigation. Technical Report. Arlington, VA.

Ciobanu, B. 2010. Industrial Research Assistance Program Support for Innovative SMEs: Webinar. Ottawa, Canada: National Research Council. September 23, 2010.

Coderre, W. 2011. Inside IRAP: 1962-1992. San Francisco, CA: Blurb.com.

Combes, R. 1992. Origins of Industrial Extension: A Historical Case Study in Georgia. MS Thesis in Technology and Science Policy. Atlanta, GA: Georgia Institute of Technology.

Cruz Castro, L., L. Sanz Menéndez, and M. Romero. 2004. Convergencia y Divergencia en las Políticas de Ciencia y Tecnología de los Gobiernos Regionales. *Revista Española de Ciencia Política*: 33–72.

De Ferranti, D. M. (Ed.). 2003. *Closing the Gap in Education and Technology*. Washington, DC: World Bank Publications.

Department of Commerce. 2012. Manufacturing Extension Partnership (MEP) Centers for South Dakota and Kentucky; Availability of Funds. Docket Number 120221142–2118–01. *Federal Register* 77 (41): 12563–566. Washington, DC: Department of Commerce.

Dhanani, S. and P. Scholtès. 2002. Thailand's Manufacturing Competitiveness: Promoting Technology, Productivity and Linkages. SME Technical Working Papers Series. Vienna, Austria: UNIDO.

DIUS. 2010. Manufacturing Advisory Service: Summary and Conclusions. Evaluation Report 1. URN NO: 87/500.

DTZ Consultancy. 2007. Evaluation of the Manufacturing Advisory Service. London, UK: DTZ.

———. 2010. Review of the Manufacturing Advisory Service and Research to Support the Business Case for Continuing and Developing the Manufacturing Advisory Service: Final Report. London, UK: DTZ.

Garcia-Quevedo, J. and F. Mas-Verdu. 2008. Does Only Size Matter in the Use of Knowledge Intensive Services? *Small Business Economics* 31: 137–46.

Georgia Tech Enterprise Innovation Institute. 2010. The Georgia MEP Operating Plan. Atlanta, Georgia: Georgia Institute of Technology.

Georgia Tech Research Corporation. 1993. A Proposal to Create the Georgia Manufacturing Technology Extension Center. Atlanta, GA: Georgia Institute of Technology.

Goss Gilroy, Inc. 2012. Evaluation of the NRC Industrial Research Assistance Program (NRC-IRAP). Ottawa, Canada: Goss Gilroy, Inc.

Hallacher, P. 2005. *Why Policy Issue Networks Matter: The Advanced Technology Program and the Manufacturing Extension Partnership*. Lanham, Maryland: Rowman & Littlefield.

HM Treasury. 2013. *Plan for Growth*. Crown Copyright.

Jarmin, R. 1999. Evaluating the Impact of Manufacturing Extension on Productivity Growth. *Journal of Policy Analysis and Management* 18 (1); 99–119.

Jenkins, T. 2011. Innovation Canada: A Call to Action. Ottawa, Canada: Publishing and Depository Services.

Kijek, F. 2010. NRC Framework for Measuring Socio-Economic Impacts of S&T. Ottawa, Canada.

KOSGEB. 2010. 2011-2015 Strategic Plan (in Turkish). Ankara; KOSGEB.

KOSGEB. 2012. 2013 Performance Plan (in Turkish). Ankara; KOSGEB.

Li, Y. 2012a. ERAWATCH Country Reports 2012: China. Brussels: ERAWATCH.

———. 2012b. ERAWATCH Profile for the Chinese National Engineering Research Centers. Brussels: ERAWATCH. http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/organisation/organisation_0013.

———. 2012c. ERAWATCH Profile for the Spark Program. Brussels: ERAWATCH, http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/supportmeasure/support_0015.

López-Estornell, M., D. Barberá-Tomás, A. García-Reche, and F. Mas-Verdú. 2012. Evolution of Innovation Policy in Emilia-Romagna and Valencia: Similar Reality, Similar Results?

Magro, E. 2011. Evaluation in a Systemic world: The Role of Regional Science and Technology Policy. San Sebastian: PhD thesis, University of Deusto.

Manufacturing Advisory Service. 2013. Annual Report. http://www.mymas.org/news/MAS_Annualreport_2013_28_05.pdf.

Manufacturing Extension Partnership. 2013. Manufacturing Extension Partnership: Making an Impact on U.S. Manufacturing. Gaithersburg, MD: National Institute of Standards and Technology.

Mas-Verdu, F. 2007. Services and Innovation Systems: European Models of Technology Centers. *Service Business* 1: 7–23.

Mas-Verdu, F., A. Vaviera-Puig, and V. Martinez-Gomez. 2008. Internacionalizacion servicios y politica de innovacion: el papel de los centros technologicos. *Comercio E Internacionalizacion de Servicios* 844: 155–65.

Molina-Morales, F., and F. Mas-Verdu. 2008. Intended Ties with Local Institutions as Factors in Innovation: An Application to Spanish Manufacturing Firms. *European Planning Studies* 16(6): 811–27.

National Academies. 2013. *21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program*. Washington DC: National Academies Press.

National Academy of Public Administration. 2004. The Manufacturing Extension Partnership Program: Report 2 Alternative Business Models. Washington DC: National Academy of Public Administration.

NIST (National Institute of Standards and Technology). 2008. The Future of the Hollings Manufacturing Extension Partnership. Gaithersburg, MD: National Institute of Standards and Technology.

———. 2013. Hollings MEP General Terms and Conditions. Version 4.1. Gaithersburg, MD: National Institute of Standards and Technology.

National Research Council. 1986. *Toward a New Era in US Manufacturing: The Need for National Vision. Manufacturing Studies Board, Commission on Engineering and Technical Systems.* Washington, DC: National Academy Press.

———. 1993. *Learning to Change: Opportunities to Improve the Performance of Smaller Manufacturers. Commission on Engineering and Technical Systems, Manufacturing Studies Board*. Washington, DC: National Academy Press.

Navarro, M. 2010. Reflexiones sobre el sistema y las políticas de innovación del País Vasco, Orkestra Working Paper Series in Territorial Competitiveness Number 2010-R04 (CAS). Orkestra - Instituto Vasco de Competitividad.

Navarro, M., U. Lorenz, M.D. Parrilli, J. Karlsen, and I. Egurbide. 2013. Las infraestructuras del conocimiento: el caso vasco desde una perspectiva internacional. Cuadernos Orkestra 2013/3. San Sebastian: Orkestra, Universidad de Deusto.

NRC (National Research Council). 2007. Value of NRC-NRC-IRAP Clients Five Times Greater than Nonclients, New Pilot Study Shows. Ottawa, Canada: NRC.

———. 2010. NRC-IRAP Support for Technology Validation. Ottawa, Canada: NRC.

———. 2013. NRC-CNRC Industrial Research Assistance Program Conditions of Contribution. Ottawa, Canada: NRC.

OECD (Organisation for Economic Co-Operation and Development). 2011. *OECD Reviews of Regional Innovation OECD Reviews of Regional Innovation: Basque Country, Spain*. Paris, France: OECD Publishing.

ONS (Office for National Statistics). 2013. United Kingdom National Accounts: The Blue Book, 2013 Edition. London, UK: ONS.

Oldsman, E. 1997. Manufacturing Extension Centers and Private Consultants: Collaboration or Competition? *Technovation* 17 (5): 237–44.

Ontario Ministry of Research and Innovation. 2013. Results-based Plan Briefing Book 2011-12. Toronto: Canada: Ontario Ministry of Research and Innovation.

OTA (Office of Technology Assesment). 1990. Making Things Better: Competing in Manufacturing. U.S. Congress, Office of Technology Assessment. OTA-ITE-443. Washington, DC: OTA.

Rico Castro, P. 2007. La politica tecnologica y sus efectos sobre el cambio de las organizaciones de I+D: El caso de los centros tecnologicos del Pais Vasco (1980-1999). Madrid, Spain: Universidad Complutense de Madrid.

Shapira, P. 2001. US Manufacturing Extension Partnerships: Technology Policy Reinvented? *Research Policy* 30: 977–92.

———. 1990. Manufacturing Modernization: New Policies to Build Industrial Extension Services. Washington, DC: Economic Policy Institute.

Shapira P., G. Kingsley, and J. Youtie. 1997. Manufacturing Partnerships: Evaluation in the Context of Government Reform Evaluation and Program Planning Vol. 20 No. 1; 103–12.

Shapira, P. and J. Youtie. 2013. Impact of Technology and Innovation Advisory Services: Compendium of Evidence on the Effectiveness of Innovation Policy Intervention. NESTA and Manchester Institute of Innovation Research.

Shapira, P., J. Youtie, and L. Kay. 2010. Building Capabilities for Innovation in SMEs: A Cross-country Comparison of Technology Extension Policies and Programmes. *International Journal for Innovation and Regional Development* 3(3-4): 254–72.

Supattaraprateep, S. 2010. Thailand Self-assessment Report and Best Practice. Daegu Initiative First-Cycle Assessment Workshop, Hong Kong.

Tacsir, E. 2011. Innovation in Services: The Hard Case for Latin America and the Caribbean. IDB Discussion Paper No. IDB-DP-203. Washington, DC: Inter-American Development Bank.

Wanichkorn, K. 2013. Investment, Innovation and Technology for Development: Thailand's Experiences, UNCTAD Investment, Enterprise and Development Commission 5th session, Geneva.

Yan, Y. 2006. Rural Technology "Spark Program" covers over 90% Counties. Chinese Government's Offical Web Portal.

Yin, R., S. Merchlinsky, and K. Adams-Kennedy, K. 1998. Evaluation of MEP SBDC Partnerships. Bethesda, MD: COSMOS Corporation.

Appendix 1. U.S. Manufacturing Extension Milestones

Key Milestones in the development of manufacturing extension in the United States:	
1890	Hatch Act establishes state agricultural extension stations
1914	Smith-Lever Act establishes USDA-state cooperative agricultural extension service
1934	Engineering Experiment Station at Georgia Tech
1955	North Carolina State University Industrial Extension Service
1960	Industrial Extension Service at Georgia Tech
1963	Tennessee Industrial Research Advisory Service
1965	PENNTAP program at Penn State University
1966	Department of Commerce State Technical Services, federal-state program (until 1971)
1982	Massachusetts Commission on the Future of Mature Industries
1985	Michigan Modernization Service
1986	Machine Action Project, Springfield, Massachusetts
	Council on Competitiveness formed, called for greater manufacturing efforts
1988	Omnibus Trade and Competitiveness Act – NIST established (from NBS)
	Modernization Forum founded as MEP trade and lobbying association
	Pennsylvania Industrial Resource Centers program established
	Southern Technology Council establishes Consortium for Manufacturing Competitiveness
1989	3 Manufacturing Technology Centers (MTCs) established - in New York, Ohio, South Carolina
	National Coalition for Advanced Technology founded
1990	2 MTCs established - Michigan and Kansas
	Office of Technology Assessment “Making Things Better” published
	Modernizing America's Industrial Base - Modernization Forum, Pittsburgh, PA - 300 attendees
1991	2 MTCs established - Minnesota and California
1993	Technology Reinvestment Project (TRP) funding through Department of Defense
	Clinton administration support for formal Manufacturing Extension Partnership (MEP)
	National Research Council “Learning to Change” reshaped program orientation
1994	TRP funds transferred to Department of Commerce (single appropriation in 2005)
	MEP centers in 32 states
1995	GAO study: Manufacturing Extension Programs: Manufacturers' Views of Services
1996	MEP centers in all 50 states; National survey of clients introduced
	USNet established (1996–1998); MEP-SBDC partnership
1998	Technology Administration Act eliminated six-year sunset clause, allowing for ongoing federal role
	Modernization Forum National Conference, Cleveland, OH, 1300 attendees
2001	Minimally Acceptable Impact Measures (MAIM) introduced
	Supply America Corporation partnership
2003–04	National Academy of Public Administration program review
2005	American Small Business Coalition created
2006	Eureka! Winning Ways pilots (full implementation 2007–08)
2008	Next Generation Strategy: The Future of the Hollings Manufacturing Extension Partnership
2009	First class of the MEP Emerging Leaders Program
2010	Partnership with E3 to promote sustainable manufacturing
	MEP awards US$9.1 million for projects to develop client engagement or business models and deployment strategies that integrate two or more of the MEP Strategic Growth Areas
2011	GAO study: NIST Manufacturing Extension Partnership Program Cost Share
2012	Center Operations Review and Evaluation (CORE) system replacement for MAIM
	National Governor’s Association Policy Academy: "Making" Our Future: Encouraging Growth Opportunities in Manufacturing through Innovation, Entrepreneurship and Investment
	MEP University closed
	MEP National Conference, Orlando, FL, more than 800 attendees
2013	National Academies study: 21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program, November 2013

Source: Authors’ elaboration from program data and reports.

Appendix 2. IRAP Milestones

Key milestones in the development of the Industrial Research Assistance Program in Canada:

1916	National Research Council established
1930	Research Information Service (RIS) established in NRC
1945	RIS became Technical Information Service (TIS) IRAP voted into existence Committee on Industrial Research Assistance created
1962	IRAP established
1965	Initial IRAP pilot period
1968	Status report
1969	IRAP's first evaluation
1960s–1970s	Program ramped up to 40 ITAs concentrated in Ottawa,
1973	IRAP and TIS reported into the Industrial Research, Assistance, and Promotion Office of the NRC IRAP Policies and Practices
1975	Science and Engineering Student Program funded (now known as the Youth Employment Program) Pilot Industry/Laboratory Program (PILP, renamed Program for Industry/Laboratory Projects in 1978, renamed LabNet) ended in the 1990s
1977	Keith Glegg Vice President of Industry and Technology Transfer until 1990
1978	IRAP-M for small projects to the Provincial Research Organizations (p. 92), IRAP-P Industry Technology Advisors, IRAP-H from SESP IRAP support changed from grants to contributions
1981	Manufacturing Assistance Program transferred from Department of industry and Technology to IRAP
1982	Consolidation of IRAP and TIS
1980s	ITA network expands to roughly 200 ITAs throughout Canada through contracting with network members
1987	IRAP Advisory Board established
1998	Canadian Technology Network partnered with IRAP to provide repayable financing for pre-commercial R&D Customer relationship management CRM software introduced (SONAR)
Early 2000s	Associate regional directors established Post project review began
2001	Network member ITAs became NRC ITAs
2002	External evaluation
2004	Canadian Technology Network integrated with IRAP
2007	7,645 clients served; 1,971 received funding External evaluation: IRAP estimated to contribute C$2 billion–C$6 billion to Canadian economy, 4–12:1 benefit cost ratio
2008–2009	Online field manual created
2010–2011	8,063 clients served; 3,098 received funding
2012	External evaluation: 11:1 benefit cost ratio Reorganization: IRAP Vice President on NRC leadership committee
2011–2012	9,385 clients served; 1,853 received funding
2012	A vice-president for IRAP established
2012–2013	11,459 clients served; 3,047 received funding

Source: Authors' elaboration from program data and reports.

Appendix 3. MAS Customer Satisfaction Questionnaire for Level 2s

1. Please rate the following where 1 is "very poor" and 10 is "excellent":

1.1	The quality of service	1	2	3	4	5	6	7	8	9	10
1.2	The capability of the Specialist	1	2	3	4	5	6	7	8	9	10
1.3	The Specialist's speed of response	1	2	3	4	5	6	7	8	9	10

1.4 How would you rate your 'overall satisfaction' with MAS

Very Satisfied / Satisfied / Dissatisfied

2. Please indicate the response that reflects your view, below:

2.1	I intend to act on the advice/information received	Yes	No	N/A	Not yet	Maybe
2.2	I would use the MAS service again in the future	Yes	No	N/A	Not yet	Maybe
2.3	I would use the MAS service again in the future even if I had to pay the full cost	Yes	No	N/A	Not yet	Maybe
2.4	I would be happy to recommend MAS	Yes	No	N/A	Not yet	Maybe
2.5	MAS is good value for money / time investment	Yes	No	N/A	Not yet	Maybe
2.6	I have taken action to make improvements to my business as a result of the assistance	Yes	No	N/A	Not yet	Maybe

3. What are the key benefits to your business now and for the future? *(following MAS interaction)*

4. How might the delivery of the service be improved?

5. How did you hear about MAS?

6. How satisfied were you with the process of referrals if the Advisor made any?

Very Satisfied / Satisfied / Dissatisfied

7. May we pass your identity along with your feedback to MAS Yes / No

Appendix 4. MAS Customer Satisfaction Questionnaire for Level 4s

1. Please rate the following where 1 is "very poor" and 10 is "excellent":

1.1	The quality of service	1	2	3	4	5	6	7	8	9	10
1.2	The capability of the Specialist	1	2	3	4	5	6	7	8	9	10
1.3	The benefits obtained from the assistance	1	2	3	4	5	6	7	8	9	10
1.4	The Specialist's speed of response	1	2	3	4	5	6	7	8	9	10
1.5	The overall value of the service	1	2	3	4	5	6	7	8	9	10

1.6 How would you rate your 'overall satisfaction' with MAS

Very Satisfied / Satisfied / Dissatisfied

2. Please indicate the response that reflects your view, below:

2.1	I would use the MAS service again in the future	Yes	No	N/A	Not yet	Maybe
2.2	I would use the MAS service again in the future even if I had to pay the full cost	Yes	No	N/A	Not yet	Maybe
2.3	I would be happy to recommend MAS	Yes	No	N/A	Not yet	Maybe
2.4	MAS is good value for money / time investment	Yes	No	N/A	Not yet	Maybe
2.5	The information and/or paperwork I was asked to complete in order to qualify for MAS assistance was clear and concise	Yes	No	N/A	Not yet	Maybe

3. What are the key benefits to your business now and for the future? *(following MAS interaction)*
