Variety in the innovation process of UK research and development service firms

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Research and development service firms (RDSFs) are a particular type of technology-based knowledge-intensive business services (KIBS). RDSFs provide clients with R&D services on a contract basis, and operate as knowledge intermediaries linking research and market. They are innovative in their own right, as well as supporting innovation efforts by their clients; they rely on their own innovation efforts to be competitive and to develop new value propositions for their clients. The present paper explores the innovation process in RDSFs, drawing on semi-structured interviews with founders and senior managers of 32 companies in the United Kingdom. Our findings suggest that RDSFs vary considerably in terms of their primary innovation drivers (i.e. whether they are mainly driven by market demands or by technological opportunities) and the outcomes they pursue (i.e. whether their outputs are mainly services to clients or a mixture of services and products and/or intellectual property). Four major orientations of RDSFs were identified: (i) technology-based innovation exploiters; (ii) science-focused innovation explorers; (iii) client-driven innovation integrators; and (iv) open innovation translators. This variety among firms normally belonging to the same, small subsector of KIBS, suggests the need for caution in generalising about behaviour in terms of such statistical groupings.

1. Introduction

Firms are increasingly developing more outward-looking innovation strategies through ‘opening’ up and acquiring R&D from external sources (Mina et al., 2014; Bianchi et al., 2015). R&D outsourcing is often interpreted in terms of open innovation, as an ‘outside-in process’ (Chesbrough, 2006; Howells, 2008; Howells et al., 2008; Enkel et al., 2009; Gassmann et al., 2010). The flow of knowledge from external sources complements firms’ in-house R&D (Howells, 1999), enriching the primary internal knowledge base (Enkel et al., 2009), and fostering more successful innovation (Bianchi et al., 2015). Most of this literature focuses on the demand side of R&D outsourcing; fewer studies examine the supply side (Consoli and Elche, 2014).

R&D services may be provided by many types of organisations, including universities and public research organisations, alongside private R&D service firms (RDSFs) (Koschatzky, 2004). RDSFs are often the favoured suppliers of R&D services to business...
(Tether and Massini, 2007), since they are capable of applying knowledge and skills to promptly address industry needs. RDSFs have come to be the major R&D performers: in the United Kingdom in 2017, RDSFs’ expenditure on R&D accounted for £5.4 billion, representing 23% of total business expenditure on R&D (BERD) (ONS, 2017). Despite this substantial activity, RDSFs have received much less attention from researchers than universities and public research organisations (Probert et al., 2013). This may be in part due to the other organisations being mainly funded through governmental financing, and thus being subject to more public scrutiny – though RDSFs may provide R&D services to government and benefit from public R&D programmes.

RDSFs provide contract R&D services to both manufacturing and non-manufacturing industries (Koschatzky, 2004; Jankowski et al., 2005). RDSFs have typically been classified as a subsector of technology-related knowledge-intensive business services (T-KIBS, as opposed to P-KIBS, professional services) (den Hertog, 2000; Muller and Zenker, 2001; Muller and Doloreux, 2009; Schnabl and Zenker, 2013; de Matos Ferreira, 2017; Miles et al., 2018). While T-KIBS have been repeatedly noted to be particularly innovative in studies using innovation surveys (Freed, 2006; Corrocher et al., 2009; Toivonen and Tuominen, 2009), there has been little attention paid specifically to RDSFs. KIBS in general have been identified as ‘facilitators, carriers and sources of innovation’ (Miles et al., 1995), ‘innovation bridges’ (Windrum and Tomlinson, 1999), ‘secondary knowledge base’ (den Hertog, 2000), ‘innovation intermediaries’ (Howells, 2006), and ‘knowledge co-producers’ (Muller and Doloreux, 2009). But RDSFs may take a more proactive role in the innovation system. RDSFs may often be intermediaries, but they can also be the upper stream of the value chain of knowledge creation (Tether and Tajar, 2006). Howells (1999), for example, note that some RDSFs undertake in-house R&D to create new knowledge and/or new technologies. Probert et al. (2013) find that some RDSFs approach manufacturing firms to propose innovative solutions to their problems, or to apply their knowledge not only through contract R&D, but also by means of collaborative R&D, IP licensing, and consulting activities.

Despite their important roles, RDSFs have only recently attracted much study; scholars have begun to examine their nature and scope (Gallaher and Petrusa, 2006), their business models (Probert et al., 2013), their skill profiles (Consoli and Elche, 2014), and innovation activities (Li et al., 2018).¹ There has so far been limited theoretical and empirical work on how innovation actually takes place in RDSFs. This leads to a question of this paper: how do R&D service firms innovate for themselves? In other words, we focus on the R&D and other innovation-oriented activity that RDSFs are carrying out for their own purposes – not the activities that they are contracted to undertake by clients.

In this paper, we suggest the following working definition of RDSFs: ‘private firms whose main economic activity is carrying out R&D’. This is in line with the KIBS literature’s focus on private firms supplying specialised services to support business processes. Also, this differentiates them from other R&D service providers – such as public research organisations and universities, and from private companies who supply R&D services only as a secondary activity.

To address our research question, we adopted a qualitative research design and applied multiple case study strategy to explore innovation in RDSFs (Yin, 2009). The findings are expected to contribute to a better understanding of innovation processes in this specific sector of KIBS; if RDSFs are not a homogeneous set of firms, the findings help us delineate the different types of activity undertaken here.

This paper is structured as follows. After a review of relevant literature in Section 2, Section 3 describes the methodology used in this study. Section 4 presents results and outlines the major four orientations of RDSFs seen in our study. These findings are discussed in Section 5, and Section 6 points out limitations and future research directions.

2. Theoretical background

2.1. Innovation in services and in KIBS

Literature about innovation in services was slow to emerge, but over the past two decades has evolved from a trickle into a flood (Miles, 2016). While Pavitt’s pioneering taxonomy (Pavitt, 1984) saw private services as being ‘supplier-dominated’, with innovation driven by technologies developed by manufacturing firms, Miozzo and Soete (2001) noted that service industries have their own characteristics in terms of patterns of innovation. In their account, RDSFs fall into the category of ‘science-based and specialised suppliers’, which can undertake internal R&D and produce highly customised solutions for customers.

Gallouj and Weinstein (1997) noted that the study of innovation in services was underdeveloped and what existed mainly considered technological innovation, translating concepts and findings from

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managing to the service sectors. As research into the topic has developed (Miles, 2016), it is clear that service industries’ methods and types of innovation often differ from those of their manufacturing counterparts. Clients’ co-production of services, and innovations, is often the most distinguishing characteristic of services. Customers for KIBS form an ‘integral part of the innovation and production process’ (Asikainen, 2015, p. 81). The interactive relationship between service providers and clients leads to new knowledge and thus innovations; these often arise through ad hoc arrangements based on clients’ requirements, rather than service providers’ independent and directed R&D activities (Gallouj and Weinstein, 1997; Toivonen and Tuominen, 2009). In other words, innovation in many services relies more on ‘soft’ sources of knowledge, such as cooperation with clients, rather than ‘hard’ sources such as R&D (Tether, 2005). The intangibility of service outputs is generally seen as a factor in the relatively low use of patenting as a way of protecting intellectual property (IP) – again, Asikainen (2015) makes this point in the case of KIBS.

However, service firms are extremely varied. Some operate more like manufacturers – even high-tech manufacturers – than others (Tether, 2005). Sector-specific innovation patterns have been examined, for example, in financial services (Desai and Low, 1987), consulting (Gadrey and Gallouj, 1998), and tourism (Sundbo et al., 2007). The heterogeneous nature of services has led to analyses of different service types; KIBS, and their specific forms and modes of innovation, have attracted much attention. Even early studies of KIBS (for example, Miles et al., 1995; Miles, 2005) highlighted that P-KIBS are more likely to adopt new technologies produced by external suppliers, while T-KIBS are, unsurprisingly, relatively more involved in technological innovation. Free (2006) found that P-KIBS rely on cooperation with customers for innovation, whilst T-KIBS may use R&D activities and highly skilled technicians to undertake innovation. Larger T-KIBS are more likely to invest in structured internal R&D activities (Miles, 2007; Abreu et al., 2010). Some scholars have identified a variety of modes of innovation in KIBS (Corrocher et al., 2009; Toivonen and Tuominen, 2009), extending beyond the traditional distinctions between P-KIBS and T-KIBS (often, several different innovation modes coexist within the same sector). For example, KIBS may innovate in different ways according to the degree and formality of collaborations (Toivonen and Tuominen, 2009), and various firm- and market-specific characteristics (Corrocher et al., 2009). To sum up, there is no standard pattern of innovation within and across KIBS (Camacho and Rodriguez, 2008; Miles et al., 2018).

2.2. Innovation in R&D Service Firms

Although research on innovation in services – especially in KIBS – is well-established, the study of innovation in RDSFs is underrepresented in the service innovation literature. T-KIBS, including RDSFs, are often treated as a homogeneous group, whose innovation processes are contrasted with those of P-KIBS. Despite sharing features with other KIBS, such as high knowledge intensity and intensive interaction with clients (Miles et al., 1995; den Hertog, 2000), the literature has identified some general features of RDSF innovation as follows:

• RDSFs’ innovation is often associated with a high level of internal R&D activities organised for their own purposes (rather than for immediate client requirements), which are often organised by an R&D department (Asheim and Gertler, 2005). These activities are a major source of new technology (Evangelista and Savona, 2003). In terms of R&D effort and technology intensity, RDSFs perform similarly to high-technology manufacturing (Howells, 2000).

• The innovation process of RDSFs draws heavily on high profile professional and technical staff (Frel, 2006). Based on a large-scale survey, Free (2006) noticed that the T-KIBS report that their innovation activity relies more on highly qualified staff than on cooperation with clients – contrasting with assertions that KIBS’ innovation mainly derives from the interactive relationship with clients (Miles, 2001; Gallouj, 2002). If these findings apply to RDSFs, one may expect relatively greater contribution of high skilled employees, as compared to clients, in the innovation process.

• RDSFs’ ‘hard’ technological activities are mainly directed at generating and developing new technological knowledge (Evangelista and Savona, 2003). Some RDSFs generate or produce proprietary knowledge and technology, which allows licensing out of intellectual property rights (IPR) in return for royalties (Probert et al., 2013).

RDSFs develop new knowledge and technologies and/or exploit existing ones, so as to help clients develop new products/processes; they thus provide customised solutions to solve clients’ technical problems. But what is the innovation for themselves – the development of new services or improved ways of producing existing services? There is a lack of systematic understanding about what drives RDSFs to innovate, how new ideas are generated and
developed, and what outcomes result from RDSFs’ own innovation processes.

3. Methodology

This study adopted a qualitative research design and applied a multiple case study strategy (Yin, 2009) in order to gain inductively a detailed understanding of RDSFs’ in-house innovation processes. Qualitative approaches can be applied to investigate organisational contexts and activity sequences (Pettigrew, 1992). The multiple case study strategy was selected, based on our intention to answer, ‘how’, research questions in a field where there is relatively limited empirical evidence (Yin, 2009). This strategy enables us to capture the variety of perspectives in a real-world context, explore similarities and differences between cases, and replicate our findings across the sample, thereby enhancing the validity and generalizability of our research (Eisenhardt and Graebner, 2007; Yin, 2009).

The study was designed as an exploratory one, with the expectation that RDSFs would – like KIBS in other subsectors – display a range of different innovation patterns. We were not primarily concerned with testing hypotheses as to, say, the dominance of knowledge from internal specialists as opposed to that derived from collaboration with clients, but rather sought to establish whether there were important ways in which RDSFs differed in these patterns. The interviews were designed to allow us to examine this question, and determine what such variations might be.

3.1. Case selection

Our working definition of RDSFs as ‘private firms whose main economic activity is carrying out R&D’, means that these are firms classified belonging to NACE Rev. 2 Section M2 Division 72: Scientific Research and Development (NACE, 2008). These are differentiated, rather broadly, according to the type of knowledge and research involved: 72.1 – Research and experimental development on natural sciences and engineering (within which is 72.1.1 – Research and experimental development on biotechnology, and 72.1.9 – Other research and experimental development on natural sciences and engineering) and 72.2 – Research and experimental development on social sciences and humanities. Since, we defined RDSFs in terms of ownership as well as primary economic activity, we considered only private firms whose main source of income is contract R&D.5

Our definition was applied to identify RDSFs in the United Kingdom, examining the FAME database for details on the companies of interest. The sectoral distribution forms a priori definition of the sample structure (Flick, 2009) that was used to select cases in this study. Our target population was selected according to the criteria (1) active private firms, who were (2) offering R&D services as their main activity. The contact details of key persons were collected from FAME. An effort was made then to identify firms whose areas of R&D activity spanned a wide range of knowledge domains, in order to capture the variety of activities that might be underway. The selection was not designed to be statistically representative of the population of RDSFs, since this exploratory research based on a non-random sample was likely to provide a wider appraisal of sectoral dynamics (Eisenhardt and Graebner, 2007).

350 requests for an interview were sent through email and LinkedIn to the identified individuals. All those responding positively were interviewed; by the end of the fieldwork, 32 interviews had been recorded. These featured RDSFs ranging across different fields of expertise, such as agriculture, biotechnologies, chemicals, pharmaceuticals, and social sciences. We keep the interviewees’ details confidential and company names anonymous – details are provided in annex (Table A1).

3.2. Data collection

The data collection, undertaken between November 2013 and August 2014, involved semi-structured interviews with CEOs or senior managers of 32 RDSFs. Interviews, lasting from 60 to 120 minutes, were conducted via telephone or face-to-face. Interviewees were asked about (1) the nature of the firm, such as size, number of employees, history, business scope, and model; and (2) in-house innovation activities, drivers, processes, and outcomes.5 Interview data were cross-checked and triangulated against information obtained from other sources, including firm reports, web pages, and news stories (Golafshani, 2003).

3.3. Data analysis

The data were analysed in three steps: description (i.e. exploring the situation in which the social behaviours happen), classification (i.e. categorising the data by codification), and connection (i.e. creating new meaning through reorganising data) (Dey, 1993).

Each of the 32 companies was described using the data collected from interviews and secondary
information. We coded each case independently (Roberts, 1990) to identify general patterns embedded in the narrative (Neuendorf, 2002). Given the exploratory nature of this study, the coding was developed inductively. The initial codes included: features of business, in-house innovation activities, drivers of innovation, ideation of innovation and its development, processes and outcomes of innovation activities, and the roles of clients. After comparing the initial coding scheme with literature on innovation in services and KIBS, the coding was refined and segmented into two broad themes: business and innovation. Thematic analysis was then employed. Each case was categorised according to the two key attributes – business theme (e.g. age, industry, employee, market, and business model) and innovation theme (e.g. driver, ideation, development, commercialisation, outcome, and relationship with clients). By compiling a matrix of the two themes, we identified patterns of innovation processes in RDSFs.

4. Results

The analysis first examined the common features of RDSF business and innovation.

• Regarding the business theme, our sample of RDSFs is mostly SMEs set up by scientists and/or industrial experts. They prefer to recruit technologists, experts and graduates with a background in science. Their businesses are based on novel technologies, which are either acquired externally or developed internally. Contract R&D is the major activity of all of these firms.

• Regarding the innovation theme, we found that RDSFs may be involved in both product innovation (usually new service development, but sometimes technology development) and process innovation. Many, but not all, firms undertake in-house R&D projects to develop wholly owned technologies, IP, or even (in some cases) products. All firms undertake process innovation, such as improving methods of analysing data, communicating with clients, and providing services. The sources of knowledge for innovation include in-house R&D, internal experts, leading clients, and ICT investment.

When focusing on in-house innovation efforts, the RDSFs were found to differ substantially according to their primary innovation drivers (technology or market) and innovation outcomes (services or services combined with IP/products). The combination of the two dimensions means that RDSFs can be classified into one of the four different types, as shown in Figure 1 below:

1. those whose innovation is driven by technological change, resulting in new/improved services – labelled as ‘technology-based innovation exploiters’;
2. those whose innovation is driven by technological change, generating new/improved services and IP/products – labelled as ‘science-focused innovation explorers’;
3. those whose innovation is driven by the market and the process results in new/improved services – labelled as ‘client-led innovation integrators’;
4. those whose innovation is driven by the market and results in new/improved services and IP/products – labelled as ‘open innovation translators’.

The following subsections provide details of the characteristics of these classes of RDSF, and a description of one typical firm operating within each.

4.1. Technology-based innovation exploiters

There are four SMEs in this category. In-house innovation is driven by technological change, and
the innovation outcome consists of new/improved services. They provide clients in the biotechnology and pharmaceutical sectors with specialised R&D services based on their own proprietary resources, know-how and technologies.

Firm 10 is an archetypal ‘exploiter’. Founded in 1999 to manufacture novel chemical compounds for pharmaceutical clients, the firm was acquired by a large pharmaceutical company in 2001 to undertake in-house drug discovery and development; but the founder did not want to manufacture drugs for only one company and in 2005 decided to spin out to be an independent R&D contractor again. By 2014, the firm had 32 employees, 20 of them were highly experienced chemists. The business is highly focused on clients’ drug discovery requirements.

The founder believes that to be successful in a fast-evolving industry, R&D service providers have to be willing and able to capture changes in the technological domains. He aims to create an ‘open culture’ to encourage chemists to generate new ideas by searching databases and literature, discussing technological questions, and learning from external knowledge and technologies. The ideas generated are evaluated by senior managers and refined through group discussions. Shortlisted ideas are then developed by individuals or small groups of employees, leading to new/improved methods and techniques to be applied in their daily business. The company does not develop new technologies internally, because of the high costs associated with in-house R&D. Their business is mainly based on exploiting existing technologies or novel technologies emerging in the marketplace. The CEO’s belief that ‘there might be processes that they can adopt to make things safer and quicker’ underpins the search strategy.

Regarding the innovation process, the RDSFs in this category share several features as follows:

• When asked about drivers of innovation, the senior managers of these firms emphasised technology as the most important factor. They observe the fast changes in technology and learn from these changes as key preconditions for successful innovation.

• Technological change drives the in-house innovation process. Technical and scientific experts are encouraged to identify technological opportunities, generate new ideas and possible solutions through searching databases and literature, and participating in group discussion and industrial conferences. Senior managers select the best ideas based on their feasibility; these are then integrated within the internal knowledge base and implemented rapidly in business practices. Constrained by their small size and limited resources, these firms do not invest in structured in-house R&D projects to develop new technologies. Rather, they prefer to exploit existing technologies or invest in new equipment as an efficient way of launching new services.

• The outcome of in-house innovation consists of new or improved services. Intellectual property and products are not being actively sought.

4.2. Science-focused innovation explorers

Eight firms are classified as ‘science-focused innovation explorers’. Their innovation processes are also driven by technological change, resulting in new or improved services bundled with IP and/or physical products. In contrast with the preceding group, all of these firms feature a strong in-house scientific and knowledge base. They have state-of-the-art R&D facilities and a high share of scientists in their employment. This allows them to provide a wide range of services.

Firm 2 is a typical ‘explorer’. The company was established in 2007 by two scientists from a large pharmaceutical company, who had failed to get their ideas implemented and decided to spin-off. The company grew fast through mergers and acquisitions, and by 2014 the company employed 250 staff, two-thirds of whom hold a PhD degree. Based on highly skilled experts, the firm offers contract-based early stage drug development services, in the areas of radiochemistry and drug metabolism, to pharmaceutical, biotechnology, chemical, and animal health clients around the world.

The firm follows a structured in-house R&D process for innovation. Scientists are encouraged to identify and explore new opportunities through projects and reading literature. The CEO believes that a bottom-up approach is the best way of generating new ideas. As pointed out by the CEO: ‘A lot of our own research is all about picking up an idea that our own scientists have... the best way to generate new ideas is that scientists come to us and say: “I have an idea and I want to test this and I want to try it”.’ The line manager will support the scientists in trying to test the ideas; senior managers and their team then discuss these and move the more promising ones to the next stage of development, with a budget allocated and people assigned to the project team. In-house R&D allows the firm to develop its own technology and IP. A successful example of this strategy concerns a four-year exploratory research project to develop a new radio-synthesis technology. The new technology forms the basis for their new
synthesis services, allowing the firm to offer new ranges of compounds.

Explorers share common features similar to those outlined for this case:

- Explorers’ innovation is driven by scientific problems; the services offered rely heavily on cutting-edge technologies, which sustain the novelty of services.
- Explorers recruit highly capable people with a scientific background, who are able to capture trends, identify problems, and generate new ideas. In most firms, a scientific board evaluates new ideas, using criteria such as potential for commercialisation, consistency with the firm’s objectives, and scope for improving current technologies. Selected ideas are developed through structured in-house R&D projects, either within a single department or across departments; in some instances, late development occurs with external partners. The boundaries of in-house R&D are however usually closed, in order to keep core technology secret and avoid conflicts over proprietary knowledge and technology.
- Explorers develop new/improved services and their own IP; all of them generate additional revenue through licensing their IP. Three firms in this group also develop products, which are manufactured by contract manufacturing organisations. This strategy allows these firms to expand their business scope and generate additional revenues.

4.3. Client-led innovation integrators

The six companies in this category provide R&D services to clients, four in the areas of social science, one in food and one in environmental issues. These firms rely more on professional knowledge and skills than on technology to provide research and analytical services. They respond to clients’ requests: integrators’ innovation process is geared towards the market, and aims at producing new/improved services.

Firm 19, an example of ‘Integrators’, was set up in 1990 by a regional water authority, with ownership transferred to the private sector in 2000. Correspondingly, the firm changed from being a publicly funded research organisation into an independent contract research company. The employee base now involves 119 experts providing research and consultancy services to clients in environment, water, and the gas industry.

In-house research activities are driven by clients. Though there is no defined process, it often starts with a client’s problem followed by exploratory activities. Researchers collect and analyse data and undertake experimentation looking for solutions. During this process, the firm may develop new ways of analysing experimentation, or new methods (such as new wastewater modelling). These new or improved services can be adapted and replicated in other contract projects. The CEO sees this as an efficient way of introducing new services and expanding their client base. The firm operates through an ‘open environment’ in order to improve communication with clients and partners and integrate external knowledge from universities, consultancies, and individual experts. The CEO stated that: ‘we develop skills and knowledge internally, but the quickest way is to go to externals’.

The six integrators report similar processes of innovation.

- All described themselves as ‘research and consultancy companies’ whose core business is ‘knowledge-driven’, rather than ‘technology-led’. Client liaison skills allow rapid response to their requests.
- Integrators’ innovation often starts with new ideas captured through their client interface during contracted projects. Researchers identify clients’ key problems, collect evidence, and analyse data to look for possible answers. This development process is based on individual or group exploratory activities rather than on structured internal R&D projects. When facing unfamiliar problems, these firms tend to seek external knowledge and capacity from partners and universities, integrating these into the innovation process.
- Integrators develop new/improved methods and solutions specific to customers’ needs. After testing and adapting, new services may be added to the firm’s portfolio.

4.4. Open innovation translators

The 14 RDSFs operate as ‘open innovation translators’. They translate market opportunities into new or improved services, IP, and products. All firms in this group have novel technologies and well-equipped R&D facilities, allowing them to provide specialised services to clients in biotechnology, pharmaceutical, food, chemistry, and telecommunication industry.

Firm 17, a typical open innovation translator, was established in 1985 after the merger of two RDSFs in the field of materials analysis, testing, and research and development. Based on proprietary materials technologies and in-house expertise, the firm provides customised solutions to clients in a range of sectors.
including construction, healthcare, and ceramics amongst others. By 2013, the business employed 200 staff, 40% of whom held a PhD degree.

According to its founder, the firm strives to understand established and emerging trends in the market and seeks to be at the forefront of leading technologies. Their innovation strategy is driven by solving key industrial challenges and forming partnerships to develop and commercialise ‘the technologies of the future’. Thus, the firm invests in internal R&D to develop new materials and related technologies to support clients’ product development. The process is well structured. Scientists and product managers propose new ideas by interacting with clients, industrial experts, and academics. Product managers discuss these emerging ideas with business managers, focusing on profitability and scalability. A scientific board usually makes the final decision whether to invest or not. If the project is allocated a budget, an R&D team is set up and begins operations.

This firm participates actively in industrial R&D collaborations, working, for example, with nine European consortium partners to co-develop anti-microbial polymers for medical use. The firm also collaborates with five leading UK universities to provide students with training opportunities in the field of therapies using antibacterial materials. Another ongoing partnership is with an Asian firm to co-develop technology for orthopaedic hip and knee implants.

The common features of open innovation translators are summarised below.

- Translators are more actively involved in the wider innovation system than the other three types. This openness allows them to capitalise on market trends, the regulatory framework, and new/emerging technologies.
- Operating in a highly dynamic context, scientists and senior managers are directly responsible for the generation of new ideas and business opportunities. Promising options are allocated for funding, usually through structured project-based development activities. Some translators also continue this process by approaching partners or venture capitalists in order to raise external funding and engage in co-operative innovation. They also tend to seek external sources of knowledge and new technologies, through involving consultancies, contractors, and universities.
- Translators innovate continuously, aiming to introduce new/improved methods, approaches, techniques, and services. All companies in this class develop own proprietary knowledge and technologies, and have in place an IP licensing strategy to generate additional revenue. Ten of the fourteen firms in this group develop their own products, which may be manufactured in their own facilities, or by contract manufacturing organisations.

The key features of four types are summarised in Table 1.

5. Discussion

RDSFs support the innovation processes of their clients and undertake innovation for their own purposes. Relying on high-skilled employees and often – though not always – on in-house R&D, RDSFs develop new products/processes, and/or improve existing ones. In-house innovation is the key to maintain the novelty of their services. RDSFs are highly knowledge and technology intensive, and novel technologies usually play a vital role in the process of producing and delivering services. In this they are not merely supplier-driven, because many RDSFs develop their own

Table 1. Summary of key features of four types of RDSFs

| Processes | Types | Type 1 exploiters | Type 2 explorers | Type 3 integrators | Type 4 translators |
|-----------|-------|------------------|------------------|--------------------|--------------------|
| Driver    |       | Technology       | Technology       | Market             | Market             |
| Ideation  |       | Tech-scientific  | Tech-scientific  | Clients/partners   | Clients/partners   |
|           |       | employees        | employees        | Employees          | Employees          |
| Development|       | Unstructured     | Structured R&D   | Unstructured       | Structured R&D     |
|           |       | individual research | projects       | individual research | projects           |
| Implementation | | Rapid application | Rapid application | Rapid application | Rapid application |
|           |       | Approach targeted | Approach targeted|                     | Approach targeted  |
|           |       | clients          | clients          |                     | clients           |
| Outcome   |       | Services         | Services         | Services           | Services           |
|           |       | Services; IP/products | Services; IP/products |                     | Services; IP/products |
technologies. They are important sources of knowledge and technologies for many of their partners.

Earlier studies have shown that KIBS are heterogeneous in their innovation characteristics. The present study suggests that, despite their belonging to one of the smallest groups of T-KIBS, RDSFs are not a homogeneous group in terms of innovation practice. RDSFs do have some common features: most, if not all of them, see their expert employees as the engine of innovation and source of knowledge, and thus they recruit highly specialised R&D personnel and tend to foster an open culture to stimulate employees’ entrepreneurial spirit and innovative thinking.

But RDSFs are rather heterogeneous, as shown by our fourfold typology. The main drivers of innovation vary – technological change for exploiters and explorers, clients’ demand for integrators, and translators. Explorers and translators often rely on in-house R&D projects in pursuit of IP and physical products, since they expect to generate additional revenue through licensing proprietary technologies and selling products. This role of in-house R&D is unusual for most service firms, but is similar to that described for other T-KIBS who develop physical or software products (Miozzo and Soete, 2001; Evangelista and Savona, 2003; Freel, 2006).

Less formalised innovation activities dominate in exploiters and integrators: our informants suggest that this is partly because exploiters lack sufficient funding for in-house R&D. Service firms tend to be rather smaller than those in manufacturing industry, which has sometimes been seen as a factor in the low R&D intensity of services overall (Miles, 2007). In these RDSFs, the main sources of internally generated innovation are the exploration and problem-solving activities undertaken by individuals and teams. Integrators view their core business as ‘research and consultancy’: development of new technologies in-house may be less important for their innovation than solutions developed in the course of learning by interacting with clients. For exploiters and integrators, expert employees and leading clients are the major source of knowledge for innovation, and the typical outcome consists of intangible and/or highly tailored solutions, methods, and techniques. In this respect their patterns of innovation resemble those outlined for many other KIBS, including the more professional services, as described by Gallouj and Weinstein (1997), Tether (2005), and Toivonen and Tuominen (2009).

RDSFs vary in terms of innovation due to features such as firm size and financial resources. But also, their precise spheres of operations vary, for example in terms of the characteristics of the specific knowledge domains. Structured in-house R&D activities could be found in firms providing for clients in biotech, chemical, pharmaceuticals, and telecommunication industries. Unstructured exploratory research activities, whilst happening in all firms, particularly characterise firms providing services to social science, environment and the food industry. We may speculate that this reflects the types of knowledge involved – for example, the need to take into account complex human, social, and ecological environments in the second of these groups. There may also be differences in the types of client and the competitive circumstances confronted by RDSFs in these fields.

Through in-house innovation activities, RDSFs not only support clients’ innovation, but also create and recombine knowledge and technologies, often producing IP for internal or external exploitation. Some RDSFs may even operate (or plan in future to operate) as manufacturers, developing their own technologies and material products, whether by investing their own resources or accessing external sources of funding. Constant innovation enables the successful firms to stay at, or near, the science and technology frontier, and play proactive roles in innovation systems both as innovators in their own right, and as agents of innovation for their clients.

6. Conclusion

The rise of RDSFs is far from being a new phenomenon. But these firms remain infrequently studied – not least in terms of their innovation practices. The findings demonstrated that RDSFs are not only intermediaries but are also innovators in their own right. They rely on in-house innovation processes to generate novel knowledge and/or develop own products, which in turn support them to carry out complex techno-scientific projects for and with their customers. This paper has also explored how the process of innovation takes place in RDSFs, which confirms the ideas of Probert et al. (2013) and Consoli and Elche (2014) that RDSFs do not form a homogenous group. Indeed, we have identified four quite distinctive types of RDSFs in terms of innovation practices.

6.1. Implications

It is generally accepted that RDSFs are important players in innovation systems, and the scale of this sector in the UK R&D environment confirms its significance. It is not clear, then, why these firms have attracted so little attention from innovation researchers. Hopefully the present study can help stimulate interest in this topic.
The variety of innovation processes among RDSFs revealed in this study should warn scholars and policymakers that RDSFs are diverse. They are certainly not performing fee-for-service business, adopting innovative products and processes from elsewhere. Rather, they innovate proactively. They develop new and improved services, products and processes. Funding, however, is a common barrier to innovation for many of these firms (though translators seem to be particularly successful in seeking and obtaining external funds). Exploiters and explorers might consider whether they can strengthen their links with the market through open innovation strategies. In terms of policy implications, governments might consider providing access to more external funding opportunities through procurement in order to strengthen their in-house innovation potential and generate spill-over effects.

 Appropriation of knowledge is also an important consideration, and the varied strategies of IP and knowledge protection among RDSFs warrant further attention. Explorers and translators focus on the ownership of IP, while exploiters and integrators need to protect proprietary knowledge from leaking by keeping their cards close to their chests. Access to the expertise provided by RDSFs can be an alternative to the costly acquisition of knowledge via hiring expert staff, but do businesses have access to these services? The availability of knowledge in the innovation system may be restricted if potential users of knowledge are constrained by financial limitations, geographical locations, or problematic access of inputs from key RDSFs. Policymakers might wish to pay attention to such issues, perhaps by encouraging collaboration between RDSFs on the one hand, and on the other hand SMEs and/or businesses in disadvantaged areas. The innovation typology developed in this study may be of assistance in identifying relevant partners on the RDSF side.

6.2. Limitations and future research

The research method used in this study was designed to understand the characteristics of innovation in RDSFs at a level of detail that could not be revealed through a large-scale survey. Indeed, insights provided could form the basis for larger-scale survey studies that would allow validation of the typology presented, and permit quantitative descriptions of the distribution of different types of firms over time and across different locations. This empirical enquiry was limited to R&D service firms in the United Kingdom. It will be worth investigating how the typology finds confirmation in other countries’ innovation ecologies (for example, where venture capital or government funding play more important roles). International comparative analysis should yield further understanding of the innovation activities in RDSFs and their wider roles in innovation systems. As suggested above, the wider implications of the emergence of what den Hertog (2000) termed a ‘second knowledge infrastructure’, alongside the familiar public knowledge infrastructure, require further appraisal. The role of RDSFs in countries where there are major public RTOs at work would be particularly interesting to examine – are they servicing parts of the economy which the public RTOs are failing to reach? Tackling problems which public RTOs neglect (perhaps one requiring shorter-term research)? Engaging more in search for IPR or products that they can commercialise? What is the relationship between public and private knowledge infrastructures – one of competition or cooperation?

The results of this paper also have implications for the ‘open innovation’ line of enquiry. The study suggests that the role of RDSFs demands more attention, and that this role may be very different across countries – and fields of knowledge – where RDSFs are more or less active. The question of whom to collaborate with, and for what, is the one where answers involving RDSFs are liable to be multifarious.

Finally, the study suggests that we should pay more attention to the factors driving RDSF evolution and strategies. How far is membership of one or other of the different categories of firm that we have demarcated a matter of historically contingent factors (such as market demands, availability of ready finance) and how far a matter of issues such as company origins (spin-off from larger business, University, etc.) and specificities of different types of knowledge (e.g. social, environmental, and biomedical expertise)? Understanding such determinants of RDSF trajectories may be helpful in examining future prospects for the sector, for its innovative activities, and for its contributions to innovation systems more widely.

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Notes

1. It is also worth noting that the Voorburg Group on Service Statistics addressed issues of measurement of RDSF outputs and prices in its 2010 conference. See papers and presentations at http://voorburggroup.org/Documents/2010%20Vienna/Papers/ (accessed 18 October 2018).

2. Section M: Professional, Scientific and Technical Activities; this section corresponds fairly well to the sort of business described as KIBS.

3. Firms are allocated to particular groups in standard industrial classifications according to their principal activity - the activity contributing the most to the unit’s total value added (NACE Rev.2, p. 22). The NACE Rev.2 Guide (p. 268) explains that the activities involved which include basic research, applied research, and experimental development (following the Frascati Manual definitions: OECD 2015, p. 29).

4. International comparisons of statistics on division 72 will need to take account of the fact that in some countries this will include a substantial body of public research organisations, which are far less prominent in the UK. The NACE framework does not take account of the ownership of organisations (public or private), but solely focuses on their main activities.
5. Interview questions were developed and refined based on the previous research on KIBS (Den Hertog, 2000; Miles, 2005; Freel, 2006; Gallaher and Petrusa, 2006; Doloreux and Shearmur, 2010) and RDSFs (Probert et al., 2013). These questions help us to better understand the features of RDSFs and their diverse in-house innovation process.

6. Six RDSFs in our sample are large firms (employing 250 people or more).

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### ANNEX

Table A1. Summary of key features of RDSFs

| Firm | Founded | Employee | Location | Industries | NACE | Number of interview | Interviewee | Type of firm |
|------|---------|----------|----------|------------|------|--------------------|-------------|--------------|
| F1   | 1999    | 81       | Cambridge| Pharmaceutical | 72.11 | 1                    | Managing director | 4            |
| F2   | 2007    | 250      | Cardiff  | Biotechnology, pharmaceutical, and chemical | 72.11 | 1                    | CEO         | 2            |
| F3   | 2001    | 69       | London   | Biotechnology and pharmaceutical | 72.11 | 1                    | CEO         | 2            |
| F4   | 2000    | 135      | London   | Biotechnology and pharmaceutical | 72.11 | 1                    | Business director | 2            |
| F5   | 2008    | 49       | Edinburgh| Life science and agriculture | 72.11 | 1                    | Innovation director | 1            |
| F6   | 2003    | 30       | Bristol  | Biotechnology and pharmaceutical | 72.11 | 1                    | Head of innovation | 4            |
| F7   | 1997    | 180      | Cambridge| Biotechnology and pharmaceutical | 72.11 | 1                    | Innovation VP | 2            |
| F8   | 1989    | 86       | Cambridge| Biotechnology | 72.11 | 1                    | Business director | 1            |
| F9   | 1990    | 35       | London   | Biotechnology and pharmaceutical | 72.11 | 1                    | Head of innovation | 1            |
| F10  | 1999    | 32       | Horsham  | Biotechnology and pharmaceutical | 72.11 | 1                    | CEO         | 1            |
| F11  | 2004    | 231      | Reading  | Pharmaceutical | 72.19 | 1                    | Vice president | 4            |
| F12  | 1999    | 1,290    | Cambridge| Biotechnology and pharmaceutical | 72.19 | 1                    | General manager | 4            |
| F13  | 1988    | 398      | Gloucestershire | Food and drink | 72.19 | 1                    | Business director | 3            |
| F14  | 1985    | 126      | Oldham   | Gaming and retail | 72.19 | 1                    | CEO         | 4            |
| F15  | 2006    | 11       | Hampshire| Chemical and healthcare | 72.19 | 1                    | CEO         | 4            |
| F16  | 1988    | 120      | Cambridge| Chemical and pharmaceutical | 72.19 | 1                    | Head of science | 2            |
| F17  | 1985    | 200      | Staffordshire | Construction and aerospace | 72.19 | 1                    | CEO         | 4            |
| F18  | 2001    | 44       | London   | ICTs | 72.19 | 1                    | Business director | 4            |
| F19  | 1990    | 111      | London   | Water, gas, and environment | 72.19 | 1                    | Innovation director | 3            |
| F20  | 2004    | 120      | Kent     | Fruit, chemical and forest | 72.19 | 1                    | Managing director | 4            |
| F21  | 1990    | 581      | Dublin   | Pharmaceutical | 72.19 | 1                    | Innovation manager | 4           |
| F22  | 2003    | 45       | Cambridge| Life science and biotechnology | 72.19 | 1                    | President | 4            |
| F23  | 2002    | 33       | Durham   | Chemical and pharmaceutical | 72.19 | 1                    | CEO         | 4            |
| F24  | 1956    | 350      | Hampshire| Telecommunications | 72.19 | 1                    | Business director | 4            |
| F25  | 2000    | 70       | Manchester| Biotechnology and pharmaceutical | 72.19 | 1                    | Chairman | 2            |
| F26  | 1989    | 120      | Essex    | Automotive and defence | 72.19 | 1                    | Vice president | 2            |
| F27  | 1995    | 292      | Blackthorn| Clinical and animal research | 72.20 | 1                    | General managing | 4            |
| F28  | 2000    | 97       | Cambridge| Social research and policy making | 72.20 | 1                    | President | 3            |
| F29  | 1995    | 60       | Oxford   | Regional development | 72.20 | 1                    | CEO         | 3            |
| F30  | 1978    | 45       | London   | Economic analysis | 72.20 | 1                    | Director of research | 3            |
| Firm | Founded | Employee | Location   | Industries                          | NACE | Number of interview | Interviewee           | Type of firm |
|------|---------|----------|------------|-------------------------------------|------|---------------------|-----------------------|--------------|
| F31  | 2001    | 40       | Warwick    | Outcome measurement                 | 72.20| 1                    | Managing director     | 2            |
| F32  | 1982    | 27       | Harrow     | Social research and therapeutics research | 72.20| 1                    | General manager       | 3            |

Source: Interview, FAME Database.