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The development of technology infrastructure in Portugal and the need to pull innovation using proactive intermediation policies

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Abstract

It was not until the 1980s that governments in Portugal began to develop a national technology infrastructure (TI). Although there is no general accepted definition of what constitutes a TI, we define it as comprising different kinds of public, semi-public and private centres and institutes of research and technology. Following a latecomer supply side technology-push rationale and using European structural funds, successive governments in Portugal invested in building a comprehensive TI-system. However, the development of such system overlooked the support needs of the enterprise sector. Hence, questions are now being raised as to whether current policies and structures of support to technology transfer and innovation are relevant and operating effectively. This, in turn, is generating a need to consider new policies oriented to stimulate demand-pull and the use of the capabilities already existent. This paper contributes to assess the outcomes of the efforts undertaken in Portugal to build an effective TI-system to support innovation and technology transfer and suggests new demand-oriented policies.

Keywords: Technology infrastructure; Technology policy; Innovation policy; Proactive intermediation policies

1. Introduction

It was not until the late 1980s that governments in Portugal began to develop a national technology infrastructure (TI). Concerns about economic competitiveness and technological diffusion, on the one hand, and the low levels of gross domestic expenditure on R&D—GERD (only 0.31% of GDP in 1982), on the other hand, motivated the 1980s' strong policy focus on expanding and re-organising the national TI.

Different types of new and existing public and semi-public technology support organisations were therefore newly established or re-organised under the assumption that they could or should produce, disseminate and promote the adoption of new technologies and innovation in enterprises. Almost two decades later, these efforts contributed to an increase in overall R&D expenditures, amounting in 2003 to 0.74% of GDP, and in particular they contributed to maintain the government as both the primary source of R&D funding and the main executer of R&D activities. Business R&D expenditures and the aggregate innovation performance (as measured by community innovation surveys (CIS), for example) remain, however, one of the lowest in Europe.

In other European countries, the development of TI was associated either with large scientific endeavours or with an incremental increase in demand for public technical assistance services, delivered by different types of centres and institutes. Taking the particular historical context of technology policies in Portugal, which contrasts with similar policies in other countries, there is a need to examine the balance of different functions performed by the Portuguese TI, its sustainability and relevance to local companies. It appears that the technology-push strategy initiated by Portugal in the 1980s and continued throughout the 1990s overlooked the level of capabilities and corresponding support needs of the enterprise sector, hence raising questions of how to orient future policies to stimulate demand and the use of the available TI.

Using secondary sources such as the science and technology policy reviews undertaken by OCDE (1986,

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1993), annual reviews and financial reporting of different TI-organisations and evaluation reports of the Portuguese TI, commissioned by the Ministry of Economy at different points in time (Coopers and Lybrand, 1992; INETI, 1996; Deloite et al., 2000; AdI, 2006), the latter often containing information on the views of the firms about the relevance of the available TI, we present in this paper a first attempt to understand the outcomes of the efforts undertaken by Portuguese governments in the past two decades to build an effective system to support innovation and technology transfer.

Section 2 begins with a conceptual discussion about technology, technology transfer and the role of TI. Section 3 discusses the development of TI, contrasting Portugal with other countries. Section 4 examines the relevance and effectiveness of three types of public, semi-public and private TI-organisations: large public research establishments (PREs), technology centres (TCs) and institutes interfacing universities. Section 5 summarises what we can learn from innovation surveys and other more specific studies on the views of the firms regarding the available TI in Portugal. Finally, in Section 6, the paper concludes with discussion and suggestions for demand-oriented technology policies.

2. A conceptual discussion about technology, technology transfer and TI

2.1. *What is technology transfer?*

Technology transfer is a concept largely influenced by the linear model of innovation and by the neoclassical treatment of technology as information. That is, technology is seen as available information and technology transfer is reduced to information transmission (Lipsey and Carlaw, 1998; Teubal, 1998). In this perspective, the "information transmission process" is subject to the usual market imperfections used by policymakers to justify public intervention in various forms.

One form of intervention is the creation of public technology institutes or centres, not only as a compensation for the less than optimal R&D performed by private firms, but also because these organisations are seen as suppliers and/or as *passive* mediators of information that should produce, disseminate and promote the adoption of new technologies and innovation in enterprises. That is, another form of tackling market failures in information transmission is to promote a *passive* intermediary function that helps recipient firms to contact technology-information suppliers.

In the neoclassical perspective, this type of "linear" intermediation is particularly important, not just to ensure equal access to information by all firms but also because of the need to support technology diffusion from high-tech sectors (where advanced technology is generated) to less technologically intense sectors or from technologically more advanced countries to less developed countries (Vernon, 1988). This concept of intermediation inspired the creation of "liaison offices" in large PREs (such as NASA in the US or CERN in Europe) and in universities. It also inspired the creation in the 1980s of the so-called innovation relay centres supported by the European Commission. The basic idea was that large public research organisations or universities would be "suppliers" seeking to sell R&D outputs and information to interested businesses, through patenting or licensing. Information could also be transferred by contracting-out research capacity to interested companies. Because intermediation obstacles to this information-diffusion process are seen as mainly associated with the costs of seeking and distributing information, neoclassical policies to support technology transfer are predominantly focused on reinforcing the mediated distribution of information.

However, this idea of "liaison" or *passive* intermediation assumes that technology spreads unidirectionally, from advanced scientific R&D to multiple applications in different sectors. Also, this approach assumes that the recipient has the capacity to absorb the technology-information and that the mediator does not need to provide any type of training and up-skilling services to the recipient. Transfer of technology is therefore a question of mediating the flow of information and not a process of providing support to enhance the recipient's learning capabilities to effectively use and absorb new technologies and to undertake the associated organisational and managerial changes.

However, if we accept the idea that technology is not the same as information, then the mediating function and the way in which technology is transferred and diffused becomes rather more complex than a mere "information transmission" process. In fact, in contrast with the neoclassical treatment of technology, the so-called evolutionary/structuralist (Nelson and Winter, 1982) approach defines technology as useful, applicable knowledge, oriented towards the creation of economic or social value. Because this knowledge is only partially appropriable, some of it being tacit and specific to the entities that have accumulated it through learning, technology transfer cannot be reduced to a linear "information transmission". Rather than a linear supplier–mediator–recipient process, technology transfer and diffusion should be considered as a process of reciprocal learning. Also, because the knowledge that needs to be transferred does not come from one single supplier and is scattered by different actors, the technology adoption and transfer process is increasingly determined by the ability of different private and public actors to create networks to assist with developing, combining and applying new knowledge. Technology transfer stops being a linear, automatic and cost-free process as the neoclassical approach would have us believe, and becomes a complex interactive learning process in which multiple players have different roles and intervene as consumers, mediators or producers of knowledge (Cohendet, 1996). The costs attached to acquiring technology may be high and they are associated to specificities of learning in each member of the network. The main difference, in relation to the previous approach, is that it no longer makes sense to think of unilateral transfer from supplier to recipient, but rather to regard technology transfer as a *technology transformation process*, in terms of the recipient's capabilities, including technical and organisational capacity to take on board ideas and technologies developed by others.

For the evolutionist/structuralist perspective, policies to support technology and diffusion cannot focus only on compensation for less than optimal R&D and on improving a mediated transmission of information. They should include also support to the complex cognitive specific processes of learning and adaptation in the receiver companies. Often tacit knowledge accumulation and learning are fuelled by informal linkages, not only to the TI but also to suppliers, fairs, trade associations and clients, that help to expose the firm to others with similar problems (Forbes and Wield, 2008). Building firm-level technological capabilities requires combining search, assessment and selection of external sources of knowledge with learning through development of internal technology capabilities (Rush et al., 2004).

That is: in this perspective, the policymaker takes the TI as one important facilitator that may help to decode or "externalise" knowledge, i.e. helps local firms to acquire and transform implicit into explicit knowledge that they can adapt and use for their own needs. As with the neoclassical perspective, this involves promotion of R&D activities. However, R&D undertaken by the TI does not compensate or substitute private R&D, but instead is taken as input for learning and generation of talented researchers and engineers. Moreover, for this perspective, support to technology-diffusion involves more than just "passive" information exchange. It involves *proactive* brokerage schemes, in which particular priorities for technological upgrading of recipient firms are first diagnosed and then, at a second stage, the TI-organisation is able to gather and assemble technical (and other kinds of) knowledge needed for the transfer process.

2.2. A working definition of TI

In line with the evolutionary views of technology and technology transfer, we see TI as part of the broader concept of National Innovation System (Freeman, 1987; Nelson, 1993; Lundval, 1992; Edquist, 1997) that includes institutions concerned with production of scientific knowledge and its transformation, as well as education, finance and softer components such as attitudes towards risk and technological innovation, etc. Hence TI as a sub-system of NIS comprises different kinds of public, semi-public and private centres and institutes of research and technology, including university-based institutes and technology transfer centres (TI-organisations). In aggregate, the *TI-system works as an institutional focussing device that helps to organise and guide the collective search for knowledge acquisition, learning and transformation.*

Justman and Teubal (1995, p. 260) proposed to use a definition of TI as "a set of collectively supplied, specific, industry-relevant capabilities intended for several applications in two or more user firms or organisations". They also proposed two different types of TI: *advanced technological infrastructure*, serving R&D in high-tech industries, and a *basic technological infrastructure*, serving diffusion processes to low and middle-tech *SMEs*. In view of our cognitive perspective of technology transfer we would add that activities taking place at basic technological infrastructure should go beyond the traditional idea of "transfer" of technology—putting enterprises in contact with supply side technological capabilities—and include help with learning in recipient firms, through knowledge de-codification, translation and transformation.

3. The development of TI

3.1. TI in Europe

Few studies have critically looked into such a diversified set of organisations, composing a TI, and examined their effectiveness and relevance as a key part of any National System of Innovation. For Europe, while some of the centres and institutes, with varying degrees of government funding, were founded in the early 20th century, or even before, there was a considerable expansion of this type of establishments in the second half of the century. In most countries in Europe, PREs with a more fundamental scientific mission were set up in areas such as civil nuclear technology, aerospace, health, construction, telecommunications, etc. Some of these PREs undertake advanced scientific research relatively independently of industry. A recent study on the public research sector in Europe emphasised the wide variety of different types of organisations and identified recent clear trends towards growing flexibility in public financing and in the employment terms of researchers (Poti and Emanuela, 2000). While increasing costs of maintaining such larger PREs led to government pressures for cost effectiveness and for higher levels of commercial income, a wide variety of responses has emerged and in some cases an international business orientation has also been adopted (PREST et al., 2002; Rush et al., 1999). Some institutions have completely left the public sector, often maintaining a contractual relationship with government. Others have been re-structured into smaller units, but now maintaining lower levels of direct government involvement and funding.

By contrast, in Southern European countries such as Portugal, centralised scientific laboratories were generally created later and their mission was associated with ensuring national scientific independence relatively to more advanced countries. As pointed out by Bell (1993), the misconceived idea was that local PREs in these latecomer countries could substitute industrial R&D and generate innovations for the local industry to exploit.

For the more advanced countries, another type of centres and institutes, also expanding rapidly in the second half of the 20th century, were those oriented towards extension services in agriculture and industry. These were not so much a product of national scientific endeavours in different areas, but instead originated incrementally, in response to the rise in demand for public technical and organisational assistance services (Bell, 1993). Because in more advanced countries industrial R&D has traditionally been carried out by private firms, demand for technical assistance grew considerably and most firms had no difficulty in linking to their local TI-organisations and in learning from their specialist outputs.

Different studies have tried to characterise the wide diversity of institutional forms associated with technology transfer (Nooteboom et al., 1992; Kandel, 1994; Segal et al., 1994; Arthur D. Little International, 2000; EC, 2004a). These can range from centres and institutes for public extension services to offices, within or associated to centres, institutes or universities. One can also find private technology associations often organised by regions or by sectors.

By contrast, for countries in the south of Europe, TI-organisations more directly associated to technology transfer and extension services were developed much later (in general from the 1980s onwards). For these countries, TI-organisations were set by government initiative and funded by European structural funds (Higgins, 1994). However, because firm-level ‘‘absorptive capacity’’ (Cohen and Levinthal, 1990) in less developed countries is lower and takes considerable time to build up (see also: Lall, 1990; Bell and Pavitt, 1993; Hobday, 1995; Giuliani and Bell, 2005), these countries usually faced greater difficulties in connecting their TI with local industrial activity, particularly when their more recently created TI-system misconceived the model of more advanced countries and did not cater for those differences. As a result, latecomer countries in Europe now have dualistic R&D structures, with government-funded institutes on the one side and a small proportion of firms undertaking R&D on the other side, who often do not establish linkages with their local TI.

3.2. *Proactive intermediation schemes. How to stimulate effective linkages?*

One interesting recent development that may help to create effective linkages between TI and all kinds of firms, particularly SMEs, is the adoption of new dynamic and proactive policy instruments for intermediation and development of systemic interactions (Nauwelaers and Wintjes, 2002; Smits and Kulhman, 2004). Proactive intermediation schemes are distinct from the passive information-intermediation support referred to in Section 2, and they may play a fundamental role in addressing the cognitive aspects of technology transfer, as well as contributing to address issues of non-technological support to innovation in SMEs (Boekholt and Giessel, 2004). One of the most successful proactive intermediation schemes for support of technological and non-technological innovation in SMEs are the ‘‘technologic-clinics’’ implemented by the Finish Innovation Agency—Tekes. According to Rhisiart et al. (2000, p. 2), SMEs frequently do not have the resources, compared to larger or more advanced firms, to search and explore technological issues. In most cases approaches to technological development in SMEs are ad hoc, based on casuistic learning-by-doing rather than on an organised explicit activity. This is common even when SMEs locate in regions with significant technology resources residing within the local TI. Therefore, the idea of creating a technology clinic implemented by a TI-organisation is to stimulate a local collective search and identification of technology issues (usually 3–5 years ahead) that could be useful for the development of groups of small- and medium-sized enterprises (SMEs) and then stimulate technology transfer and innovation, with the assistance of the TI involved. A technology clinic usually has three stages. First, together with a group of firms the TI-organisation undertakes a 3–5-years foresight exercise for searching and selecting relevant technological issues. Second, targeting a wider group of SMEs, the TI organises awareness campaigns and promotes the need to respond to technological challenges. Third, with support from the local government, the TI-organisation issues a call in which subsidised support is offered for those firms interested in adoption and development projects on the identified technologies.

Another example of a successful approach to proactive intermediation directed to SMEs is that of the IRAP programme implemented in Canada since 1948 (Lipsey and Carlaw, 1998). The Industrial Research Assistance Program (IRAP) provides access to consultancy services for technology adoption and incremental improvements. The program is delivered by an extensive integrated network of 260 experts working at different TI-organisations. IRAP experts are subsidised to provide diagnostic consultancy that can be followed by detailed problem solving. The program may include support for SMEs to hire qualified technicians during 3–4 months, undertake small development projects including laboratory testing and technical certification, and support longer R&D projects.

3.3. *Contrasting the development of TI in Portugal*

Prompted by the need to raise public and private R&D expenditures, amounting to only 0.31% of GDP in 1982, and recognizing that public research was isolated and dispersed through many different directorates, Portuguese governments in the late 70s decided to centralise older structures and create the so-called *Laboratórios do Estado*—large PREs, attached to different ministries and organised by sectors such as agriculture, fishery, industry, construction and health, or by technology application areas such as geophysics, geology and hydrography. In the 1980s there were nine main large PREs: LNETI—*National Laboratory of Engineering and Industrial Technology*; INIA—the *National Institute for Agriculture Research*; LNIV—*National Laboratory for Veterinary*; INIP—the *National Institute for Fishery Research*; LNEC the *National Laboratory for Civil Engineering* founded in 1946; INS—*National Health Institute*; INIC—*National Institute for Scientific Research* (at the Universities); IICT—*Institute for Tropical Research*; IH—*Institute for Hydrography*.

For research and technology of potential interest to industry, one of these 9 was the LNETI—*National Laboratory of Engineering and Industrial Technology* attached to the Ministry of Industry and Energy and created in 1977. At the time, the creation of this large laboratory was source of much controversy. As pointed out by the OCDE (1986), the choice of a single institute to serve industrial and energy research and technology support needs of industry was at odds with trends in countries such as Austria, France or the Netherlands (that divided TNO—the Netherlands Organisation for Applied Scientific Research, into 16 autonomous institutes focusing particular sectors), which were adopting a more decentralised approach.

In the beginning of the 80s, perhaps to counter the centripetal choice made with the creation of LNETI a few years earlier, the Portuguese Government decided to adopt the recommendations of the first ''National Technological Plan'' (CPA/MIT, 1983). This plan, among other things, recommended the creation of private non-profit technology associations, TC (sector oriented), serving industry in different regions. However, it was only after the arrival of European structural funds, from 1989 onwards, that almost all of these new TCs were established. At the same time, university departments, or in some cases individual university researchers, also started to create their own research institutes (private non-profit). In many cases, these institutes were not real interfaces for promoting technology transfer with local enterprises, but instead a channel for not having to deal with the heavy university administrative burden and to facilitate access to European funds for R&D (both structural funds and R&D framework programmes) (Oliveira, 2003).

In the first community support framework (CSF), for the period 1989–1993, around 523 million euros went to create and expand the local TI serving industry and service sectors. This included the creation of 9 TCs in sectors such as moulds, footwear, leather, ornamental rocks, wood and furniture, textiles and clothing ceramics and class-making, etc.; 13 institutes for new technologies interfacing with universities; 8 centres for support of technology transfer, some of them also interfacing universities; 8 business incubation centres; 2 science and technology parks; 12 university-based institutes, the so-called ''CIENCIA institutes'' with at least 200 researchers, and 35 smaller university research centres (Caraça, 1999; Selada, 1996; SECT, 1995).

In the second community support framework, from 1994 to 1999, the focus of Portuguese technology policy was on consolidating and enhancing the functioning of the TI (MPAT, 1994), putting emphasis in stimulating demand. However, direct funding to sustain current expenditures of different centres and institutes created in the first period of structural funds proceeded and although only a few new centres and institutes were created total public expenditure in this period for TI amounted to 539 million euros.

Over the third period of European structural funds, from 2000 to 2006, again the idea was that demand for R&D and technical services would become the main source of funding for the existing TI, created and expanded in previous years. However, the fact is that usage of the available TI was taking longer than expected to materialise and therefore a total public expenditure amounting to around 306 million euros continued in this period to be the main source of sustainability for all TI-organisations.

4. The effectiveness of Portuguese TI

Following from the previous sections showing that the Portuguese TI was the result of technology-push policies largely financed by the first three community structural funds frameworks since 1988 (Higgins, 1994), in this section we try to assess in more detail the balance of different functions and the effectiveness of the Portuguese TI. We use a very simple methodology based on four functions. First we try to assess the contribution of each TI-organisation to scientific and technological knowledge acquisition and learning, having as proxy fund-raising capacity for strategic and longer-term R&D projects (lasting more than 1 year). Second, we will examine the transmission of knowledge to client firms through technical assistance projects. These are reflected in TI-organisations' own revenues for short services (short projects lasting less than 1 year), including: technical consultancy, diagnosing, compliance to standards, metrology, certification, etc. Third, we attempt to register indicators of passive brokerage and dissemination of information, such as the number of mailings, awareness campaigns, demonstrations actions, fairs and exhibitions, etc., in which TI-organisations participated. In order to identify a more proactive approach to brokerage and intermediation, we examined annual activity reports of each TI-organisation. Finally, we also try to assess the capacity to transfer/transform technologies by spinning off new businesses and creating new companies. In the following we consider three types of TI-organisations: large PREs, TCs and university interface institutes.

4.1. *Large PREs: the cases of LNETI and LNEC*

Of the 9 main PREs established in the late 1970s or before, we examine LNETI and LNEC. LNETI—*National Laboratory for Industrial Engineering and Technology* was founded in 1977 for energy and industrial research support, in 2002 was renamed INETI and more recently was reorganised under the reform of laboratories, launched in 2006 by the Ministry of Science Technology and Higher Education—RCM no. 89/2006. LNEC—*National Laboratory for Civil Engineering* was founded in 1946 for the support of national public works and construction.

These are large laboratories with around 1000 people, but with quite different proportions of research staff relatively to total human resources. For LNETI only around 1/3 of total human resources correspond to research personnel (Table 1).

In the 1980s, the OECD review of Science and Technology Policy in Portugal questioned why demand for the use of industrial technology capabilities at LNETI was not higher as the institute appeared to be ''oriented more towards research as such than towards the dissemination of its findings throughout the industrial system'' (OCDE, 1986, p. 65).

As we can see from Table 1, there are some differences between LNETI and LNEC with respect to the balance of R&D activities versus technical support servicing and diffusion of information, and in our view this is reflected in differences in the capacity to generate own revenues. At LNEC 50% of total funding comes from own revenues, the latter corresponding to technical services and small projects, possibly in line with the needs for support of local companies. While from 1983 to 1990 LNETI progressed remarkably through increases in own revenues (from 4.3% to 43.1%), mainly because of increases in contract R&D and in Promoting the Diffusion of Information, Technical and Support Services (small projects assistance) remained low up to 1990 but, departing from a low base, increased to around 27% in 2003. Finally, one must note that in both institutes fund-raising capacity from the European Framework Programmes is a small proportion of total sources of funding, possibly indicating that the institutes pay little attention to their participation in international R&D activities.

4.2. Sectoral technology associations

As seen above, another major component of the Portuguese TI are sectoral technology associations (known in Portugal as *technology centres*). These were founded in the late 1980s, located in regions that specialise in particular industrial sectors. These centres are small not-for-profit associations in sectors such as footwear, textiles, moulds, wood and furniture, leather, ornamental rocks, ceramics and glass making, etc. Their researchers and technical staff range from 11 to 138 and the number of local associated firms averages around 315 companies.

From 1996 to 2004 all these centres managed to increase their own revenues. Also, technical support services, mainly consisting of testing, accreditation, industrial normalisation activities and metrology, have a relatively higher weight when compared with R&D, as illustrated by the ratio of R&D sources of funding in total funding—Table 2.

The increase of own revenues in activities other than contract R&D illustrates the significant efforts that TCs make to respond to the support needs of local firms in their sectors of specialization. However, the ratio of own revenues to operational costs—Table 2—suggests that the financial situation of these TCs remains fragile and that without public funding these centres could not function.

In addition, although these centres may have hundreds of client firms—Table 2—on average the five main clients represent 40% of the total own revenues for technical support services (Deloite et al., 2000), and therefore such a concentration on a limited number of clients suggests that they could increase market penetration in their own segments.

From Table 2 we can also conclude that, although showing an upward trend, patenting and scientific publishing at TCs are negligible activities. However, mailings and demonstration actions appear to be the most used mechanisms for technology dissemination. In our readings of annual activity reports we found no reference to the practice of proactive intermediation schemes despite these being particularly appropriate to help these centres to stimulate demand for their services. Finally, Table 2 also shows that there is a very limited capability to generate new-technology-based spin-off firms.

4.3. University interface institutes and associations

A third component of the Portuguese TI corresponds to institutes and associations whose initiative and mission have considerable input from academia—the so-called *interface institutions*, or university-based institutes for R&D and technology transfer. The large majority of these institutes were also founded in the late 1980s and early 1990s, with the support of the first community support framework 1988–1992.

In Table 3, we select 14 institutes referred by the Ministry of Economy as having an important contribution to technology transfer. Arguably, at least some of the so-called ''CIENCIA Institutes'', created in 1994–1999 but funded by the Ministry of Science, could also be added to the list of interface institutes, as they may also have R&D collaborations with local companies and, to a lesser extent, provide technical assistance services. The sample is, nevertheless, a very heterogeneous group.

Fig. 1 suggests that there are different types of university interface institutes. Institutes such as AEMITEC, AESBUC, INESC-Porto and INEGI are essentially university front-offices. However, while INESC-Porto and INEGI are involved in contracting R&D activities to universities, the other two are rather more centred on contracting technical support, including training. Institutes such as RAIZ, INOVA, IDIT or IPN are more involved in developing their own internal capabilities than in subcontracting-out. While institutes such as RAIZ and IBET are almost

Table 1
Indicators and financial resources of INETI and LNEC (euros, current prices)

	INETI (former LNETI)						LNEC			
	1983	%	1990	%	2003	%	1997	%	2003	%
Total number of people (FTE)	1265		1164		783		936		719	
Total number of researchers and technicians (FTE)	392		314		213		630		498	
R&D	3,629,095.31	35.8	15,728,594.09	65.4	23,012,717.37	57.4	5,088,413.56	20.7	6,587,862.46	23.7
Technical and support services (inc. training)	501,737.04	4.9	1,728,833.51	7.2	10,785,208.07	26.9	11,602,566.18	47.2	15,343,882.18	55.2
Promoting the diffusion of information	203,958.15	2.0	5,226,903.16	21.7	4,314,884.51	10.8	7,890,728.27	32.1	5,865,143.37	21.1
Internal support activities (inc. investments)	5,814,166.93	57.3	1,378,178.59	5.7	1,951,113.05	4.9				
Total	10,148,957.43	100	24,062,509.35	100.0	40,063,923.00	100.0	24,581,708.00	100.0	27,796,888.00	100.0
Of which										
Operating budget										
Government subsidies	4,389,451.28	43.3	8,654,143.51	36.0	18,308,666.00	45.7	8,579,324.00	34.9	10,578,561.00	38.1
Own revenues	438,238.07	4.3	10,380,483.04	43.1	16,285,019.00	40.6	12,503,297.00	50.9	14,388,910.00	51.8
Participation in EU framework programmes					2,276,683.00	5.7	254,571.00	1.0	829,805.00	3.0
Plan budget (PIDDAC)	5,321,268.08	52.4	5,027,882.80	20.9	3,193,555.00	8.0	3,244,516.00	13.2	1,999,612.00	7.2
Total	10,148,957.43	100.0	24,062,509.35	100.0	40,063,923.00	100.0	24,581,708.00	100.0	27,796,888.00	100.0

Notes: Government subsidies correspond to OF FF110 "Orçamento Estado—funcionamento". Own revenues correspond to OF FF123 "Receitas Próprias".
Sources: OECD, 1986, 1993, INETI annual reports, LNEC annual reports.

Table 2
Sectoral technology associations

	CATIM		CENTINFE		CEVALOR		CITEVE		CTC		CTCOR		CTCV		CTIC	
	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004
Total number of people (FTE)		85.0		47.6		32.0		163.0		45.0		17.0		58.0		18.4
Total number of researchers and technicians (FTE)		69.0		39.6		18.5		138.0		38.0		11.0		50.0		15.4
Sources of funds																
Own revenues (%)	45	75	50	44	33	52	48	57	92	51	67	66	54	58	35	51
Subsidies to current expenditures (%)	33	18	22	44	45	41	15	28	8	49	16	25	27	33	27	24
Subsidies to investment (%)	21	7	28	12	22	8	37	15	0	0	18	9	19	9	38	25
Total sources of funds (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Ratio of R&D sources of funding in total funding (%)	7	6	3	18	38	10	29	22	29	29	21	24	100	4	47	30
Ratio of own revenues to operational costs (%)	41	72	45	40	28	45	46	51	65	41	53	67	48	53	31	46
Promoting the diffusion of information																
Estimated number of clients per year	480	2.120	212	274	557	354	1.298	1.463	546	460	200	274	428	374	87	224
No. of scientific publications per year (on SCI pub.)								2						1		
No. of conference papers per year (subject to refereeing)			0	11	2	20		10					2	16		
No. of patents registered (cumulative)		1						3		2		2	2	4		
No. of participation in fairs/exhibitions/seminars (2002–2005)				3		19				16						
No. of demonstration actions organised (2002–2005)		4		24		70		59				2		9		3
Mailings for information diffusion (2002–2005)		22		118		78		225				33		36		55
Promotion of technology-based activities																
No. of business plans analysed				1										1		
No. of new (spin-off) firms created				1										1		

Sources: INETI, 1996; AdI, 2006.
CATIM—Technology Centre for Metalworks; CENTINFE—Technology Centre for the Mould Making Industry, Special Tools & Plastics; CEVALOR—Technology Centre for Ornamental Stone Industry; CITEVE—Technology Centre for Textiles & Clothing Industries; CTC—Technology Centre for Footwear; CTCOR—Technology Centre for Cork; CTCV—Technology Centre for Ceramics & Glass-making; CTIC—Technology Centre for the Leather Industry.

Table 3
Interface institutes

	AEMITEQ		AESBUC		IDITE-Minho		RAIZ		AIBILI		IBET		ICAT	
	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004
Total number of people (FTE)		11.0		73.0		18.0		55.9		30.0		56.0		68.0
Total number of researchers and technicians (FTE)		9.0		53.0		15.0		47.8		20.0		48.0		60.0
% of external work contracted out to universities	75	75	100	100	50	30	0	0	0	0	50	48		na
Sources of funds														
Own revenues (%)	48	81	10	23	56	65	100	67	16	41	14	36	50	48
Subsidies to current expenditures (%)	14	4	54	74	44	24	0	29	23	41	58	52	39	52
Subsidies to investment (%)	37	15	37	3	0	11	0	4	60	18	28	12	11	0
Total sources of funds (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Ratio of R&D sources of funding in total funding (%)	0	0	na	0	na	0	100	100	100	34	100	100	na	na
Ratio of own revenues to operational costs (%)	42	76	7	20	34	51	95	64	14	38	15	37	32	37
Promoting the diffusion of information														
Estimated number of clients per year	93	121	6	1.400	120	na	2	2	11	25	na	74		na
No. of scientific publications per year (on SCI pub.)					16	5	3	37	0	11	28	48		
No. of conference papers (subject to refereeing)					6	3								
No. of patents registered						2				1		10		
No. of participation in fairs/exhibitions/seminars (2002–2005)														
No. of demonstration actions organised (2002–2005)		3				2				1		3		
Mailings for information diffusion (2002–2005)		9		100		29				5		6		
Promotion of technology-based activities														
No. of business plans analysed						6								
No. of new (spin-off) firms created						6								

	IDIT		INEGI		INESC PORTO		INOV		INOVA		IPN		UNINOVA	
	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004	1996	2004
Total number of people (FTE)		26.0		107.8	na	143.3		69.4		35.0		61.2		57.4
Total number of researchers and technicians (FTE)		18.0		89.8	na	116.6		62.0		26.0		53.0		43.4
% of external work contracted out to universities	0	0	70	59	0	70	0	28	0	0	38	30	na	na
Sources of funds														
Own revenues (%)	87	68	34	50		31		57	27	40	88	50	14	62
Subsidies to current expenditures (%)	13	32	32	44		67		40	28	54	10	41	86	38
Subsidies to investment (%)	0	0	34	6		2		3	45	6	2	9	0	0
Total sources of funds (%)	100	100	100	100	0	100	0	100	100	100	100	100	100	100
Ratio of R&D sources of funding in total funding (%)	0	4	78	61	na	77	na	41	86	11	0	0	na	85
Ratio of own revenues to operational costs (%)	33	48	31	51		20		61	23	37	39	61	9	50
Promoting the diffusion of information														
Estimated number of clients per year	240	1.550	281	319	na	62	na	40	na	na	260	250	30	77
No. of scientific publications per year (on SCI pub.)			5	35	0	39	0	6			0	4	15	48
No. of conference papers (subject to refereeing)			24	70		104		12					8	102
No. of patents registered				3		10		11				1		3
No. of participation in fairs/exhibitions/seminars (2002–2005)														
No. of demonstration actions organised (2002–2005)		3				4		4		1				48
Mailings for information diffusion (2002–2005)		4								92				
Promotion of technology-based activities														
No. of business plans analysed				6		8				1		176		
No. of new (spin-off) firms created				5		8				1		48		

Sources: INETI, 1996; AdI, 2006.

AEMITEQ—Association for Technological Innovation and Quality; AESBUC—Association for the Higher School of Biotechnology at the Catholic University; AIBILI—Association for Biomedics Research and Light and Images Innovation; IBET—Institute for Experimental & Technological Biotechnology; ICAT—Institute of Applied Sciences and Technology; IDIT—Institute for Development and Technological Innovation; IDITE Minho—Institute for Development & Technological Innovation in the Minho Region; INEGI—Institute of Mechanical Engineering and Industrial Management; INESC—Porto-Institute of Engineering and Computer System in OPorto; INOV-INESC—Innovation in New Technologies; INOVA—Institute of Technological Innovation in the Açores; IPN—Institute Pedro Nunes; RAIZ—Institute for the Pulp and Paper Industry; UNINOVA—Institute for the Development of New Technologies.

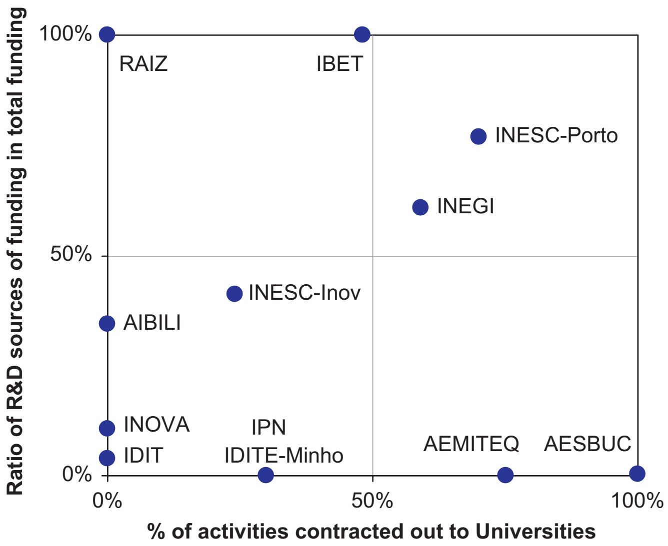

Fig. 1. Different types of university interface institutes.

exclusively dedicated to R&D, others such as AIBILI and INESC-Inov find a more balanced approach between R&D activities and technical support services, and still others such as IPN or IDITE-Minho have a strong component of technical servicing activities. As in the case of TCs the ratio of own revenues to operational costs shows that these institutes are dependent on public subsidies.

As could be expected, dissemination of information follows the above orientation. Institutes more heavily committed to contract R&D declare that information diffusion is based upon conference papers and publications on international scientific journals—Table 3. Institutes oriented towards technology support services rely on demonstration actions and mailings. For the period of time considered, the number of patents registered in these institutes is also unusually low. Table 3 also show that, unlike the large PREs and TCs seen above, university interface institutes, and in particular IPN in the period considered, generated 68 new spin-off firms.

5. The view of local firms on the available TI

In this section we complement the supply side analysis of Section 4 by revising previous studies examining visibility, interest and usage of the services provided by the TI-system in Portugal. Some of these studies also provide data on the relative impact of the services used on the firm's development. We must note, however, that evaluations based on perception surveys are dependent on the capabilities of the recipient firms. Contingent SMEs (Dankbaar, 1993; Arnold et al., 2000) do not know how to define their own technological needs and therefore they tend not to look for technology support services and do not generate demand. This means that for countries such as Portugal, where the large majority of firms are SMEs, surveys focusing on the relevance and usage of services provided by the national TI-system have to be interpreted with great care.

In the early 90s a large survey (520 valid replies) commissioned by the Ministry of Industry and Energy to Coopers and Lybrand (1992) concluded that technology services demanded by medium-sized firms (200–499 employees) to TCs and university interface institutes concentrated essentially on ‘‘information and advice services’’ (75% of total respondents) and on services related to ‘‘testing, measurements and quality checks’’ (65%). Contract R&D was relatively less demanded (10%).

A similar survey for the Lisbon region, LISTART (1999) (160 valid relies), also found that the most frequent need for support was ‘‘information’’ (64% of respondents referring frequent and very frequent needs) and that the second most needed support was ‘‘product development’’ (45%). In this survey, respondent firms were also asked to indicate their relative utilization of 36 different kinds of services grouped in four categories: business services, education and training, funding for investment, R&D and technology services. Services under the heading of business services were more frequently mentioned. Another finding was that, although around 80% of respondents declared that rapid changes in technology were their main motive to seek external technology support, effective use of services offered by the public TI (12% of the respondents) was much lower than the use of private consultants (88%) and the use of specialised equipment suppliers (25%).

The results of the CISIII (EC, 2004b) innovation survey can also be used here to understand the needs for technology support in Portuguese firms. According to the CISIII survey, sources of information for innovation in Portuguese firms follow a pattern similar to that of European firms, but the proportion of enterprises with innovation activities, involved in innovation co-operation with universities, is relatively lower (9% in Europe compared with 5% in Portugal). According to CISIII, the main source of external co-operation for innovation in Portugal is external suppliers (including suppliers of equipment, materials, components or software), thus confirming the above findings of other more specific surveys on the relevance and use of services provided by the Portuguese TI-system.

In the same line of argument, a study on the interactions of Portuguese TI-organisations with local firms (Oliveira, 2003), found that only 15.9% of companies (on a survey with 687 valid replies) acknowledged to maintain regular contacts with TI-organisations. The services most used were associated with ‘‘product testing’’ and, according to respondents that experienced the use of TI services, the main impact was on improvement of product development processes. These findings are more or less in line with the results of another survey commissioned by the Ministry of Economy (Deloite et al., 2000) (around 300 valid replies) that found that more that 50% of firms using the services from public TI-organisations identified weak impacts in areas such as human resources and training, but stronger impacts on the companies' capabilities to practice product innovation.

Overall, all the above studies and surveys, undertaken at different points in time, point out that there may be problems of information, awareness and misperceptions about how to find and use the already available technological capacity installed in TI-organisations. These problems may reflect the cognitive gap and the low level of technological capabilities in SMEs. These findings, combined with those of the previous sections, suggest a need to balance the standardised testing and certification services that form the bulk of technical support services (in TCs and in some of the university interface institutes) with proactive intermediation schemes and initiatives focused on specialised "hands-on" technical consultancy for small low-capability SMEs.

6. Final issues for discussion: How to stimulate demand from SMEs?

Portugal began to build its national TI later than most European countries. Re-organised from previously dispersed structures, large centralised PREs were created in the late 1970s and the smaller TCs and university interface institutes were set, essentially, from 1989 onwards, taking advantage of European structural funds. The rationale behind these efforts was that in the long run public technological resources could be transferred and would generate innovations for local industry to exploit. Instead of developing organically as a response to industrial demand, as was the case with similar TI-systems in other European countries (Rush et al., 1997), Portugal followed a "science and technology-push" approach to technology policy. As argued by Bell (1993), lagging countries departured from the misconceived idea that their national TI could be a temporary substitute for private R&D and innovation. In Portugal, the common belief of policy makers in the late 1980s was that initial emphasis on building up a TI would be "crowded-out" in the 1990s with a rise in demand for R&D collaboration and/or technical servicing. Overall, and despite notable progress in linking with industrial needs, particularly in the late 1990s, the available studies on interest and usage of the services provided by the TI-system in Portugal suggest that local companies are not taking full advantage of the available TI. Progress in collaborating and servicing the private sector appears to be limited, strongly suggesting that there is a need to change emphasis from a supply-side perspective of technology policy to a cognition-based approach to technology intermediation. In the following we present three suggestions for further stimulating demand.

First, perhaps the best policy for creating demand for technical support services and R&D is insertion of qualified technical people in SMEs. As in the case of IRAP, seen above, this may be done by subsidising for a short period of time personnel expenditures associated to qualified technical staff. The low levels of technical staff in many firms probably explain why most firms express higher needs for information and higher levels of interaction with specialised suppliers, relatively to their levels interaction with local TI-organisations. Support to insertion of qualified people is a major first step to gain basic skills, facilitate problem specification and search for adequate local support at TI-organisations.

Second, subsidies to current expenditures, that most of these different types of organisations receive through access to European structural funds, should be re-directed and used as incentives to SMEs to contract-out services from TI-organisations. This would still be an indirect way to subsidise the national TI-system, but with the advantage of stimulating the creations of linkages, acting on the demand side, hence forcing TI-organisations to adapt their service portfolio, extend their limited client base and adapt a more proactive role in stimulating demand.

Third, the recurrent needs of local SMEs for dissemination of information strongly suggest that it is necessary to set up new schemes for proactive intermediation. Because many firms, SMEs in particular, lack the expertise to define their own needs and do not know how to make the best use of the available TI, proactive intermediation services may prove an essential instrument to raise awareness and demand. The advantage of mechanisms such as the technology clinics, implemented in Finland by Tekes, is that they explore technological priorities defined by the TI but in collaboration with SMEs. Other examples of proactive intermediation schemes are the IRAP Programme in Canada (see Lipsey and Carlaw, 1998) or the Steinbeis Foundation in Baden Wurttenberg, Germany.

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