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Design and policy choices for technology extension organizations

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Abstract

Governments, anxious to assist the SMEs in their countries to survive and grow, face not only policy choices about how to assist with technology, financial resources and business direction, but also the complex issues of how to design organizations that can deliver these policies effectively. This study is a comparative analysis of how "technology extension" (TE) organizations are designed to support SMEs in seven countries. The study focuses on the design requirements for such organizations and on the design choices that have been used to satisfy the design requirements, given different policy frameworks. Prescriptive advice on the design of TE organizations is offered to both policy makers and managers of such organizations. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Job creation is one of the central functions of governments. In the first half of the 1990s, unemployment had become unacceptably high in many of the industrialized countries of the West and job creation dominated the policies of governments in power and the election platforms of competing parties. However, winning parties that placed "jobs, jobs, jobs" on their election platforms largely found themselves unable to deliver on their promises. The subsidies and support for large private enterprises and the "make work" programs in the public sector that appeared to have impact in the past were no longer effective strategies for reducing unemployment. Governments began to back away from their dependence on these strategies alone. In casting about for

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alternatives, many became more conscious of the contributions of small- and medium-sized enterprises to job creation.[1] By the mid-1990s, much earlier in some countries, such as Spain, with a high unemployment rate and a high proportion of SMEs, government industrial policy choice began to focus on the idea that SMEs could be an important component of national economic goals.

Governments in most countries now directly confront the question of how to help SMEs both lower their failure rate and grow to become job creating employers. Some governments have been doing this for a long time. However, they have used a wide variety of approaches and they have had varying degrees of success. Many governments are unclear about either the effectiveness or the appropriateness of their policies. The question about how to make SMEs succeed is not trivial. Success is problematic. The choices are many and complex and the results of decisions made are difficult to evaluate.[2] More importantly, even when appropriate policy decisions are made, their implementation is neither obvious nor easy. It is a challenge to design organizations that can deliver selected policies effectively. This article focuses on organization design issues that support policies to increase the effectiveness of SMEs in society, particularly technology-based SMEs.

1.1. SMEs as job creators

Large companies have been cutting back in size over the last few years, largely because of advances in technology but also because increasing global competitiveness has made them highly sensitive to their cost structures. These factors have been behind much of the negative reporting about companies who preserved their bottom lines by reengineering their processes and taking other drastic measures that destroyed countless number of jobs. This plague of downsizing and outsourcing drove many of those who were affected, particularly managers, to create businesses of their own, often in the service sector. At the same time, small company start-ups have been increasing for a variety of other reasons, among them, the low cost of start-ups in areas, such as software and selected electronic areas, increased franchising, a new value placed on entrepreneurship, an increasing desire on the part of women to start their own enterprises to avoid the gender-based constraints of the "glass ceiling", business school graduates, computer scientists and entrepreneurs who value the autonomy and wealth potential of small, high technology start-ups and/or are not attracted to the career profiles in large corporations, and mid-level managers who have become disenchanted with the control and dehumanizing orientation of large organizations.

In concert with an increase in the *cachet* of entrepreneurship in society is increasing evidence that small- and medium-sized companies are creating more new jobs than are large companies.[3] This has invited increasing attention from government policy planners interested in fostering SME development. Typical is a quote from Edith Cresson, co-author with Martin Bangemann of the European Commission Green Paper on Innovation:

> SMEs account for 66% of jobs and 60% of turnover in the European Union. Since 1988, net job creation in SMEs has outpaced job losses in large companies (Innovation and Technology Transfer, Feb. 1996, p. 5).

[1] The definition for small and medium enterprises (SMEs) varies with each government and sometimes with different programs within a government. We focus on the criterion of number of employees, assigning the term 'small' to organizations with fewer than 50 employees and 'medium' to organizations with fewer than 500 employees. This has been a creeping definition. Many organizations that used fewer than 200 employees as the upper limit for medium-sized enterprises have revised the upper limit to 500 in the past few years.

[2] Two journals have recently published special issues dedicated to the evaluation of SME support programs: Research Policy, Vol. 25, 1996 and The Journal of Technology Transfer, Vol. 23, No. 1, 1998.

[3] Referring to manufacturing specifically, Kane (1998), drawing on data from the 1992 Census of Manufacturing in the United States noted, "…that while manufacturing employment declined by 2.0 million at large plants in the 25 years from 1967 to 1992, it grew by 1.7 million at smaller firms. By 1992, manufacturers with fewer than 500 workers accounted for 98.6 percent of all manufacturing establishments (up from 98.1 percent in 1967), 64.9 percent of all manufacturing employment (up from 54.5 percent), 56.9 percent of manufacturing's annual payroll (up from 48.4 percent), and 54.9 percent of manufacturing's value added (up from 48.7 percent)." (p. 9).

While governments and society want new entrepreneurs to succeed, the failure rate for SMEs is high. Both managerial and technological reasons account for most SME failures. Governments, however, have tended to focus on the inability of SMEs to keep their product or service technologies up-to-date or to develop new products or services. Surprisingly, this is even the case when a technological innovation was the basis of the SME's start-up. Too many SMEs do not have the time or capital or competence to appropriately engage with technology, and their early successes, or at least their ongoing viability, are not sustained.

> The underlying premise is that the key cause of the decline in U.S. manufacturing competitiveness has been the inability of smaller manufacturers to implement manufacturing process technologies and techniques which would support high-quality, low-cost production, while allowing for rapid changes in product design. There is widespread acceptance of this belief. The large American original equipment manufacturers (OEMs) have increasingly turned to off-shore suppliers because they are often considered superior to U.S. firms in price, quality and service. (Simons, 1992, pp. 168–169).

The above reference is to manufacturing process technologies in particular. Across the board, though, SMEs are generally assumed to have difficulty in exploiting the advantage that increasingly complex technologies can provide.[4] According to the European Commission Green Paper on Innovation: "Access to the know-how and information is far more difficult and proportionately more expensive for SMEs than for large businesses" (Innovation and Technology Transfer, 1996, p. 17). Governments see this as a serious concern because adopting new technology is often crucial to the long-term survival of a company. In innovation-oriented economic development, it is the technology-based SMEs that contribute best by stimulating or becoming users of the knowledge-based economy. This has led some governments to single out specific new technologies as part of their industrial policy, e.g., software and biotechnology, which can spin off many new and small start-ups that, in turn, can lead to commercial and export success.

1.2. Technology extension

We refer to the subject of supporting SMEs with technology as "technology extension" (TE) and use the phrase to distinguish it from three other phrases: "technology transfer" and "industrial extension" (Simons, 1992) and "industrial modernization" (Shapira and Roessner, 1996; Shapira and Youtie, 1998). All three are used to address the issue of transferring technological know-how to industry, but in different ways.

Technology transfer is becoming a more specialized term to refer to the increased efforts by large governmental, university and other public sector laboratories to commercialize their technologies by transferring them to large industrial corporations. It is a supply-side focus created by the large laboratories. It differs from the demand-side focus that reflects the needs of small- and medium-sized enterprises. The last few years of budget reductions to the large research and development labs have led to aggressive efforts on their part to find commercial applications for their research and, in the process, secure sources of funding to off-set the cutbacks they are experiencing from their normal funding sources. Their technology transfer orientations are often complex and sophisticated and better suited to the large corporations that are the objects of their interest than to the SMEs that are the focus of this article.

Industrial extension is derived from the Agricultural Cooperative Extension Service in the United States that formally started in 1914. It was a very successful initiative that used field agents to transfer new agricultural technologies and products directly to farmers. While the use of direct field agents is one of the more effective

[4] The definition of technology can range from hardware-based equipment to knowledge management. The latter can be quite abstract but is also more inclusive of the information and ideas that underlie many of today's innovations. This study's perspective on technology takes information and a service orientation into account but still tends to be closer to the hardware-based end of the technology definition spectrum.

approaches we have studied, many governments have chosen to carry out the transfer of technology to SMEs without utilizing field agents. Industrial extension has also come to represent a broader domain, where SMEs are often backward,[5] of assisting with business planning, strategic direction, accounting and financing, marketing research, and manufacturing processes in addition to technological assistance.

In the United States, *industrial modernization* has surfaced in the last few years as a popular term to describe this field. Shapira et al. (1996, p. 185) refer to it as "... the application of improved technologies and business practices to strengthen competitiveness and productivity, particularly among small- and mid-sized manufacturing enterprises". Further on, in the same paragraph, they state that "Industrial modernization programs typically focus on the deployment of known technologies and proven business practices, training methods, and management approaches, rather than the creation of new technology". In effect, industrial modernization appears to be an alternative term to industrial extension. The U.S. Department of Commerce's National Institute of Standards and Technology (NIST) is the major sponsor of industrial modernization programs in the USA through its Manufacturing Extension Partnership (MEP), which combines government, industry, and academic resources to foster technological modernization (Shapira et al., 1996). Shapira et al. (1996) analyzed data from MEP centers and found that most of the services they provided were focused on pragmatic issues rather than highly sophisticated technologies.

> The primary services provided by these programs included assistance with business systems and management (23% of all activities reported), quality (14% of activities), market development (12% of activities), manufacturing process (11%) and human resources (9%). A secondary set of services, each representing between 5 to 7% of all activities included assistance with product design, environmental management, plant layout, and computer-aided design and manufacturing. Assistance with automation or robotics is among the lowest ranked categories (just over 1% of activities), reflecting the fact that industrial modernization services are mostly aiding firms to upgrade their existing business practices, methods, and techniques rather than promoting the deployment of leading-edge technologies (which can be too complex or untried for most small companies). (p. 190)

None of the organizations we studied were engaged in technology transfer as we have described it above. Several of the organizations we studied do have industrial extension or industrial modernization type mandates as we have referred to them above. Others have limited their activities to assistance with technology or have only begun to expand their activities beyond the domain of technology to include some of the business components of industrial extension. Given this variety of policy choices, it is clear that no term is going to fit well for all the different country situations we studied. Most, however, seemed to have a much greater percentage of their activities focused on technology than the proportions cited by Shapira et al. (1996) in categorizing NIST's MEP center data. As such, we have chosen "technology extension" as a term that best fits most of our situations. Governmental and quasi-governmental agencies are traditionally reactive with respect to clients, anticipating that their clients will approach them. The organizations we studied or learned about were proactive or were becoming increasingly so in reaching out to the SMEs that are so important to their local, regional or national economies. We finally settled on the term "technology extension" not only because the other terms did not quite fit, but also to reflect the type of proactive attitude and behaviour we observed in the organizations we studied, even when they were not structured to directly approach their clients. We also recognized the similarity of the term to others being adopted, e.g., Manufacturing Extension Programs, Technology Extension Service (Oldsman, 1996).

[5] Kane (1998, p. 9) notes that "...small and midsize U.S. manufacturers lag behind their larger counterparts in awareness and implementation of modern management and shop floor methods, such as work teams, just-in-time and cellular manufacturing, inventory management and control, quality systems, bottleneck scheduling, and planned preventative maintenance."

Shapira (1992) has reported on the very successful program of 170 public centers that support the 870,000 small manufacturers in Japan. The centers are referred to as *kohsetsushi* centers. The services and activities these centers offer fall into the following categories:

1. Applied research, with even companies sending their researchers to the centers for training;
2. Information dissemination, through seminars, exhibitions, newsletters and research reports and by maintaining technical libraries;
3. Testing, of materials and products to comply with Japanese and foreign standards;
4. Advice and guidance, solving technical problems and implementing new technologies;
5. Training and the use of laboratories, to allow companies the use of advanced equipment for research and prototype development;
6. Technology diffusion groups, that "sponsor groups of small companies that meet to exchange information and cooperate on sharing technology and developing new products and markers" (p. 69).

Some of the TE organizations we studied offer services similar to those offered by the *kohsetsushi* centers although few offer all these services and activities. Some offer still other services than those listed above.

The basic model of a TE service is illustrated in the shaded areas of Fig. 1, where the TE organization role between the sources of technology and the SMEs can range from being a reference source to being a broker to directly consulting on the client's problem. For example, Clarke and Dobson (1991) examined 42 programs in 28 states in the USA that served 17,500 clients in 1990, but whose range of clients served was from as few as 20 to as many as 3000 in that year. The choice depended on whether in-depth technical assistance was provided or whether the center served primarily as a referral service to other state and national programs of assistance.

The decisions about what services to offer are some of the key policy choices that governments must make, which is illustrated in Fig. 1. Once having made the policy choices, either because of context or constraint, there is then a second set of choices to make about how to design the TE organization to deliver the policies. This second question is the primary focus of this article. However, we will set the context for this focus by first discussing some of the policy choices that were made by the governments, in the countries where we studied TE organizations, in deciding the mandates of their TE organizations to provide assistance to each country's SMEs.

1.3. The TE organization design process

The TE organization in a country could be a nationwide system or it could be regional or local in its primary focus. The TE system may be comprehensive or it may use a very limited aspect of the many ways in which technology can be extended to SMEs. For some nations, the sources of the technology they provide could be within their own governmental organizations or the sources may be externally acquired from a variety of other technology-oriented organizations.

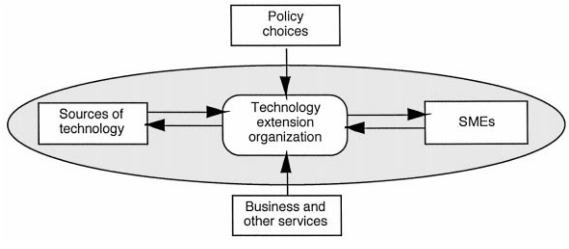


Fig. 1. Technology extension organization interfaces.

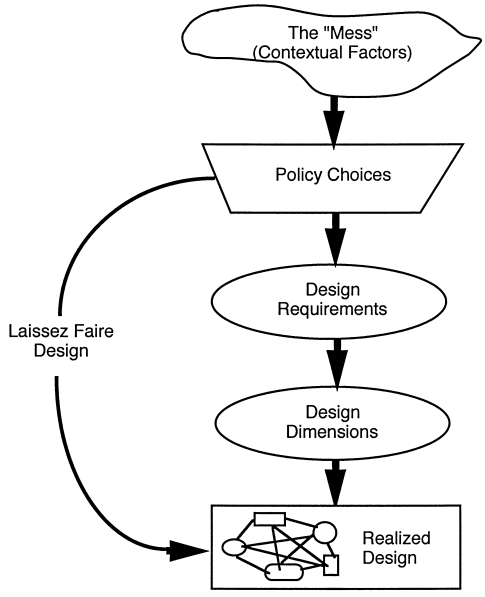


Fig. 2. Technology extension organization design process.

The TE role may be less oriented towards directly assisting with technology than towards helping SMEs to access such sources. TE organizations may see their primary role as that of providing financial assistance for SMEs to enable them to buy or develop the resources needed to enhance their level of technological competence. Extensive networks of financial assistance and incentive programs can be found within the public and private sectors of almost every industrialized country to indirectly support TE rather than offer direct technological assistance.

We refer to this kind of a contextual situation as a *problematique* or "mess" (Ackoff, 1981) because there is no simple or even complex response that accomplishes the objective every time. Each country's situation is different. In each country, the perspective of the government with respect to its SMEs affects the TE role that evolves. The policies of the particular party in power may affect the TE approach. Culture, history, economics, labour market policies, and a host of constraints and/or enabling conditions all have impact on the approach taken. These are *contextual factors* that are critical components of the "mess" associated with each TE organization. These contextual factors become manifested in particular *policy choices* for that organization (see Fig. 2); policy choices that can result from explicit decisions, or policy choices that have evolved out of a series of decisions over time or even a set of *laissez-faire* actions or some combination of both explicit decisions and laissez-faire actions.

The specific focus of this article is on the design of the TE organization (the *realized design* in Fig. 2) within the boundaries set by policy choices. While policy choices are critical inputs to the design process such policy choices and how they are made are not the primary focus of this article. Nevertheless, we will introduce some key policy choices that must be addressed by governments interested in TE[6] to illustrate the impact they have on the TE organization design process.

[6] Policy issues associated with technology extension can be pursued in more detail in Shapira (1990), Clarke and Dobson (1991), Simons (1993), Stymne et al. (1996).

Organizational choices about how TE will be carried out follow from the policy choices. We were especially interested in studying the "organizational innovations" (Stymne et al., 1996) that enabled successful TE to occur. We wished to understand the extent to which such innovations enabled TE organizations to foster the success and the development of technological competence in SMEs. From our analysis, we were also interested in differentiating between organizational innovations that appeared more effective with respect to extending technology to SMEs than those that appeared less effective.[7]

What we learned is that there are some organization design criteria for the design of TE organizations that are necessary in and common to all countries, even though different TE organizations in different countries implement these criteria in different ways. We refer to these criteria as *design requirements* and we see them as central to the organization design choices necessary for the design of TE organizations (Fig. 2).

In satisfying the design requirements, the different TE organizations we have studied have arrived at different *realized designs* as organization designers have emphasized different aspects of the design requirements. We refer to this range of ways of responding to a design requirement as a *design dimension* (Fig. 2). Some of these realized designs have satisfied many of the design requirements. Some of the TE organizations have satisfied only a few of them. Hence, some of the TE organizations have been more comprehensive than others in carrying out their task. The policy choices, design requirements and design dimensions shown in Fig. 2 are the heart of the TE organization design process and we will examine this process in more detail in the sections that follow.[8]

Of course, it would be interesting to be able to say which particular design choices are preferable and which are more problematic. For example, could certain ways of organizing TE be linked to higher growth in the population of SMEs? We do not rule out that one could find superior designs of TE organizations that may even, for a time, evolve into dominating designs. However, we have not in this study tried to link design features to general indicators of success. Instead, we have tried to use the following ways of reasoning and reporting:

1. The main problems of TE organization have been formulated as design requirements.
2. The design choice of the each TE organization for each design requirement has been investigated.
3. We have noted if the specific choices made appear to have solved the problems they should cope with or not. We also assessed whether a TE organization that has made a certain design choice has encountered fewer problems in coping than a TE organization that has made other choices. In this way, we hope to provide a wide and interlinked set of observations and analyses that can help the designer of TE organizations to make informed choices. Our analyses may also serve as a point of departure for further studies of the consequences of different choices in the design of TE organizations.

There is no one best way to organize (Lawrence and Lorsch, 1967) and the concept of organizational choice is central to the design of organizations. Organization designs are frequently a mixture of explicit decisions taken and less explicit practices followed for historical or cultural or social or business reasons that are difficult

[7] We had no empirical measures of effectiveness. Some TE organizations have attempted to measure their effectiveness to better direct their efforts (Luria and Wiarda, 1996). Some have done so primarily to convince the governments and/or legislatures that funded them that they merited continued support or even more support. Testimonials from contented SMEs have not carried too much weight with the controllers of government budgets. Numbers of new jobs created by an SME was frequently the focus of efforts to demonstrate effectiveness, but the attribution of cause to the creation of jobs was problematic, and sometimes increased efficiency led to job loss rather than job creation, at least in the short run (Oldsman, 1996). It is also difficult to disentangle the contribution of technology from a good business plan or a creative new product or service or a well-researched market niche (Berry and Taggart, 1998).

[8] Shapira (1996) has referred to efforts by NIST to establish best practice program management and service approaches in infrastructure initiatives in the domain of industrial modernization such that innovative practices developed in one region of the USA can be quickly copied by others. We have attempted to keep the relationship of policy choices, design requirements and design dimensions tightly coupled in our research and believe that design requirements and design dimensions disaggregate what has been referred to as best practices.

to trace or rationalize, especially after a period of time. We have used the role of a hypothetical "organization designer" to emphasize this. This hypothetical organization designer can be quite real, as when it comprises the officials of policy making government departments and the managers of TE organizations. The former exercise choice over policy and the latter exercise choice in selecting design dimensions and other organizational attributes that help realize the set of design requirements.

Alternatively, the organization designer can represent a process through which a particular organization design evolves out of a series of practices or actions taken and for which it is sometimes difficult, after the fact, to attribute specific responsibility for decisions. The *laissez faire* arrow in Fig. 2 represents this alternative. Policy makers make explicit policy decisions but undervalue or underestimate the next steps, often by assigning them to a category entitled "implementation". They assume that this category of activities will come about without too much explicit management or attention. They ignore the design of the organization that must convert the policies to action. In effect, the task of the hypothetical organization designer to which we have just referred is largely ignored or devalued or left to chance or dismissed as not worthy of policy makers' attention.

2. Research process

This study examined TE organizations in Canada, Germany, Italy, Spain, Sweden, the United Kingdom, and the United States.[9] Our investigations lasted over several years, from 1992 to 1996. We also drew on literature and country knowledge about Japan, although a specific TE organization in that country was not studied.

In the TE area (as well as in each of the three other areas studied), a "lead case" was selected as an example of an innovative and interesting response to the question of how to organize (design) for that area (Stymne et al, 1996). The lead case for the TE area is a national organization situated in Canada called the Industrial Research Assistance Program (IRAP). A case study describing IRAP was prepared and used as a baseline against which other organization were compared (Kolodny, 1996). Organizations carrying out TE in each of the other countries participating in the study were then identified; some were national organizations, some were regional, some were local. We did not explicitly attempt to identify TE organizations that were similar to the lead case.[10] The focus of the study was the design of TE organizations and a diversity of country responses to the subject of TE provided a good data set from which to address the research questions. However, researcher's ease of access to particular organizations was also an important consideration in the choice of TE organization.[11]

Contextual data, managerial data and organizational data were collected for each of these organizations and a case study was written for each.[12] The case studies were shared among the different members of the international research team. We met face-to-face once or several times per year and developed the detailed comparative analysis tables that eventually became the data sets for this study.

[9] This research study is a part of a larger study in which four important areas were selected for studying the outcomes of innovative organizational design practices (Stymne et al, 1996). The four areas were chosen because they have wide economic repercussions and they are the focus of much debate and study. Considerable amounts of both public and private money are at present being invested for organizing these activities to get better performance. This article concentrates on one of the four areas, namely: *How to organize a government program for technology extension to small- and medium-sized enterprises*. The other three areas are: how to organize for the globalization of a domestic business concept; how to organize industrial activities for continuous improvement (Lillrank et al, 1998); and how to organize a modern public service.

[10] For example, the Fraunhofer Society Institutes in Germany, as an ongoing organization, is more comparable to IRAP than the fixed term program that was selected from Germany.

[11] We were quite explicit in our choice of researchers, selecting colleagues in the different countries who had a long standing interest in the issues of organization design and technological innovation.

[12] These background papers were prepared as a collection of case studies (see Kolodny, 1995; Campanini and Gavetti, 1996; Carlsson et al., 1996; Figuera and Ramos, 1996; Latniak, 1996; Shani, 1996; Steward, 1996).

3. The TE organizations studied

Seven TE organizations in seven different countries were studied. Brief descriptions of each follow.

3.1. Canada — the IRAP network: a nationally integrated program

The IRAP in Canada is designed to help technology-based SMEs acquire, adapt, commercialize and manage new and complex technologies in partnership with the Canadian research community. IRAP is a part of the National Research Council Canada (NRC), which runs the national laboratories for science and technology. The program integrates both provincial technology assistance programs and the programs of specialized technology centers into the IRAP network to provide a combined national/regional/local perspective (Kolodny, 1995). In 1996–1997, IRAP provided assistance to approximately 10,000 companies. Assistance is primarily technological and is provided without charge. IRAP also provides financing; however, all IRAP projects that are assisted financially are shared undertakings in which IRAP's proportion of the cost is less than that invested by the client. Most of the client base is companies with 50 or fewer employees. The clients range from software developers and biotechnology entrepreneurs to farmers, fishermen and loggers.

IRAP's assistance is delivered through 240 field-based Industrial Technology Advisors (ITAs) who are physically located within 'network member' organizations across all parts of Canada. In total, there are over 120 network members that serve as sources of technology including universities, community colleges, provincial research organizations, centers of excellence, specialized technology centers and industry associations. The ITAs serve as gatekeepers to the IRAP network for the technology capabilities within that network member's organization. In effect, IRAP does not attempt to build additional infrastructure for technology development but rather operates out of existing technology locations and attempts to link the capabilities through continuously enhanced electronic and organizational communication systems.

The ITAs are selected in conjunction with the network member and over two-thirds of them are on contract with the network member organization, although their salaries and support costs are provided to the network member through a contribution agreement with IRAP. In this way, ITAs and IRAP are integrated into provincial and local sources of technology as well as into national laboratories and sources of technology. After evaluating the needs of the company, the ITA becomes the link to all the technological experience and knowledge that is available through this vast network of formal and informal contacts. The network of ITAs, network members, and communication systems is the foundation of IRAP's delivery system.

3.2. Italy — ASTER: a regional program

Italy's ASTER program is regional and centered in the Emilia Romagna area in Northern Italy. ASTER brokers' relationships with sources of technology and with programs of support available from the European Community to provide services for SMEs in the region (Campanini and Gavetti, 1996). It also facilitates access to the European market. ASTER was founded by the Regional Industrial Development Board in 1985 and is today a private enterprise. ASTER is one of a network of 10 service centers, each of which has a specific task in the regional industrial policy. ASTER "...plans, promotes and supports the improvement of the industrial competitiveness of the companies by supplying them with services with a special emphasis on SMEs needs for internationalization, business cooperation, technology transfer, innovation, quality improvement and information".

ASTER distributes a monthly summary of the most recent and relevant EU projects in technology-related fields. The publication goes to 1000 organizations that represent small businesses (e.g., town councils, industrial federations, regional craft federations, etc.) and to 8000 SMEs. In addition, ASTER directly contacts the firms that are considered particularly suitable for a certain project. Sometimes ASTER also takes a more active role by

managing or organizing the whole or a part of a project. ASTER may help SMEs with answering proposals or by gathering data on technology-related topics or by organizing training courses in technology-related areas or by assisting firms in establishing cooperation in commercial and technological areas.

3.3. The United States — California Manufacturing Technology Center (CMTC): a local support program

The CMTC was established with the aim of promoting the technological capabilities and the competitiveness of small- and medium-sized manufacturers in California. It was founded in 1992 as one of seven regional MTCs that were initially funded by The NIST, a part of the U.S. Department of Commerce. The CMTC program is located in Torrance, CA and is affiliated with the California Employment Training Panel, The California Community Colleges, The California Trade and Commerce Agency, and El Camino Community College. CMTC's mission is "...to provide a staff of professionals who understand the needs of the California manufacturer, and cost effectively apply appropriate technologies to improve the competitiveness of the California small- and middle-sized manufacturer."

Two years after it was founded, CMTC attained nonprofit status, and as such, gained more autonomy from NIST/U.S. Department of Commerce. The operating philosophy of the Center adheres to the following principles: create jobs in California, deploy technology rather than create it, leverage resources, provide fast bureaucratic-free responses, and serve small- and medium-sized manufacturers under 500 employees. The CMTC provides assistance to its clients in several ways: solutions to specific manufacturing problems; financial assistance for research by helping companies obtain subsidized loans; help in implementing programs, such as TQM, SPC, ISO 9000; marketing and business advice; and free seminars and workshops. The CMTC has evolved to a local program from being part of a national one (Shani, 1996).

3.4. Germany — the 3rd Manufacturing Technologies Program: a national / sectoral program

The German 3rd Manufacturing Technologies Program (MTP3) was a time limited program that focused on promoting the diffusion of Computer-Integrated Manufacturing (CIM) concepts from 1988 to 1992 and was extended to 1995. It was directed at a particular sector — manufacturing — with the specific objective of fostering the adoption of new CIM technology by manufacturing SMEs (Latniak, 1996). The program was a national one, directed at SMEs as a counterbalance to previous support that had been directed at large companies. The target group of SMEs were those with high export rates and whose products would dominate their sectors. Some 4500 companies were identified with approximately 3750 of those in the mechanical engineering and machine tool industry (550 more were in the electrical industry and 200 in the precision engineering and optical industry).

MTP3 used a concept referred to as "indirect-specific" meaning that applications for assistance in predefined fields of technology were supported and the procedure for being accepted for support within those predefined fields was greatly simplified. By subsidizing a large group of companies in the predefined CIM areas, it was hoped that widespread technology diffusion could be realized. This also reflected a shift in policy strategy from development to implementation and a diffusion-oriented approach that aimed to produce "structural effects" without primarily supporting hardware investments.

MTP3 used a mix of policy instruments to support technology diffusion, e.g., training, consulting, information and documentation to support users' technology, standardization efforts, and the combination of projects to solve the problems of applicants working in cooperation (e.g., along a supply chain). 16 CIM Transfer Centers were initially created for demonstration and consulting (five more were added later). Institutions, such as universities, chambers of commerce, and industry associations, were incorporated into transfer activities.

3.5. Spain — the REDINSER program: a variety of policy mandates

Spain's REDINSER program is a rather loosely knit network of quite independent TE centers that have evolved in very different ways. The program has a wide variety of technically oriented centers including one, since closed down, that was created to serve the garment industry of Madrid, which accounted for a sizable part of the industrial output and employment in the region (Figuera and Ramos, 1996). Some centres have disappeared, others continue to assist with technology only, while still others have enlarged their scope to include more industry extension activities in addition to TE, such as:

- organization of training courses, seminars and workshops on product and process technologies, plant management and maintenance, industrial logistics, etc.;
- helping SMEs to implement programs of inventory reduction, quality improvements, etc.;
- assistance to obtain financial support, such as grants, subsidized loans for energy saving, technology upgrading, etc.

In addition, some of the more dynamic and firmly entrenched centers were, by 1995, creating more restricted and sharply focused networks.

3.6. Sweden — the Business Partners: an industrial extension program

The Swedish Business Partners organization places as much or more emphasis on helping businesses with business planning advice as it does with technical help programs (Carlsson et al., 1996). The organization evolved through several initiatives by local and central governments to help local businesses to obtain financing. That objective was continued with the creation of ALMI Business Partners, a corporation of 24 companies, one for each county of Sweden. Each company is 51% owned by ALMI (owned by the Swedish Government) and 49% by the County Council, which is governed by locally elected politicians. The scope and activities of the 24 companies vary considerably. Of the 560 employees of the companies, the largest had 40 employees and the smallest 14. However, only 40 of the employees are technical specialists. The Business Partners assists SMEs by:

- scanning the environment to channel relevant information to clients, such as whether there is a demand for a product or service;
- working as a local partner in the many public schemes aimed at technical and economic development;
- advising them to contact one of the "Technology Parks" which have been established near many universities and which can provide services for new ventures at subsidized rates;
- directing them to actors specialized in different phases of the development process (e.g., the Export Council); and
- finding other possible partners among "Investor Societies" that have their own offices and advisors at different locations who might help them in assessing and evaluating market possibilities for new products.

In the mid-1990s, the focus of the Swedish Government shifted from mainly regional development to include an emphasis on technical development, inventiveness and knowledge. For example, the concept of "Technology Bridges" was introduced. They have been given the legal form of foundations. Their purpose is to facilitate the transfer of technology by supporting various programs for contacts between universities and other centers of technological knowledge and small- and medium-sized firms. In addition, in some of the Business Partner organizations, some former business advisors have been specialized in "technology advisor (TA)" roles. A network of 25 TAs has been initiated to exchange information among themselves. The goal is to create TAs who are generalists rather than specialists. These changes in policy and organization were taking place while our research was being conducted, which has created a certain ambiguity that is reflected in our evaluations.

3.7. United Kingdom — the Business Links program: a service gateway

By the late 1980s, the key technology transfer problems in the United Kingdom were how to overcome a government support model based on specific company R&D projects and how to facilitate a higher articulation of demand from the small firm sector. In 1993, a Government White Paper advocated a new innovation and technology transfer support system that would link users and suppliers of science and technology and improve the local delivery of innovative services. It was resolved to establish a network of business services, particularly to smaller firms, that would work through a variety of other institutions to provide both business and technical help. Under the title "Business Links", a new network of gateways to technology support was undertaken (Steward, 1996). The Business Links were to include the active commitment of major providers of business support services in its area, including: Chambers of Commerce, Training and Enterprise Councils, Local Authorities, Local Enterprise Agencies, the Department of Trade and Industry, and the Employment Department. The Business Links were established as independent partnerships that were intended to be self-financing after 3 years.

Each Business Link was to have an Innovation and Technology Councilor (ITC) to advise on sources of science and technology expertise. Local networks (Nearnet) were proposed to provide technological assistance as well as a national network of centers of technological expertise to assist SMEs (Supernet). The ITC's role was to proactively visit companies, facilitate access to service providers, provide an ongoing relationship with clients, network with other ITCs, identify local best practices in innovation and act as a focus for local networks. Two hundred such Business Link centers were to be established by 1995, each of which would have approximately three Personal Business Advisors (PBAs) to maintain regular contact with a portfolio of companies and construct an integrated package of services to meet their needs. A range of programs, particularly targeted at small firms, were identified or developed.

The Business Links network represented a shift of focus to a 'service gateway' rather than the traditional view of 'service provider'. It was a decentralized emphasis on regional technology centers and councilors. It was also a move towards integration rather than specialization and an information rather than a transaction orientation. Technology transfer and technological information services was one dimension of a broader set of business services. This represented a stronger emphasis on managerial capability rather than new technology as a key to successful innovation.

4. Policy choices

Most governments are determined to provide some forms of assistance to their SMEs. However, the policy options are many. In this section, we explain some of the policy choices that were made (or that evolved as a consequence of the "mess") in each of the countries where we studied TE organizations. It is important to point out that the policy choices described here are illustrations of only a few of the many decisions that emanate from the "mess". They are intended to be indicative of the wide set of policy options that governments must confront in order to carry out TE to SMEs.

Technology extension programs could be national ones directed at all SMEs in that country or they could be targeted at specific sectors only. They could be local initiatives intended for a particular region, state or province because the initiative arose with that particular regional (e.g., provincial or state) or local government. Alternatively, TE programs could be combinations of local, regional and national programs.

As a part of a specific industrial policy orientation, some TE organizations may be designed to support specific industrial sectors such as biotechnology, or microelectronics or advanced manufacturing or a technological domain, such as high technology. Other TE organizations work with a policy of assisting all SMEs irrespective of the level of technology, a mandate that can include farmers and fishermen. Under such a mandate, supporting SMEs with "appropriate technology" rather than high technology leads to quite different

TE organizational arrangements. Even TE organizations with broad SME mandates may make exceptions, e.g., the Canadian IRAP program excludes retail stores.

SMEs need help in areas other than technology, e.g., financing, strategic direction, marketing, manufacturing processes. A major choice decision for governments is whether to assist with technology alone or to extend beyond the domain of technical assistance, an approach sometimes referred to as industrial extension. In our study, we have examined organizational arrangements and innovations that different governments have employed to provide assistance to SMEs in either or both industrial extension and TE areas.

Many other policy choices need to be addressed in the domain of TE. Among them:

- The TE organization can provide in-depth assistance to clients or it can serve as a referral (broker) service.
- Policy makers (government) must decide if the TE service will have a national electronic network linking sources of technology or, if not, which sources of technology will be made available to clients served.
- The boundary between subsidized government service and private service providers must be defined. This is an increasingly important issue as many governments struggle with the questions of what services might be privatized.
- Policy makers must address the question of where TE providers should be located in the economic spectrum. A shift is taking place from universities and colleges to public not-for-profit economic development organizations as well as to for-profit organizations.

5. Design requirements for the organization of TE

Canada's IRAP program was selected as the lead case study because of the high regard in which it is held in Canada[13] and because its TE approach is comprehensive. While IRAP's program has strongly informed the set of design requirements we have developed, we have also identified effective organizational design innovations in the other country organizations whose TE approaches were not as comprehensive as IRAP's.

The set of all the organizations studied was thoroughly analyzed from the case studies and the accompanying interview, observational and archival data. Based on the analysis of the lead case and the comparison cases, a *minimal set of design requirements for an effectively functioning organization to carry out TE*[14] was developed. This set of (six) design requirements is listed in Table 1. This is not a complete list of all design requirements that a TE organization should meet, and some policy choices will dictate design requirements in addition to or different from those listed in Table 1.

A matrix of data collected was then developed for each (country) TE organization studied. In the top row of the matrix, one column for each of the design requirements in the minimal set was listed. In a subsequent row, the actual practices of the particular TE organization to achieve that design requirement were identified (the "design dimensions"). The next row of the matrix is the "realized" design, which describes the kind of impact the particular design dimensions selected have had on the target population, the SMEs that the TE organization is attempting to serve.

Subsequent rows in each organization's matrix identified factors within the context of each country's TE organization that could help explain why the particular form of TE organization was chosen (i.e., historical, economic, institutional, labour-market and cultural explanations). A final row identified the choice decisions

[13] Before it was elected, the current government in Canada committed to increase support for the IRAP program. This was realized with an increase of $30 million to IRAP's budget in April 1997 and a further increase of $34 million in April 1998, for a total budget of $130 million. Agreements with other government departments increased this total to $150 million.

[14] The operational statement for the lead case is: "To enhance the success of SMEs by assisting them with technology and good service".

Table 1
Design requirements in organizing for technology extension

Design requirement	Explanation
DR-1. The technology extension organization must be visible and easily accessible to the SMEs.	SMEs rarely have the resources to search for help or to maintain even their own technology. To effectively assist SMEs, the TE organization must make its services known and be easily accessible.
DR-2. The technology extension organization must make itself trustworthy to the SMEs it serves.	Trust is difficult to establish where SMEs exhibit a high distrust of any kind of government intervention. In several of the TE organizations we studied, the success of the transfer process was highly dependent on the trust that the SME placed in the particular TE organization.
DR-3. The technology extension organization must provide SMEs with access to appropriate sources of technology.	The value of the service provided by the TE organization is closely related to the ability of the organization to connect the SME with the appropriate sources of technology.
DR-4. The technology extension organization must make itself credible with the sources of technology.	Good relationships with and respect from the sources of technology are central to the ability of an organization to develop competence in technology extension. To be sustainable, this relationship should be characterized by trust and interdependence.
DR-5. The technology extension organization must respond quickly to the requests of SMEs.	SMEs tend to believe that a TE organization cannot understand their problems and that the service provided will be slow and bureaucratic. The SME has to believe that it can quickly get appropriate assistance.
DR-6. The technology extension organization should complement the weaknesses of the SMEs it serves.	Even when SMEs know how to reach theirs goals, they may not be able to carry through projects that require information searching or coordinated actions. TE organizations can and should complement the strengths and weaknesses of their SMEs.

made by the management of the organizations studied that had also contributed to the realized design. The set of country matrices then constituted the principal data base of this study.

6. Technology extension organization design in seven countries

In this section, we provide examples, drawn from our empirical data, of how the different country TE organizations we studied put into practice each of the design requirements. These are the "design dimensions" shown in Fig. 2. The design dimensions reflect the organizational design practices of the TE organization in each country with respect to each specific design requirement. Each country situation is a reflection of the constraints and contingencies and boundary conditions for such organizational design decisions that are established by the contextual factors (the mess) and the policy and managerial choices.

With such data points from seven TE organizations in seven countries (in fact, multiple data points because there may be several design dimensions associated with each TE organization's approach to a particular design requirement), it then becomes interesting to compare TE organizations with each other.

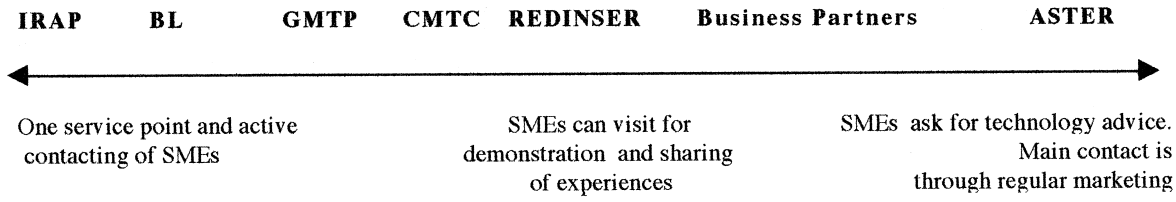
In the discussion that follows, we carry out comparative analyses to explain different approaches to TE organization design. These comparisons are not value judgments about how each TE organization should be designed to meet the particular design requirement. Such a comparison would only be meaningful if it was made in reference to the "mess" associated with each organization and the particular policies chosen for that organization by its relevant level of government and its local management with respect to the type of TE service it has decided to provide. The comparative analysis of the design dimensions is a way to illustrate the range of organizational alternatives the organization designer has to work with given a particular design requirement.

The comparative analysis discussion for each design requirement begins with an illustration from the lead case followed by references to the other country cases. This is followed by general comments about the particular design requirement.

6.1. DR-1: the TE organization must be visible and easily accessible to the SMEs

The Canadian lead case, IRAP, decentralizes its operations by distributing some 240 ITAs throughout the country in a wide variety of local institutions that are sources of technology and are easily accessible to SMEs. By having formal links with and a physical presence in over 120 such institutions in the country (IRAP refers to them as "network members"), IRAP makes itself and its services widely known. The ITAs are also proactive in making cold calls to create new contacts and make SMEs aware of their services. To further enhance its visibility, IRAP cultivates relationships with financial institutions that make loans to small businesses and with business school faculty who assist SMEs with business plans. It also participates actively in both technical conferences and industry trade shows.

The dimension below illustrates one form of contact between the SMEs and the TE organization that responds to the accessibility aspect of this design requirement.



The UK Business Links and the German MTP chose network designs similar to that of the lead case. The German MTP provided simple access to the chosen strategic sector by assuring that there was only one partner to be addressed in any aspect of the project's management (proposals, finances, etc.). The German MTP program, the CMTC, the Spanish REDINSER centers and the Swedish Business Partners TE organizations all worked with or work with technology demonstrations and experience sharing. Many, but not all, of the Spanish REDINSER centers are, like IRAP, proactive and directly contact their potential clients, as do the ITCs with the UK Business Links program.

The Swedish Business Partners have achieved accessibility by becoming firmly entrenched in the local environment. The clients of the CMTC usually contact the organization through conferences and trade shows within the manufacturing sector and also via referrals from community colleges and universities. The CMTC is also geographically close to its customers. ASTER has only one operating unit and contact is mainly established though the monthly ASTER bulletin.

A general marketing approach seems to be an appropriate accessibility position when the TE organization plays the role of a broker for funding sources or for business help. Technical help, on the other hand, appears to require a more direct involvement on the part of the TE organization. By focusing the TE organization contact with the SME to a single agent, accessibility appears to be enhanced and facilitated.

ASTER's design choice can be explained by the strong entrepreneurial culture of Emiligia Romana SMEs. In effect, strong activism and dynamism by the entrepreneurs in the community may substitute for a more active TE organization role.

The organizational design choice of the Swedish Business Partners organization appears to be the result of a history of providing regional development funding. With this history, and with little previous experience in TE, it has been difficult for the Business Partner organizations to adopt the active role of technology advisor.

The organizational design choice of the UK Business Links organization is institutional in that the organization is based on links to existing, locally based organizations, such as Chambers of Commerce and local authorities, but also on many other support centers as the program expanded.

6.2. DR-2: the TE organization must make itself trustworthy to the SMEs it serves

Organizationally, IRAP is part of the NRC Canada, a science and technology research organization that has a high level of credibility in Canada. Many scientifically trained and/or technology-oriented entrepreneurs probably have encountered references to the NRC in their technical and university studies. This organizational arrangement also buffers IRAP from the typical rules and procedures that constrain other government departments and allows them to respond quickly and innovatively to entrepreneurs and SMEs. To further increase the level of credibility, IRAP selects technology advisors very carefully, with 15 years of prior technical experience and a demonstrated ability to interact successfully with SMEs as a criteria for selection.

One way to satisfy this design requirement is illustrated by the two dimensional matrix in Fig. 3. One dimension represents the reputation of the TE organization, a type of credibility that comes from affiliation with other trusted organizations or from a history of providing good service. The other dimension reflects the development of trust in the agents of the TE organization. To earn this trust, agents require not only technical competence but also a competence that includes understanding how to develop and communicate solutions for the SMEs they serve.

As Fig. 3 illustrates, the German MTP and the CMTC both acquired acceptance in their industries, but for different reasons. The CMTC has focused on continuous improvement rather than just solving the firm's immediate production problem. The GMTP developed a high level of competence in specific areas as a path to gain its credibility. The UK Business links has gained trust through its use of local management led by the private sector. The Swedish Business Partners, in contrast, has not been able to build trust in either the reputation of its agents or the provincial TE organizations themselves. In the case of the Spanish REDINSER, no standardized designs have been used to build trust, but a number of different approaches have been effective in different centers.

In most economic climates, government agencies have tended to support and subsidize their larger enterprises in the belief that they were the best creators of jobs and economic prosperity. In fact, large organizations in the private sector have often provided future careers for senior civil servants. In such climates, SMEs have been wary of governments whose bureaucratic procedures were geared to large organizations and whose disinterest in SMEs often showed in the attitudes and interactions of key government officials.

Credibility with SMEs is enhanced when the TE organization supports them with agents that can demonstrate appreciation of the SME's concerns and buttress that understanding concretely, particularly with respect to technology. Many small business people are deficient in business skills and the agent who can assist along this dimension also acquires credibility. However, the agent with more than one arrow in his/her quiver has a better

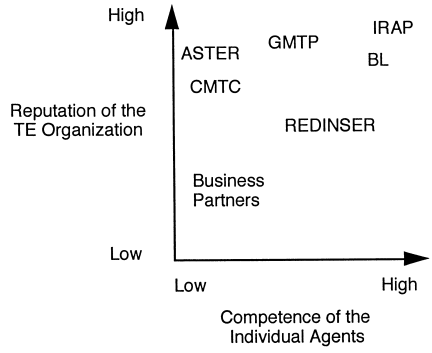


Fig. 3. Organization and Individual.

chance of increasing that credibility. TE organizations that can back up their agents with access to widespread technical help as well as business help provide a strong foundation for agents to be able to demonstrate their competence.

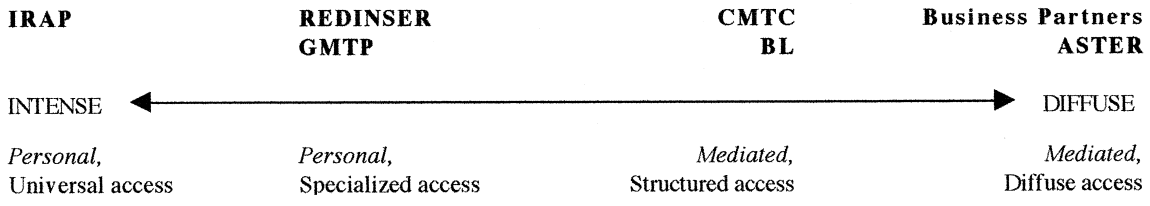
Trust between organizations and individuals is built in cycles of interactions and achievements. Even where particular technology agents have established effective one-on-one relationships with entrepreneurs and/or SMEs, their practices must be institutionalized in the TE organization if a reputation of trust is to be sustained. The difficulties of the Business Partners organization can be seen as the result of having little in the history of the program to support its claim of having expertise in the technology development of small businesses.

6.3. DR-3: the TE organization must provide SMEs with access to appropriate sources of technology

IRAP has developed a network of 120 member organizations (universities, provincial research organizations, community colleges, specialized technology centers, industry associations), with each of them representing an important potential source of technology for the SMEs that IRAP serves, many of whom do not employ a single engineer or scientist or even a technical team to cover the range of technologies related to their products and/or processes. It has physically located its technology agents (called ITAs) within these organizations. Each ITA has a mandate to become familiar with all the technical resources within the institution where she or he is located. The ITAs are linked to each other electronically through e-mail and groupware in an electronic network. Any ITA can ask for assistance for his or her SME client over this network and have access to all 240 ITAs as well as to the vast set of technology resources they have access to within the 120 network member organizations. The ITA may also call on representatives from the network member to interact directly with their client.

The ITAs are themselves selected with a view to how their particular technical competence can contribute to IRAP's network, with the result that almost every technical specialty is represented somewhere or quite often among the 240 ITAs. IRAP has also established relationships with technology development officers and scientific advisors of the Canadian government in major cities around the world to provide an international feed of sources of technology into the IRAP network.

The TE organizations studied appeared to vary significantly on the intensity of the connection they have established between their sources of technology and their SME clients. This design dimension is represented as follows:



The German MTP was similar to IRAP in that the centers worked closely with acknowledged centers of competence. However, direct contact between the source of technology and the SME appeared to have been limited.

The Spanish REDINSER centers access technology within the system in a wide variety of ways. However, the diversity of the centers has proven to be a disadvantage. Direct contact with sources of technology is poor because there is no system of direct connection between REDINSER and the Spanish universities and research centers. These resources are only mobilized through specific arrangements with particular REDINSER centers. As a result, a large part of the technological potential of the country is far from fully used for TE activities. Furthermore, in contrast with IRAP, the Spanish REDINSER agents are specialized in industrial extension activities rather than in technological areas.

ASTER and Business Partners have largely been unsuccessful in their cooperation with universities. In fact, in Sweden, a small but growing number of proactive SMEs that are highly innovative have established direct links with universities and technology institutes. Similarly, proactive Spanish SMEs directly approach their sources of technology.

ASTER's role along this design requirement is quite different than IRAP's. This is because the SMEs in the Emiligia Romana region are oriented around specific industrial sectors and among themselves have a high level of technological sophistication. It is difficult for ASTER to provide technological competence in this situation.

The CMTC program has access to the Technologies for Effective Cooperation Network (TECnet) through which a consultant in any one of the country's MTCs can tap into the resources available through the Internet. Personnel at TECnet will direct the request to the appropriate technological groups, bulletin boards, and specialists around the globe. Similarly, the UK Business links has developed an electronic database that can tap into local, national and international sources of technology.

TE organizations can cast their nets widely to provide sources of technology to their SME clients or they can themselves be the primary source of technical knowledge, particularly if their mandated technological area is relatively narrow. The German MTP, for example, chose narrow specialization because integrated solutions were considered to be too complex for and expensive for SMEs. This was a managerial choice (Fig. 2). However, if the competitive domain of the SMEs they serve is a global one, the decision to have a narrow area of technological specialization is increasingly risky, because without a wide perspective on how technology is changing worldwide, the TE organization and its clients can be blindsided by unanticipated technological innovations.

However, keeping a broad perspective on technological change is costly and often outside the mandate of the TE organization. Most sources of technology are interested in the state-of-the-art in their technical area and are less interested in technology that may be appropriate for SMEs but not at the leading edge of the particular field. This places a significant burden on the TE organization to be interpreters of new technical developments (and to be sufficiently aware of the needs of their present and future clients to know in which directions to interpret). It places a further burden on them as they must communicate effectively with a constituency that does not always share their concerns.

As Design Requirement 3 illustrates, the TE organization can be proactive about assisting SMEs with technical change through the personal involvement of the TE organization agent. Their success in being proactive though will be affected by the trust the SME has in the agent (Design Requirement 2) and that, in turn, may be a consequence of whether the agent is perceived as technically competent (e.g., the case of IRAP ITAs in contrast to the REDINSER agents whose expertise is in industrial extension). However, if the TE organization's response is a mediated one, it is likely to wait for the SMEs it serves to approach it about a technological concern. That may be too late for some SMEs because technological innovation may have made their product or service technology obsolete.

As the shaded area of Fig. 1 illustrates, to be effective the TE organization must manage both interfaces: to the sources of technology and to its current and potential clients. Each interface is with a very different set of actors, yet both sets of interactions are often carried out by the same agents of the TE organization.

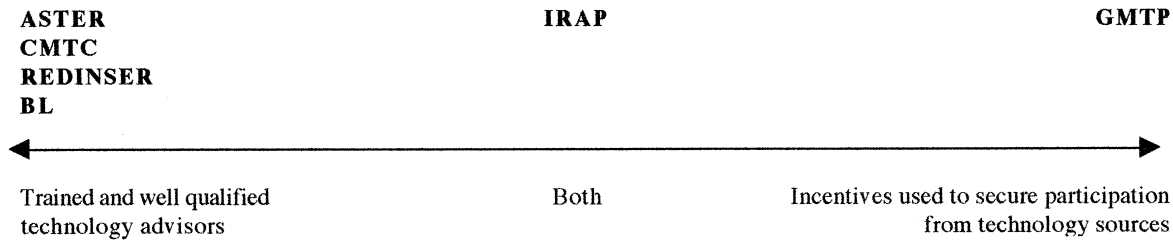
6.4. DR-4: the TE organization must make itself credible with the sources of technology

Good relationships with sources of technology can be achieved through earned respect or it can be purchased through incentives or it can be a combination of both approaches. IRAP recruits technology advisors with a minimum of 15 years of industrial experience, which is an important source of credibility for their interactions with the network member organizations to which they are assigned. However, they also recruit for a problem solving attitude and a general technological curiosity, because each ITA must assist SME clients with a range of technical problems for which their own particular specialty may have limited relevance.

IRAP ITAs are each assigned a $5000 annual training budget to allocate as they see fit to sustain their technical competence. IRAP contracts for the development of courses in areas where it feels there is a widely shared need among ITAs, e.g., biotechnology, and ITAs have the option of making these courses part of their annual training budget. IRAP intentionally arranges meetings of ITAs at the location of and on the day after a major technical conference to encourage ITA attendance at the conference and to promote interaction and familiarity among ITAs interested in the subject area of the conference.

ITAs bring research contracts to their sources of technology both by brokering relationships between the network members and their SME clients and by providing financial support to SMEs to assist them to contract for technical solutions from the network members.

The dimension illustrated below captures the two means of developing trust with sources of technology.



With 10 years of experience, some of the Spanish REDINSER centers have acquired a good reputation and they now have legitimacy as sources of valuable knowledge. In the short term, the German MTP established good contact between itself and its sources of technology. However, there was no long-run relationship because the German MTP was a fixed length program.

At UK Business Links, research and technology advisors are supported and trained by a central government department. The Swedish Business Partners have not developed strengths in either aspect of this design requirement.

While it is the general goal of every TE organization to have the SMEs they serve succeed in the marketplace with their product or service, their more immediate and more explicit goal is to enhance the technical competence of their SME clients, i.e., to leave the SMEs more self-sufficient technologically as a consequence of having engaged with the TE organization. IRAP refers to this as helping their clients climb the technological ladder. The TE organization requires good ongoing access to sources of technology if it is to facilitate the long-term development of the SMEs it assists. This results in a long-term perspective on the part of the TE organization towards its own technological reputation, which underscores the importance of its credibility with sources of technology. Interestingly, this outlook can be in contrast with the perspective of the SMEs they serve. The SMEs desire short-term solutions to their technical problems and often do not see beyond the outcome of their particular and current need, e.g., enhancement of an existing product or development of a new one. It is often difficult to convince SMEs to take a long-term perspective with respect to developing technological competence because short-term survival so dominates their mind set.

Technology agents must achieve their credibility outside of their own specialist domain, as they would have to do when interacting with, say, the wide variety of specialist researchers and scientists in a technical university. The characteristics that allow technology agents to be successful with SMEs, e.g., a technological competence and curiosity and good interpersonal skills, should be the ones that can also gain them credibility with researchers and scientists in such institutions, but may not be effective for all technology agents. Even when the process of staying in touch with technology is less direct, e.g., through reading journal articles or attending technical conferences or courses, technological competence and curiosity skills are still needed.

If the TE organization's mandate is to assist with business solutions as well as to assist with technology, the acquisition of business competence by the TE organization agents may be purchased at the cost of their

technological orientation, which can make it more difficult for them to manage the boundary with their sources of technology. This forces most TE organizations into a difficult balancing act with respect to staffing and orientation. This is the situation that confronted the Spanish REDINSER organization over a longer period of time until it evolved towards a balance that reflected credibility with its sources of technology. It is a balance that the Swedish Business Partners organization has been unable to attain.

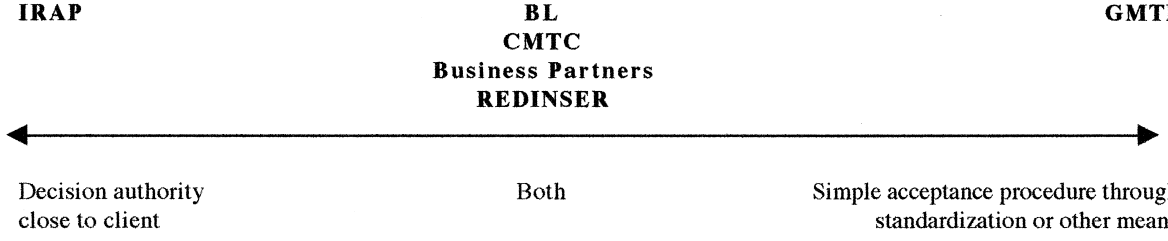
6.5. DR-5: the TE organization must respond quickly to the requests of SMEs

IRAP is arranged as a network organization with every ITA reporting directly to his or her regional manager to keep the organizational lines of communication short and fast. To respond even more quickly to SME requests for small amounts of financial assistance, ITAs have authority to allocate up to $15,000 of financial support to SMEs without higher approval.[15]

IRAP explicitly sets out to disabuse SMEs of the idea that all responses from government are slow and bureaucratic. As an organization, it actively examines its procedures and processes to expedite responses to its clients. For example, in the typical process for evaluating requests for larger amounts of funding assistance (> $15,000), the decision must be made by a committee comprising a senior ITA, one or more experts capable of judging the particular technology, either from within IRAP or hired from outside, and the regional director or a representative. Such committees typically meet every 6 weeks to evaluate requests from SMEs (with ITAs usually accompanying their SME clients to such meetings in an advocacy role). Recently, in the British Columbia Region, in an attempt to expedite even this process, evaluation committees were asked to meet at the client's location as soon as possible after a request had been received to judge the application. The major constraint on speed was usually the time it took to schedule the technology experts' travel arrangements.

On the technology side, IRAP responds considerably more quickly because all ITAs are electronically connected to each other. Through this network of 240 ITAs and their collective specialist knowledge, as well as their locations in and access to the 120 network member organizations, ITAs can bring an enormous wealth of technology to bear against an SME's technical problem in a matter of hours. A continuous effort to have ITAs know each other on a personal basis facilitates this sharing of information from one ITA to another across the entire country and further expedites the problem-solving process.

The following dimension illustrates one aspect of how TE organizations increase the speed of their responses to SME requests for assistance.



The German MTP allocated a fixed amount of money to the development of a technology. This was followed by a very simple acceptance procedure, as long as funds were available.

[15] Legally, only one-third of the ITAs have this authority — the one-third who are formal employees of IRAP and the National Research Council Canada. The remaining two-thirds of the ITAs are contract employees with their particular network members. As such, they are not legally allowed to commit the Canadian government in terms of authorizing financial support. However, IRAP sees this as a technicality that it must abide by and to deal with it has established a system of senior ITAs who are IRAP employees who will authorize an ITAs commitment to an SME client on a simple telephone call.

The CMTC works with standardized initial inquiry forms and a similar type of form is used in Swedish Business Partners. In Business Partners, the technology advisors have decision authority on technology advice. However, all the financing decisions have to be decided upon by the person in charge of finance, and necessary meetings are held only once a month, resulting in slow service.

The UK Business Links uses locally managed financially independent organizations, operating in a normal business context.

Technology extension organizations, irrespective of their affiliation or how they are organized, are seen by SMEs as governmental institutions. With that perspective, SMEs expect service that is bureaucratic and slow. More often than not, SMEs approach TE organizations for assistance when it is very late and their needs are urgent. They are genuinely surprised when TE organizations respond quickly to their requests. Increasingly, TE organizations recognize this imperative and attempt to be responsive. They are often shackled by the procedures of traditional governments, but as the importance of SMEs to government economic objectives is appreciated, there is no better time for them to request relief from the procedures and regulations that prevent them from responding quickly to the SMEs they are mandated to serve. This relief can take the form of exemptions from procedures, such as IRAP enjoys through its NRC affiliation, or it can take the form of outsourcing the approval function to commercial sources, as in the case of the United Kingdom's Business Links organization.

6.6. DR-6: the TE organization should complement the weaknesses of the SMEs it serves

IRAP explicitly sets out to reduce the technological risk that its SME clients face by carefully controlling which SMEs will be eligible for its assistance and, once having accepted to assist them, by applying all the extensive resources at its disposition to the client's problems.[16]

SMEs fail as often for business reasons as they do for technological reasons. It is this knowledge that prompts so many governments and their TE organizations to provide both industrial extension and TE services. IRAP's NRC affiliation is a liability here because NRC's mandate is strictly scientific and technological and by extension IRAP's mandate is similar. As a consequence, IRAP has addressed the issue of industrial extension with reluctance and its approaches are varied and tentative. Some of the ITAs have MBA degrees and provide business assistance based on their personal competence. IRAP asks all SMEs who apply for larger amounts of financial support to submit a business plan with their request, but provides little guidance to the SMEs or the ITAs about how to develop such a plan. In the Ontario region, IRAP has a contractual agreement with one university's business school to provide up to three days of business assistance to SME clients of ITAs at no cost, but only if the ITA has first assisted them with technology.

Several design dimensions can be called upon to illustrate the variables an organization designer must consider to respond to design requirement DR-6. The first is a dimension that determines the range and kinds of services that a TE organization offers, which, at one extreme, suggests it will respond to whatever the client base — the SMEs — needs and, at the other extreme, suggests that it is the TE organization that will determine SME needs and, *de facto*, which kinds of SMEs it will assist.

[16] IRAP only accepts clients where the risk is moderate. Potential clients whose technological risk is low are encouraged to seek funding from banks and technical support from more traditional avenues. Potential clients with very high technological risks that IRAP believes will lead to failure are not accepted unless they believe they can lower the risk through their involvement. IRAP's niche is clients whose technological risk is moderate but can be reduced to low through IRAP's assistance.

GMTP	ASTER REDINSER	CMTC Business Partners	BL IRAP
Technology extension organization decides on SME needs	Technology extension organization functions mainly as broker	Regional SME needs control the service	SME makes decisions on needed assistance

A second design dimension that addresses the complementarity between the TE organization and its SME clients is illustrated by the intersection of the two primary ways a TE organization can help an SME — through industrial extension and/or through TE — and the range each can cover from direct support to serving in a brokering role (Fig. 4).

Because of the nature of its business environment, ASTER has chosen not to be more competent in the specific technologies than its clients. It is complimentary to the SMEs by managing European Union and Regional projects, acting as an intermediary. The Spanish REDINSER works to promote and support the modernization of the products and processes of Spanish firms, especially through working as a broker for new information technologies, electronics, and automation.

The CMTC provides a wide range of services, including individual project engineering, demonstration displays, training courses, and assistance in selection and use of software and equipment. In addition to this, many of the centers have large data bases with computer solutions that the SMEs could not create alone. Marketing and business help is provided as well as help in implementing programs.

The German MTP chose to be complimentary by using “indirect-specific measures”, meaning diffusion and implementation of a specific technology rather than giving general technological assistance. It was also complimentary by supporting standardization efforts of the specific technology and thereby reducing technological risk for the SMEs. Standardization was put in place in order to avoid parallel development of multiple software tools and machinery that can not (or only hardly) be integrated into a common production environment.

TE organizations are created to complement the weaknesses of SMEs in a country or region. However, there are so many ways SMEs can demonstrate weakness that TE organizations are forced to choose where they can have impact and how their limited resources can provide the greatest return to the economy. While these appear to be policy choices, influenced by contextual and historical factors, they are also decisions that are affected by the organizational designer’s ability to develop organizational design dimensions that deliver the preferred policy option. The resources of a larger organizational network of the TE organization can be a significant asset here, as it is for IRAP and the CMTC in the delivery of technology. Yet, even when resources are limited, there are alternatives, as ASTER demonstrates by brokering resources from the European Community for its regional SME clients.

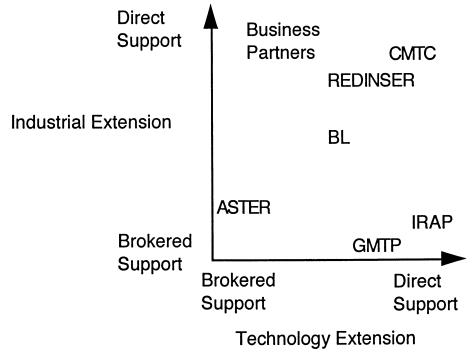


Fig. 4. Industrial Extension vs. Technology Extension.

Our data was collected at a point in time and did not capture the evolution of TE programs. Some TE organizations have changed their mandate and their mission with time. The CMTC evolved from a dominant focus on TE to where it currently identifies 60% of its services as general business related, or industrial extension.

7. Conclusions

The design of Spanish REDINSER is largely a result of the historical development in the country. In the 1940s, the Spanish government had created a number of research centers to counterbalance the power of universities, which were considered to be a potential source of dissidence and subversion. In the early fifties, several multinational corporations established modern factories in Spain, and with them came new technology. The country entered a long period of accelerated growth, requiring widespread modernization and massive introduction of technological innovations. However, in the mid-sixties, the modernization process of industry was criticized for its excessive reliance on foreign technology. This eventually led to an increase in the government's efforts to update the scientific and technological facilities at universities and research centers. In 1983, a larger reform of higher education included provisions that finally paved the way to effective cooperation between firms and work teams of universities and research centers. Since then, several programs have been put in place to promote this cooperation. REDINSER was created in the mid-eighties as an initiative of the Ministry of Industry.

In Sweden, a sizable amount of technology transfer has taken place between the larger companies and their subcontractors. The problem of TE has, thus, been less visible. Now, however, when the number of companies diminish and they place more orders outside of Sweden, developmental activities become an issue of survival for the small firms and an issue of economic revival for policy makers. Unfortunately, the history of Business Partners — working with regional development and distributing money — has turned out to be an impediment to developing necessary trust with SMEs and sources of technology.

As these two country situations indicate, historical factors, contextual factors and institutional factors have significant impact on the design of TE organizations. We cannot contemplate organization design without taking them into account. Nevertheless, even independent of "the mess", there are explicit design choices that of themselves create significant differences in the carrying out of TE services.

Both the Canadian IRAP organization and the Italian ASTER organization have been effective in carrying out their TE mandates. However, they are at almost opposite ends of most of the design dimensions in the way they satisfy the different design requirements. The policy choices and the managerial choices emanating from their different contextual situations have allowed the organizational designers of each of these TE organizations to develop very different, yet quite appropriate, responses to their situations. It is not difficult to imagine organization designers making choices related to the organizational design of both these TE organizations that could have been considerably less effective. Our measures of effectiveness are very subjective and allow considerable scope for variation in the design decisions taken. It often takes years and the subjective assessment of many SME clients that have been served over those years to conclude that a TE organization is being effective or not in its environment. Even when they are judged effective, we are unable to determine if there was not a set of policy or organization design choices that could not have improved them considerably.

Even when policy choices are explicit and boundaries, constraints and conditions are clear, the design of a TE organization forces the organization designer to come face-to-face with a large number of choices. When they are not clear, the task is considerably more complex because of the high interdependence between policy choices and design alternatives.

An explicit set of design requirements helps to constrain the organization design decision set, but again, for each design requirement there is more than one design dimension to consider. Furthermore, as we have illustrated frequently here, there is a range of responses possible for each design dimension.

Our discussion of the design dimensions associated with each design requirement has treated them independently. However, the actions taken to satisfy any single design requirement will almost always have implications for several of the other design requirements. This can complicate choices and force design decisions to be trade-offs in satisfying different design requirements. Alternatively, the interdependence can work to the organization designer's advantage.

For example, design requirements 2 and 4 state explicitly (as the shaded area of Fig. 2 illustrates) that the effective TE organization must develop credibility and effective functioning with each of its key interfaces: to the SMEs and to the sources of technology. These boundaries are not, however, independent of each other. The closer TE agents are to their clients, and the more they address their clients needs with off-the shelf available (appropriate) technology, the less relevant their and their clients experiences are to researchers and universities (Shapira, 1990). Alternatively, we see the interdependence of design requirements working advantageously, as when a TE agent responds rapidly to an SME's urgent technical problem (DR-5) and, in the process of doing so, improves the TE organization's image of trustworthiness with the SME (DR-2) and complements the SME's weakness (DR-6).

Industrial design or architectural design are generally perceived as processes with significant subjective attributes. Final decisions about form and content of the design are choices made by the designer taking into account the users' needs. It is often the creativity of the designer that is held out to be the factor that distinguishes between ordinary design and outstanding design, and even this determination is a subjective one. Is organization design any different? Once policy choices are made, the organization designer still has considerable influence on the design requirements that follow from those choices and, after that, even more influence on the design dimensions — the alternate ways of responding to the design requirement(s).

What shapes that influence? Context is one important factor: historical, economic, cultural, institutional, and labour markets, in particular. Managerial preferences is another important factor. Whether the TE organization managers are technically oriented or entrepreneurially oriented will affect the relationships they choose to establish with SMEs and sources of technology. Whether TE organization managers are selected from and continue to be civil servants or whether they come from private practice may affect their perspectives in several different ways, ways that will impact the organization's arrangements. Will the TE managers be evaluated by particular performance criteria, and how easy is it to establish those criteria when the ultimate measure of their success is not how effectively they deliver their services but how effective their SME clients are in the marketplace, in creating new jobs, in advancing their technological competence? (Shapira et al., 1996).

Too frequently, policy makers believe the bulk of their work is over when the policy choices have been made. Our research highlights the significant role the design of the TE organization can have on the effectiveness of those choices.

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