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Open innovation in services: knowledge sources, intellectual property rights and internationalization

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The paper investigates the direction of knowledge flows and, more generally, the pattern of open innovation that is taking place within services across Europe. Using the Eurostat Fourth Community Innovation Survey (CIS4) dataset, on 17 service sectors across 18 countries, we find significant differences between service innovation leaders and followers. Key findings are that a concentration of radical innovation is to be found mainly in knowledge-intensive research and development sectors; that leading innovators across all sectors tend to use intellectual property rights to protect their ideas; and that leading service innovators engage in international sales. We do not find evidence that external sources of information acquisition are significant in radical service product innovation. By contrast, innovation followers rely more extensively on external sourcing of knowledge and new ideas (with decreasing returns to innovation performance), and tend not to export. These findings contribute significantly to our understanding of the knowledge flows and the asymmetries in knowledge sharing in service sectors across Europe.

Keywords: services; innovation performance; open innovation; R&D; intellectual property rights (IPR); internationalization

JEL Classification: O32; C24

1. Introduction

It is widely accepted among innovation scholars and policy-makers that knowledge is a key prerequisite for innovation, and in recent years various models of internal and external knowledge sharing have been proposed. According to the 'traditional' innovation model, internal research and development (R&D) is the primary source of knowledge generation (see, for example, Rothwell 1992) and, hence, the protection of internal ideas via intellectual property rights (IPR) enforcement is strategically important for firms. At the macro level, R&D is the primary driver of economic growth. This model has its origins in the work of Schumpeter (1912), who observed that radical innovations, i.e. the first commercial application of a novel scientific discovery or engineering breakthrough, are those which

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lead to large, qualitative changes in the social and economic world. In order to successfully develop and commercialize a radically innovative product, Schumpeter (1912) reasoned, a firm must have well-developed internal R&D competences which give it an advantage over rivals. R&D and IPR of internally generated ideas have received much attention in empirical research and in policy discourse.

It is increasingly argued that this traditional model of innovation is being replaced by an alternative 'open innovation' model in which external sources of information and knowledge sharing outside the organization are seen as the key resources for the development and execution of innovation, in services and in manufacturing (Chesbrough 2003, 2006, 2011). This new model of knowledge sharing seems to be the 'antithesis of the traditional vertical integration model where internal R&D activities lead to internally developed radically new products that are then distributed by firms' (Chesbrough 2006, 1). Indeed, empirical evidence appears to support the view that open innovation is a means to increase innovative performance (Laursen and Salter 2006; Lilien et al. 2002; Pullen et al. 2012), and that a great range of external sources are considered as part of the innovation process by firms; notably inputs from clients and customers (von Hippel 1988; Tuomi 2002), and from higher up the supply chain and beyond (Miozzo and Soete 2001).

Despite the fact that around 70% of most developed economies are now service based, there is little prior empirical research on the extent of use of openness across service sectors, or whether differences exist in the degree of use of sources and the degree of novelty of their offerings. Those large-scale empirical studies that exist have focused mainly on manufacturing. Current knowledge is therefore restricted to case studies in specific services, such as the software industry, consultancies and other knowledge-intensive business services (KIBS) (see Huizingh 2011 for a recent survey).

At first sight, it may appear that service sectors are likely to engage with external sources for innovation. Service firms tend not to have formal R&D departments. Furthermore, recent research highlights the potential inputs of other private-sector firms in service innovation (Rubalcaba et al. 2012), and also public- and third-sector actors (Gallouj, Rubalcaba, and Windrum 2013; Windrum and García-Goñi 2008). The first key issue addressed in the paper is whether the open model, besides promoting inter-firm diffusion of information in services, also promotes the generation of radically new ideas and service offerings. This addresses the current research gap, providing a better understanding of the strategic use of external knowledge sourcing across services.

A second issue which, in our view, requires deeper understanding is the role of IPR in open innovation in services. Due to the nature of open innovation, one would expect knowledge sharing to increase not only the inflow of external knowledge but also the outflow of internal knowledge, reducing the protection barriers and the ring-fencing of ideas via the use of IPR. Yet, alongside the growth of the open innovation model, there has been a growth in the market for technology. Arora, Fosfuri, and Gambardella (2001) suggest that internal ideas are increasingly protected, rather than shared across the economy. In our paper, we address this puzzle, and explore reasons for a symmetry in knowledge flows by testing the significance of IPR in services as well as the existence of any substitution effects between the outsourcing of new ideas (inflow of ideas) and the extent of intellectual property protection (outflow of ideas).

The link between open innovation and learning-by-exporting is a third issue that, to our knowledge, has not been empirically addressed in prior research. The learning-by-exporting thesis states that exporting firms benefit from the technical and managerial expertise of foreign importing firms or else from the expertise of other foreign contacts, such as overseas suppliers, clients, universities and public R&D labs (Silva, Africano, and Afonso 2010;

Wagner 2012). This thesis has a natural link with the open innovation thesis. Access to non-domestic external knowledge can give an innovative advantage over rivals that access a smaller set of domestic-only contacts. This may be particularly important for services, given the highly customized nature of service offerings.

Comprehensive data that link sources of knowledge acquisition, IPR and innovation in services are particularly scarce. The paucity of large-scale studies on openness in services is in part due to the fact that services have been poorly represented in innovation surveys. The few existing large-scale international studies of studies on openness that do exist, such as Grimpe and Sofka (2009) and Sofka and Grimpe (2010), use the Third Community Innovation Survey (CIS3). While all manufacturing activities were surveyed in these papers, the coverage of services was very limited, and several key business services as well as sectors such as hotels and restaurant were not included.

In this paper, we take advantage of the opportunity to study innovation and openness in services provided by the Fourth Community Innovation Survey (CIS4). The Eurostat CIS4 database is a large-scale micro-aggregated firm level dataset covering the period 2002–2004. It was coordinated by Eurostat for 17 service sectors in 27 countries.

We test three hypotheses using these data. The first hypothesis explores the relationship between the intensity of external search depth (the inflow of ideas) and the innovation performance of services. The second hypothesis tests whether IPR protection and openness are not substitutes, i.e. if innovation performance is higher when opening up to the inflow of ideas while maintaining high IPR protection methods. Third, we test whether international sales of services are complementary with external search depth.

We estimate two sets of models for each hypothesis because we distinguish between the proportions of service innovations conducted by innovation leaders and followers. Innovation leaders are engaged in the development of novel service products that are 'new to the world' while innovation followers are engaged in the development of catch-up service products that are 'new for the firm but not new to the world'.

Using the generalized linear model (GLM) for fractional response variables, we find that in-house R&D intensity, IPR protection and export orientation are key explanatory factors which affect the rate of launch of novel service products that are 'new to the world'. External knowledge sourcing is not found to be a key explanatory factor. Rather, the findings indicate that external knowledge sources are an important explanatory variable in services with a high proportion of catch-up innovation, i.e. product innovations that are 'new to them but not new to the world'. Those services engage in external knowledge sourcing and do not ring-fence their internal ideas via IPR such as patents and copyrights.

Overall, our findings suggest that the traditional model of internal knowledge creation with IPR protection remains the most significant driver of radical innovation, or at least that this is the model largely adopted by services engaged in radical innovation. By contrast, the 'open' model of external knowledge sourcing and the sharing of internal knowledge is most effective in the diffusion of existing innovations across services and therefore across innovation followers. These findings have important implications for policy and provide a better understanding of the nature of knowledge flows, asymmetries in knowledge sharing in services, as well as in the role that they play in the generation and the diffusion of innovations.

The paper is organized as follows. Section 2 defines the main research hypothesis. Section 3 introduces the data, the variables specification and the methodology used to test the main hypotheses. Section 4 reports the statistical results. The overall findings and reflection are brought together in Section 5 of the paper.

2. Open innovation in services and research hypotheses

Innovation scholars have long highlighted the collective nature of the innovation process (Allen 1983). Firms must combine their internal research efforts with those of other organizations in innovation systems (Edquist 1997), and find the correct balance between the development of internal knowledge and the incorporation of valuable external knowledge to advance their technologies (Teece 1988). Innovative firms are critically reliant on their absorptive capacity to recognize, adopt and exploit external knowledge (Cohen and Levinthal 1990; Nelson and Winter 1982).

Chesbrough (2003, 2006, 2011) was one of the first scholars to argue that external sources of information and knowledge sharing outside the organization have become the key resources for the development and execution of innovation, in services and in manufacturing, and that this 'open innovation' model is displacing a traditional model of innovation in which internal R&D is the 'primary' source of knowledge generation for firms. As noted in the introduction, the traditional model has its origins in the work of Schumpeter (1912). In the traditional model, a firm must have well-developed internal R&D competences in order to successfully develop a radically new innovation that is commercially successful. Differential intramural R&D capabilities are thus an important factor explaining the performance of rival firms. As a consequence, effective IPR protection of this R&D is strategically important to firms' maintaining an innovation advantage. R&D and IPR of internally generated ideas have accordingly received much attention in empirical research and in policy discourse.

In the open innovation model, the balance between internal and external sources of knowledge acquisition is radically different. A great range of external sources are now considered to be part a firm's innovation process – notably inputs from clients and customers (von Hippel 1988; Tuomi 2002), and from higher up the supply chain and beyond (Fritsch and Lukas 2001; Miozzo and Soete 2001; Ozman 2009; Veugelers 1997). Firms can no longer solely rely on their own internal capacities to successfully develop and commercialize innovations, but must 'open up' and engage more substantially with external organizations, consequently scaling down their in-house R&D resources, while expanding the scope of their innovation activities (Gianiodis, Ellisy, and Secchi 2010; Laursen and Salter 2006). Other scholars argue that open innovation builds upon in-house R&D capabilities and the knowledge base as they are complementary rather than substitutes (Cassiman and Veugelers 2006; Hagedoorn and Wang 2012).

A number of factors have been put forward to explain the shift from the traditional model to the open innovation model (see the review by Dahlander and Gann 2010). One factor is an increase in the complexity of goods and services, which requires innovators to engage with, and draw upon, a wider range of external sources for relevant information and knowledge. It is argued that no single organization has sufficient human talent inside its boundaries to cover all the scientific and engineering disciplines which contribute to its product offerings (Markman, Siegel, and Wright 2008). Collins (2006) proposes that the key to successful innovation today lies as much in the ability to engage in open information sourcing and sharing as it does the ability to perform traditional applied science and engineering.

Empirically, the relationship between open innovation and innovation performance, in terms of the degree of novelty and the financial returns from the introduction of an innovation, has been researched in manufacturing with mostly positive results. Laursen and Salter (2006) in their milestone empirical work test the impact of open innovation on the degree of novelty of the final product in manufacturing. They find that radical innovation is associated with the intensive use of a few key external sources of collaborations, while the extensive margins of use of external sources increase by later adopters aiming to access and scan information from mature networks on innovations and new opportunities.

Empirical studies of service sectors have not always identified evidence of a positive relationship between open innovation and increasing innovation performance. Knudsen and Mortensen (2011), for example, found a negative effect of openness on new product development, while Czarnitzki and Thorwarth (2012) found no significant influence in service provision, i.e. design, conducted in collaboration with external partners for new product success. Arguably, these results reflect differences in the nature of services and manufacturing goods. Services are intangible, can easily be copied by rivals, have short time to market and can have a shorter life cycle than tangible goods (Battisti et al. 2013; Miles 2005; Windrum 2007).

This could well have important implications for the access and use of external knowledge and ideas for radical new service offerings, as well as for the rate of adoption of existing services. We therefore explore the following hypothesis:

Hypothesis 1a. External knowledge sourcing is a significant determinant of radical and incremental product innovation performance in services.

There is now a body of empirical evidence in manufacturing indicating limits to the benefits of external sources for innovation (Katila and Ahuja 2002; Laursen and Salter 2006; Leiponen and Helfat 2010). This evidence suggests that, initially, there may be a positive effect in using external sources but that firms can over-search or else become too heavily reliant on external sources of innovation (Dahlander and Gann 2010). Laursen and Salter (2006), for example, using CIS3 data for UK manufacturing, find an inverted U-shaped relationship between innovative performance and external search depth of UK manufacturing. We therefore explore the following hypothesis:

Hypothesis 1b. There are decreasing returns in external search depth to services product innovation performance.

Following the argument that an opening up of knowledge flows increases product innovation, one would expect to observe a decline in the use of IPR, as this impedes knowledge sharing across the economy. However, as noted by Hall (2010), it appears that open innovation has gone hand-in-hand with the parallel development and growth of a market for technology, which is characterized by firms becoming increasingly less vertically integrated (Arora, Fosfuri, and Gambardella 2001), particularly in sectors that are high in knowledge assets and poor in physical tangible assets. These firms need to retain ownership of some of their knowledge assets to secure revenue streams and some of the returns on their innovative activity. This implies that secrecy, rather than openness, is the foundation of technology collaborations, and that IPR are particularly important in knowledge-intensive services.

Some scholars have associated the ‘external-learning experience’ to the rate of patent applications (Fosfuri and Tribó 2008) and the rate of engagement in innovation cooperation arrangements (Franco, Marzucchi, and Montresor 2012). This would suggest that IPR and openness are complements rather than substitutes. In this context, market institutions are frequently cited as affecting open innovation. Strong appropriability regimes and high technology intensity have been associated with a higher degree of reliance on internal factors (Chesbrough and Crowther 2006). Zachariadis (2003), for example, using data from 10 US manufacturing industries from 1963 to 1988, found a positive relationship between R&D intensity, patenting, rate of technological change and the growth rate of output per worker.

Effective IPR protection and technology standards are needed to facilitate the increased use of inter-organizational network relationships and alliances in innovation (Kale, Singh, and Perlmutter 2000; Oxley and Sampson 2004), to share knowledge and the risk associated with innovation (Neyens, Faems, and Sels 2010; Perkmann and Walsh 2007; Rothaermel and Deeds 2006). Networks can include all types of partners: specialist start-ups and other businesses, universities and public research bodies, and third-sector organizations (Fritsch and Lukas 2001; Ozman 2009; Veugelers 1997). Therefore, it is perhaps the different use of IPR, via, for example, technology licensing or sharing aimed at setting industry standards (Gassmann and Enkel 2004; Guilhon, Attia, and Rizoulières 2004) rather than an increase in secrecy, that has led to an increased market for technology observed in recent years (Hall 2010). This would reinforce the view that open innovation is a business model that is designed to purposefully allow and facilitate knowledge and technology transfers across organizational boundaries, enabling organizations to appropriate value (Gianiodis, Ellisy, and Secchi 2010).

Despite their importance, the current understanding of the roles of IPR and openness in services is extremely limited. Services are often thought to make limited use of intramural R&D and IPR while making greater use of other (external) mechanisms to absorb and acquire external knowledge for innovation. However, this is not necessarily true. Research by Greenhalgh and Rogers (2006), using a large sample of UK firms, finds that service innovators also engage in patents and other forms of IPR, and that larger services firms are significantly more likely to actively use IPR in any given year than smaller services firms. Herein lies an important limitation to current understanding of the use of IPR in innovation. In order to address this, we formulate the second of our hypotheses for services innovation:

Hypothesis 2. In service sectors where there is a high level of external knowledge acquisition there is also a high level of IPR protection.

Globalization is another factor that is often cited as contributing to a shift towards open innovation. An increasingly international division of labour and knowledge has increased the number, and geographical diversity, of relevant knowledge sites, forcing firms to access external knowledge to support their value chain activities (Rothaermel and Hess 2007) and, thus, to create and manage connections with other organizations (Hess and Rothaermel 2011). In a globally competitive environment, the generation and transfer of knowledge are key to sustainable competitive advantage (Mudambi and Tallman 2010).

Trade in services has been the fastest growing component of international trade since the early 1990s. Average annual growth rates are around 10% and the total export volume of services in 2006 was $US2800 billion (WTO 2008). Importantly, the composition of services trade has changed towards high-skill intensive categories, such as business services in the private sector and, particularly in the US and the UK public/private higher-education services. Liberalization of service trade has become a key issue in trade negotiations. Opportunities to access foreign markets and upgrade technological capabilities, products and services have increased due to falling transport costs and trade barriers, and greater international intellectual property protection afforded by WTO accords (Narula and Dunning 2000).

Still, we know very little about the service firms who engage in trade – in contrast to manufacturing exporters. An important recent contribution is Breinlich and Criscuolo (2011). Using UK data drawn from national CIS3 and the Annual Respondents Database, they identify a set of stylized facts for UK service exporters. First, service exports and imports are highly concentrated among the few firms that trade with many countries and in many service types. Second, service exporters and importers are larger than non-traders in terms of employment, turnover and value added. They are also more productive, more capital intensive and pay higher wages. Third, there are substantial differences across active service traders in the total value of exports and imports, number of countries traded with, number of services traded, and mean exports and imports per country and type of service.

An issue that has not been empirically tested in prior empirical research on open innovation is the existence of a complementary link between exporting and new opportunities for external search. From the open innovation perspective, a key potential advantage enjoyed by service exporters over non-exporters, in addition to larger markets and revenues, is access to a wider set of (foreign) external sources – of overseas suppliers, clients, universities and public R&D labs – from whom to gain information and knowledge for product innovation. It is on this basis that Chesbrough (2011) posits a positive relationship between radical service innovators and international profile.

A link exists between this argument and the learning-by-exporting thesis, which states that exporting firms can benefit from the expertise of foreign importing firms and/or from the expertise of other foreign contacts, such as overseas suppliers, clients, universities and public R&D labs. The idea that exporting firms may benefit from foreign importers' technical and managerial expertise of importers and other foreign contacts was first discussed and empirically studied in the mid-1980s and early 1990s. Key early contributions include Rhee, Ross-Larsen, and Pursell (1984), Westphal, Rhee, and Pursell (1984), Grossman and Helpman (1991) and the World Bank (1993).

The learning-by-exporting thesis differs to the self-selection thesis. The self-selection thesis posits that exporting firms were already more efficient than their (non-future exporting) rivals, and that these efficiency differences may have existed for many years before the more efficient firms started to export (Aw and Hwang 1995; Bernard and Jensen 1999; Bernard et al. 2007). The higher productivity of exporting firms is often related to firm-level technological advantages, due to R&D investments and the introduction of product and process innovations (Crépon, Duguet, and Mairesse 1998; Huergo and Jormandreu 2004). Thus, the self-selection thesis is a pre-export explanation of productivity differentials whereas the learning-by-exporting thesis is a post-export explanation for differences in firm performance.

Empirical evidence on learning-by-exporting is mixed (Silva, Africano, and Afonso 2010; Wagner 2012). A key contributing factor highlighted by Silva, Africano, and Afonso (2010) is that learning-by-exporting should be measured directly using innovative performance. However, given a lack of suitable data on innovative activities, most studies have followed an indirect approach, using productivity measures. A key advantage of the fourth CIS dataset, which we use in this paper, is that it provides information on firm innovation performance, and the different external sources of information and knowledge that are used in the innovation process.

Both the learning-by-exporting and the self-selection thesis predict a positive relationship between exports and innovation performance. As noted, the direction of causality differs between the alternative explanations but this cannot be tested using a single cross-section dataset. However, a distinction can be made between these two theses using data on external search depth and international sales. The learning-by-exporting thesis predicts a positive correlation between innovation performance and an interaction between international sales and sales depth. This provides us with the following test hypothesis:

Hypothesis 3. International market sales are complementary to external search in innovation performance.

3. Data and methodology

The Eurostat CIS4 database is the micro-aggregated pan European version of the CIS4 carried out by national statistical offices across enterprises with 10 or more employees, in the 27 Member States of the EU, plus Iceland and Norway. The fourth round of the CIS was the first to collect reliable statistical data on service sectors.[1]

Eurostat CIS4 was released in 2005 and contains information on a broad range of innovative activities in various sectors of economic activities between 2002 and 2004. The data version we use is the transformation of the above micro-data into sector-level data performed by Eurostat to comply with disclosure conditions and to provide comparable and consistent set of data free of country or sector sample bias.[2]

From the total sample, we concentrate on 19 service sectors across 18 countries: Belgium (BE), Bulgaria (BG), Cyprus (CY), Czech Republic (CZ), Germany (DE), Estonia (EE), Spain (ES), France (FR), Greece (GR), Hungary (HU), Italy (IT), Lithuania (LT), the Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Romania (RO) and Slovakia (SK). Austria, Iceland, Ireland and Malta are excluded due to the very small number of observations in many sectors. Denmark, Finland, Latvia, Luxembourg, Slovenia, Sweden and the UK are excluded due to missing data on our key variables, or else because data were not made available to Eurostat by national statistical offices. A complete list of the 19 service sectors in our data set is provided in Table A1 in the appendix.

3.1. Dependent variable

The CIS4 questionnaire follows the Oslo Manual (second edition, 1997) in defining product innovation, and in distinguishing between leaders in product innovation and innovation followers. The former are concerned with the development of service products that are ‘new to the world’. The latter are concerned with the development of service products that are ‘new for the firm but not the world’. Of particular relevance to our study are the data which CIS4 also gathers on product innovation performance. The questionnaire asks respondents what percentage of total firm turnover in 2004 was generated by innovative service products, introduced during 2002–2004, that were ‘new to the world’. This provides the data for the dependent variable *INNWORLD*. A different dependent variable, *INNFIRM*, uses respondent information that records the percentage of total firm turnover in 2004 that is due to service products introduced during 2002–2004 that were ‘new to your enterprise but not new to the world’. The Eurostat CIS4 database provides information on the average percentage in each sector by country. These are our measures of innovation performance, reflecting the degree of novelty of the new service products.

3.2. Independent variables

To test Hypothesis 1a concerning the impact of openness in services, we develop a novel measure of external search to capture *DEPTH* which is appropriate for the micro-aggregated data. The information on external sources is collected through a question that asks firms to indicate the significance of the following six categories of external sources to the enterprise’s innovation activities during the three-year period 2002–2004:

- Suppliers of equipment, materials, services or software.
- Clients or customers.
- Competitors or others enterprises in the same industry.
- Consultants, commercial labs or private R&D institutes.

- Universities or other higher-education institutions.
- Government or public research institutes.

The question asks respondents to indicate the significance of each category on a four-point Likert scale of ‘high significance’, ‘medium significance’, ‘low significance’ or ‘not used’.

The issue of country-specific response bias arises with respect to the use and importance of external sources for product innovation. Unlike R&D, sales and employee data, the use of external sources is not routinely collected by firms. Hence, the scope for self-reporting bias is greater (Hall 2010; Mairesse and Mohnen 2010; Mohnen, Mairesse, and Dagenais 2006). To address this, and to control for sector differences and specificities in the use of the various external information sources, we transform the data into a binary indicator, indicating whether the proportion in each sector is above the average country response. For each of the six categories, a value of 1 is coded if the proportion is above the national average. A value of 0 is coded if the proportion is below or equal to the national average. Using these scores, *DEPTH* takes a value of 6 if all six categories are used intensively in the sector of that particular country, i.e. all six categories have individual scores of 1. The Cronbach alpha coefficient for this variable is 0.8, indicating a high degree of internal consistency for this variable.

To test Hypothesis 1b that there are *decreasing returns from the depth of use of external sources and service innovation performance*, we allow the impact of DEPTH to be non-linear. To do so we use two approaches. The first is to include both a linear and a quadratic specification of the average number of external sources that are used intensively by firms in each sector, i.e. *DEPTH* and *DEPTH*2*. This is a frequently used approach but it has the disadvantage of introducing multicollinearity into the estimated model and, hence, the possibility of biased estimated coefficients. We therefore resort to a second approach that uses a set of dichotomous variables based on quintiles of the underlying distribution of *DEPTH*. In our data, the first quintile *DEPTH_q1* codes sectors in which firms, on average, use between 0 and 1.0 external source intensively. This is the base case in our estimated models. The second quintile *DEPTH_q2* codes sectors where firms use 1.1–2.0 external sources intensively, *DEPTH_q3* sectors where firms use 2.1–3.0 external sources intensively, *DEPTH_q4* sectors where firms use 3.1–4.0 external sources intensively, and, finally, *DEPTH_q5* sectors where firms on average use 4.1–6.0 external sources intensively.

We use the intra-sector proportion of firms that use *PATENTS* and *COPYRIGHTS* as a proxy for intellectual property protection and for the size of the market for technology (Arora, Fosfuri, and Gambardella 2001; Hall 2010). We test Hypothesis 2 – that *IPR protection and openness are positively correlated* using the interaction terms *PATENTS*DEPTH* and *COPYRIGHTS*DEPTH*.

A positive correlation coefficient between innovation performance and these interaction terms indicates open accessing of an inflow of external knowledge while simultaneously ring-fencing internal ideas. It indicates that the uni-directional inflow of knowledge is more effective than non-disclosure of internal ideas alone or external knowledge sourcing alone, i.e. IPR and open innovation are complements. This should be interpreted as evidence that a lowering of protection barriers and secrecy around novel ideas combined with an open stance to the inflow of external knowledge does not enhance performance more than if only one source of knowledge – either internal or external – was used in isolation. In other words, IPR protection and open innovation are not substitutes.

Hypothesis 3 that international market exposure is complementary to external search depth is tested via an interaction term between *INTSELL* and *DEPTH*. The variable *INTSELL* is a continuous variable that is constructed using data on the proportion of firms, in each sector, whose main sales markets are international. We expect the sign of the interaction term *INTSELL*DEPTH* to be positive and significant with respect to innovation performance suggesting the presence of important complementarities from their joint practice.

3.3. Control variables

Sector levels of intramural R&D expenditure, as a share of total turnover, provide the data for the variable *R&D_INT*. We control for sector heterogeneity based on R&D intensity by creating a set of dichotomous variables, *R&D_q5*, *R&D_q4*, *R&D_q3*, *R&D_q2* and *R&D_q1*, in the following way. First, the average value of intramural R&D expenditure is calculated for each of the 17 sectors. Next, the sectors are ranked into quintiles of R&D intensity, with *R&D_q5* the highest ranking quintile corresponding to the most R&D-intensive sectors (e.g. R&D and computer services) and *R&D_q1* the lowest ranking quintile (e.g. retail and repair services). The complete list of quintiles is provided in Table A1 in the appendix.

It can be argued that some countries may appear to be more 'open' because they specialize in sectors where openness is used intensively or else reflect country-specific institutional factors. To control for country-specific variation, we construct a set of 18 country dummies to control for national effects that may affect the propensity to innovate in different countries.

Finally, we use *LOGEMP*, the number of employees (expressed in logarithms). For each sector in each country, we have information on the average number of employees per enterprise in that sector. This provides a control variable for the impact of firm size on innovative performance.

3.4. GLM estimators

The dependent variables *INNWORLD* and *INNFIRM* are censored from above and from below since proportion data take values that lie between zero and one. To address this issue, a set of Tobit censored regression models is often used. However, the Tobit model has a number of well-known limitations, such as the range of predicted values falling outside the range zero and one (Long 1997). Also, the Tobit model is not appropriate in the presence of non-normal or highly skewed residuals. Suggested treatments for this are performing a lognormal transformation of the model (for further details see Filippucci, Drudi, and Papalia 1996) or a logit transformation of the data and then use ordinary least squares or weighted least squares.

We follow a preferable approach, which is to specify a GLM for fractional response variables (Papke and Wooldridge 1996). For our proportion data with predicted values that fall between 0 and 1, we estimate models with a logit canonical link function and assume the dependent variable is generated from a binomial exponential family. We estimate robust standard errors for all the GLM models.

4. Results

4.1. Descriptive results

CIS4 provides key insights into different intra-organizational relationships that service firms establish, and the extent to which IPR, such as patents and copyrights, are used to protect the knowledge and information generated in these relationships.

As illustrated in Table 1, external sources closely located along the value chain are of greatest significance. The highest ranking category is clients/customers. On average,

Table 1. External sources of information and knowledge for innovation activities.

Source	Highly relevant source of information (%)
Suppliers of equipment, materials, services or software	25.84
Clients or customers	26.02
Competitors or other enterprises in your industry	15.44
Consultants, commercial labs or private R&D institutes	8.77
Universities or other higher-education institutions	5.12
Government or public research institutes	4.63
Average	14.30

across all service sectors and countries, 26% of respondents state that clients/customers are a highly relevant source of information. Organizations on the supply side of the value chain, i.e. suppliers of equipment, materials, services or software, are the second highest category with an average of 25.8% of respondents stating these are a highly relevant external source. Competitors are the third highest information source (15.4%), followed by the category 'consultants, commercial labs or private R&D institutes' (8.8%).

Table 2 reports descriptive statistics on the maximum and minimum values, mean and standard deviations of the dependent and independent variables (to 2 d.p.), and the partial correlations between the variables. On average, 7% of turnover is attributable to innovation for the sub-population of service firms who state they introduced innovative service products that were 'new to the world' (*INNWORLD*). Interestingly, an average of 7% of turnover is also recorded as attributable to innovation for firms who stated they introduced new products which were not new to the market but new for them (*INNFIRM*).

On average, across all services about 3% of the firms engage in internal R&D, between 6% and 8% use IPR (*COPYRIGHTS* and *PATENTS*) protection methods, and 24% are export oriented. On average, they use between two and three sources of external knowledge intensively (*DEPTH*). The average firm size is 43 employees.

The partial correlation between *INNFIRM* and the external search variable *DEPTH* is statistically significant ($p < .10$). By contrast, the partial correlations between *INNWORLD* and *DEPTH* are not significant ($p < .10$). Furthermore, there are obvious differences in the sizes of the estimated coefficients: the coefficient between *INNFIRM* and *DEPTH* is 0.176 while that between *INNWORLD* and *DEPTH* is 0.0006.

Another interesting finding concerns the partial correlations between the IPR methods (*COPYRIGHTS* and *PATENTS*) and *INNWORLD*, and between these IPR and *INNFIRM*. Interestingly, the correlations between both forms of IPR (*COPYRIGHTS* and *PATENTS*) and *DEPTH* are significant for *INNWORLD* but not for *INNFIRM*. This is likely to be affected by the fact that services engaged in radical innovation use some form of IPR protection, in contrast to followers engaged in catch-up innovation. As shown in Table 2, the partial correlation between *INNWORLD* and the two measures of IPR is positive and significant at the 5% level (see Column 1). By contrast, the partial correlations with *INNFIRM* (see Column 2) are not significant.

Unsurprisingly, we observe evidence of high and significant correlation between *RDINT* and *PATENTS*, and between *RDINT* and *COPYRIGHTS*. As noted, there exists a large body of existing empirical research indicating that sectors where IP protection is prevalent also tend to be those in which there are high levels of intramural R&D.

We find that *INTSELL* is negatively correlated to *DEPTH* ($r = -0.178$, $p = 0.033$) suggesting a substitution effect between domestic and international knowledge sourcing.

Table 2. Descriptive statistics and partial correlation coefficients on dependent and independent variables.

		N	Min.	Max.	Mean	Std. dev.	1	2	3	4	5	6	7	8
1.	*INNWORLD*	170	0.00	0.99	0.07	0.11	1							
2.	*INNFIRM*	173	0.00	0.40	0.07	0.08	0.189	1						
							(0.027)							
3.	*DEPTH*	175	0.00	6.00	2.54	1.40	0.006E–1	0.176	1					
							(0.713)	(0.036)						
4.	*PATENTS*	175	0.00	0.73	0.08	0.12	0.179	−0.090	−0.012	1				
							(0.034)	(0.294)	(0.886)					
5.	*COPYRIGHTS*	175	0.00	0.73	0.06	0.09	0.150	0.004	−0.051	0.652	1			
							(0.088)	(0.960)	(0.566)	(0.000)				
6.	*RDINT*	175	0.00	0.85	0.03	0.11	0.180	0.085	0.111	0.580	−0.303	1		
							(0.005)	(0.032)	(0.185)	(0.000)	(0.000)			
7.	*INTSELL*	175	0.00	1.00	0.24	0.21	0.461	0.102	−0.178	0.211	0.460	0.421	1	
							(0.000)	(0.227)	(0.033)	(0.010)	(0.000)	(0.000)		
8.	*LOGEMP*	175	0.93	7.12	3.77	1.33	0.041	0.203	0.001	0.071	0.048	0.282	0.064	1
							(0.002)	(0.016)	(0.991)	(0.395)	(0.563)	(0.000)	(0.453)	

This indicative evidence based on simple measures of association is directly relevant for our third test hypothesis. Interestingly, the partial correlations in Columns 1 and 2 suggest that international sales (*INTSELL*) is strongly correlated with *INNWORLD* ($r = 0.461, p = 0.000$) but not with *INNFIRM* ($r = 0.102$, $p = 0.227$). The estimated coefficient between *INNWORLD* and *INTSELL* is over four times larger than that between *INNFIRM* and *INTSELL*, and the coefficient for the former is statistically significant, while the latter is not.

4.2. Statistical results

The results of our estimated GLM causal models are presented in Tables 3 and 5 for *INNWORLD* and in Tables 4 and 6 for *INNFIRM*. There are four estimated models in each table. Models 1–4 test the significance of external knowledge sourcing (*DEPTH*) (Hypotheses 1a and 1b), while Models 5–8 test the significance of the interaction terms (Hypotheses 2 and 3) upon firm's innovation performance.

In particular in Tables 3 and 4, we test the significance of external knowledge sourcing (Hypothesis 1a) and whether there are decreasing returns from external search depth (Hypothesis 1b) upon service product innovation performance using three alternative specifications. The first model tests for the presence of *DEPTH* alone while the second model tests for the presence of an inverted-U relationship between innovation performance and depth using the linear variable *DEPTH* and the quadratic variable *DEPTH*2*. The third model tests for a non-linear relationship between innovation performance and depth using the set of quintile dummies *DEPTH_q5*, *DEPTH_q4*, *DEPTH_q3* and *DEPTH_q2* based on the underlying distribution of intensive external source use. The fourth model tests for the significance of IPR (*PATENTS* and *COPYRIGHTS*) when the R&D measure is omitted.

Our results show that the simple measure of external knowledge sourcing (*DEPTH*) is not statistically significant, either in the estimated *INNWORLD* or in the estimated *INNFIRM* models (Model 1 in Table 3 and Model 1 in Table 4, respectively). The non-linear specifications of *DEPTH* are significant in all the estimated *INNFIRM* models, i.e. where innovations are new to the firm but not new to the world (Models 2–4 in Table 4), but are not significant in any of the estimated *INNWORLD* models, i.e. where innovations are new to the world (Models 2–4 in Table 3).

For innovations that are new to the firm but not new to the world, we find a significant and negative quadratic term suggesting the existence of an inverse-U relationship (see Model 3 in Table 4) while we find that relative to the base quintile *DEPTH_q1*, *DEPTH_q2* has the largest estimated coefficient in INNFIRM followed (in order) by *DEPTH_q3*, *DEPTH_q4* and *DEPTH_q5* (see Model 4 in Table 4).

These results confirm Hypothesis 1a that external search depth is a significant driver for the performance of services engaged in innovation catch-up (*INNFIRM*). They also confirm Hypothesis 1b of decreasing returns from external search depth. These findings for services are in line with previous studies on manufacturing companies (see, for example, Laursen and Salter 2006). However, contrary to previous findings for manufacturing firms, this only applies for non-radical services innovations (*INNFIRM*) undertaken by innovation followers.

We find that the patents and copyrights play a significant role, especially when used jointly with open innovation (*DEPTH*), by radical service innovators (Tables 3 and 5). Unsurprisingly perhaps, we find no evidence of IPR being important for service innovation followers (Table 4). An exception is perhaps copyrights. We find that their use reduces the rate of incremental innovation (Table 6) signalling that perhaps their presence increases

Table 3. Estimated GLM models for innovation leaders (*INNWORLD*).

Model	*INNWORLD* Model 1		*INNWORLD* Model 2		*INNWORLD* Model 3		*INNWORLD* Model 4	
Independent variables	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE
DEPTH	−0.061	0.067	−0.051	0.059				
DEPTH 2*			−0.023	0.018				
DEPTH_q2					−0.413	0.588	−0.258	0.617
DEPTH_q3					−0.571	0.602	−0.699	0.530
DEPTH_q4					−0.257	0.195	−0.320	0.206
DEPTH_q5					−0.228	0.140	−0.226	0.154
INTSELL	3.312***	0.882	3.173***	0.818	3.221***	0.765	3.033***	0.910
COPYRIGHTS							−0.142	1.417
PATENTS							2.062**	0.809
R&D_q5	1.139**	0.484	1.508***	0.479	1.565***	0.483		
R&D_q4	1.083**	0.472	1.053**	0.476	1.300**	0.491		
R&D_q3	1.013**	0.482	1.044**	0.493	1.270**	0.542		
R&D_q2	0.810***	0.297	1.011***	0.336	1.156***	0.407		
LOGEMP	0.238*	0.125	0.282**	0.126	0.234*	0.124	0.265*	0.122
COUNTRY DUMMIES	YES		YES		YES		YES	
Joint significance	51.06		51.39		48.85		61.03	
	(0.000)		(0.000)		(0.000)		(0.000)	
Constant	−4.149***	0.603	−4.225***	0.679	−3.429***	0.752	−1.867	0.779
No. observations	170		170		170		170	
Log pseudo-likelihood	27.5		27.3		27.8		21.3	
Scaled deviance	8.5		8.3		7.9		6.2	
Pearson chi-square	9.2		9.5		8.9		6.6	
Akaike information criterion (AIC)	0.753		0.764		0.786		0.881	
Bayesian information criterion (BIC)	−679.7		−674.8		−664.9		−475.9	

Note: Base: *R&D_q1*; Models 3 and 4: *DEPTH_q1*.
*$p < .10$.
**$p < .05$.
***$p < .01$.

Table 4. Estimated GLM models for Innovation followers (*INNFIRM*).

Model	*INNFIRM* Model 1		*INNFIRM* Model 2		*INNFIRM* Model 3		*INNFIRM* Model 4	
Independent variables	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE
DEPTH	0.015	0.042	0.021	0.039				
*DEPTH**2			−0.021**	0.009				
DEPTH_q2					1.093**	0.530	1.292**	0.531
DEPTH_q3					0.507**	0.253	0.600**	0.259
DEPTH_q4					0.300*	0.168	0.321*	0.179
DEPTH_q5					0.106	0.106	0.123	0.113
INTSELL	0.884	0.752	0.790	0.796	0.876	0.637	0.836	0.553
COPYRIGHTS							−1.112	1.076
PATENTS							−1.042	0.981
R&D_q5	0.260	0.101	0.744**	0.322	0.793**	0.357		
R&D_q4	−0.048	0.328	−0.077	0.313	−0.113	0.356		
R&D_q3	−0.180	0.359	−0.173	0.344	−0.138	0. 377		
R&D_q2	−0.385	0.238	−0.222	0.258	−0.265	0.293		
LOGEMP	0.260***	0.101	0.291***	0.098	0.286*	0.098	0.231**	0.119
COUNTRY DUMMIES	YES		YES		YES		YES	
Joint significance	68.61		71.47		78.09		157.39	
	(0.000)		(0.000)		(0.000)		(0.000)	
Constant	−3.388***	0.361	−3.374***	0.376	−3.429***	0.752	−1.867	0.779
No. observations	173		173		173		173	
Log pseudo-likelihood	29.5		29.4		29.3		22.7	
Scaled deviance	5.8		5.6		5.3		3.7	
Pearson chi-square	6.0		5.8		5.5		3.9	
Akaike information criterion (AIC)	0.746		0.756		0.778		0.881	
Bayesian information criterion (BIC)	−705.4		−700.4		−690.3		−449.0	

Note: Base: *R&D_q1*; Models 3 and 4: *DEPTH_q1*.
*$p < .10$.
**$p < .05$.
***$p < .01$.

Table 5. Estimated GLM models with interactions for Innovation leaders (*INNWORLD*).

Model	*INNWORLD* Model 5		*INNWORLD* Model 6		*INNWORLD* Model 7		*INNWORLD* Model 8	
Independent variables	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE
*INTSELL*DEPTH*	−1.172***	0.354	−1.289***	0.376				
*COPYRIGHTS*DEPTH*					1.182*	0.594		
*PATENTS*DEPTH*							0.089	0.685
DEPTH	0.233**	0.092	0.258**	0.108	−0.099	0.087	−0.121	0.104
DEPTH_2	−0.007	0.015	−0.008	0.017	−0.025	0.021	−0.024	0.020
INTSELL	5.714***	1.225	5.521***	1.256	2.061**	0.953	3.067***	0.952
COPYRIGHTS			−2.758**	1.222	−2.260***	1.593	−1.045	1.522
PATENTS			3.134**	1.313	1.204	1.257	−4.019*	2.052
R&D_q5	0.530**	0.213						
R&D_q4	1.428***	0.506						
R&D_q3	0.721	4.518						
R&D_q2	11.744**	5.644						
LOGEMP	0.260**	0.118	0.270**	0.136	0.271*	0.147	0.271**	0.148
COUNTRY DUMMIES	YES		YES		YES		YES	
Joint significance	53.85		81.62		63.79		63.40	
	(0.000)		(0.000)		(0.000)		(0.000)	
Constant	−4.012***	0.630	−3.943***	0.669	−2.958***	0.703	−2.92***	0.695
No. observations	170		170		170		170	
Log pseudo-likelihood	21.3		21.3		21.7		21.1	
Scaled deviance	7.3		6.0		6.7		6.7	
Pearson chi-square	8.6		6.3		7.2		7.2	
Akaike information criterion (AIC)	0.818		0.865		0.871		0.870	
Bayesian information criterion (BIC)	−650.0		−481.1		−480.4		−480.4	

Note: Base: *R&D_q1*; *DEPTH_q1*.
*$p < .10$.
**$p < .05$.
***$p < .01$.

Table 6. GLM models with interactions for Innovation followers (*INNFIRM*).

Model	*INNFIRM* Model 5		*INNFIRM* Model 6		*INNFIRM* Model 7		*INNFIRM* Model 8	
Independent variables	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE
*INTSELL***DEPTH*	−0.456*	0.236	−0.356	0.249				
*COPYRIGHTS***DEPTH*					−0.183	0.695		
*PATENTS***DEPTH*							−0.498	0.432
DEPTH	0.120*	0.060	0.095	0.065	0.099	0.087	0.051	0.058
DEPTH_2	−0.016	0.010	−0.020	0.009**	−0.025	0.021	−0.024**	0.009
INTSELL	1.621*	0.920	1.912**	0.936	3.061***	0.953	1.329*	0.7015
COPYRIGHTS			−1.952**	0.924	−0.888	1.593	−2.074**	1.017
PATENTS			−0.557	0.891	1.204	1.257	0.158	1.353
R&D_q5	0.034	0.171						
R&D_q4	0.304	0.342						
R&D_q3	2.137	2.684						
R&D_q2	2.395	4.857						
LOGEMP	0.293***	0.094	0.239**	0.116	0.271	0.147	0.231*	0.119
COUNTRY DUMMIES	YES		YES		YES		YES	
Joint significance	70.24 (0.000)		81.62 (0.000)		63.79 (0.000)		147.08 (0.000)	
Constant	−3.840***	0.337	−3.627***	0.376	−2.959***	0.703	−3.460***	0.368
No. observations	173		173		173		173	
Log pseudo-likelihood	29.4		22.9		21.6		22.9	
Scaled deviance	5.4		4.1		6.7		4.1	
Pearson chi-square	5.6		4.3		7.2		4.3	
Akaike information criterion (AIC)	0.813		0.868		0.871		0.869	
Bayesian information criterion (BIC)	−674.8		−493.6		−480.4		−493.5	

Note: Base: *R&D_q1*; *DEPTH_q1*.
*$p < .10$.
**$p < .05$.
***$p < .01$.

the likelihood of introduction of significantly more innovative products. Interestingly for the same firms we do not find any interaction effects between the use of external sources and the use of IPR.

This supports the hypothesis that innovation performance is higher for firms that both engage in external knowledge acquisition and maintain high IPR protection methods, i.e. IPR protection and openness are not substitutes, although this applies only to radical service innovators and not to service innovator followers.

Hypothesis 4 proposes that international market exposure is complementary to external search depth and, hence, there will be a positive coefficient for the interaction *INTSELL*DEPTH*. Selling on the international market (*INTSELL*) is highly significant across all models for innovator leaders (Tables 3 and 5). It is not significant for innovation followers (Table 4). Interestingly, the introduction of the interaction term makes *INTSELL* significant in the service innovation leaders (*INNWORLD*) model and the *DEPTH* variable significant, although in a patchy way, in the *INNWORLD* model. This suggests that there exist three clear groups previously undetected: those that source external knowledge, those that export and those that engage in both activities. While their combination cancelled out in previous models, we are now able to disentangle their impact.

The returns from international market exposure (*INTSELL*) are far higher than the returns from external knowledge acquisition (*DEPTH*). These results are especially true for innovators leaders (Table 5). Those that engage in both activities (*INTSELL*DEPTH*) do perform least well than those that engage in international sales alone (*INTSELL*) or in external knowledge sourcing (*DEPTH*) alone. This seems to suggest that export-oriented services are less open to external knowledge sourcing. Yet again, there are notable differences between the service innovation leaders (*INNWORLD*) and services that engage in innovation catch-up (*INNFIRM*). The estimated coefficients for *INTSELL*DEPTH* are robustly statistically significant in all the *INNWORLD* models (Table 5) but not in the estimated *INNFIRM* models (Table 6).

Finally, we note that the control variables *LOGEMP* and the country dummies are statistically significant and have positive coefficients in all of the estimated models. We also find that innovation performance is strongest in sectors with higher R&D intensity such as *R&D_q5* which comprises sectors with very high R&D intensity, i.e. R&D services, computer and related activities, financial intermediation and 'other business activities' that notably include KIBS. In contrast to the *INNWORLD* models, none of the R&D quintiles are statistically significant in the *INNFIRM* models (Table 4) relative to the base quintile *R&D_q1* that comprises service sectors with very low R&D intensity, i.e. retail trade; machinery and equipment rental; repair of personal and household goods; sale, maintenance and repair of motor vehicles; retail sale of automotive fuel and air transport (Table A1). We also find that the sector R&D intensity is significant in all the models for radical service innovation (Tables 3 and 5). The largest estimated impact is exerted by services that fall into *R&D_q5* followed by *R&D_q4*, *R&D_q3* and *R&D_q2*.

Together, these findings provide support for Hypotheses 1a and 1b that external knowledge sourcing is important and there is an inverted relationship between innovation performance and external search depth across service sectors. The crucial qualification is that the relationship holds for service firms engaged in catch-up product innovation (*INNFIRM*) but not for service firms engaged in radical product innovation (*INNWORLD*). In other words, service companies involved in catch-up innovations benefit significantly from externally sourced ideas. On the contrary, we do not find evidence that external sources of information acquisition are significant in radical service product innovation. The latter seems to make significant use of IPR and is based in knowledge (R&D)-intensive sectors.

The empirical findings do not provide support for Hypothesis 3 that positive synergistic effects exist between the intensity of knowledge sourcing and international sales. Indeed, a negative coefficient is found for the interaction term INTSELL*DEPTH in both of the estimated models for innovation leaders (Table 5). Given the significant coefficients estimated between innovation performance and exports for services innovators, i.e. service sectors with high rates of novel product innovation have high rates of exports, and service sectors with lower levels of product innovation have lower levels of exports, the evidence lends supports to the self-selection thesis.

5. Discussion and conclusions

This paper contributes to a set of key empirical questions regarding the use of external sources for innovation in services, the role of IPR and the contribution of external domestic and international sources to innovation performance in services. We have applied a novel measure of search depth to the Eurostat CIS4 database, which, for the first time, provides a representative and comprehensive range of data on service sectors.

One of the key findings of this paper is that more 'traditional' internal sources of R&D are the main knowledge inputs used by innovation leaders who engage in radical product innovation, not external sources. This has important implications for the existing literature on services innovation. While service firms tend not to have formal R&D labs, in the manner of manufacturing firms, R&D activities do occur in services firms, spread across diverse sets of employees engaged in product, process and organizational innovations over time (Battisti et al. 2013; Gallouj and Djellal 2010; Tether 2005), and this activity affects both the rate of introduction of new internal processes and the supply of new service products. Innovation leaders across Europe have indicated, in their responses to the CIS4 questionnaire, that their employees are actively engaged in intramural R&D activities which directly contribute to the development of novel service products.

The Schumpeterian discussion of the nature of radical product innovations provides an explanation for the importance of internal R&D sources over external sources. Radical product innovations are based on new forms of knowledge and skills, which are held by relatively few organizations – i.e. by innovation leaders. Given that there are few external sources with the relevant knowledge and skills, it is not surprising that innovation leaders do not use external sources when engaging in radical innovation.

We find that radical service innovations are found mainly in knowledge-intensive sectors, i.e. R&D for new service products is strongly tied to human capital in banking and insurance, and in knowledge-intensive businesses-to-business services (KIBS) such as legal and accountancy services, engineering and design, advertising, market research and management consultancy. This finding supports prior research by Tether and Hipp (2002) and Salter and Tether (2006) which highlighted the importance of professional employees' knowledge and expertise to the innovative performance of knowledge-intensive service firms.

Another key finding is that external search is important to the catch-up performance of innovation followers, irrespective of the knowledge intensity of the sector they operate within. Innovation followers are second movers with the requisite absorptive capacity to understand and learn lessons from radical product innovators (Cohen and Levinthal 1990). These firms learn lessons from the production of new product features offered by radical product innovators, from the positive evaluations of feedbacks clients and final consumers to these new features, from private/public third-sector organizations in supply chains established by product innovators. These are key sources from which innovation followers must learn in order to survive. As epidemic diffusion models indicate, the process of information acquisition lowers the technological and financial risk of subsequent producers of radical product innovations (see, for example, Antonelli 1985; Levin, Levin, and Meisel 1992; Mansfield 1963, 1998; Romeo 1975).

Our research findings indicate strong diminishing returns to the number of external sources which are intensively used by second movers. Rather than an extensive use of external sources, services in our sample use, on average, between one and two external sources intensively. This appears to be consistent with findings in the manufacturing sector (see, for example, Laursen and Salter 2006) and suggests the presence of significant costs and diseconomies of search in information acquisition.

The results indicate that innovative leaders in services protect their ideas via patents and copyrights. By contrast, services innovation followers do not use IPR, reflecting the limited degree of novelty of their products. If anything their use appears to reduce the rate of innovation, perhaps suggesting – indirectly – that their presence increases the likelihood of introduction of more innovative products. We find important differences between services in sectors such as R&D services and computer services, which heavily engage in intramural R&D and use IPR to protect their ideas, and firms in service sectors such as retail, hotels and restaurants, where a need to absorb knowledge from the external business environment is more important often due to limited capacities and opportunities to undertake R&D.

Finally, this paper considered internationalization as a means by which firms may extend the scope of external sources for information and knowledge. The empirical findings identify a positive association between international sales and radical product innovation. This is a necessary but not sufficient finding in support of the open innovation thesis because variations in export sales may be due to productivity differentials that are driven by firms' R&D capabilities (the self-selection thesis). It is not possible, with cross-section data, to test the direction of causality associated with these competing explanations (e.g. self-selection into exporting by more efficient firms). It is notable that international sales are statistically significant in the estimated models of radical product innovation, where R&D and firm size are the explanatory variables, while international sales are not significant in the estimated models of incremental product innovation where search depth is significant.

In order to discern between access to new external sources and self-selection as drivers for exporting, we tested the existence of a complementary interaction between foreign sales and the depth of external sources of information and knowledge used for radical and incremental innovation. Negative coefficients are consistently estimated, and are statistically significant for radical product innovators. When taken together with the other findings, this lends support to the proposition that international presence is due to productivity advantages rather than a search for external sources of information and knowledge.

As always, empirical analysis is constrained by the available data. First, our findings pertain to CISs conducted in Europe. Other patterns may exist in other different regions of the world. Second, while the CIS is the best available data source for multiple European countries and sectors, it is not perfect. The survey provides cross-section data. Addressing directions of causality and endogeneity issues requires panel data. As Mairesse and Mohnen (2010) observe, strategic decisions, such as to engage in R&D and/or use external sources for innovation, are largely determined simultaneously and are jointly dependent on third factors, which we do not know or do not observe and for which we have very few exogenous or environmental variables that can serve as relevant and valid instruments.

Some companies may be successfully engaging in the open innovation paradigm in some sectors, in some countries. However, due to the nature of our dataset, we are unable to control for firm heterogeneity at company level. This indicates the need for further research using large-scale international datasets.

The most significant finding of this paper for managers and for policy-makers is that radical innovations in service products tend to be found in R&D-intensive service sectors in Europe that make use of IPR, and which are international exporters. These knowledge-intensive, highly competitive sectors do not significantly engage in open innovation. These knowledge-intensive services typically consist of highly customized products such as financial services, environmental services, architectural services and other consulting activities. Although the variety of services offered can be highly standardized and diversified, their final combination is customer-specific and highly confidential in nature. Radical innovations in these services are not co-produced using a plurality of external sources but rely mainly on knowledge-intensive internal competences.

External sources are found to positively contribute to the incremental innovation performance activities of innovation followers (second-movers) that seek to catch up with leading innovators in their industries. This is consistent with the epidemic information-based model found in the diffusion of innovation literature. These models claim that information acquisition reduces the uncertainty and the risk of adoption of existing innovations favouring their spread across the economy. This is contrary to the open innovation model where external cooperation and information acquisition lead to radical innovation. Furthermore, this finding holds across service sectors. Taken together, our findings indicate that the old innovation model continues to prevail in the provision of radical services rather than the open innovation model, highlighting the need for caution regarding the proposition that a paradigm shift has occurred in innovation in services.

These research findings have clear implications for R&D and other innovation policies. In line with existing policy research (Gallouj, Rubalcaba, and Windrum 2013; Rubalcaba, Gallego, and Den Hertog 2010), existing innovation policy programmes need to be extended to services, to include specific programmes for promoting R&D in services, raising participation of services firms in horizontal R&D schemes and encouraging the contribution of KIBS in collaborative R&D schemes. These policy options are not incompatible with non-R&D innovation policies, such as innovation vouchers to facilitate the absorption or acquisition of knowledge and technology, technological extension projects, standards encouraging innovation and promotions of innovation through public procurement. These are important for all service branches but are particularly important for distributive trades and sectors such as tourism where there is less scope for developing R&D activities, and where the use of external collaborations to become followers is relatively more significant.

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Notes

1. Prior studies of open innovation by Laursen and Salter (2006), Grimpe and Sofka (2009) and Sofka and Grimpe (2010) used CIS3 data.
2. For further details, see: http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/inn_esms.htm

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Appendix

Table A1. Quintiles of R&D sector intensity for service sectors across 18 EU countries.

	Very high R&D intensity (q_5)	NACE codes
1.	R&D	K73
2.	Computer and related activities	K72
3.	Other business activities	K74
4.	Financial intermediation, except insurance and pension funding	J65
	High R&D intensity (q_4)	
5.	Activities auxiliary to financial intermediation	J67
6.	Post and telecommunications	I64
	Medium R&D intensity (q_3)	
7.	Real estate activities	K70
8.	Land transport; transport via pipelines	I60
9.	Hotels and restaurants	H55
10.	Water transport	I61
	Low R&D intensity (q_2)	
11.	Wholesale trade and commission trade, except of motor vehicles and motorcycles	G51
12.	Insurance and pension funding, except compulsory social security	J66
13.	Supporting and auxiliary transport activities; activities of travel agencies	I63
	Very low R&D intensity (q_1)	
14.	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	G52
15.	Renting of machinery and equipment without operator	K71
16.	Sale, maintenance and repair of motor vehicles; retail sale of automotive fuel	G50
17.	Air transport	I62