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Intermediation and the role of intermediaries in innovation

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Abstract

This paper investigates the issue of intermediation and the role of intermediaries in the innovation process. The aim of this paper is three-fold. Firstly, to review and synthesis the literature in this field; from this to develop a typology and framework of the different roles and functions of the intermediation process within innovation; lastly to try and operationalise the typology within the context of UK using case study material.

Keywords: Innovation; Intermediation; Technology transfer; Intermediaries

1. Introduction

Analysis of systems of innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993; Edquist and Johnson, 1997), innovation and scientific networks (Freeman, 1991; Callon, 1994; Hohn and Lütz, 1994) and the innovation becoming more open or distributed over time (Coombs et al., 2003), in turn associated with increasing levels of collaboration and outsourcing (Chatterjee, 1996; Howells, 1999a), has led the analysis to investigate more closely the role of the nodes and links in this process. Within this more complex realm, has emerged a set of actors who may be broadly termed as 'intermediaries' and who perform a variety of tasks within the innovation process. The different roles that these actors play within the innovation process have been variously described as third parties (Mantel and Rosegger, 1987), intermediary firms (Stankiewicz, 1995), bridgers (Bessant and Rush, 1995; McEvily and Zaheer, 1999), brokers (Hargadon and Sutton, 1997; Provan and Human, 1999), information intermediaries (specifically associated with information exchange; Popp, 2000) and superstructure organizations (Lynn et al., 1996).

The aim of this paper is three-fold. Firstly, to review and synthesis the literature in this burgeoning, yet surprisingly disparate, field; from this to develop a typology and framework of the different roles and functions of the intermediation process within innovation; and lastly to operationalise the typology within the context of the UK using case study material. It should be noted that the word innovation intermediary is used to denote a range of organizations including brokers, third parties and agencies that are involved in supporting the innovation process (see Section 4.1 for a more complete definition).

2. The role of intermediaries in innovation

2.1. Background review

The role of intermediary in innovation and technological development can be traced back to 'middlemen'

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in the agricultural, wool and textile industries of 16th, 17th and 18th century Britain (Hill, 1967; Farnie, 1979; Smith, 2002). These middlemen not only plied their trade, but were important informal disseminators of knowledge about technical improvements in agriculture, cloth making and in the collection, separation, carding and spinning of wool.

Interest in the role of intermediary in the innovation process has emerged from a number of different sources and research fields over the last 20 years. These include: (a) literature on technology transfer and diffusion; (b) more general, innovation research on the role and management of such activities and the firms supplying them; (c) the systems of innovation literature; (d) research into service organizations and more specifically Knowledge Intensive Business Services (KIBS) firms. Each of these literature sources will be briefly reviewed below. The grouping of these studies into four main groups is meant to highlight the different emphasis placed by studies on the role of intermediaries and the process of intermediation in innovation literature.

2.2. Diffusion and technology transfer

The first real interest in intermediaries in relation to innovation was in the field of diffusion and technology. It was realised early on that 'change agents' (Hägerstrand, 1952; Rogers, 1962) had a powerful influence on the speed of diffusion and uptake of new products and services by household and firm adopters. The initial significance of third parties was in their information dissemination and their impact on adoption rates within a diffusion community. However, Mantel and Rosegger (1987, p. 127) highlighted other roles that such third parties played in the diffusion process, including: support in decision-making of whether to adopt or not; as a specification writer or standard setter; and, as an evaluator of the technology once it was in the market.

Work by Watkins and Horley (1986, pp. 244–245) has taken a more prospective look into what intermediaries might do to help the technology transfer process between large and small firms as part of a policy initiative. They identify the role that such intermediaries could play in: identifying partners in the first place; helping package the technology to be transferred between the two firms; selecting suppliers to make components for the technology; providing support in making the deal between the firms concerned. By contrast, Seaton and Cordey-Hayes (1993, pp. 49–50) in reviewing a number of projects covering technology transfer, highlighted the role of the Defence Technology Enterprise (DTE) as an intermediary involved in technology exploitation. The study evolved into exploring how intermediaries, such as the DTE, interact with their clients in the technology transfer process. Shohert and Prevezer (1996) also explored the role of intermediaries in relation to technology transfer, amongst other institutional groups, within biotechnology in the UK. They emphasise the important role that intermediaries play in helping to formalise informal collaborations in terms of contractual and licensing arrangements. As with Watkins and Horley's work, Shohert and Prevezer (1996, p. 293) also take a more prospective examination of what intermediaries might become more involved in. More specifically, the provision of specialist negotiation and contractural skills in knowledge processes was seen as a key attribute and role they should develop.

2.3. Innovation management

This second group of studies is closely related to the first, although the focus is somewhat different. Instead of highlighting the role of intermediaries in the diffusion and technology transfer process, here the analysis is more about intermediaries as organizations and what type of activities they are involved in. Nevertheless, there is a clear acknowledgement that a key function of intermediaries is their role in the technology transfer process. Thus, Hargadon and Sutton (1997, p. 716) in their study focus on how brokers, as agents, facilitate the process of knowledge and technology transfer "across people, organizations and industries." McEvily and Zaheer (1999) highlight the role of regional institutions (such as regional industrial extension centres) provide in helping to compensate firms which have a poor advice network and lack bridging ties (i.e., unique, non-redundant ties in a network); i.e., such regional institutions provide important compensatory links to a firm's linkage network.

However, Hargadon and Sutton (1997, p. 723) from their study of one technology broker (IDEO, U.S. design consultancy) also stress that brokering is more than just a linking role, but also helps transform the ideas and knowledge being transferred. They identify the role of broker as not just supporting a linkage role but as a knowledge repository whose knowledge its workers use to provide solutions that are new combinations of existing ideas to their clients.

2.4. Systems and networks

The systems of innovation (and technological systems) literature in defining a system of innovation have also recognised the existence of intermediary organiza-

tions. Stankiewicz (1995, p. 174; see also Carlsson and Stankiewicz, 1991) in his analysis of industrial automation in Sweden identified the role of 'intermediary firms' that help adapt specialised solutions on the market to the needs of individual user firms. On a broader level, Stankiewicz (1995, p. 198) also recognises the existence of 'bridging institutions' that help link players within a technological system. Similarly, Lynn et al. (1996, p. 97) in their study of 'innovation communities' also identify a group of organizations that help to link and transform relations within an innovation network or system. These types of organizations would form what Lynn et al. (1996, p. 98) would term 'superstructure' organizations, which act to provide collective goods to their members and help to facilitate and coordinate the flow of information to 'substructure' firms (those actually producing the 'innovation' or its technological complementaries). Both studies also highlight that such organizations may be both public and private in nature.

Callon (1994, 1980), on a wider level, identifies the important role of intermediaries in initiating change within science networks and more localised configurations, local collectives. Van der Meulen and Rip (1998, pp. 757–758) also identify a much wider institutional role for intermediary bodies (centred on research councils, other funding bodies, universities and research organizations) which are in the strategic level between the policy level and the operational level (research performers) and how they form an 'ecology' of influences on other agents within the system. These two latter studies in turn link in with a wider set of literature associated with principal-agent models and 'boundary organizations' in science and research policy (see Braun, 1993; Guston, 1996, 1999; Cash, 2001; Kelly, 2003). Although these studies concentrate on policy formulation they identify the important role that such agencies play, for example, in: the policy process (Braun, 1993, p. 141); their role in technology transfer and the often complex networks in which they may operate (Cash, 2001, p. 444).

2.5. Intermediaries as service organizations

The role of intermediaries and the process of intermediation has also been explored in the context of service activity and service innovation, in particular in relation to the growth of KIBS (O'Farrell and Moffat, 1991; Miles et al., 1995; Miles, 2000; O'Farrell and Wood, 1999; Bettencourt et al., 2002; Wood, 2002a). Many KIBS firms have close and continuous interactions with their clients which can involve crucial, but largely hidden, functions in supporting innovative change within their client companies (Wood, 2002b, p. 997; see also Bessant and Rush, 1995).

In turn, this has also been recognised in the increasing role of KIBS organizations in the wider innovation system (Howells, 1999b; Czarnitski and Spielkamp, 2000; Muller and Zenker, 2001). In this context, Howells (1999b, p. 125) seeks to highlight the proactive role that certain types of service firms play as innovation intermediaries within innovation systems; whilst Czarnitski and Spielkamp (2000) identify the role that business-related services play as 'bridges for innovation' to other manufacturing and service firms.

2.6. Summary and synthesis

What can be concluded for this review? There are four preliminary conclusions to be drawn from this review. Firstly, although for review and pedagogic reasons this paper has identified four main conceptual strands of work, in practice there are obvious overlaps between these four main groupings. Thus, Shohert and Prevezer (1996, p. 295) in exploring the role of technology transfer in UK biotechnology also emphasise the pivotal role of intermediaries in the growth and development of UK biotechnology as essentially a sectoral system of innovation. Equally, Stankiewicz (1995, p. 174) in his analysis of industrial automation as a technological system is examining this through the lens of the diffusion of automation in Swedish industry; whilst several studies examining KIBS firms have also sought to revaluate the role of service firms within innovation systems. Because of this, Table 1, which seeks to list all the main studies associated with this literature on intermediation and innovation,[1] does so simply in terms of the chronological order of publication.

However, secondly, there is a distinction between studies that have focused on intermediaries as *organizations* and intermediation as a *process*.[2] This does lead to differences in approach and in terminology (and for this reason these two approaches are distinguished in Table 1), and this will be explored later. Thirdly, there is a surprisingly low level of cross-referencing between

[1] As highlighted later, it does not seek to list all the studies on intermediation in general, only those focused on innovation and technology.

[2] Interestingly, if we take Archibugi and Michie's (1995) useful bi-polar conceptual typology of innovation research as 'subject' and 'object' based, there does not seem to any study in this field that takes a truly object-based approach to intermediation. An exception here is the case of Callon (1994, p. 411) who provides a much richer view of networks in which intermediaries operate; these networks are seen to comprise not only actors, but also physical artefacts and concepts (statements and texts) with which the actors relate to.

Table 1
Summary of studies examining intermediaries and the intermediation process in innovation

Term	Study	Definition/role
Organizations		
Intermediaries	Watkins and Horley (1986)	Explores role of intermediary agencies support technology transfer to small firms
Third parties	Mantel and Rosegger (1987)	Persons or organizations that intervene in the adoption decisions of others
Brokers	Aldrich and von Glinow (1992)	Agents facilitating the diffusion of in a social systems of new ideas from outside the system
Intermediaries	Seaton and Cordey-Hayes (1993)	Examines the role of intermediaries in technology exploitation
Intermediary agencies	Braun (1993)	Role of mission agencies in formulating research policy
Intermediaries	Callon (1994)	Role of intermediaries in effecting change within science networks and local collectives
Consultants as bridge builders	Bessant and Rush (1995)	Role of independent consultants as bridge builders in the innovation process
Intermediary firms	Stankiewicz (1995)	Adapt solutions available in the market to the needs of the individual user
Intermediaries	Shohert and Prevezer (1996)	Public and private organizations that act as agents transferring technology between hosts and users
Bricoleurs	Turpin et al. (1996)	Agents seeking to develop new applications for new technologies outside their initial development field
Superstructure organizations	Lynn et al. (1996)	Organizations that help to facilitate and coordinate the flow of information to substructure firms
Knowledge brokers	Hargadon (1998)	Agents that help innovation by combining existing technologies in new ways
Intermediary level bodies	Van der Meulen and Rip (1998)	Help orient the science system to socio-economic objectives
Innovation intermediaries	Howells (1999b)	Proactive role that certain types of service firms play as intermediaries within innovation systems
Technology brokers	Provan and Human (1999)	Actors filling gaps in information and knowledge in industrial networks
Regional institutions	McEvily and Zaheer (1999)	Provide ‘surrogate ties’ by serving as functional substitutes for a firm’s lack of ‘bridging ties’ in a network
Boundary organizations	Guston (1999)	Role of boundary organizations in technology transfer and ‘co-production’ of technology
Boundary organizations	Cash (2001)	Role of boundary organizations in technology transfer
Knowledge intermediaries	Millar and Choi (2003)	Organizations that facilitate a recipient’s measurement of the intangible value of knowledge received
Processes/activities		
Innovation consultancy services	Pilorget (1993)	Role of consultancy firms specifically to promote innovation; involves a variety of actors including consultancy firms and intermediary agencies
Technology brokering	Hargadon and Sutton (1997)	Technology brokering is where an organization routinely creates new products by making connections between existing solutions in other sectors or technologies
Innovation bridging	Czarnitski and Spielkamp (2000)	Provision of knowledge or services that are complimentary to firms
Knowledge brokering	Wolpert (2002)	Intermediaries that facilitate the exchange of information about innovation amongst companies

studies in this research domain, even for later studies, although there are some exceptions (most notably those originating from a diffusion or technology transfer perspective). Some of the apparently novel assertions made by some studies may not appear so new when viewed in light of earlier studies; but more importantly here, such lack of cross-fertilisation has arguably limited the development of research in this field.

Fourthly, the review also highlights the generally partial view of the role of intermediaries in the innovation process taken by such studies which has not generally been well-grounded theoretically. Instead, the review has revealed the highly eclectic nature of the literature with most studies, although acknowledging the role intermediaries, still see them as being tangential to their main field of enquiry, such as innovation diffusion or inno-

vation systems. This is not meant to be a criticism of previous studies, as they have generally focused only on a particular function of intermediaries (for example, as a facilitator in the diffusion process or as a technology broker) on a primarily pragmatic (non-theoretical) level. By taking all these studies on intermediaries together we can finally see a much wider, more varied and holistic role for many intermediaries in the innovation process and this is where the paper seeks to make a particular contribution. On this basis, the next section will seek to unpack more specifically what functions, processes and relationships are associated with innovation intermediation. Using this as a framework, the paper will then explore the process of intermediation drawing on evidence from UK case study material (Section 4).

3. Innovation intermediation as a function, process and relationship

Section 2 has reviewed the various studies analysing the role of innovation intermediaries. Taking the perspective of intermediation as a process, the studies predominantly focus on two main functions associated with intermediation – namely the information scanning and gathering function and the communication function – both of which might be associated with the 'front end'[3] of innovation intermediation (Lynn et al., 1996; Wolpert, 2002). This broad stage is equivalent to what Seaton and Cordey-Hayes (1993) term as the 'scan and recognise' and 'communication and assimilate' phases and what Hargadon and Sutton (1997) identify as the 'access' and 'acquisition' phases. Many studies stop here, seeing the primary role of intermediaries as providing *information* scanning and exchange functions.[4]

Other studies, however, take a more involved role for intermediaries at this stage, by focusing on specific *technologies* which intermediaries help transfer between firms and organizations. The emphasis here is on existing technologies finding new uses and applications in different sectors and industries (Aldrich and von Glinow, 1992; Stankiewicz, 1995; Turpin et al., 1996; Shohert and Prevezer, 1996; Hargadon and Sutton, 1997; Hargadon, 1998). By specifying technologies rather than information, the studies imply that intermediaries have more complete knowledge about the various technological domains in which they operate – although again the studies do not usually spell this out in more detail. Thus, even here, the studies outlining the role of intermediaries in technology transfer do not stress, or detail, the interactions by the intermediary between the different parties; rather it is more a matter of providing or imparting existing knowledge about a technology. The metaphor frequently used here is 'cross-pollination' or 'bridging' between previously unrelated or unconnected groups (Bessant and Rush, 1995, p. 102; Hargadon and Sutton, 1997, p. 731; McEvily and Zaheer, 1999, p. 1136); for example, helping to link members of a particular social system to new ideas created or invented elsewhere (Aldrich and von Glinow, 1992).

Exceptions to this are the study by Hargadon and Sutton (1997) and Hargadon (1998), which seeks to emphasise the combinatorial role of intermediaries, and the study by Bessant and Rush (1995), which highlights the articulation and diagnostic role of consultants. In their study of IDEO as a technology or knowledge broker, Hargadon and Sutton (1997) found that IDEO not only scanned and acquired information but also stored this in some kind of centralised knowledge base and further added to and manipulated it so that it could, in turn, be used for future clients. Hargadon and Sutton (1997), therefore, suggest in their study a much more involved, sophisticated and proactive role of intermediaries with regard to technology and innovation.

Other roles and functions of innovation intermediaries highlighted in existing studies are rather partial and fragmentary. Seaton and Cordey-Hayes (1993) mention the function of applying what has been transferred or imparted for effectiveness or competitive advantage. Mantel and Rosegger (1987, p. 127) also see a wider role for intermediaries as standard setters, or as evaluators of a technology *after* it has been transferred. However, Bessant and Rush (1995) provide the widest range of functions (although those listed cover all intermediary roles of consultants not just those in relation to innovation). These include (Bessant and Rush, 1995, p. 101): articulation and selection of technology options; scanning and locating new sources of knowledge; building linkages with external knowledge providers; development and implementation of business and innovation strategies. Bessant and Rush (1995, p. 102) also highlight the more interactive and diagnostic role of intermediaries. Consultants, therefore, help define and articulate the needs of the client in relation to innovation. In outlining the different roles or functions of intermediaries in innovation processes, these studies

[3] Taking, for pedagogic reasons only (see Kline and Rosenberg, 1986), a modified 'linear' view of the innovation right from initial fundamental research through to commercialisation and beyond.

[4] We do not belittle this role; through specialised collection, collation and synthesising activities, intermediaries do play a very important role in networks (Popp, 2000, p. 154) and the economy as a whole (Casson, 1997, pp. 154–155).

identify or imply different phases or stages. Thus, Seaton and Cordey-Hayes (1993, p. 48) identify three stages: scanning and recognition; communication and assimilation; application. Hargadon and Sutton (1997), by contrast, have: access; acquisition; storage; retrieval; output. The paper will now explore these functions and roles in more detail by using case study material from the UK.

4. Intermediation and the role of intermediaries in innovation: the case of the UK

4.1. Research framework: case studies of innovation intermediaries in the UK

The research was based on a set of case studies that involved semi-structured interviews with managers in the 22 organizations (plus their eight subsidiary companies), based on specific project collaborations, together with their overall strategies and work practices. The primary survey material collected by interview was also supported by the collation and synthesis of secondary documents made available by the organizations, detailing specific projects and clients, and, in the case of Association of Independent Research and Technology Organizations (AIRTO) members, through discussions at meetings with senior members of the Association. Further details and a list of case study organizations appear in Appendix A. Construction of a readily identifiable population list of innovation intermediaries from which to survey proved difficult for a number of reasons: lack of an accepted definition and consensus of what an 'innovation intermediary' was; organizations identified as providing intermediary roles in innovation processes are complex and multiple entities, whose primary role may often not be as an intermediary (Section 4.3); no formal designation or recognition of the sector by government or statistical bodies.

In terms of the first issue a working definition of an innovation intermediary used in this study was: "An organization or body that acts an agent or broker in any aspect of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between, bodies or organizations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations." This definition seeks to include other terms that have been used to broadly describe such processes as 'third-party' or 'broker'. Organizations that were seen as providing clearly identifiable intermediary services in relation to innovation were selected. Given that this was an exploratory study in part to help articulate what an innovation intermediary is, it was decided not to attempt to construct, at this stage, a complete population list of innovation intermediaries in the UK. Instead AIRTO members (Appendix A) were invited to participate, plus a number of other organizations and consultancy or testing companies were included in the survey.

Taking for pedagogic reasons a modified, recursive and interactive but 'linear' view of the innovation process (Kline and Rosenberg, 1986, p. 209), right from initial fundamental research through to commercialisation and beyond, a number of functions or roles associated with innovation intermediation can be envisaged. The research follows a modified inductive strategy (Blaikie, 2000) so that, a priori, the study began with conceptualisation of five main functions or roles that went well beyond the early phases of information scanning and exchange which, up until now, has been the predominant concern of studies (Section 3). These are: scanning and information processing; knowledge processing; gatekeeping and brokering; testing and validation; commercialisation. On this basis, via interview and other evidence, the case study organizations were then analysed in terms of what intermediary function they undertook, and the set of relationships associated with it, for their client firms.

From this process, it became apparent, a posteriori, that the case study organizations undertook considerably more functions than originally conceived. They covered ten functions in all and included new unrecognised or undervalued roles including, for example: foresight and diagnostic work; accreditation, validation and regulation and standards work; independent advice and mentoring on protecting intellectual property; and, evaluation on the outcomes of innovation collaboration. These functions are listed in Table 2. Not only were there more main functions or roles identified, but also they could be

Table 2
Innovation intermediation functions

1. Foresight and diagnostics
2. Scanning and information processing
3. Knowledge processing and combination/recombination
4. Gatekeeping and brokering
5. Testing and validation
6. Accreditation
7. Validation and regulation
8. Protecting the results
9. Commercialisation
10. Evaluation of outcomes

Table 3
Typology of intermediation in the innovation process

Type	Function	Comments	Example of organization providing the function
1. Foresight and diagnostics			
(a) Technology foresight and forecasting	Foresight, forecasting and technology roadmapping		CERAM, Oakland, PERA, SIRA
(b) Articulation of needs and requirements			Oakland, PERA, SIRA
2. Scanning and information processing			
(a) Scanning and technology intelligence	Information scanning and technology intelligence	Information gathering and identification of potential collaborative partners	PERA, Oakland, CERAM
(b) Scoping and filtering	Selection and clearing function	Selection of collaborative partners	PERA, Oakland
3. Knowledge processing, generation and combination			
(a) Combinatorial	Helping to combine knowledge of two or more partners		AMTRI, BSI, CERAM, DsX, LCG Bioscience, LGC, MERL, NEL, PA Group, PERA, Roke Manor Research, Scientific Generics, Scipher, SIRA, TTP, UrbiNetics
(b) Generation and recombination	As (a) above, but also generating in-house research and technical knowledge to combine with partner knowledge		AMTRI, BSI, CERAM, DsX, LCG Bioscience, LGC, MERL, NEL, PA Group, PERA, Roke Manor Research, Scientific Generics, Scipher, SIRA, TTP, TTP Communications, UrbiNetics
4. Gatekeeping and brokering			
(a) Matchmaking and brokering	Negotiation and deal making	Facilitating contract negotiation once partner(s) selected	Generics, TTP
(b) Contractual advice	Finalising the contract	May involve specialist IP expertise (see 8)	Generics, QED, UMIP
5. Testing, validation and training			
(a) Testing, diagnostics, analysis and inspection		Test chambers and laboratories	7Layers UK, AMTRI, BSI, CCFRA, MERL, LCG Bioscience, LGC, Premier Research, UrbiNetics
(b) Prototyping and pilot facilities			AMTRI, CERAM, Roke Manor Research
(c) Scale-up		Including manufacturing modelling to overcome bottlenecks	CERAM, Roke Manor Research
(d) Validation		Validation of analytic methods	BSI, CCFRA, LGC, NEL
(e) Training		Joint training in use of new technologies	CCFRA, PERA, SIRA
6. Accreditation and standards			
(a)	Specification setter or providing standards advice	Includes developing reference designs	BSI, NEL, PERA, UbiNetics
(b)	Formal standards setting and verification		BSI, NEL
(c)	Voluntary and de facto standards setter		BSI, NEL, CERAM
7. Regulation and arbitration			
(a) Regulation		Formal regulation	–
(b) Self-regulation		Quasi-formal basis as an agency involved in self-regulation	–
(c) Informal regulation and arbitration		Informal arbiter between different groups, for example, between consumers and producers	BSI

Table 3 (*Continued*)

Type	Function	Comments	Example of organization providing the function
8. Intellectual property: protecting the results			
(a) Intellectual property (IP) rights advice	Protecting the outcomes of collaboration	Help clients assess their ideas for IP protection	QED IP Services, Generics Asset Management
(b) IP management for clients		Securing IP rights and their management	QED IP Services, Generics Asset Management
9. Commercialisation: exploiting the outcomes			
(a) Marketing, support and planning	Market research and business planning	Identify market opportunities and develop business plans	Generics Asset Management
(b) Sales network and selling	Support in the selling and commercialisation process	Help establish and run sales channels	–
(c) Finding potential capital funding and organising funding or offerings	Early stage capital	Assessment and filtering capability for funding – 'proof of principle' funding	E-Synergy, Generics Asset Management, UMIP
(d)	Venture capital	'Follow on' funding	UMIP
(e)	Initial Public Offering		Generics Asset Management
10. Assessment and evaluation			
(a) Technology assessment		General assessment of performance and technologies (see 1)	CERAM, Oakland, PERA
(b) Technology evaluation		Specific evaluation of products and technologies once in the market (see 1)	–

further broken down into particular activities which the intermediaries, may or may not be involved in. These are listed in Table 3 , together with the innovation intermediaries in our study that could be allocated to these particular tasks.

4.2. Unpacking innovation intermediation

Although there is insufficient space to go through these in detail a number of specific comments and descriptions can be made about the functions that have been articulated in Table 3, before a broader analysis is undertaken. What became apparent from the analysis was that many firms seek help to identify what they might need from partners or even more generally what their innovation and business strategy should be. A number of intermediaries provide such services, usually they are organizations which already provide scanning and technology intelligence functions, and essentially go back to supporting the client with even more fundamental issues concerning where they should be searching and seeking information in the first place. Thus, organizations, such as CERAM and SIRA provide, respectively, technology forecasting and technology roadmapping (TRM) services to complement their technology intelligence and search functions, for example, provided by PERA's dedicated Knowledge Centre. Similarly, LGC (formerly the Laboratory of the Government Chemist) acts an 'intelligent interface' between its client and its 'task environment' in relation to analytical, environmental and testing matters. This includes providing advice on what the client company should be doing in the future with regard to analytical activities, how it should react to the changing regulatory environment, providing hazard assessments, and outlining what improvements can be made in relation to measurement and testing techniques and so on.

Moving on from foresight and diagnostics and scanning and information processing (functions 1 and 2), is a range of functions covering what might be termed knowledge processing, generation and recombination. This function involves more than just collecting and collating information and forwarding this onto the client, but also involves some modification. This is either (function 3a, the combinatorial function) by combining it in a more specific directed way with existing information from either outside or within the firm, or (function 3b – the recombinatorial/fusion function) by generating in-house research and technical knowledge to combine with the client's knowledge.

Whilst the knowledge generation and processing activities are more inward looking functions, the gate-

keeping and brokering roles (function 4) necessitate more outward looking activities associated with matchmaking and brokering collaborative deals for the client firm(s). Following this are testing, validation and training and accreditation functions in the innovating process (function 5). A number of case study firms owe their origins either to their formal testing, accreditation or standards setting role, based on their former role as government laboratories, such as LGC, NEL TUV (owned by a German company TUV SÜD, formerly the National Engineering Laboratory) and, with organizations like BSI and BRE have moved out of these initial roles into much wider functions. They have also been joined by newer units, such as 7Layers UK, a test laboratory jointly owned by TTP Communications and a German company, 7Layers. The growth of these functions has been particularly due to the fact that these units are seen as being independent and impartial by supplier and user firms alike. One organization noted that its success had been due to it being seen as 'neutral ground', where genuinely impartial outcomes were produced. Specialised training services has also been a growth function, as these organizations use their specialist facilities to help train workers from different organizations in the use of new technologies or laboratory techniques.[5] By contrast, the role of intermediaries as arbiters and regulators (function 7) were more limited. Only BSI had some informal role as a regulator (7c), whilst often the function of an *arbiter* was difficult to separate from the function of the *validator* of, for example, analytic methods (6c; with validation in a sense being a precursor to arbitration).

The last two main functions were associated with protecting (function 8) and commercialising (function 9) the outcomes of innovation and collaboration. This appears to have been a growth area for innovation intermediaries. Scipher plc and the Generics Group are two companies that have set up dedicated units to provide such services. In relation to intellectual property advice and management, Scipher has set up QED with its two subsidiary units, QED Intellectual Property Limited and QED IP Services Limited to provide a complete service for license revenue generation from its clients' IP assets. Similarly in terms of commercialisation support, the Generics Group has established Generics Asset Management to help identify market opportunities, develop business plans and to assess and provide filtering capability for funding. These are also functions that many Industrial Liaison Offices (ILOs) of universities and other Higher Education Institutions (HEIs) provide and UMIP is one such example, providing 'proof of principle' funding for innovations.

Lastly, there are assessment and evaluation roles (function 10) provided by innovation intermediaries to essentially service 'post innovation' evaluations (10b), although they can be a more general assessment function (10a). This role could be seen as the starting point for many firms using intermediary services and often the outcomes of this activity then feed directly into undertaking functions 1 and 2, noted earlier.

4.3. Innovation intermediation and innovation intermediaries: conceptual and theoretical issues

We consider that this analysis has highlighted five main conceptual issues.

(1) Firstly, the functions of an innovation intermediary are more numerous and diverse than previous studies have implied. The number and diversity appears to be widening along the innovation value chain as organizations providing such functions:
   (a) move upstream (scoping and intelligence) or downstream (IP protection and commercialisation) in relation to the innovation chain into new roles, illustrated by such organizations as BSI, Scipher or Generics,
   (b) diversify into new industries or technologies, explified by CERAM, QinetiQ or SIRA, and/or
   (c) shift into new markets overseas, such as that taken by BMT and QinetiQ.

   These shifts are because both intermediaries and their clients discover new needs and requirements for their intermediary roles; for example, moving from undertaking information scanning and technology intelligence to more fundamentally determining where to look in the first place (foresight and diagnostics role). This may be combined with the fact that such intermediaries are also diversifying away from reliance on their traditional core sectors, which are often in decline (such as CERAM in relation to the pottery industry), and deploying their competences in other sectors or applications. Thus, CERAM is using its modelling and manufacturing skills gained in ceramics manufacture to provide technical advice (through the Manufacturing Advisory Service – West Midlands) to small and medium enterprise in the West Midlands region across a range of different manufacturing industries. This diversification strategy is also extending in rela-

[5] How far this is an intermediary rather than a more general collaborative arrangement within a network is difficult to determine (Section 3).

tion to geographical space. Intermediaries are also seeking overseas clients especially in their core technologies. Again the domestic decline and shift of their core technology/sector may provide an additional push factor. A long held example of this is the British Maritime Technology (BMT) which moved rapidly to service Japanese and Korean markets as their shipbuilding industries grew whilst the indigenous, UK industry declined.

(2) Secondly, the de facto assumption in much of the discussion and analysis of intermediaries is that they operate in a simple triadic 'one-to-one-to-one' basis between, for example, a supplier and its customer in some kind of vertical relationship. However, in distributed innovation systems, intermediaries are increasingly involved in more complex relationships, such as 'many-to-one-to-one', 'one-to-one-to-many', 'many-to-one-to-many', or even 'many-to-many-to-many' collaborations, forming both vertical and horizontal relationships in increasingly distributed innovation networks. The context of the (multiple) relationships and linkage networks of intermediaries are becoming more important. The increasing number of relationships also changes other attributes such as power dependency between the intermediary and its clients. Thus, the more clients an intermediary has, the more power the intermediary is likely to have over any particular client (see Braun, 1993, p. 140).

There are a number of provisos here. The word 'many' should often be replaced with 'several'. Secondly, although intermediaries are often used to working in large supplier consortia (much of which goes back to the historic origins of some of the intermediaries as former Industrial Research Associations in the UK; see Johnson, 1973) they are less likely to be involved in multiple customer (of the innovation as a product or process) consortia and even less likely to be involved in multiple intermediary collaborations. However, even this may be changing with, for example, CERAM's materials modelling subsidiary CSMA entering in a joint venture with TWI, the world's leading knowledge organization for materials joining and bonding, to offer a unified set of services to clients in relation to materials characterisation and analysis.

(3) Closely related to the above assumption, is that it is usually assumed that the supplier initiates and uses the intermediary to help supply customers with a new innovation (i.e., that the implied interaction is 'technology push' and often manufacturing to service led). However, increasingly customers are becoming more proactive here. CERAM, for example, was approached by IKEA, the large multinational Swedish retail company with extensive global operations, which was being supplied by low cost ceramics manufacturers in central and eastern Europe but found that its pottery had a very high fracture and breakage rate. IKEA had considerable and long-term experience with the furniture and wood industry, but very little experience of the pottery and ceramics industries. CERAM therefore put forward a proposal to the company to improve their suppliers performance in terms of reducing breakage and wastage rates through the use of computational modelling, process and tunnel kiln simulation.[6] Working with the ceramic factories across central and eastern Europe, CERAM is managing to accurately predict the thermal and mechanical performance of the pottery being produced and also reducing the quantity of experimental trials required before full scale production. Through this work, CERAM is managing to reduce very high wastage rates in the suppliers' factories, and is also providing an 'intelligent consumer' role for IKEA, in the future commissioning and purchasing of ceramics for its stores. In this case, therefore, the *custome*r, IKEA, directly approached the *intermediary*, CERAM, to solve a problem it had with its suppliers.

(4) Linked to the above, innovation intermediaries are, therefore, not only providing immediate, 'one-off' intermediary services to their clients, but are also seeking to offer longer term, 'relational' innovation capabilities to them as well. These collaborations can last for periods of years, not months. They also provide opportunities for the intermediaries to get to know their clients better as well as to gain more lucrative, value-added contracts. In this latter context, Oakland provides advice to a major, process-based manufacturing company on what external research links (especially in relation to university links) the company would find valuable for its long-term development. This is, however, not just a simple scoping, inventory type exercise of finding potentially useful research expertise in universities and other research centres. It also involves gaining a deeper understanding of what the client company actually needs, identifying what the client compa-

[6] In turn involving Finite Element Analysis (FEA), a form of computational modelling, Factorial Experimental Design (FED), and Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM).

nies' core competences are (i.e., what is important for its long-term success), and then mapping potentially useful research links with this profile. This centres on identifying where external research capabilities could fill the current and future research and technical gaps (or 'weak areas') that the client company could not provide or would do better not providing itself.

(5) There is also the issue of 'when is an innovation intermediary not an innovation intermediary'? Innovation intermediaries were often not only involved in providing mediated innovation services linking their clients with other organizations, but also supplying services direct to their clients on a one-to-one basis, which involved no other interaction with other organizations. Intermediaries therefore can, and do, provide other functions within an innovation system, such as contract research (function 3a) testing or training work (function 5), which have no third-party or brokerage function whatsoever. It is apparent that the most prevalent role of the intermediaries surveyed is in the knowledge generation and combination/recombination roles (function 3) which have undoubtedly grown out of their traditional contract research and technical activity working directly with clients on a one-to-one basis. The role of innovation intermediation may therefore be only one amongst a number of other roles an organization may undertake in terms of its strategic remit.

4.4. Limitations and future research

This study has three main limitations, which in turn has implications for future research. Firstly, despite seeking to widen the notion of what an innovation intermediary is and does, the study focused on *organizations* (primarily private, non-profit or charity organizations) and therefore remains somewhat narrow in its analysis of this role. Individuals, professional bodies, research councils, advisory bodies and trade unions (see, for example, Mantel and Rosegger, 1987; Braun, 1993; Van der Meulen and Rip, 1998; Swan et al., 1999) could also be considered as providing intermediary roles, but these were not covered by the survey. Callon (1994, pp. 414–415) also notes that intermediaries are comprised of a wide range of heterogeneous entities. Along these lines, we need to develop better conceptual frameworks and methodological tools to adequately deal with the wide and complex mix of entities that are innovation intermediaries.

Secondly, although the case studies revealed the shift in the range and nature of intermediation activities provided by the organizations surveyed, the study does not provide a proper temporal perspective on the development of innovation intermediation within the UK system, only a 'snapshot' at a particular point in time. The study has implied that this type of intermediation process has had a highly dynamic pattern of growth and development, it may be that it has just become more visible in terms of the organizations providing such a function.

Thirdly, the study covered the UK and therefore reflects the potential peculiarities of UK system of innovation. Arguably, one area of relative success for the UK (and The Netherlands; Van der Meulen and Rip, 1998) has been the structural diversity of the types and variety of its organizations and institutional frameworks, and the growth of organizations that may be described as innovation intermediaries is just one such example. By comparison, although French innovation system has undergone much change in recent years (Mustar and Larédo, 2002), there remain significant gaps between the public and private spheres of research and innovation (Lallement and Paillard, 2004), which could be potentially bridged by innovation intermediaries. Indeed, this may now be occurring at a local level with intermediary institutions of transfer emerging with the support of local and regional authorities (Branciard, 2000). The growth and range of bridging functions provided by UK innovation intermediaries reflect the demands and needs of organizations in the UK and the structural weaknesses and defects of the UK system (for example, low rates of intra-mural R&D). Other forms of intermediation may emerge and grow more strongly in other national innovation systems.

Further research into the range of intermediaries, the type of functions or roles they offer and how these have evolved over time, clearly still needs to be done, together with coverage of this phenomenon in other national and local systems. In addition, much more research needs to be undertaken into the nature of the *relationships* that intermediaries exist in, over and above this more detailed outline of their functions and activities. As noted in the above section, most of the discussion about intermediaries has been in the context of their *function* and not their network relationships. Simple triadic structures are mainly implied, whilst where more complex multi-actor relationships in terms of intermediation are, en passant, acknowledged they are then largely ignored.

5. Conclusions

This paper has reviewed and synthesised the disparate literature in the field of innovation intermediation and has attempted to develop a typology and framework of

the different roles or functions of intermediaries within the innovation process, and has attempted to apply this within the context of the UK. The study has revealed that intermediaries provide a much wider, more varied and holistic role for their clients in the innovation process than has generally been acknowledged. Associated with this, there is also a much wider range of innovation intermediation functions than has been usually considered. There is some evidence, given the caveat noted above, to suggest innovation intermediation has grown over time. Certainly, although organizations providing such intermediation functions tend to remain specialised around particular activities, the range of services being offered does appear to be increasing over time. In addition, the organizations providing intermediation functions do not solely or even wholly restrict themselves to intermediary functions, but also cover more traditional contract research and technical services which involve no third-party type collaboration (see AIRTO, 2000). Care is therefore needed in classifying and describing an organization solely as an 'innovation intermediary'.

The study has also suggested the systemic value that innovation intermediaries may play in policy terms in an innovation system. This is not only in terms of improving connectedness within a system, particularly through bridging ties, but also in its 'animateur' role of creating new possibilities and dynamism within a system. Assessing the impact of innovation intermediaries is also going to be difficult, given their indirect (and intermediate) effect on a business's value chain, but the growth in the number and range of these actors within the system belies the benefits they create to their clients and to the innovation system overall. However, even here we need to take care. In the Dutch case, the very richness and success of the intermediary level within the overall science system is seen as potentially creating institutional inertia, which may result in problems for the strength and vitality of the system in the longer term (Van der Meulen and Rip, 1998, p. 768).

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Table A
Participating companies and organizations

Companies and organizations
Name
1. AIRTO (including E-Synergy)
2. AMTRI (including AMTRI Veritas)*
3. BRE*
4. BSI Group
5. Campden and Chorleywood Food Research Association (CCFRA)*
6. CERAM Research (including CSMA)*
7. DsX
8. Generics (including Generics Asset Management and Scientific Generics)
9. LCG Bioscience
10. LGC*
11. MERL*
12. NCC*
13. Oakland
14. PA Group
15. PERA*
16. Premier Research
17. Roke Manor Research
18. Scipher (including QED and QED IP Services)
19. TTP
20. TTP Communications (including 7Layers UK)
21. UbiNetics
22. UMIP

Appendix A

Table A lists those firms and organizations who participated in the survey over a thirty-six month period. The first organization listed in row 1 is Association of Independent Research and Technology Organizations (AIRTO). AIRTO provided access and feedback to all its member organizations which in 2005 had 38 members (see http://www.airto.co.uk), but in addition a number of its member organizations formed more detailed case studies and these members are starred to denote their membership. A pivotal role was played by CERAM in this respect. Additional information and material from, for example, from BMT, QinetiQ and SIRA who are members of AIRTO, were used as illustrations in the study (see Table 3) even though they did not form the main case study organizations. Six of the organizations listed below have their origins as former Industrial Research Associations (Johnson, 1973) and several continue many of these functions, such as having membership schemes and research club activities. The Campden and Chorleywood Food Research Association most clearly retains these functions, as its name denotes. The origins of CERAM go back to 1920 with the establishment of the British Refractories Research Association, which merged in 1948 with the British Pot-

tery Research Association founded in 1937, to form the British Ceramic Research Association, the precursor to CERAM.

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