"Interface Structures": a response to the challenges of promoting "Triple Helix"

Jordi Molas-Gallart
jormoga@ingenio.upv.es

Elena Castro-Martínez
ecastrom@ingenio.upv.es

Ignacio Fernández-de-Lucio
ifernand@ingenio.upv.es

INGENIO (CSIC-UPV), Valencia (Spain)

Abstract

There has been abundant research on the relationships between different actors in an innovation system, particularly when cultural differences and divergent organisational practices pose a barrier to collaboration and knowledge exchange among different actors. In this paper we focus on situations in which actors lack awareness of what themselves and other relevant actors in the system can offer or require. To respond to this situation, policy practitioners in different contexts have devised remarkably similar responses to the problem of developing linkages when actors in the system do not perceive a need for these to exist. We have developed the concept of "interface structures" to refer to this type of organisations. The paper discusses this notion, relates it to similar concepts in the literature, and concludes that they constitute a different type of organisational approach. They aim to generate changes in the attitudes and expectations of actors, and when successful they will lead to the formation of Triple Helix linkages.

Keywords: interface structures, knowledge transfer, bridging organisations

The authors acknowledge the financial support received from the Spanish National R&D Plan (Project ref.: SEJ2005-05923/EDUC).

ISBN: 978-81-904262-9-9

1. Background: defining and characterising interface structures

The "Triple Helix" model has drawn attention to the patterns of linkages that emerge among different institutional sectors (public sector, private industry, academia). Given the dynamic and evolutionary features that the model emphasizes, Triple Helix linkages have often been studied from a systems perspective (Carlsson, 2002; Carayol, 2003). Innovation systems approaches focus the attention on the existence of situations where the relationships between different actors in the system are weak, and where divergent cultural traits and organisational practices pose a barrier to the collaboration and coordination among them. There has been abundant research about the study of these relationships, especially in areas like university-industry linkages where, it has often been argued, cultural differences and other barriers have hampered a fluid relationship (Agrawal, 2001; Carlson et al., 2002; Carayol, 2003). A large literature has developed on the setting up of "intermediate" organisations (Howells, 2006).

This literature usually takes as its subject the problems emerging in countries where there is an advanced research and industrial infrastructure, and where potential technology customers are assumed to be able to articulate a demand that could then be serviced by public research organisations. Here cultural differences, managerial capacities, divergent interests, all pose barriers to knowledge transfer, but there is an assumption that, in the absence of these barriers, potential technology customers would be able to articulate a demand that could then be serviced by universities and other public research organisations. If some difficulties are overcome and enough information is available then relationships will develop. Yet, in some cases the actors may lack the competence to establish collaborations, either because they cannot articulate their own demand or do not have the necessary research capabilities to offer solutions to existing problems. The concept of "bridging organisation" refers to organisations seeking to establish and maintain interactions among system actors while at the same time compensating for weaknesses including lack of buyer competence, lack of supplier technological capacity, and inadequate research capabilities within the research system, among others. (Carlsson 1994,14, 16). Bridging

organisations have therefore a broader remit than technology commercialisation and traditional technology transfer organisations.

While Carlsson focus on the bridging organisation and its role within and innovation systems, others have focused on the bridging function. Bessant and Rush (1995) analyse the bridging role of consultants in technology transfer and identify their roles as including the identifications and articulation of user needs, training, education information and communication, the location of key sources of knowledge, and the establishment of links with the external knowledge system, among many others. The bridging function of consultants is therefore multifaceted. Bessant and Rush argue that "the diversity of the consultant role and the flexibility in modes of operation and interaction mean that there is considerable scope for consultants to act as key bridging intermediaries across a wide range of users" (Bessant and Rush 1995,101). They focus on the variety of roles that such individual consultants can play in technology transfer.

This research has focused on characterising the intermediation role and analysing its location within and innovation system. More recently interest has started to focus on the organisational practices that make bridging organisations effective. Sapsed, Grantham and DeFillippi (2006) address the role of bridging organisations connecting entrepreneurs in emerging industries. They argue that the "key effect of brokerage is the extension of a firm or entrepreneur's network, such that ideas and information can be taken from one context into another", and that in this process "there is more occurring than simply introductions between unfamiliar parties". By analysing a specific case of small entrepreneurs in the computer gaming industry they endeavour to contribute to the theoretical development on the distinctive role of bridging organisations within an innovation system, and how these can be structured and co-ordinated to be effective. This paper follows in the same direction adopting an entirely different empirical focus.

We are interested in situations where actors lack awareness of what the system can offer or even of their own needs. In other words, we address parts of the system in which the actors "don´t know what they don´t know". Yet, this problem does not occur because of the novelty of the areas of activity, or of

their recent entrepreneurial nature, but rather because of more deeply entrenched cultural and institutional barriers. We do not focus on small entrepreneurial groups operating in emergent markets, but on large organisations operating in long-standing markets or performing long-established functions.

We show how, to respond to this situation, policy practitioners in different contexts have devised remarkably similar responses, which have an organisational rather than a purely instrumental nature. They have developed what we have defined elsewhere as "interface structures" (Fernández de Lucio et al., 1996). This paper develops this notion. Unlike Sapsed, Grantham and DeFillippi (206) we are not focusing on operational practices but on organisational responses and their structural context. We will focus on the characteristics on "interface structures" rather than on their management and day-to-day practices.

Based on case studies of two different experiences we define the concept of "interface structure", identify its role and characteristics (networked structure, broad portfolio of activities,…), and their role supporting the relationships among different system actors. The paper presents the case studies of a network of University-Industry technology transfer organisations set up in Spain in the late 1980s (OTRI Network), and an organisation set up in the United Kingdom to improve the relationship between government defence research establishments and their socio-economic environment (the Defence Diversification Agency). After the case studies we draw some common traits that bring together these initiatives originating in such different contexts, and based on these traits we develop the concept of Interface Structure. We conclude by placing this context within a systemic view of innovation.

2. The OTRI Network and University-Industry technology transfer in Spain

2.1. Background

During the mid 1980s the Spanish innovation system was being rapidly transformed. Spain was emerging from almost 40 years of military dictatorship (a new democratic Constitution was approved in 1978) with a model of

economic development that has sometimes been described as "dependent": research was virtually non-existent, and the little that was done was often carried out in large government research organisations with weak linkages to their socio-economic environment. In the mid 1980s a whole set of legal initiatives was enacted attempting to develop new research and innovation capacities (University Reform Act –1983-, Act for the Promotion and Coordination of Scientific and Technical Research, usually referred to as the "Science Act –1986-, and a new Patent Act –1986). Linked to them the First National R&D plan was launched in 1988. Until then, Universities had carried out very little research, typically funded through their own resources. Also, until the University Reform Act, it was illegal for Universities to obtain resources additional to their normal budgets by entering, for instance, into contractual agreements with firms and other organisations. The only linkage between Universities and firms was organised through 4 "University-Enterprise Foundations" that had been created during the 70s and early 80s, to manage the contracts that research groups from a few universities might have obtained through their own initiative.

The situation in the government research establishments had been marginally better. The Spanish Council for Scientific Research (CSIC), the main research establishment in the country, had several applied research institutes with a tradition of collaboration with industry, although paradoxically, this had weakened substantially since the 1950s (López García, 1999). In the mid 1980s CSIC launched several initiatives to promote collaboration with industry, like the creation of a technology transfer office (1985), and the launch of collaboration programmes (PECOS) (Fernández de Lucio, 1988).

On the demand side, the Spanish development model had been based on cheap labour and energy costs, foreign investment and foreign technology (García Delgado, 1995). During the 1960s and 1970s Spanish firms carried out virtually no R&D: in 1964 Spanish firms spent 0.03% of GDP in R&D. By 1984 this percentage had grown to a paltry 0.18%. The lack of formal research activities was accompanied by the low educational level of Spanish industrial labour force: by 1984 only 2% of industrial employees had a university degree (Más et al., 2004).

Within this context, policy-makers were aware of the need to support the collaboration between public research organisations and industry. The managers of the National Research Plan were asked to support a relationship that had been, until then, non-existent. Rather than supporting University-Industry collaboration, science policy managers were placed in the difficult job of creating it.

2.2. The OTRI Network: genesis and main characteristics

The creation of technology transfer offices in Spanish universities was a "top-down" policy initiative. In 1989 the managers of the National R&D Plan, included among their activities the setting up of Offices for the Transfer of Research Results (OTRIs) in all Spanish universities. The OTRI´s were originally designed with, among others, the following objectives (CICYT 1988):

- To identify capacities and results with potential non-academic applications generated by research groups
- To facilitate the transfer of research results from the research groups to industry and other users
- To support researchers when entering contractual negotiations with firms and other clients and help them manage research contracts and to help them protect their Intellectual Property with the appropriate legal tools
- To provide researchers with information on opportunities available through European programmes and help them develop research projects

These were all areas in which Spanish universities and research centres had little if any experience. The OTRIs´ main goal was to facilitate University-Industry collaboration, but they had a broad set of objectives. For instance the managers of the Spanish National R&D Plan used the OTRIs as conveyors of information to the academic community, and relied on them to disseminate information and support the access to the different policy instruments in

support of University-Industry relations that they would develop and implement over the years.

Importantly, the OTRIs were set up as a network co-ordinated and supported by a central unit (the Office of Technology Transfer –OTT) within the National Plan Secretariat (Castro et al., 1991; Fernández de Lucio et al., 1996).[1] The role of this central co-ordination was paramount. The OTRIs themselves were very small units, intended to be close to their local research capacities (mainly in the universities) and local needs. Yet, for this same reason, they lacked, specialised capacities and, importantly, experience. The central OTT coordinated activities, facilitated the exchange of information and experiences, and provided, among other services, management training in areas like Intellectual Property, and the dissemination of information on research opportunities.

As the OTRIs themselves gained capacity and experience, the central support role of the OTT diminished in importance and the Office was formally closed in the late 1990s. However, the OTRIs continued to work as a network. In 1997 the Vice-Chancellors of all Spanish universities formally created the OTRI Network, which continues to organise training, establish working groups, and develop other activities typically oriented towards training and the dissemination of good practice.

All Spanish Universities and the Spanish Council for Scientific Research (CSIC) joined the initiative and set up their OTRIs. Similarly, all newly created universities have, since their establishment, set up OTRIs affiliated to the network. The outcome of this process was the establishment of a geographically distributed network of small units, displaying close links with and detailed knowledge of their local environments.[2]

The emergence of a network of small units was not an accident, but was designed into the policy initiative. An OTRI would have two or three employees, which would operate as generalists without a clear definition of

---

[1] The arrangement was called OTRI Network/OTT.

[2] Our previous research has shown how, in fact, all OTRIs have established collaborative links with firms from their specific regions (Castro et all., 2005).

their functions, supported by an administrative post. Their main role was to stimulate the relationships between industry and academia, on the one hand encouraging academic researchers to get involved in work with industrial partners by offering information and personalised support, while, on the other hand, providing information to the industrial community about the capabilities available in academic research centres and universities. In this way, the OTRI played the role of a facilitator, rather than that of a technology broker, trying to support the creation of a market for research services and outputs where none existed. Spanish academics had developed an inward-looking culture, oriented towards teaching, less concerned by research, and without any interest in technology transfer activities. Within this context, the OTRI had to operate as a client-oriented service, avoiding the bureaucratic and legalistic approaches that are still today characteristic of universities and research establishments' administrations.

Given the distributed nature of the OTRI network, not all OTRIs developed following exactly the same model. Some developed more rapidly, particularly those situated within universities with applied research capacities, and where groups of lecturers became rapidly involved and increasingly experienced in establishing contractual relationships with the private sector. Often, OTRIs had to take over managerial functions for which they had not been originally intended, as the central university services proved unable to administer research contracts and programs. In these cases the OTRIs became overwhelmed with administrative tasks and found it difficult to engage in the functions for which they had been originally intended.

2.3. Outcomes

Whatever the difficulties experienced by specific OTRIs, there can be little doubt that they play an important role in the major change that Spanish universities were to experience in the late 1980s and early 1990s. For instance, according to OECD data, the share of universities' R&D funded by firms grew from 0.4% in 1981 to 8% in 2002, superior to the OECD average (OECD, 2004). This might be attributed to causes other than the emergence of these offices; yet the table below shows how several indicators of OTRI activity and outcomes have grown rapidly, suggesting an important role in

drawing public research funds to universities. Even when the main goal of the offices was not the generation of research contracts but to establish links and generate mutual interest between two hitherto separated communities, they managed an increasingly large number of contracts generating substantial resources.

Table 1 University OTRIs: activity and output indicators

	1989	1995	2001	2002	2003	2004	2005
Number of universities	32	48	57	57	58	58	60
Professional staff (FTE)	64	154	179	234	294	348	434
Number of R&D contracts	695	3.270	8.687	8.323	7.958	9.830	10.088
Income from R&D contracts (M€)	8	120	218	252	258	282	339
Number of national patent applications	24	140	264	301	317	307	336
Number of international patent extensions			43	66	107	93	117
Number of options and license contracts			50	53	78	143	106
Income from licenses (M€)			0,49	1,14	1,69	1,9	1,7
New spin offs created			39	65	87	90	88

Sources: Own elaboration of CICYT annual reports (1989 and 1995) and University's OTRI Network annual surveys (2001-2005)

The amount and value of R&D contracts managed have recently stabilised after a protracted period of rapid growth, reflecting probably that the community of university researchers that were receptive to the OTRIs "message" and capable of engaging in contractual research relationships with external partners has been reached in its totality, and that the growth generated by the creation of new universities and the hiring of young academics has stopped. Recently the OTRIs have been involved in supporting new transfer tools like the creation of spin-off firms in science-based sectors. This is a new avenue likely to require further cultural and legal changes.

3. The UK Defence Diversification Agency

3.1 Background: commercialisation and the government defence labs

The creation of the UK Defence Diversification Agency (DDA) is linked to the process of commercialisation in 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. Policy measures seeking to obtain more "value-for-money" from government research investments introduced greater accountability and a growing commercialisation of the relationship with Government users. In the defence area, most of the previously independent establishment were progressively merged into the Defence Research Agency (1991) and the Defence Evaluation and Research Agency –DERA- (1995), which committed to seek maximum wealth creation from its research activities. As executive agencies of the Ministry of Defence (MoD), these organisations gained the flexibility to become more commercial in their operations resulting in significant growth in DERA's external income and the development of a more entrepreneurial culture among its scientific and technical staff (Arthur D. Little 2000). [3] Later most of DERA was turn into a new firm (QinetiQ) which is now being floated in the stock market.

The creation of the DDA is related to this process. The Labour Party administration set up the DDA to address three priorities:

- To encourage the widest possible exploitation of military technology by civilian firms
- To encourage a growing variety of defence suppliers
- To encourage the transfer of suitable civil technology into military programmes.

To these ends the DDA was tasked with encouraging access to government defence labs, providing information about the capabilities they had available, stimulating transfer of MoD's Intellectual Property Rights, seeking partnership with companies for programmes of co-development and adaptation, and providing information about future equipment needs and technological trends to potential new suppliers. Therefore, the objectives laid out for the DDA considered the transfer of technology from military to civilian applications, and vice versa. Initially, the model implicit in the description of DDAs tasks was linear: potential technology users in the civilian industry would be made aware

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

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; instead there was a focus on providing information through, for instance, databases of technological capabilities to which it was expected civilian firms would respond. The proposal could be seen as a continuation of other attempts at organising and stimulating technology transfer from the defence research establishments that had been tried with little success during the 1980s and early 1990s.[4] As we will see below the model that was eventually implemented diverted from this initial sketch.

3.2 Implementation: The DDA

The Defence Diversification Agency (DDA) was established in 1998 and began its first year of operation with a budget of £2 million. During its first year of operation the DDA created of a network of support activities and personnel across the country. It was set up with a small centre and, initially, five regional offices. With an original remit of promoting technology spill-overs between the defence and civilian sectors, the challenge facing the fledgling organisation 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 organisations, which typically focused on a relatively narrow range of technologies and sectors, the DDA had to develop activities covering virtually all technological sectors.

Further there was no tradition among civilian firms of access to defence research capacities. The latter had developed in a closed environment, and there was a widespread belief outside defence circles, that their activities

[4] For instance, for the failed experience in the late 1980s with the creation of an independent technology broker to commercialise defence technology (Defence Technology Enterprises) see Spinardi (1992). A detailed analysis of another, more successful experience with more sophisticated models of technology transfer see Molas-Gallart and Sinclair (1999) analysis of the Dual-Use Technology Centres.

were very specialised and irrelevant to civilian needs. Further, the highly publicised and recurrent scandals in the industry involving time and cost overruns, and dubious export practices involving the payment of bribes and other "sweeteners" to potential customers, had built an image of the defence industries as inefficient and stuck to outmoded managerial practices.

This situation created substantial challenges. First, there was not a market "out there" waiting to access the capacities that the defence labs had to offer; on the contrary a customer base had to be built virtually from scratch. To do so, the DDA established a network of regional representatives (Technology Diversification Managers –TDM) working in close collaboration with the local "Regional Development Authorities",[5] and other local organisations including the government-funded "Business Links". By 2004 the DDA was working from 26 different locations, each with at least one "Technology Diversification Manager" (TDM). The TDM's objective was to be close to the local needs and to establish links with firms and organisations that could, in principle, be interested in working with the defence labs or for the defence agencies.

The second problem was how to identify potential partners operating in different sectors with very limited availability of resources. 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 problem, the DDA developed a portfolio of tools to carry out technology audits of firms, and identify possible technology requirements. The TDMs apply these tools free of charge to selected firms. The Regional Development Authorities and the TDMs identify firms that, for their characteristics, may benefit from the technology offerings available at the defence labs, and offer them a technology audit for free. If firms want to pursue the opportunities identified through the audit 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

[5] The Regional Development Authorities are government-funded agencies whose main task is the promotion of regional economic development.

contact have been established and the future partners start moving towards the signature of contractual agreements.

The main DDA stakeholder, the UK Ministry of Defence soon focused its attention on another of the DDA's original objectives: 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. The distributed network of TDMs has also helped in the identification of local capabilities that could be of interest to defence production.

3.3 Outcomes

Since its creation the DDA has grown to reach a total staff of 60, distributed between the central offices and a regional network of 26 TDMs. 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 helped brokering 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 technology brokers. Brokering technology transfer deals is not the focus of DDA's activity. The flexible approach to the identification of technological opportunities implemented by the DDA has led to a broad variety of initiatives including, among others:

- *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 audits in SMEs. Currently the DDA carries out about 160 audits each year.

- *Marketing assistance* - Identifying potential new suppliers of advanced technologies to the UK Ministry of Defence.
- *Regeneration activities*. The DDA has, for instance, 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.
- *Managing incubators*. The Farnborough Entreprise Hub and the London Business Innovation Centre are two examples of incubators managed by the DDA and supported by a group of regional and local authorities
- *Dissemination* - Participating in and organising 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 its own technology audit 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.

This is a broad set of activities spreading over a broad variety of industrial sectors, technologies, and regions. 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.

4. Analysis: towards "Interface Structures"

Although they emerge from very different contexts and address different communities, the OTRI Network and the DDA experience share interesting commonalities. In both cases the problem they faced was to create a relationship between actors that did not have a tradition of collaboration, yet they dealt, at least at one end of the relationship, with large organisations with well-defined cultures. In Spain, there had hardly been any relationship between universities and industry prior to the creation of the OTRI Network. In the UK, civilian firms, particularly SMEs had no experience of collaborating with defence research laboratories. In both cases, the parties were unaware of each others' capabilities and needs, and no "market" for technology or technology services existed. Under these circumstances traditional a concentration on technology commercialisation strategies will not be adequate.

What is remarkable about the experience of the OTRI Network and the DDA is that without any previous knowledge of each other they developed a similar approach, which translates into a different kind of organisation we call "Interface Structures". We use this term to refer to organisations set up by one or more agents to promote and facilitate relationships in all matters related to innovation between different actors of an innovation system (Fernández de Lucio et al. 1996). The objective of an interface structure is to act as a promoter and catalyst of the relationships between different actors in the system, addressing the problems that have impeded the establishment of long-term linkages, but without becoming directly involved in the innovation process itself. In addition to a traditional brokering role (setting up connections across communities), interface structures "stimulate" otherwise passive actors to use these connections actively.

Interface structures like the ones analysed in this paper have undertaken much broader roles than those typically attributed to the much studied

technology transfer organisations. Interface Structures have a set of distinctive and common characteristics:

- *"Catalyst role"* In chemistry a catalyst helps two other elements to interact in a chemical reaction, which would not occur in the absence of the catalyst. The catalyst however does not participate in the reaction, a good catalyst is the one that does not spend itself in it. This is a good analogy with the role of the "interface structures" we are analysing here.[6] Their role is to put in touch two actors that would not otherwise interact, even if they were put in contact, and assist them to reach agreements that will take the relationship further. Interface structures inject a new "dynamic" into the innovation system, making its actors increasingly aware of opportunities in other parts of the system, and more active through the establishment of new relationships, *without* the interface structure itself getting directly involved in these new relations. The OTRIs may participate in licensing and other contractual agreements, but only as a further service they offer to their "customers" in universities and research establishments. Their strategy can be considered "mixed", having both commercialisation and catalyst roles, but with the latter usually dominating. The DDA case is even clearer in this respect: it does not get involved in technology commercialisation activities: its practice is to step aside once two groups start "talking business". In this respect, it cannot be more different from a typical commercially-oriented technology broker, which derives its income and main "raison d'etre" from licensing deals and other commercialisation practices.

[6] The term "catalytic" has also been used to refer to a market-friendly approach to the development of technology policies (Teubal, 1997). For Teubal technology policies oriented to the "functional promotion of socially desirable technological activities" (Teubal 1997,1165) need, among other requirements, to stimulate firm-based learning, diffuse new routines within the firms, reduce transactions costs, integrate the national production/innovation system, and build markets in connection with socially desirable technologies (Teubal 1997,1168). Our approach is consistent with Teubal's proposals, but instead of using the term "catalytic" to describe a broad set of policy goals as Teubal does, we employ it to define the operational objectives guiding the development of a specific set of organisational structures within an innovation system.

- *Customer-led*. Interface structures are not clearing houses for technologies and capabilities developed in research organisations; in other words their role is *not* to push technologies developed by scientific establishment to new sectors and customers. Instead, one of the problems they face is that neither the communities with which researchers could establish mutually profitable links have developed and articulated their demand for technology, nor the scientists and technicians are aware of what could they offer to potential commercial customers. The orientation of the interface structure is therefore customer-led: helping companies define and convey their technological needs, and helping researchers understand better how their capabilities can be used outside their normal practice environment (in our cases academic or defence). The DDA, for instance, stimulates technological demand through the use of formal analytical tools (their technology audits). The OTRI Networks has focused on "educating" researchers on management and commercial practices necessary to be able to operate outside the academic environment.
- *Decentralised and networked*. To be able to provide the networking opportunities and act as a catalyst, Interface Structures need to be close to their potential clients and, therefore, have to establish a network of geographically dispersed operations. Both the OTRI Network and the DDA have offices all over the national geography, and have a system to network their operations. Network is necessary because of the small size of the local offices (a few individuals at most, sometimes only one person).
- *Individualised approach and "know-who" capacities.* To be able to establish and strengthen networks at the local and regional level Interface Structures have to emphasise personal contacts, and be able to respond to the individual demands of specific researchers and potential users and beneficiaries of their technological capabilities. For instance, while one of the DDA failed predecessors, Defence Technologies Enterprises Ltd., built a database of technologies on offer, the DDA is building a database of thousands of contacts in

industry and academia, seeing its growing network of contacts as one of its main assets. In Spain, although the OTRI Network/OTT did not build a centralised contact database, yet it focused a substantial part of its activity in providing point of contacts to both industrialists and researchers. In practice both organisations develop a "know-who" expertise (OECD 1996) as a crucial capacity to support their daily activities.

- *Generalist rather than specialised*. Traditional technology brokers that operate as commercial intermediaries and seek to generate funds from the licensing of technologies and other commercial activities are typically targeted in their operations and the set of skills they have to deploy, often focusing in a few technological areas. In contrast, Interface Structures have a broader set of goals and activities, will have to rely on generalists who are able to generate new personal networks, and will not focus on narrow disciplinary or technological specialisations. The networked and customer-led characteristics of Interface Structures causes them to be involved in a variety of transfer and collaborative mechanisms, and of sectors of application and technology fields. These call for a flexible technological and sectoral coverage to be able to adapt to the needs of the client base, requiring their local representatives to be generalists able to network within and across different communities ("know-who"), rather than technical or functional specialists. Functional expertise (for instance on legal or financial matters) will be provided through the central services (DDA), or through the networking activities (OTRI Network).

5. Conclusions

As we have seen in this paper, Interface Structures can emerge in very different contexts, but respond to a similar problem: the need to bridge different communities and institutions with different cultures and practices, and which are both unable to articulate their technological needs or offerings, and unaware of the capabilities or needs the other have. From this perspective the concept of Interface Structure can be integrated into a "systems of innovation" framework: they facilitate, promote and stimulate linkages among the

components of an innovation system. There are relevant in situations in which the relationships between elements of the innovation system are not occurring spontaneously or fluidly (Polt et al, 2001); that is, in systems that lack "articulation" (Fernández de Lucio et al., 2003).

The concept can also be integrated within a Triple Helix model. Here the "focus is on the network overlay of communications and expectations that reshape the institutional arrangements among universities, industries and government agencies" (Etzkowitz and Leydesdorff 2000,109). Interface structures operate where such communications take place and affect the way in which expectations and relationships are formed.

The roles of an Interface Structure are complex and go far beyond the development of an organisation to operate as a conveyor belt for technologies. Its position within a dynamic system will, however, tend to be weak. Without a clear commercial orientation Interface Structures require the support of other organisations, which in the cases we have analysed are always located within the public sector. The DDA depended on the budgetary support of the Ministry of Defence and relies on the assistance of Regional Development Authorities. The OTRI Network was initially funded by central government (through the Spanish National R&D Plan) and regional authorities. Within this context both organisations can be easily affected by policy changes. Pressures to become, for instance, more commercial in their strategies and day to day practices would completely change their nature, affecting most if not all of the characteristics we have identified in this paper. Here too, both sets of organisations analysed in this paper appear to be following a similar developmental path. The OTRIs have been pushed to diversify their sources of income by increasingly focusing on project-based funding. The UK Ministry of Defence will withdraw its DDA funding, pushing the agency towards a commercial structure.

These pressures and changes were predictable, particularly as the impacts of Interface Structures are often difficult to translate into easy to interpret quantitative indicators and may appear to be vague to policy-makers. How does one for instance translate the "strengthening of the linkages in an innovation system" into a clear measure of policy impact on social and

economic welfare? This difficulty to present the rationale for Interface Structures through "hard" impact data and using concepts that do not "hang" on complex theoretical frameworks (innovation systems, triple helix) possibly constitutes their main weakness today as a policy instrument and explains that their diffusion remains limited.

Another challenge faced by Interface Structures stems from the dynamic nature of the context within which they operate. As their "client" organisations learn about each other's capabilities, become more dynamic, and learn how to establish links and collaborate with each other, their initial role may start to become obsolete. Becoming victim of their own success is a distinct possibility, and may generate internal pressures to develop new roles and objectives.

6. References

Agrawal, A. (2001). University –to-industry knowledge transfer: literature review and unanswered questions. *International Journal of Management Reviews,* 3(4), 285-302.

Arthur D. Little (2000). *Value from research: achieving innovation with LPRIs*. Brussels and Luxembourg: ECSC-EC-EAEC.

Bessant, J., and H. Rush (1995). Building bridges for innovation: the role of consultants in technology transfer. *Research Policy,* 24 (1), 97-114.

Carayol, N. (2003). Objectives, agreements and matching in science-industry collaborations: reassembling the pieces of the puzzle. *Research Policy*, 32(6), 887-908.

Carlsson, Bo. (1994). Technological Systems and Economic Performance. In M. Dodgson and R. Rothwell (ED.), *The Handbook of Industrial Innovation*. Pp. 13-24. Cheltenham: Edward Elgar.

Carlsson, B.; Jacobsson, S., Holmén, M., Rickne, A. (2002). Innovation Systems: analytical and methodological issues. *Research Policy,* 31, 233-245.

Castro-Martínez, E., Fernández de Lucio I. (1991). Hacia un Sistema integrado Ciencia-Tecnología-Industria. In *Actas Simposium International*

*New Tecnologies and Socieconomic Challenge (*pp. 315-324), Barcelona: Institut Catalá d' Estudis Mediterranis.

Castro-Martínez, E., Cortes-Herreros, A.M., Nicolás-Gelonch, M., Costa-Leja, C. (2005). Una aproximación al análisis del impacto de las universidades en su entorno a través de un estudio de las actividades de las OTRI universitarias españolas. *Proceedings XI Seminario Latino-Iberoamericano de Gestión Tecnológica (ALTEC 2005)*. Salvador de Bahia.

CICYT (1988). *Las Oficinas de Transferencia de resultados de Investigación y la Oficina de Transferencia de Tecnología*. Madrid: CICYT. Internal memo.

Etzkowitz, Henry, and Loet Leydesdorff (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research policy,* (29),109-123.

Fernández-de-Lucio, I. (1988). *Valoración y transferencia de tecnología*. Madrid: CSIC. Internal memo.

Fernández-de-Lucio, I., Conesa, F., Garea, M., Castro-Martínez, E., Gutiérrez, A., Bodegas, M.A. (1996). *Estructuras de interfaz en el Sistema español de Innovación. Su papel en la difusión de tecnología*. Valencia: Universidad Politécnica de Valencia.

Fernández-de-Lucio, I.,Jiménez-Sáez, F., Gutiérrez-Gracia, A. and Castro-Martínez, E. (2003). The evaluation of the national food technology programme: the articulation of the Spanish food innovation system, *Int. J. Agricultural Resources, Governance and Ecology*, 2(3/4),343-360.

García Delgado, J.L. (1995). La economía española durante el franquismo. *Revista Temas*, 12, 27-32.

Grovlen, M. and K. Aarvak (1997). Technology transfer from R&D institutions to SMEs. The Norwegian TEFT Programme. *Industry & Higher Education,* 11(1), 50-53.

Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Research Policy*. 35, 715-728.

López García, Santiago (1999). El Patronato "Juan de la Cierva" (1939-1960). III Parte: La investigación científica y tecnológica. *Arbor*, 637(Tomo CLXII), 1-32.

Mas, M., Pérez, F., Uriel, E., Serrano, L., Soler, A. (2004). *Capital Humano en España y su distribución provincial. Banco de datos*. Retrieved April 10, 2007, from IVIE site: http://www.ivie.es/banco/capital.php

Molas-Gallart, J. and T. Sinclair (1999). From technology generation to technology transfer: the concept and reality of the Dual-Use Technology Centres. *Technovation*, 11, 661-671.

OCDE (1996). *The Knowledge-based Economy*. Ref. nº OCDE/GD(96)102. Paris: OCDE.

OECD (2004). *Main science and technology indicators*. Paris: OCDE.

Polt, W., Rammer, C., Scharting, D., Gassler, H. Schibany, A. (2001). Benchmarking Industry-Science Relations: the Role of Framework Conditions. *Science and Public Policy*, 28 (4), 247-258.

Sapsed, Jonathan, Andrew Grantham, and Robert DeFillippi (2006). *A Bridge over Troubled Waters: Bridging Organisations and Entrepreneurial Opportunities in Emerging Sectors*. Retrieved April 11, 2007, from SPRU 40th Anniversary Conference - The Future of Science, Technology and Innovation Policy site: http://www.sussex.ac.uk/Units/spru/events/ocs/index.php

Spinardi, G. (1992). Defence Technology Enterprises. *Science and Public Policy,* 19(4), 198-206.

Teubal, M. (1997). A catalytic and evolutionary approach to horizontal technology policies (HTPs). *Research Policy,* 25, 1161-1188.