CHAPTER 7

A DEMAND-LED, NETWORK-BASED APPROACH TO TECHNOLOGY TRANSFER

The experience of the UK Defence Diversification Agency

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INTRODUCTION

There has been no shortage of academic analysis of technology transfer. Thousands of articles, books and reports have been written discussing the concept, presenting case studies, developing taxonomies of transfer processes, discussing barriers and enablers, and developing evaluation methodologies. Several literature reviews (Zhao and Reisman 1992; Autio and Laamanen 1995; Bozeman 2000) underline the variety of approaches to technology transfer and the diversity of contexts to which the notion has been applied (international technology flows, inter- and intra-industry transfers, and inter-organizational transfer within a country). The analysis of international technology transfer dominated the early literature, while over the last 20 years the focus has shifted to the relationships between, mainly public, research organizations like Government Research Establishments and universities, and the wider economy.

The policy challenge that drives this work is the perceived failure to exploit the assets generated by scientific research. Already from the mid 1960s, personnel in US government research establishment were consistently encouraged to establish closer contacts with industry (Bradbury et al. 1978). In the UK, like in many other European countries, there is a widespread belief that industry and society at large have failed to take full advantage of the scientific capacities and technological developments generated by an extensive, publicly funded, research infrastructure.

There is a common thread linking most academic approaches to the analysis of technology transfer and the attempts at improving the UK record at civilian

W. Hulsink and H. Dons (eds.), Pathways to High-tech Valleys and Research Triangles: innovative entrepreneurship, knowledge transfer and cluster formation in Europe and the United States, 139-154.

exploitation of its defence R&D effort: they are both based on 'technology push' models of transfer. It has long been acknowledged that the technology transfer literature has focused on providing 'access' to technology. The goal has been to seek ways in which the technological capabilities generated in research organizations could be passed on to potential users and beneficiaries outside the context in which such capabilities were created. This chapter discusses a broader approach developed by the Defence Diversification Agency (DDA) to promote the wider exploitation and further development of the capabilities existing in the UK defence research establishments. The paper first describes the approaches to the transfer of technology between defence-oriented government research establishments and the wider economy that have developed, particularly, since the 1980s. We then discuss the creation of the DDA against the framework of previous attempts at promoting defence-to-civilian technology transfer in the UK. We present its strategy, approaches and organization and characterize it as a new type of 'interface structure' linking different actors of an innovation system. We conclude with a discussion of the suitability of this approach to other contexts and the difficulties to implement it.

DEFENCE RESEARCH ESTABLISHMENTS AND TECHNOLOGY TRANSFER

The exploitation of the scientific and technological capacities of defence research establishments emerged with force as a policy and academic concern in the 1980s. In the US, the 1980 Stevenson-Wydler Technology Innovation Act included technology transfer among the missions of all national laboratories, including those with a defence role. The Act was followed by a stream of supporting legislation establishing technology transfer tools and procedures (Shama 1992). In the UK the concern about the relationship between the UK's high defence R&D expenditure and the competitiveness of the national economy was amply discussed in academic articles and policy documents. Attention focused on whether the UK's defence research resources were not contributing as much as they could to national wealth creation. A series of reports during the 1980s and 1990s (Maddock 1983; Council for Science and Society 1986; Advisory Council on Science and Technology 1989) expressed concern at the limited civil benefit obtained from defence R&D spending. Further, the best known and most successful example of technology transferred from UK military research establishment to the civilian markets, the case of liquid crystal displays[1], was exploited by Japanese, and not UK companies (Barnes and Holeman 1987).

Analysts started to identify different ways in which the research establishments were responding (or could respond) to these concerns. Shama (1992) identified a continuum of strategies evolving from 'passive' to 'national competitiveness':

- In a 'passive strategy' the research establishments limit themselves to publishing their technologies hoping for clients to come forward. The laboratories provide information and respond to inquiries.
- In addition to the above activities, and 'active' strategy pursues a policy of acquiring formal rights to technologies and seeks to obtain revenue streams

through licensing. An active strategy may also include the performance of work under contract for private-sector clients.

- An 'entrepreneurial approach' moves further by taking part in the setting up of joint ventures to exploit laboratory-developed technologies.
- Finally, the 'national competitiveness strategy' is "based on the idea that the national laboratories should contribute to the social and economic well-being" of the country (Shama 1992). Consequently, the laboratory endeavours to find technologies that can address social and economic problems and makes of these technologies the focus for technology-transfer activities.

In each of these strategies the focus is on 'technologies' developed by the laboratories: all the approaches identified share a common 'technology push' outlook. Whether explicitly or implicitly, they focus on R&D outputs with potential application in products and services with commercial or social relevance. Therefore, the strategies are based on a linear model of innovation in which product development follows applied and basic research. The literature on 'technology commercialisation'[2] provides a clear example of this approach: the goal that drives the analysis is to find mechanisms through which research establishments can derive economic benefits from selling the outputs of their research. These approaches, particularly popular during the 1980s and 1990s, led to several attempts at developing technology-transfer organizations, programmes and strategies based on technology-push strategies, which by and large failed to deliver the expected results. Below we are going to review some of the experiences in the UK that responded to a linear understanding of the technology-transfer process.

A comparatively more receptive approach to the demand side of technology transfer can be found in the theory and practice of technology brokering. Brokers, as specialist intermediaries in technology-transfer operations, have at times combined technology push and demand-led approaches in their quest for finding new business by matching potential users and suppliers of new technology. In an analysis of technology brokers, Morgan and Crawford see them as offering a service mainly to medium-sized firms and to develop four main tasks: technology audit, technology search, partner identification, license negotiation and pricing (Morgan and Crawford 1996). Such four tasks can be applied to both the technology supplier and the buyer; however, the approach remains focused on commercialization: the final goal of the broker is considered to be an IP-licensing agreement. Both in the literature and practice of technology transfer less effort has been aimed at understanding the needs of organizations acquiring technology and knowledge developed outside their organizational boundaries (Cordey-Hayes and Longhurst 1996).

By the late 1990s the importance of the demand side in the efforts to transfer technologies from defence research establishments to the rest of the economy was becoming more evident to both practitioners and analysts alike. In a classification of different approaches to the transfer to civilian application of technologies developed initially for military use, Molas-Gallart (1997) identified four main types of transfer mechanisms, underlining the importance of 'adaptational mechanisms', where both transferor and transferee work together in adapting the technology to its new applications. An adaptational approach takes into account from the very beginning

the needs and requirements of the final user, and therefore is incompatible with a conventional technology-push strategy. Yet, because of the differences between military and civilian research and industrial organizations, attempts at building such collaborations require changes in the ways in which defence R&D and production is organized: technology transfer becomes a difficult and risky exercise requiring institutional re-design. In practice, the models of military–civilian technology transfer that have developed since the late 1990s have become more complex and multifaceted (Molas-Gallart and Sinclair 1999). The DDA emerges as a new type of organizational response to a problem whose complexity is increasingly being recognized. The next section traces the development of the DDA against a background of problematic attempts to exploit the technological capacities present in British defence laboratories.

THE DEFENCE DIVERSIFICATON AGENCY

Genesis: commercialization and the government defence labs

The creation of the DDA is linked to the process of commercialization and organizational change in the UK defence research establishments, which is, in turn, part of a series of reforms in government research establishments implemented mainly during the 1980s and 1990s, but initiated by the 1965 *Science and Technology Act.* Against a background of budgetary containment, policy measures seeking to obtain more 'value-for-money' from government research investments introduced greater accountability and a growing commercialization of the relationship with Government users ('contractorization'). In the defence area, most of the previously independent establishments were progressively merged into the Defence Research Agency (1991) and the Defence Evaluation and Research Agency – DERA (1995). As executive agencies of the Ministry of Defence (MoD), these organizations were able to implement commercially-oriented management practices.

Further, a clause was added to DERA's 'Framework Document' committing the organization to seek maximum wealth creation from its research activities. Together with new incentives to support technology transfer, the result was significant growth in DERA's external income and the development of a more entrepreneurial culture among its scientific and technical staff (Braun et al. 2000)[3]. Later on, most of DERA was turned into a new firm (QinetiQ) currently undergoing a privatization process.

The creation of the Defence Diversification Agency (DDA) is related to this process. It is the direct result of a Labour Party election manifesto pledge; yet the nature and goals of such agency were not defined until after the 1997 election. A process of consultation was soon set in motion, leading to the March 1998 Green Paper (Cmnd. 3861), and the November 1998 White Paper (Cmnd. 4088) giving formal notice of an intention to proceed with the creation of the DDA. The White Paper stated that the DDA would address three fundamental priorities:

1. To encourage the widest possible exploitation of military technology by companies servicing only civil markets, the DDA would provide knowledge of what was available and encourage access to the government defence laboratories.

It would stimulate transfer of MoD's Intellectual Property Rights and seek partnership with companies for programmes of co-development and adaptation.

2. To encourage a growing variety of defence suppliers, the DDA would draw upon knowledge within MoD about future equipment needs, technological trends, sources of advice and assistance and relative market assessments and make this database available on a confidential basis to industry.
3. To encourage the transfer of suitable civil technology into military programmes, a DDA database would be provided to enable civil companies to discover the potential for their products in UK defence programmes and to consider partnership or other programmes of co-development and adaptation.

The objectives that the White Paper laid out for the DDA considered the transfer of technology from military to civilian applications, and vice versa. Yet, the model implicit in the objectives laid out remained linear: potential technology users in the civilian industry would be made aware of the technology offerings from DERA, or of opportunities in the defence markets. The possibility of more interactive collaboration through the engagement in programmes of co-development and technology adaptation was mentioned but it did not feature prominently. The proposal could be seen as a continuation of other attempts at organizing and stimulating technology transfer from the defence research establishments that had been tried during the 1980s and early 1990s.

The experience of the organizations and initiatives that preceded the DDA in the effort to channel technologies from the defence labs into civilian use was not very encouraging. Perhaps the most important of these initiatives in the UK was the setting up in 1984 of Defence Technology Enterprises Ltd. (DTE), a technology-brokering company set up to identify technologies emerging from defence research establishments and to market them to civil clients. Led by merchant bankers Lazard Brothers and seven other city institutions, DTE had a 'franchise' to transfer technology out of the research establishments: The Ministry of Defence undertook to grant exclusive licences for technologies for which DTE had found a commercial exploitation outlet and allowed DTE personnel, sometimes referred to as technology 'ferrets', to be placed within various Defence Research Establishments. As the 'ferrets' located technologies with commercial potential, information was entered into a database of technologies 'for sale'[4]. Outside firms could, upon payment of a fee, access these databases and be informed of innovations with commercial potential. DTE would also broker agreements between firms and the relevant MoD offices once a technology had been located.

The database soon bulged with hundreds of technologies with commercial potential, and DTE assembled an impressive number of firms accessing the database (Herdan 1988). It would have seemed that the elements of success were in place. Yet, although a number of agreements were brokered, DTE was liquidated in 1990 as the initial expectations failed to materialize. Several reasons have been put forward for the failure of DTE. First, many of the most promising dual-use technologies generated by the defence research establishment were already being commercialized directly and many research establishments had their own dissemination channels, often based on long term relationships. Second, as commercialization goals gained prominence, the research establishments became

paradoxically but understandably more reluctant to disclose technologies with commercial potential through public-access means like databases. Third, the financial institutions supporting DTE may not have given the company the necessary time to establish a venture of this type.

Fourth, and probably most important, DTE was implicitly based on an underlying concept of technology transfer that was inadequate (Spinardi 1992). It implicitly assumed that the main problem in the technology-transfer process was locating a transferable blueprint or patent; once this had been done the transfer of the technology itself was relatively straightforward, through a normal commercial transaction.

A parallel initiative to the creation of DTE was the Civil Industrial Access Scheme (CIAS), launched in the mid-1980s as a joint technology-transfer initiative between the Ministry of Defence and the Department of Trade and Industry. The objective was to enable industry to benefit from the skills and facilities in MOD's research establishments. Industry was invited to access MOD technology through short-term tests and evaluations carried out at the research establishments' facilities, and through long-term collaboration in the development of ideas and techniques of mutual interest. Such long-term collaboration could be carried out through the provision of advice by defence scientists or the formal attachment of industrial researchers to the defence labs. Marketing officers were appointed and prepared lists of skills and facilities that could be of interest to commercial clients. The scheme did not appear to be very successful.

The other major institutional development was the establishment of Dual Use Technology Centres (DUTCs) in the mid-1990s, whose objective was to bring industry and academia together with DRA (as it then was) to work jointly on projects of mutual benefit (House of Lords 1994). DUTCs were described as open laboratories in which companies could participate and gain access to DERA's technologies and facilities. In practice, DUTCs became not one model but several variants. Six DUTCs were created, from large existing research centres that were directed to engage in collaborative programmes with industrial partners, to new research infrastructures (like supercomputers) built to be shared between private firms and the research agency.

The different DUTCs pursued different approaches to technology transfer. While some were relatively small facilities, oriented to the joint use and funding of specific facilities or pursuing single technology transfer mechanisms, others like the Structural Materials Centre were very large research centres implementing a wide range of policies to facilitate the exploitation of their research capabilities and results.

Although there has been no systematic evaluation of the results of CIAS and the DUTCs, available evidence suggests that their outcomes had a limited scope[5]. The DTE was a commercial failure. As the DDA started its activities it became the only organization with a wide remit to develop improved interactions between defence laboratories and the rest of the innovation system. The following section reviews DDA's structure, approaches and main activities since its creation.

The DDA organization

The Defence Diversification Agency (DDA) was established in 1998 and began its first year of operation with a budget of £2 million. Rather than acting, as some had thought, to support the defence sector at a time of transition through the provision of real material assistance, the DDA's first year of operation saw the creation of a network of support activities and personnel across the country[6]. It was set up with a small centre and, initially, five regional offices.

With an original remit of promoting technology spill-over between the defence and civilian sectors, the challenge facing the fledgling organization was to establish mechanisms able to deal with a large variety of technological fields and industrial sectors. The defence research establishments had developed technological capabilities across a broad range of generic technologies with potential applications in many sectors, and the range of civilian technologies applicable to defence systems were not limited to any specific sector. Unlike other technology-transfer organizations, which typically focused on a relatively narrow range of technologies and sectors, the DDA had to develop activities covering virtually all technological sectors. This created a substantial challenge: how to identify potential partners operating in different sectors and from different parts of the country. Often, the technological requirements of a firm would not have been articulated; how can one then identify possible fields for technological co-operation when we do not know what a potential partner would need?

To address this 'technology integration conundrum', the DDA has developed a portfolio of tools to carry out technology audits of firms and a process to identify possible technology requirements and link the firms with scientists and technicians in the defence research establishments. The technology audit tool (Technology Opportunity Study – TOPS) is applied to firms identified by the DDA regional representatives (Technology Diversification Managers – TDM) working in collaboration with the Regional Development Authorities, government-funded agencies in charge of promoting regional economic development. Two aspects of this approach are worth underlining:

- The approach to technology brokering developed by the DDA to respond to the 'technology integration conundrum' is based on a distributed network of brokers working in close collaboration with local and regional agencies, local technology providers and the government's Business Links organizations. By 2004 the DDA was working from 26 different locations, each with at least one 'Technology Diversification Manager'.
- The networking and brokering activities of the DDA regional representatives are supported by the Regional Development Agencies. Technology audits are provided to selected firms, free of charge. If firms want to pursue the opportunities identified in the TOP Study, the DDA will facilitate contacts and a further exploratory analysis with scientists and technicians from the defence research establishments. The DDA will usually step aside from the process once these contacts have been established and the future partners start moving towards the signature of contractual agreements. Unlike traditional technology brokers that operate as commercial intermediaries and seek to generate funds from the

licensing of technologies and other commercial activities, the DDA does not seek to generate licensing revenues and focus on building contacts among potential partners. This can be achieved because funding streams are not project-related; rather, core funding is obtained from MoD and the Regional Development Authorities[7] for the DDA to develop its broad range of activities.

The MoD soon focused its attention on only one of the objectives laid out in the White Paper (see above) that preceded the creation of the DDA: the identification of civilian technologies of interest to military applications. Driven by the growing importance of civilian-led IT for military applications, the problem here is not only how to find relevant technological capabilities among civilian suppliers, but how to insert them in time into new weapons systems.

Activities and outcomes

Since its creation the DDA has expanded its network of regional contacts from the original 5 offices to its current 26, and currently has a staff of over 60. It has generated a large number of collaborations between firms and the defence research laboratories, and has introduced many commercial firms to defence markets. Since its establishment the DDA has advised technology transfer contracts with a direct value of £17 million. In 2004, for instance, it placed 18 contracts between firms that had so far focused on civilian markets and the Ministry of Defence, and brokered 104 technology-transfer contracts. Yet, it would be misleading to assess the outcomes of DDA's work by using the type of indicators that have been applied to traditional commercial technology brokers. Brokering technology-transfer deals is not, by far, the most important DDA activity. The flexible approach to the identification of technological opportunities implemented by the DDA has led to a broad variety of initiatives, including:

- *Technology and knowledge brokering* (matching the technological needs of commercial firms with the capabilities existing at the defence research laboratories). At times this will result in the licensing of specific technologies, but, more often, the defence research establishments will provide technology services, mainly the testing and evaluation of new technologies and products. This activity revolves around the implementation of 'Technology Opportunity Studies' in SMEs to identify technology opportunities. Currently the DDA carries about 160 TOPS each year.
- *Marketing assistance*. The main activity within this area is the identification of potential new suppliers of advanced technologies to the MoD. The DDA will help firms find contacts within the MoD and support them through the processes needed to become MoD suppliers.
- *Regeneration activities.* The DDA has contributed to the development of an under-used military airfield into a specialist test and evaluation centre for both military and civilian Unmanned Aerial Vehicles, and plans to be involved in further regeneration activities.

- *Incubators*. The Farnborough Entreprise Hub and the London Business Innovation Centre are two incubators in the English South East managed by the DDA. The incubators are supported by a group of regional and local authorities
- *Dissemination*. The DDA participates in and organizes industrial events to present networking opportunities, introduce the procurement needs and practices of the MoD, discuss financing mechanisms for new companies and products, and explain Intellectual Property protection and evaluation practices. These activities are typically oriented to SMEs.
- *Development and implementation of knowledge and technology management tools.* In addition to the TOPS methodology, the DDA is developing, together with a British SME, a software tool to quantify the effect of technology and knowledge transfer.
- *Project evaluation*. The DDA has helped the Welsh Knowledge Exploitation Fund develop a process for the evaluation of research proposals, identifying scientists from defence laboratories able to provide technical and scientific appraisals of the proposals.
- *Other support and consultancy activities*. The DDA has helped small and medium companies expand their international operations, brokered deals with venture capitalists, help identify opportunities for UK defence firms to fulfil their international offsets obligations, and helped new firms obtain support grants. It also provides a financial-planning service based on a Value-Based Modelling method to carry out cost/benefit analysis of new technology acquisitions. Finally, it provides consultancy services to government agencies; for instance, it surveyed the commercial market for intellectual asset software tools as input prior to the establishment of a Scottish Intellectual Asset Management Centre.

This is a broad set of activities, which, moreover, spreads through a broad variety of industrial sectors and technologies. Examples of technologies that, having been first developed for a military use, have been developed into civilian applications with the help of the DDA cover virtually all industrial sectors, including electronics, health, renewable energies, transport, industrial coatings, monitoring services, etc. Further, the types of institutional and contractual arrangements by which the regional offices of the DDA relate to the regional development authorities and other local partners vary from region to region.

A MODEL OF TECHNOLOGY TRANSFER

The variety of mechanisms, sectors, approaches and organizational agreements that characterize DDA's activities are the expression of its demand-led, decentralized strategy. Common to all of them, however, is DDA's emphasis on the importance of personal contacts and networking activities, and on the need to be responsive to the demands of potential private and public clients. Unlike its predecessor, the DTE, which built a database of technologies, the DDA has built a database of thousands of contacts in industry, government laboratories and academia, seeing its growing network of contacts as one of its main assets. This exemplifies DDA's active approach to technology brokering[8].

A second relevant characteristic of the DDA's approach is the distributed, networked nature of its operations. This is necessary to be able to implement a nation-wide demand-led approach. There are some precedents of brokering organizations setting up a regional network of contact points to support technology transfer objectives. In Norway, for instance, a programme was running in the mid-1990s to increase contacts between small and medium-size firm and technological R&D institutes. The programme centred around 10 regionally-based 'technology attachés' from the research institutes, whose role was to seek opportunities for projects in their regions. In 40 companies visited by the attachés, they carried out a company analysis and a technology audit (Grovlen and Aarvak 1997). The structure set up by the DDA is not only bigger, but is supported by the Regional Development Authorities, and has a wider remit and a wider range of activities.

The DDA as an 'interface structure'

The technology-transfer model developed by the DDA responds to a nuanced view of the role of technology brokers and technology transfer offices. Spanish and Latin-American analysts have used over the past decade the concept of 'interface structure' to refer to organizations whose role is to support the relationships among the different organizational actors involved in a system of innovation. (Fernández de Lucio and Conesa Cegarra 1996) define an Interface Structure as an organization set up by one or more agents to promote and facilitate the relationships, in all matters related to innovation, among different actors of an innovation system. These actors will typically be different types of organizations with diverse institutional cultures and practices. One of the main challenges of an interface structure is to bridge such 'cultural gap' across different types of institutions[9]. Fernández de Lucio and Conesa distinguish two roles for the interface structure (Castro Martínez et al. 2005):

1. *Intermediation* between different agents in the innovation process. Intermediation often requires a direct participation of the interface structure in the innovation process.
2. Encouraging the establishment of relationships among different groups of organizations involved in different innovation tasks, and stimulating innovative activities among economic and social agents ('dynamizing'). Elements of such 'dynamizing' role include increasing awareness of opportunities and increasing the density of exchanges among organizations in the innovation system. This function involves a much broader coverage and reach of activities than the more targeted intermediary functions.

The roles of an interface structure are therefore complex and go far beyond the development of an organization to operate as a conveyor belt for technologies. The DDA goals and activities can be defined as those of an interface structure. Its demand-led approach involves 'dynamizing' activities in that it seeks to engage firms and organizations in a dialogue to identify innovation needs and analyse whether these can be supported by any group in the UK defence laboratories[10].

Setting up interface structures

The 'interface structure' approach is coherent with our current understanding of the innovation process. If we view innovation as the result of a complex set of interactions, with research organizations, industrial firms and users mutually influencing each other, technology brokerage cannot be built as a simple transfer process from researchers to technology users. Yet, as the DDA example shows, building such 'interface structures' is a complex task requiring a diversity of approaches, and therefore a managerial challenge. The DDA's six-year experience in establishing and running this type of organizations suggests several lessons concerning the challenges faced in the development of interface structures.

1. *Establish a decentralized structure.* Unlike specialized technology transfer organizations, which tend to favour centralized systems revolving around repositories of technical documentation, interface structures require a decentralized structure so that specific initiatives can be tailored to local technological requirements and needs. This is particularly important when the remit of an interface structure covers a broad geographical area. Then interface structures have to be supported by other local or region-based organizations. In the UK DDA's regional contact points have worked in collaboration with the Regional Development Authorities. It is clear, however, that the way in which other brokering organizations set up their network will depend on their scope and, above all, the institutional set up in which they operate.
2. *Stimulate technological demand.* A demand-led approach is not equivalent to conveying technological demands that are already articulated. On the contrary, most technological requirements are not clearly expressed (firms don't know what they don't know). The role of a technology broker is to stimulate demand ('dynamizing' potential technology users). The DDA stimulates technological demand through the use of formal analytical tools (TOPS is applied to the identification of the technological needs of firms).
3. *Have a flexible technological and sectoral coverage to be able to adapt to the needs of the client base.* Technology transfer organizations often focus on specific sectors and technological fields. We can find, for instance, 'technology centres' providing support to a specific industry. As sponsorship is at times derived from industrial organizations operating in a specific sector, this is a natural avenue to undertake. Also, it may appear that by bounding the area of operations to a specific set of technologies, the brokers can operate more efficiently. DDA's experience is, however, different. It was set up with a remit that, *de facto*, covered almost all technologies. This was first seen as a problem by the managerial team, but has now developed into a strength. This is because many of the technological requirements that DDA has identified in its studies were not limited to a single technological field, and were often not in the sector in which the firm operated. For instance, a TOPS analysis of a renal unit in a hospital identified a surface-coating technology derived from defence research to be applied to catheters. Demand-led technology brokerage will often lead to solutions that have emerged in unrelated sectors.

4. *Develop a broad set of specialized skills supported by technology generalists.* The Technology Development Managers in charge of managing DDA's regional operations will have a broad technological expertise, their main strength being the ability to identify groups and individuals able to deal with a problem, or providing a potential market for a technological solution. In addition interface structures will need functional experts (legal, financial, …) capable of providing support across the different types of projects and initiatives in which the organization will be involved.

In summary, the philosophy underpinning the development of the DDA sees the function of a technology broker as that of a facilitator identifying different types of needs across a broad client base, rather than that of a commercial intermediary. The failed experience of the Defence Technology Enterprises underlined the limitations of narrow 'technology brokering' models oriented to the commercialization of specific technologies. Adapting an 'interface structure' model, the DDA has re-defined the role of a technology broker in a more complex, multi-faceted manner.

MOVING FORWARD: A DIFFICULT ENVIRONMENT

The structure set up by the DDA responds to the need to bridge different communities and organizational forms, operating in different contexts and with different cultures and practices. The interface structures we have defined here are relevant in situations in which the relationships between different actors in an innovation system are not occurring spontaneously or fluidly (Polt et al. 2001). The DDA has focused its brokering activities on small and medium-sized firms. As it has long been recognized, information about innovations is neither freely nor widely available, and an 'awareness gap' develops that is broader among SMEs. To address this gap, policies need to include a promotion and diffusion component making use of a wide range of channels (Bessant and Rush 1995). The variety of channels and activities that 'interface structures' need to set up are their strength and, at the same time, their weakness. Because their roles are broad, their position within an innovation system will tend to be weak. Without a clear commercial orientation (the interface structure is much more than a commercial 'technology shop'[11]) an Interface Structure will need the support of other organizations. The DDA depended for many years on the budgetary support of the UK Ministry of Defence; once this was withdrawn in 2006 the organization had to seek alternative sources of funding and was left in a difficult situation.

This development is not surprising. Public support can be difficult to maintain in a policy context dominated by accountability practices resting on narrow quantitative indicators of success and impact. The impacts of 'interface structures' are often difficult to translate into simple indicators and may thus appear vague and difficult to manage in 'evidence-driven' policy environments. The policy theory that underpins the rational for 'interface structures' revolves around the notion of weaknesses in the linkages that bring together the different components of an innovation system (Fernández de Lucio et al. 2003). These notions are, however, difficult to translate into clear measures of economic and social policy impact:

policy initiatives based on systemic views of innovation processes are difficult to evaluate, particularly if there are political requests for univocal measurements of policy effects (Molas-Gallart and Davies 2006). The rationale for the public support of interface structures depends on relatively complex theoretical frameworks and this constitutes one of their main weaknesses.

It is possible for 'interface structures' to survive the partial or total withdrawal of public funding, but they will be obliged to increase their commercial activities. Increased commercialization is likely to involve a change in the remit and scope of an interface structure. Some of the functions discussed in this paper will be dropped or reduced, and others changed. The 'dynamizing' role discussed above is likely to lose relevance within the organization's activity as it is not directly associated with economic gain. Consequently, brokering activities may shift towards more traditional technology commercialization work.

As an interface structure, the DDA attempts to help firms and organizations lacking 'bridging ties'[12] and to provide compensatory links to their network of linkages (Howells 2006). This type of activities has often been carried out under 'extension schemes': initiatives to use external actors to build community capacities. Although the concept of 'extension' has been used mainly in the context of agricultural and health policies, initiatives like the US Manufacturing Extension Program have explicitly applied it to a different industrial environment[13]. Yet if public funding is reduced or withdrawn the nature of the organization must necessarily change. When the funding arrangements change, an interface structure can shift from an extension model to a commercial technology-brokering role. This is a situation that can occur in other environments and which has, for instance, concerned analysts of agricultural entrepreneurship and innovation. Further research is needed to understand the implications of a move across these different models of intermediation for the sectoral and local innovation systems within which they operate.

NOTES

1 By the mid 1980s most of the £19 million per year that the defence research establishments were generating as income from licences stemmed from LCD-licensing agreements. (Hooper 1996)

2 See for instance, (Radosevich and Kassicieh 1994; Kuhn 1984)

3 Yet, DERA's main function remained to support the needs of the Ministry of Defence.

4 Soon the activities of the ferrets were widened to include a more demand-led approach; that is 'working from the other end', identifying industrial problems and 'hunting' for solutions in the military laboratories. (Smith 1987). This approach emerged as an afterthought and continued to be based on the assumption that the 'ferret', as go-between, could easily understand and convey both the technologies on offer by the defence laboratories and the problems encountered by potential clients.

5 A more detailed analysis of the experience with the Dual-Use Technology Centres can be found in (Molas-Gallart and Sinclair 1999).

6 The Government argued that this form of support was wholly appropriate as the greater part of the defence industry had already adjusted to the new post-Cold War defence-spending levels by the time the Agency was established. (UK Government 1998b).

7 The Regional Development Authorities' share of DDA's budget has grown over the years, but the MoD remains the dominant funder. Total budget for 2004 was £5.44 million, of which £3.12 million was income from MoD.

[8] As we have already discussed most of the literature and practice on technology transfer implicitly or explicitly take a technology-push strategy: the point of departure are the specific technologies, or at times technological capabilities, that the broker believes may have an application beyond their initial intended purpose.

[9] The term 'cultural gap' has often been applied to describe the different objectives and practices in government labs and universities on the one hand, and industry on the other. The argument states that while research organizations will usually be concerned with long-term research addressing basic scientific and technical problems, industry will be mainly concerned with short-term answers to specific difficulties and the development of new products. This poses an important barrier to technology transfer across both types of organization. (Council on Competitiveness 1992) Baron further argues that a 'cultural gap' exists as well within the firm: secondees from industry working at government laboratories "have no idea how to transfer technology within their own organization. There is as much a cultural difference between the research and applications departments within a company as there is between Government and industry". (Baron 1990)

[10] It must be noted that this goes beyond previous models proposing the establishment of consortia between research establishment and firms with the objective of identifying areas of collaboration and setting up collaborative ventures encompassing the early development, feasibility stages through to commercialization. (Dorf and Worthington 1987) The type of collaboration agreements in which DDA is involved is much broader, including as well consultancy and technical support contracts, problem-solving, development and supply of production technology, etc.

[11] As we have argued, the model of activity the DDA has developed engages in functions that go well beyond those normally attributed to technology brokers. The 'interface structure' model is, if anything, closer to the role of a 'bridging organization' as defined by Bessant and Rush (1995). In their approach, 'bridging organizations' engage in a varied set of activities including scanning and locating new sources of knowledge, building linkages with external knowledge providers, developing and implementing business and innovation strategies, and help define and articulate the needs of 'clients'. Bessant and Rush, however, focus their attention on the role of consultants as 'bridges', do not explore the importance of 'dynamizing' activities in contexts where potential partners may not be even be aware of their own needs, neither do they analyse other forms of organizational arrangements like the geographically distributed networks that constitute one of the main characteristics of the DDA as an interface structure.

[12] A bridging tie can be defined as the only link between a firm and contacts in economic, professional and social circles not otherwise accessible to it.

[13] The MEP shares several characteristics with the DDA: mainly their networked structure relying on local centres to deliver services mainly to local SMEs, the diversity of services supplied, and their nature as non-for-profit organization receiving public funding.

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