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EMPIRICAL ARTICLE

Innovation strategies, innovator types and openness: a study of KIBS firms in Spain

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Abstract This paper studies the determinants of innovation strategies in knowledge-intensive business services, by examining the relationship between these strategies and two dimensions of innovativeness: the type of innovator (internal, collaborative or external) and the degree of openness (reliance on internal or external information sources). First, we describe the characteristics of innovator types and their degree of openness. Second, we investigate the extent to which different innovation strategies—determined by examining innovation expenditures and cooperation in innovation—are associated with different innovator types and with different degrees of openness. The data used in this paper are part of the Technological Innovation Panel carried out by the Spanish National Institute of Statistics. The results obtained show that innovation strategies do not lead in any mechanical way to a higher or lower degree of openness. The recognition of the importance that external knowledge can have for innovation is not incompatible with the existence of firms that prefer to rely mainly on their internal capacities to innovate. However, it seems that when firms decide to cooperate for innovation, they are more likely to innovate collaboratively than in isolation.

Keywords Innovation strategy · KIBS · Spain · Open innovation

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1 Introduction

An important and recently noted phenomenon is that firms' innovation success depends on their ability to effectively co-ordinate and integrate a broad range of external sources of knowledge (Love et al. 2014; Barge-Gil 2010). A key driver for firms' innovation is access to external knowledge from industry peers or other partners, and such access is perceived as a critical element allowing firms to increase and complement their ideas and technologies. A crucial implication is that firms are now shifting from closed to open innovation strategies in their business model. Innovation is now conceptualised as an open process where 'external ideas and external paths to the market are on the same level of importance as that reserved for internal ideas and paths to the market in the earlier era' (Chesborough et al. 2006).

There is considerable amount of debate in the literature by scholars on open innovation (OI) and the importance of external sources of knowledge. From a theoretical point of view, open innovation 'corresponds to companies that are really able to manage a wide set of technological relationships that impact on the whole innovation funnel and involve a wide set of different partners' (Lazzarotti and Manzini 2009, p. 24); and closed innovation 'corresponds to companies that access external sources of knowledge only for a specific, single phase of the innovation funnel and typically do so in dyadic collaborations' (Lazzarotti and Manzini 2009, p. 24). Although the resource-based view of the firm highlights the relevance that internal activities, and in particular R&D, have for innovation success, the truth is that openness, commonly associated with the acquisition of external knowledge by means of both formal and informal cooperation, is increasingly recognised as a dynamic complementary element. In other words, as Cassiman and Valentini (2015) affirm, the interaction between inflows and outflows of knowledge is at the heart of the open innovation framework.

This paper aims to contribute to the literature on OI by examining the relationship between the innovation strategies followed by firms and, on the one hand, the type of innovator (internal, collaborative or external) and, on the other, the degree of openness (reliance on internal or external information sources). First, we link our study to the stream of literature analysing the determinants of OI. We describe the characteristics of innovator types and their degree of openness. We are interested in whether the characteristics of innovator types map on to those of open and closed innovators. Second, we link our study to the stream of literature analysing innovation strategies (identified by examining expenditures on innovation-related factors and innovation-related collaborations), which shows that innovative firms are shifting from a closed to an open approach, and suggests that firms can and should use external as well as internal information and knowledge (Love et al. 2014; Laursen and Salter 2006). Our starting point is, recalling the title of Cohen and Levinthal's paper (1989), that innovation strategies and OI practices can be regarded as "two faces" of the same coin. In this context, we investigate the extent to which different innovation strategies (i.e. the nature of innovation-related expenditures and degree of cooperation with outside actors) are associated with different types of innovators (i.e. whether innovations are developed internally, in

collaboration or externally) and with different degrees of openness (i.e. whether outside or internal information is considered more important by the firm).

The research focuses on knowledge-intensive business services (KIBS). This sector constitutes a service subsector comprising establishments whose primary activities depend on human capital, knowledge and skills (Muller and Doloreux 2009). The reasons for selecting this industry are threefold. First, it is a knowledge-intensive sector where continuous innovation is crucial. Second, firms in this industry rely on innovation-driven collaboration with clients, but also on other external partners to increase technological and economic returns and to better exploit their resources and competences. Third, prior research in this context has looked either at high-tech or manufacturing firms, and not the service industry.

To accomplish these tasks, we use data from the Technological Innovation Panel of the Spanish National Institute of Statistics (PITEC) for the period 2010–2012, which provides a sample of 803 KIBS firms. This database provides detailed information about firms' internal innovation activities and innovation outcomes, so that innovation strategies can be defined. It also provides information about how innovations are developed (by the firms, or in collaboration) and about innovation behaviours, allowing us to distinguish different degrees of openness with regard to innovation (closed to open).

The rest of the paper is organised as follows. Section 2 describes previous research on innovation strategies and the determinants of OI, with a special emphasis on KIBS. Section 3 describes the data used, the sample of firms and the variables used in the empirical analysis. Section 4 presents the empirical results. Finally, Sect. 5 concludes and discusses the implications of the findings for future research.

2 Literature review

2.1 In search of innovation strategies: internal activities and external knowledge sourcing

Research on strategic innovation increasingly recognises that a combination of internal and external knowledge sources is key for innovation (Love et al. 2014; Doloreux and Shearmur 2013; Vega-Jurado et al. 2009; Cassiman and Veugelers 2006; Cassiman and Valentini 2015). A theoretical and empirical literature has developed in this respect and can be categorised into three streams.

The focus of the first stream is on innovation-related internal activities and knowledge-sourcing activities within a firm. Internal knowledge acquisition and creation, or learning, takes place within the boundaries of firms. The resource-based view of firms assumes that firms are bundles of resources and capabilities that develop competitive advantage (Grant 1996). These resources and capabilities are valued through the development of unique processes or skills to enhance competitive advantage. Among them, R&D, usually measured by R&D spending or the share of employees assigned to this activity, is a key determinant of innovation (Frenz and Letto-Gillies 2009). In the same vein, other studies show a positive relationship between the success of an innovation and the use of complementary knowledge and internal

resources (Mongo 2013; Doloreux and Shearmur 2013; Becheikh et al. 2006). For example, training, acquisition of machinery, equipment and software, as well as various marketing activities, can influence innovation and increase the ability of a company to develop and apply new knowledge. According to the knowledge-based view, through these activities, firms can generate innovations and contribute to successive generations of technologies. These internal capabilities also provide foundations for understanding and recognising the value of new information and creating new knowledge through interpreting and combining information (Cohen and Levinthal 1990).

The second research stream focuses on the role of external knowledge sources as determinants of innovation. Different theories have suggested that innovation is a process of continuous interactive learning between a firm and its external environment, and that the market introduction of innovations largely depends on firms' capabilities to build and engage in strong links with external partners. There is growing recognition that exposure to heterogeneous knowledge provides firms with multiple learning occasions, enlarging their knowledge base and improving its use for innovation (Lazzarotti and Manzini 2009; Baba et al. 2009; Sammarra and Biggiero 2008). Recent studies have emphasised the importance of firm openness for the acquisition of external knowledge through formal and information cooperation agreements (Tödtling et al. 2009). The common argument is that, for many firms (and industries), a competitive advantage emerges from the ability to engage in collaboration to access new knowledge and specialised capabilities held by other firms and/or organisations. In this view, networks may enable firms to remain competitive and maintain the flow of essential information and necessary knowledge concerning commercial trends and new technologies, but also to support more focused and intensive exploitation of capabilities developed within individual firms (Dahlander and Gann 2010; Chiaroni et al. 2011).

The third research stream recognises dynamic complementarities in innovation strategies where a combination of internal and external knowledge sources is used by firms. The idea is that innovation organisation cannot rely solely on internal sourcing activities, but also requires knowledge from beyond firm boundaries (Cassiman and Veugelers 2006; Cassiman and Valentini 2015). In developing innovation, in addition to doing internal R&D, firms tap into knowledge through processes of interaction between different economic players, including private firms, colleges and HEI (higher education institutions), research centres, technology transfer organisations, industrial association, unions and other institutional forms (Chesborough et al. 2006). However, empirical studies on complementary innovation activities have produced mixed results. Love et al. (2014) examine the existence of complementarities between internal R&D and external linkages in innovation and show no evidence of complementarity. Similarly, Vega-Jurado et al. (2009) show that a strategy directed towards the acquisition of external knowledge may only be to promote ideas and provide resources necessary for innovation. Furthermore, the authors demonstrate the lack of complementarities between internal R&D activities and the use of external sources of innovation.

2.2 Innovation strategies and KIBS

Theoretical reflections and empirical results from national and sectoral studies have provided rich understanding of the peculiarities and specificities of innovation strategies

in the KIBS sector (Asikainen 2015; Hipp et al. 2015; Mongo 2013; Muller and Doloreux 2009; Tether 2005). Together, these studies emphasise multiple characteristics that are unique to services, though Tether (2005), Camacho and Rodriguez (2008) and Mongo (2013) provide evidence of an intensification of innovation activities and a rate of innovation comparable to that of the manufacturing sector.

However, innovation strategies in KIBS and the activities that support innovation differ from manufacturing. First, innovation relies less on formal R&D activities. With the exception of sectors linked to information technology and R&D, the success of innovation is not directly linked to R&D activities: indeed, KIBS generally dedicate fewer resources to R&D than manufacturers (Miles 2008). Some authors even point out the need for revising the definition of research and development in the light of the specificities of services (Djellal et al. 2003; Gallaher and Petrusa 2006; Gotsch and Hipp 2012; Hipp and Grupp 2005). Second, a crucial element to KIBS innovation is technology acquisition (Tether 2005; Miles 2008). In this sense, innovation is closely linked to the commercialisation of new services emanating from the increased use of new technologies, particularly information technologies. Pioneering work by Barras (1986) highlighted that learning processes consequent to the use of new technologies led to innovation, in a process he termed "reverse product cycle". Third, the development of human capital is particularly important for KIBS, as they rely on highly qualified and educated workers to innovate (Muller and Doloreux 2009; Shi et al. 2014), to such an extent that the contributions of these employees is often considered the single most important element of innovation. Fourth, new service development often necessitates frequent interactions, and a close interaction between KIBS and client organisations (Koch and Stahlecker 2006). Thus, innovation in KIBS is heavily dependent on external relations established with clients and technology suppliers. Non-technological innovation is often the primary element in many new services (Miles 2008). Finally, due to its intangible nature, innovation in services is more difficult to protect. Services are therefore more likely to use alternative methods to patents, such as trademarks (Cho et al. 2012; Gotsch and Hipp 2012).

When looking at innovation in KIBS, innovation is often conceptualised as a singular process (Gallouj and Savona 2009). Given the intangible nature of services, innovation is often a new idea, a new approach, or a new method to introduce a service on the market or to significantly improve existing services (OECD 2005). The innovation process is relational to the extent that the user is connected directly to the service producer. It develops in a sequence of operations and evolves via customer feedback aimed at finding a solution to a particular problem identified by the client organisation (den Hertog 2000). Thus, the innovation process and its results tend to be customised, though the degree of customisation varies: for example, whereas there are some fairly standard products offered by computer systems services, this is less frequent for services such as management consulting or marketing. Given that the innovation process is often characterised by a high degree of interaction with the client, innovation in KIBS becomes a process adapted to the needs and expectations particular to the client organisation. Finally, the innovation process in services is evolutionary and cumulative insofar as the KIBS firm and the client organisation allow their knowledge base to evolve mutually as the innovation develops (Strambach 2008).

The exact nature of innovation within KIBS is difficult to define. The innovation strategies adopted by KIBS are far from homogeneous. Based on the works of Rodriguez and Camacho (2010), Corrocher et al. (2009), Doloreux and Shearmur (2012), Ferreira et al. (2013) and Hipp et al. (2015), KIBS adopt different strategies related to innovation and contrasting behaviours can be observed, with differences noted between the different KIBS sectors.

2.3 Positioning the work: innovation strategies and degree of openness

In this exploratory article, we enrich existing literature by analysing, first, the association between a firm's innovation strategy and its degree of openness, and second, the association between a firm's characteristics and its degree of openness. Our study extends previous research in three ways.

First, we explore how differences in the use of internal activities and the search for external knowledge sources lead to different innovation strategies. The focus is to depict the possible complementarity between firms' internal capabilities and external resources for developing new products, processes and organisational innovation (Doloreux and Shearmur 2013).

Second, the preceding studies on open innovation say relatively little about the way in which an innovation strategy affects the degree of openness of a firm. Most studies have focused on the contributions of both internal and external sources in determining innovation performance (Cassiman and Valentini 2015; Love et al. 2014; Vega-Jurado et al. 2009). These studies hypothesised and found a positive relationship between a higher degree of openness and innovation performance, with very few exceptions (Knudsen and Mortensen 2011). To our knowledge, there is no work on the relationship between the degree of openness and firms' internal and external knowledge activities strategy.

Third, we contribute to the existing empirical literature by analysing the relationship between innovation strategies and the degree of openness in the KIBS sector. Most studies on the use of different sources of knowledge (internal and external) and open innovation have provided interesting insights for manufacturing industries, but few of them focus on services, despite, as Chesbrough (2010) highlights, services engaging in open innovation. In particular, business services "are more active seekers of external knowledge than manufacturing firms" (Mina et al. 2014, p. 60). Therefore, to our knowledge, there is no study that has examined the association between innovation strategies and the degree of openness of KIBS. The results should provide some insights on the multidimensional facets of innovation in the service sector and the extent to which they differ from manufacturing.

In sum, as West et al. (2014, p. 810) point out in their review of the contribution and evolution of open innovation, it "provides rich possibilities for new, fundamental discoveries". In particular, this study responds to the call for future research expressed by Barge-Gil (2010): he highlighted the need to investigate the knowledge and information strategies chosen by firms and their effect on the adoption of more or less open innovation strategies.

3 Methodology

3.1 Variables and measures

As mentioned in Sect. 1, the main aim of this paper is to assess the relationship among innovation strategies, types of innovation developed (internal, collaborative or external) and degree of openness (open, semi-open or closed) in KIBS.

The identification of innovation strategies is based on two main sets of innovation indicators. The first set of indicators relates to innovation expenditures: in-house R&D, external R&D, acquisition of machinery, equipment and software, acquisition of external knowledge, preparations for production and/or distribution, training and market introduction of innovations. The second set of indicators relates to innovation cooperation, that is, active participation with other firms or non-commercial institutions in innovation activities excluding pure contracting out work with no active cooperation. Eight types of innovation cooperation partners are distinguished: other firms within the group, suppliers, clients from the private sector, clients from the public sector, competitors, consultants and commercial laboratories, universities and higher education institutions and public and private research centres.

Concerning the type of innovations developed, to distinguish among internal, collaborative and external innovators, we use three questions on who developed the product (good or service) and process innovations introduced by the firm. The survey provides four options: the firm itself, the firm together with other firms or institutions, the firm by adapting or modifying goods, services or processes originally developed by other firms or institutions and other firms or institutions. A firm is classified as an internal innovator when all the innovations introduced were developed by the firm itself. In contrast, a firm is considered an external innovator when all the innovations introduced are developed by other firms or institutions. In cases where innovations are developed together with other firms or institutions, or by adapting or modifying goods, services or processes originally developed by other firms or institutions, the firm are classified as a collaborative innovators.

In relation to the degree of openness, drawing on the work of Barge-Gil (2010) for Spanish manufacturing firms, we use a question on the importance of different sources of information for the firḿs innovation activities. In this question, firms rank, where relevant, as high, medium or low the importance of their internal information and of ten types of external information provided by market, institutional and other sources. As Hollenstein (2003) notes, from an econometric point of view, the information content of subjective assessment measures is higher than those of quantitative measures. A firm is classified as an open innovator when at least one external source of information is more important than its own internal information. On the contrary, it is classified as a closed innovator when the most important external source of information is less important than its own internal information. Finally, a firm is considered a semi-open innovator when the most important external source of information is as important as its own internal knowledge.

To control for differences in the structural characteristics of firms, four main indicators are incorporated into the analysis: industry, size, age and export activity.

Table 1 Operational definitions of the variables employed in the analysis

Variables	Description
Innovation indicators	
Innovation expenditures	
RD	Dummy coded 1 if the firm spends internal R&D
External RD	Dummy coded 1 if the firm spends on external R&D
Machinery	Dummy coded 1 if the firm spends on acquisition of machinery, equipment and software
External knowledge	Dummy coded 1 if the firm spends on acquisition of external knowledge
Preparations	Dummy coded 1 if the firm spends on preparations for production/distribution
Training	Dummy coded 1 if the firm spends on training
Market intro	Dummy coded 1 if the firm spends on market introduction of innovations
Cooperation	
Firm	Dummy coded 1 if the firm cooperates with firms within the firm group
Suppliers	Dummy coded 1 if the firm cooperates with suppliers
Private clients	Dummy coded 1 if the firm cooperates with clients from the private sector
Public clients	Dummy coded 1 if the firm cooperates with clients from the public sector
Competitors	Dummy coded 1 if the firm cooperates with competitors
Consultants	Dummy coded 1 if the firm cooperates with consultants or commercial labs
Universities	Dummy coded 1 if the firm cooperates with universities and higher education institutions
Research centres	Dummy coded 1 if the firm cooperates with public and private research centres
Type of innovator	
Internal	Dummy coded 1 if all innovations are developed by the firm itself
Collaborative	Dummy coded 1 if any innovation is developed together with other firms or institutions or by adapting or modifying goods, services or processes originally developed by other firms or institutions
External	Dummy coded 1 if all innovations are developed by other firms or institutions
Degree of openness	
Open	Dummy coded 1 if at least one external source of information is more important than its own internal information
Semi-open	Dummy coded 1 if the most important external source of information is as important as its own internal knowledge
Closed	Dummy coded 1 if the most important external source of information is less important than its own internal information
Structural characteristics	
t-KIBS	Dummy coded 1 if the firm belongs to divisions 62 or 72 of the ISIC Rev. 4
p-KIBS	Dummy coded 1 if the firm belongs to divisions 69, 70, 71, 73 or 74 of the ISIC Rev. 4
Size (large)	Dummy coded 1 if the firm has more than 200 employees
Age (young)	Dummy coded 1 if the firm is 10 years or younger
Export	Dummy coded 1 if the firm sells abroad

Table 1 provides a summary of the operational definitions of the different indicators employed in the analysis.

3.2 Sample and data

The data used in this paper are part of the Technological Innovation Panel (PITEC) carried out by the Spanish National Institute of Statistics with the aim of studying innovation activities in Spanish firms. The PITEC began in 2003 and is a panel survey: it follows the same representative sample of firms over time. In 2003, there were only two samples of firms: one composed of large firms (those with 200 or more employees) and the other comprising firms which spend on intramural R&D. This latter sample was enlarged twice, in 2004 and in 2005. Two additional samples were incorporated in 2004: a sample of firms with less than 200 employees which spend on external R&D and do not spend on intramural R&D, and a sample of firms with less than 200 employees and with no innovation expenditures.

The panel design of the survey makes it possible to analyse how innovation activities change, and to take into account heterogeneity among firms in terms of decision making or innovation. Moreover, new questions are added in almost every wave. For instance, the questions used to distinguish among internal, collaborative and external innovators were introduced for the first time in the 2012 edition of the PITEC which was released in May 2014.

For confidentiality reasons, the data included in the PITEC are anonymised: the values for five key quantitative variables (turnover, investment, number of employees, innovation expenditures and number of R&D employees) are replaced by approximate values generated by means of a "hiding" process. Other quantitative values are expressed as percentages of the approximated total values, and the International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4 codes are replaced by a 44 industry breakdown. In the case of KIBS, three industries are distinguished: computer programming, consultancy and related activities (which correspond to division 62 of ISIC Rev. 4); scientific research and development (which corresponds to division 72 of ISIC Rev. 4); and other business services (which correspond to divisions 69, 70, 71, 73 and 74 of ISIC Rev. 4, that is, legal and accounting activities; activities of head offices and management consultancy activities; architectural and engineering activities, technical testing and analysis; advertising and market research and other professional, scientific and technical activities). Following the pioneering work by Miles et al. (1995), KIBS can be divided into two main groups: traditional professional services (p-KIBS) "such as accountancy and legal services, market research and personal services" and new technology-based services (t-KIBS), that is, "various new services connected with technology, and with the production and transfer of knowledge about new technology" (Miles et al. 1995, p. 27). In our case, the first two industries (62 and 72) cover t-KIBS,[1] while the third one (69 to 74) corresponds to p-KIBS.

[1] As Shearmur and Doloreux (2009) and Tether et al. (2012) show, the p-KIBS/t-KIBS distinction is not ideal, since particularities are found between sub-sectors within the broad categories. However, given that only three KIBS sub-classes are available, the p-KIBS/t-KIBS distinction has the merit of being consistent with many other studies.

Table 2 Distribution of the sample of KIBS firms according to the type of innovation developed and the degree of openness

	Type of innovation			
	Internal	Collaborative	External	Internal and external
Degree of openness	495	308	28	13
Open	74	57	8	2
Semi-open	287	196	16	7
Closed	134	55	4	4

The analysis is confined to KIBS firms (1510 firms) and only to those which develop innovations over the period 2010–2012 (844 firms). Table 2 shows the sample distribution according to the type of innovation developed and the degree of openness.

As can be seen in Table 1, over half of innovative KIBS firms are classified as internal innovators. Collaborative innovators accounted for about 36 % of the total. The number of external innovators is low: only 28 out of the 844 innovative KIBS firms are classified as such. It is necessary to mention the existence of a "special" (although very small) group of innovative KIBS which are at the same time internal and external innovators. In most of the cases, these are firms that introduce product innovations, developed by themselves, and external process innovations, developed by other firms or institutions. As the main objective of this paper is to shed light on the relationship between innovation strategies, innovation type and degree of openness, the two small latter groups (external, and internal and external innovators) are excluded from the analysis. Our final sample of innovative KIBS consists of 803 firms which are internal or collaborative innovators over the period 2010–2012.

4 Results

4.1 Descriptive results

This section provides an overview of the innovation expenditures and innovation cooperation patterns across internal and collaborative innovators, and across open, semi-open and closed innovators. As seen in Table 3, consistent with previous literature (Muller and Doloreux 2009), in-house R&D is the most important innovation expenditure for all groups of KIBS firms, whilst the number of firms spending on the acquisition of external knowledge, that is, the purchase or licensing of patents and non-patented inventions, know-how and other types of knowledge is almost negligible. Concerning cooperation, universities and other higher institutions are the most relevant innovation partners, followed by clients. This confirms the role of KIBS as bridges for innovation, capable of transmitting and adapting the general knowledge generated by the science and technology component of the innovation system.

Table 3 Innovation expenditures and innovation cooperation by type of innovator and degree of openness

	Internal innovators $n = 495$				Collaborative innovators $n = 308$				χ^2 test
	Open $n = 74$	Semi-open $n = 287$	Closed $n = 134$		Open $n = 57$	Semi-open $n = 196$	Closed $n = 55$		
Innovation expenditures									
In-house R&D	75.6	75.9	73.1	75.1	87.7	88.2	78.1	86.3	***
External R&D	31.0	25.4	20.9	25.0	43.8	55.6	34.5	49.6	***
Acquisition of machinery, equipment and software	10.8	12.5	7.4	10.9	5.2	18.8	16.3	15.9	*
Acquisition of external knowledge	0.0	1.3	0.7	1.0	1.7	7.6	3.6	5.8	***
Preparations for production/distribution	4.05	4.8	4.4	4.6	8.7	12.2	14.5	12.0	***
Training	16.2	23.6	25.3	23.0	22.8	33.6	27.2	30.5	*
Market introduction of innovations	28.3	26.1	20.1	24.8	35.0	35.2	43.6	36.6	***
Cooperation									
Other firms within the firm group	0.0	5.9	8.2	5.6	24.5	33.6	29.0	31.1	***
Suppliers	8.1	10.8	6.7	9.2	43.8	42.3	43.6	42.8	***
Clients from the private sector	10.8	19.1	11.1	15.7	54.3	55.6	36.3	51.9	***
Clients from the public sector	4.0	8.7	3.7	6.6	29.8	29.5	14.5	26.9	***
Competitors	9.4	12.8	10.4	11.7	38.6	43.3	34.5	40.9	***
Consultants or commercial laboratory	9.4	8.3	5.9	7.8	26.3	37.2	27.2	33.4	***
Universities and higher education institutions	20.2	23.0	12.6	19.8	56.1	60.2	47.2	57.1	***
Public and private research centres	20.2	16.0	11.9	15.5	59.6	62.2	34.5	56.8	***

* Significant at 10 % level

*** significant at 1 % level

Statistically significant differences can be detected between the six groups of firms analysed, both in terms of innovation expenditures and innovation cooperation.

As expected, collaborative innovators not only tend to cooperate more than internal ones, but also spend on a wider variety of innovation activities. In terms of innovation expenditures, the greatest difference is found in the percentage of firms spending on external R&D activities: while almost half of collaborative innovators spend on external R&D, this percentage reduces to only one-quarter of internal innovators. In contrast, the difference is quite low in terms of the percentage of firms spending on the acquisition of machinery, equipment and software.

As previously noted, the percentage of cooperating firms is higher for collaborative innovators regardless of the innovation partner. The greatest differences are observed for the percentage of firms cooperating with public and private research centres, universities and higher education institutions and clients from private institutions. In spite of being the three main cooperation partners for both groups, the percentages are substantially different: while more than half the collaborative innovators cooperate with these three types of partner, the percentage reduces to 20 % in the case of internal innovators cooperating with universities, and to 15 % in the case of internal innovators cooperating with research centres and private clients.

If we turn to the degree of openness, we note that, within the group of internal innovators, semi-open firms tend to cooperate more. Interestingly, in the case of collaborative innovators, the differences between semi-open and open firms are not pronounced: for instance, the percentage of firms cooperating with suppliers and with clients (from the private and from the public sector) is almost identical in both groups. As expected, even within the group of collaborative innovators, the percentage of cooperating firms is substantially lower when firms are closed.

4.2 Identifying innovation strategies: factor analysis and cluster analysis

Cluster analysis is used for grouping firms based on their similarities in terms of innovation expenditures and innovation cooperation. This multivariate technique allows us to identify innovation strategies, as it places firms into homogenous groups which are not predefined but based on the data. As can be seen in Table 1, the number of innovation indicators is quite high (seven categories of innovation expenditures and eight types of innovation cooperation partners). In addition, it can be expected that a high degree of redundancy exists, that is, many of these variables are highly correlated with one another. This is why, as a first step, factor analysis is performed to synthesise into uncorrelated components the information contained in the indicators on innovation. As a second step, hierarchical cluster analysis is performed to group firms into homogeneous categories which can be interpreted as different innovation strategies. Finally, we examine differences between firms adopting each innovation strategy in terms of structural characteristics: sector (t-KIBS versus p-KIBS), size, age and export activity.

As shown in Table 4, from the 15 variables, four factors are extracted and rotated orthogonally. These four factors accounted for 52 % of the total variance. The first,

Table 4 Principal component analysis: factor loadings

	F1 Cooperation	F2 R&D efforts	F3 Market preparations	F4 Machinery and training
Consultants	**0.705**	−0.004	0.098	−0.085
Private clients	**0.685**	0.258	0.026	0.050
Public clients	**0.682**	0.138	−0.028	0.093
Suppliers	**0.678**	−0.113	0.153	−0.023
Universities	**0.674**	0.359	−0.097	0.139
Research centres	**0.651**	0.340	−0.061	0.144
Competitors	**0.623**	0.278	0.050	0.050
Firm	**0.512**	−0.171	0.298	−0.184
RD	0.124	**0.755**	0.175	−0.133
External RD	0.225	**0.657**	−0.018	0.128
Market intro	0.007	0.193	**0.726**	−0.030
Preparations	0.083	−0.146	**0.645**	0.175
External knowledge	0.064	0.157	**0.456**	0.335
Machinery	0.010	−0.148	0.013	**0.800**
Training	0.045	0.161	0.254	**0.666**
Variance (%)	23.31	10.549	9.238	9.042
Bartletťs test	χ^2	2354.828		
	Sig.	0.000		
KMO test	Overall MSA	0.861		

Bold characters indicate factor loadings greater than 0.40

KMO Kaiser–Meyer–Ohlin, *MSA* measure of sampling adequacy

which captures 23 % of the total variance, represents cooperation activity in innovation. The second, accounting for 10.5 % of variance, represents R&D expenditures, regardless of whether R&D is undertaken in-house (by the firm), by other firms, by public or private research organisations or purchased. The third factor, which accounts for 9 % of variance, reflects activities related to the market introduction of innovations such as market research, advertising or testing, as well as the purchase or licensing of patents and non-patented inventions, know-how and other types of knowledge. Finally, the fourth factor—also 9 % of variance—reflects the importance of machinery acquisition, purchase of equipment (including computer hardware) or software and of training for the introduction of innovations.

A hierarchical cluster analysis is conducted on the factor scores. The number of clusters is chosen partly on the basis of interpretability—a solution in the vicinity of 5 was being sought. Given that choice, the exact number was determined so that increasing the number of clusters would not much improve the explanatory power of the classification. Four clusters were obtained which can be interpreted as different innovation strategies. To this end, Table 5 reports the mean factor scores of each cluster. Our short descriptions of the clusters are: independent innovators, Barras-type innovators, balanced innovators and highly cooperative innovators.

A first look at Table 5 reveals that the number of firms is not equally distributed across innovation strategies. The first group, independent innovators, consists of 381

Table 5 Cluster description: mean factor scores

	n	F1	F2	F3	F4
Independent innovators	381	−0.569	0.261	0.071	−0.454
Barras-type innovators	171	−0.290	−1.069	−0.513	0.908
Balanced innovators	48	0.221	0.514	2.521	0.990
Highly cooperative innovators	203	1.260	0.290	−0.297	−0.148

Table 6 Selected characteristics of firms by cluster

	t-KIBS	p-KIBS	Size (large)	Age (young) 3	Export
Independent innovators	63.5	36.4	10.7	35.9	60.1
Barras-type innovators	38.6	61.4	13.4	29.8	53.2
Balanced innovators	68.7	31.2	14.5	43.7	72.9
Highly cooperative innovators	65.0	34.9	24.1	33.0	74.3
χ^2 test	***	***	***	–	***

*** Significant at 1 % level

firms which do not cooperate, but mainly rely on R&D and, to a lesser extent, on market preparations and external knowledge to innovate. The second cluster, called Barras-type innovators, contains 171 firms whose innovation activities correspond to the reverse product cycle described by Barras (1986), where the introduction of new technologies improves efficiency, thereby leading to process innovations and, later, to product innovations. In this group, the acquisition of machinery, equipment and software and training are the key innovation activities. The 48 firms belonging to the third cluster not only cooperate, but also spend on all types of innovation activities. In other words, their innovation strategy can be considered to be "balanced" from all points of view. Finally, the fourth cluster comprises firms with a strong propensity to cooperate in innovation and whose innovation expenditures focus on R&D.

To better describe the characteristics of the firms adopting each innovation strategy, Table 6 reports some structural characteristics of firms within each of the four clusters. As well as distinguishing between t-KIBS and p-KIBS firms, we show size (percentage of firms with more than 200 employees), age (percentage of firms of 10 years or younger) and export activity (percentage of firms selling abroad).

Barras-type innovators tend to be p-KIBS, whereas all other types of innovator tend to be t-KIBS. Regarding size, large firms are more prominent amongst highly cooperative innovators, which supports the idea of a positive relationship between size and cooperation in innovation. The same happens in the case of export activity: around three-quarters of highly cooperative and balanced innovators sell their products in international markets suggesting the existence of a positive relationship between export activity and cooperation in innovation.

4.3 Is there an association between innovation strategies, types of innovators and degree of openness?

In this section, we examine whether innovation strategies which, by construction, are relatively homogeneous groups, map on to the type of innovation developed and/or on to the degree of openness. Table 7 shows the cluster composition of internal and collaborative innovators and, within each of these categories, of open, semi-open and closed innovators.

Table 7 reveals that independent innovators are strongly concentrated in the group of internal innovators, while many highly cooperative innovators are collaborative innovators. In other words, firms that use external knowledge to innovate tend to be more open. However, a considerable proportion of collaborative firms (30.8 %) are independent innovators, whereas very few internal innovating firms (12.1 %) are highly cooperative. The presence of Barras-type innovators is somewhat higher amongst internal innovators, which is in line with the reverse product cycle innovation model described by Barras: the learning processes caused by the introduction of new technologies lead to innovations, while balanced innovators are more common in the group of collaborative innovators. Independent innovators are almost equally likely to be open and closed, whereas they are less likely to be semi-open. In the case of highly cooperative innovators, most firms tend to be semi-open, although the differences between open and closed firms are very small for collaborative firms. The low number of balanced innovators which are closed deserves special attention: this reflects the importance that cooperation in innovation has for these firms. That is, recognition of the importance that external knowledge can have for innovation is not incompatible with the existence of firms that prefer to rely mainly on their internal capacities to innovate. However, it seems that when firms decide to cooperate, they are more likely to innovate collaboratively than in isolation.

Table 7 Distribution of firms across clusters depending on the type of innovation and the degree of openness

	Independent innovators	Barras-type innovators	Balanced innovators	Highly cooperative innovators
Open	62.1	27.0	1.3	9.4
Semi-open	53.6	26.4	4.5	15.3
Closed	64.1	27.6	1.4	6.7
Total internal	57.7	26.8	3.2	12.1
Open	35.0	8.7	10.5	45.6
Semi-open	27.5	13.2	12.2	46.9
Closed	38.1	12.7	3.6	45.4
Total collaborative	30.8	12.3	10.3	46.4
All	47.4	21.3	6.0	25.3

The figures in this table are percentages that sum to 100 from left to right

4.4 Do firm characteristics differ between internal and collaborative innovators and the degree of openness?

In this sub-section, we investigate whether there are differences in the structural characteristics of firms depending on the type of innovation developed and the degree of openness.

Only differences in two characteristics are statistically significant (Table 8): size and export activity. The share of large firms is higher in the group of collaborative innovators, in particular when they are closed: one out of four semi-open and collaborative innovators has more than 200 employees. As Barge-Gil (2010) notes, this can mainly be explained by the fact that larger firms commonly have a great capacity to absorb external knowledge than their smaller counterparts.

Concerning export activity, despite the percentage of firms selling abroad being higher for collaborative than for internal innovators, rather than being associated with innovation type (internal or collaborative) the presence of exporting firms is linked to the degree of openness: for both collaborative and internal innovators, the percentage of exporters is higher when firms are semi-open.

5 Conclusions

5.1 Summary of the results

The main objective of this paper is to shed light on the relationship between the innovation strategies followed by KIBS firms, the type of innovation developed and their degree of openness. The empirical analysis reveals a clear correspondence between two of the innovation strategies identified and the innovation type (internal or collaborative). Thus, most internal innovators are independent and many collaborative innovators are highly cooperative: the connection is not straightforward, though, because whereas collaborative innovation is not incompatible with independence, internal innovation is (almost) incompatible with high levels of

Table 8 Selected characteristics of firms by type of innovation and degree of openness

	t-KIBS	p-KIBS	Size (large)	Age (young)	Export
Open	54.0	45.9	6.7	29.7	62.1
Semi-open	57.1	42.8	14.6	35.1	66.2
Closed	56.7	43.2	11.9	35.8	49.2
Total internal	56.5	43.4	12.7	34.5	61.0
Open	56.1	43.8	10.5	26.3	61.4
Semi-open	65.8	34.1	18.8	38.7	68.8
Closed	58.1	41.8	25.4	25.4	61.8
Total collaborative	62.6	37.3	18.5	34.0	66.2
χ^2 test	–	–	**	–	**

** Significant at 5 % level

cooperation. Barras-type innovators are over-represented amongst internal innovators, and balanced innovators among collaborative innovators. Whilst most independent innovators are internal innovators, they are equally likely to be open or closed. Although most highly cooperative innovators are collaborative, amongst those that are internal a higher proportion is semi-open.

To better describe the structural characteristics of firms belonging to each group, these characteristics are analysed for different innovation strategies (clusters), types of innovation developed and degree of openness. Statistically significant differences between t-KIBS and p-KIBS were only found concerning innovation strategy: in particular, we observe that the predominance of Barras-type innovators is higher in p-KIBS. However, differences in size and export activity are significant in both the analyses performed. Thus, from the point of view of innovation strategy, large firms concentrate on the group of highly cooperative innovators. When size is analysed in terms of type of innovation and degree of openness, the greatest share of large firms is found amongst collaborative, but closed, innovators. This suggests that recognition of the importance of their own internal knowledge for innovation is not an obstacle for cooperation in the case of large KIBS firms. As for export activity, the percentage of exporting firms is substantially higher in the two clusters where cooperation is an important element of innovation strategy. In terms of innovation type and degree of openness, although the share of exporting firms is higher for collaborative than for internal innovators, the differences are more pronounced when we look at openness: the greatest share of exporting firms are semi-open.

5.2 Contribution to theory

Two contributions emerge from this study. First, by considering the relationship between the degree of openness and a firm's internal and external knowledge activities, the study contributes to the literature on innovation, which is mainly focused on the effect of openness on firms' innovation performance (not its strategy). The study reveals that establishments that have recourse to external innovation partners tend to also be more open in terms of information acquisition. However, the study also shows that innovation can occur in relative isolation, and therefore not all firms adhere to the open innovation paradigm (Shearmur 2015). These findings also show that innovation strategies do not lead in any mechanical way to a higher (or lower) degree of openness. This implies that firms engaging in external knowledge acquisition should not overlook the effect of their internal technological capabilities: on the one hand, a certain absorption capacity is needed to benefit from external knowledge (Cohen and Levinthal 1990), and, on the other, appropriability plays an important role, leading to what Laursen and Salter (2014) called the "the paradox of openness", that is, although openness can be important to develop innovations, once these are going to be commercialised protection becomes necessary.

Secondly, by analysing innovation strategies and degree of openness, the study contributes to the literature on services. To date, no previous empirical work has investigated how different innovation strategies are connected to different degrees

of openness in KIBS. This absence is remarkable if we take into account that KIBS are innovative and build their competences and capabilities through different internal and external activities to perform innovation (Doloreux and Shearmur 2013; Tether et al. 2012; Corrocher et al. 2009; Miles 2008). Another way of looking at the importance of KIBS in innovation, which also reveals the complexity of the innovation process, is by way of the role they play in supplying knowledge to the economy-wide innovation processes (Doloreux and Shearmur 2013). Firms can access complementary resources and knowledge by having recourse to KIBS, but little is known about how they act as sources and drivers of open innovation. More specifically, little is known about how firms build upon internally and externally provided services to acquire new capabilities and about how the use of these services fits into their innovation and openness strategies. Further detailed work here would be welcome. We can say little about how the relationship between the use of KIBS and external linkages varies with the degree of openness of a firm.

5.3 Contribution to practice

What do these results suggest regarding the management of innovation and open innovation practices in KIBS? First, managers have to take into account that the different types of innovation strategies interact differently with different open innovation practices. Second, the results of this study suggest that managers of innovation should pay attention to the complementarity that exists between different forms of knowledge use in the innovation process. In the end, what seems to matter is that different forms of knowledge can be combined to define different innovation strategies, which will lead to different degrees of openness. These combinations of forms of knowledge actually constitute idiosyncratic combinations at the firm level; therefore, the use of and search for knowledge by different firms within an industry are subject to great variation. It is thus difficult for an organisation to determine which activities, or combinations of activities, are optimal to increase innovation performance.

5.4 Limitations and future research

Some limitations and directions for future research are worth mentioning. First, the data employed are cross-sectional. The characteristics of the database—in particular the recent introduction of some key variables that we rely on—do not allow taking into account the extent to which internal technological capacities derived from different internal activities can encourage, or inhibit, the exploitation of external knowledge sources. Previous research using similar databases, whether at the firm or industry level, has encountered the same problem (Vega-Jurado et al. 2009; Barge-Gil 2010; Cruz González et al. 2015). This study cannot examine these interaction effects. Future research should capture these interactions by using longitudinal data for a more rigorous analytical method in defining and interpreting innovation strategies. Second, although we followed well-established methodological procedures (Barge-Gil 2010), we used a nominal variable for openness and do not distinguish the ways firms pursing different strategies may adopt different openness

strategies. Future research should strive to capture variability in firms' strategic intent, because it may provide further insight into the relationship between innovation and openness strategies. Third, the findings of this study are limited to a single industry sample and a single industrial context. Of course, the external validity of this study needs to be examined in other industries and in other contexts, especially given the high heterogeneity across services (Battisti et al. 2015; Mina et al. 2014).

To summarise, while a growing amount of research emphasises the importance and implications of openness strategies, little academic research focuses on its relationship with innovation strategies adopted by firms. Therefore, exploring this relationship is of strategic concern to any firm conducting internal technological activities and open search activities.

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