Evolution of inbound openness profiles in the innovation practices of small and medium-sized enterprises in Spain and Portugal

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Abstract: The purpose of this article is to shed light on the patterns of inbound open innovation practices of SMEs and to explore potential size and country specificities. We base the analysis on data provided by three waves of the Eurostat Community Innovation Survey (CIS) for Spanish and Portuguese firms. The study identifies five innovation clusters with different openness profiles: closed innovators, absorbers of specialised knowledge, acquirers, co-operators and absorbers of industry knowledge. We find no substantial differences between small and medium-sized firms with regards to their innovation profiles, but there are substantial differences between the profiles of Spanish and Portuguese firms and the trends in said profiles. Portuguese firms increasingly rely on technology acquisition and Spanish firms on public institutions. These results could help shape national policy on intellectual property and public research systems, among others.

Keywords: cluster analysis; SMEs; inbound open innovation; innovation activities; innovation policy; Spain; Portugal; Community Innovation Survey; CIS.

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1 Introduction

Open innovation is becoming a new paradigm for managing innovation in firms. It encourages enterprises to look outside their boundaries and to improve their innovative performance through exchanging and/or sourcing knowledge from external stakeholders such as customers, users, suppliers, universities, technological centres, other firms and so on (Gassmann et al., 2010; Chesbrough, 2006). Such knowledge can flow from outside the firm in, known as inbound open innovation, and from inside the firm out, known as outbound open innovation (Chesbrough, 2003; West et al., 2014). In this study, we focus on inbound open innovation.

Since the concept of open innovation was introduced, most academic research in this field has focused on large firms (Chesbrough, 2003; Chesbrough and Crowther, 2006; Christensen et al., 2005; Dodgson et al., 2006; Kirschbaum, 2005). Some studies, however, have highlighted the importance of open innovation from the perspective of SMEs (Kim and Park, 2010; Laursen and Salter, 2006; Lee et al., 2010; Parida et al., 2012; Spithoven et al., 2013; Van de Vrande et al., 2009; Verbano et al., 2015).

According to West and Bogers (2014), the relative scarcity of empirical research using large databases and SMEs leaves many questions about open innovation in relation to these types of companies unanswered. One of these questions concerns the heterogeneity of the openness profiles of SMEs or, in other words, the possible differences in their innovative practices in an open innovation context (see Verbano et al., 2015). Furthermore, little is known about the differences between small and medium-sized firms with regards to innovative openness (see, for instance, Van de Vrande et al., 2009). This is also the case with differences in the openness profiles of SMEs between countries. In this respect, Gassmann (2006) and Huizingh (2011) suggest examining the external context characteristics of open innovation and Bogers et al. (2017) stress the need for further research on open innovation at levels of analysis higher than the firm, including national and governmental, and the use of large data bases. In this article, we compare Spain and Portugal. To the best of our knowledge, no studies have yet been published on typologies of open innovation profiles of SMEs for Portugal and one study has been published that includes the case of Spain (García-Martínez et al., 2014). Importantly, these two countries have consistently comparable overall innovativeness scores (European Commission, 2009, 2017) and SME share in their economies. One of the main points in this article is to show that country differences can emerge even when comparing relatively homogeneous economies.

This study contributes to answering some of the remaining questions about open innovation and SMEs (Bogers et al., 2017). It does so by obtaining different clusters of SMEs with both closed and open innovation profiles categorised according to their inbound open innovation activities, sources of knowledge for innovation and patterns of cooperation and using a much larger dataset than those used in the scarce cluster analyses (Verbano et al., 2015) that have been published on open innovation profiles in SMEs. The present article not only compares countries and firm sizes with respect to open innovation profiles, but – to the best of our knowledge – includes the first portrait of the evolution of said profiles over time.

Given that open innovation and knowledge transfer are key elements in the policy agenda of the European Commission (European Commission, 2013, 2016) and that there is a need to not only develop monitoring systems on how well organisations and institutions are performing in these aspects at the Member States level, but also to assess the progress of said performance over time (Debackere et al., 2014), the results constitute a step towards showing that significant differences exist across countries, even when they have similar overall innovativeness levels (Balaz et al., 2005; Debackere et al., 2014; García Manjón, 2010). This is even more relevant as we show these differences evolve over time. The results of this study could contribute to tailoring open innovation policies for both small and medium-sized firms to country specificities.

This article is structured as follows: Section 2 presents a brief overview of the existing literature on open innovation in SMEs and the empirical quantitative studies on open innovation in SMEs in Europe; there follows, in Section 3, an explanation of the data and methodology used; Section 4 contains the analysis of the results; and last, these results are discussed and conclusions drawn in Section 5, along with comments on the limitations and suggestions for future related research.

2 Review of the literature

2.1 Open innovation in small and medium-sized enterprises

Over the last few decades, various studies have disagreed about the relationship between the size of the firm and the role the firm plays in innovation (Gopalakrishnan and Damanpour, 1997). Larger size is usually associated not only with more available resources to generate innovation (Cassiman and Veugelers, 2006; Christensen et al., 2005; Lee et al., 2010; Lichtenthaler, 2008; Spithoven et al., 2013), but also with economies of scale that allow firms to maximise the performance of the technological and human capital at their disposal. Conversely, larger size is also associated with more bureaucratic procedures that tend to create an unfavourable environment for innovation processes (Keupp and Gassmann, 2009; Lichtenthaler, 2008; Lichtenthaler and Ernst, 2007).

Smaller firms, on the contrary, are more flexible and entrepreneurially minded and less bureaucratic when it comes to innovation (Acs and Audretsch, 1991; Christensen et al., 2005; Lee et al., 2010; Van de Vrande et al., 2009). They are also more willing to take risks, have more specialised knowledge, are more adept at taking decisions quickly and integrate the innovations they have generated more effectively (Narula, 2004; Parida et al., 2012). Regarding limitations for innovation, however, it must be remembered that smaller size is associated with more difficulties in generating resources (Lee et al., 2010) and less experience and know-how when it comes to developing costly innovations (Narula, 2004).

Different studies sustain that the openness of the innovation process can also be significantly advantageous for SMEs (Brunswicker and Vanhaverbeke, 2015; Debackere et al., 2014; Henkel, 2006; Laursen and Salter, 2006; Parida et al., 2012). The size effect is most commonly studied in the empirical literature, with comparisons between large firms and SMEs as a group (see Lee et al., 2010; Narula, 2004; Spithoven et al., 2013); articles that contrast small and medium-sized firms, on the other hand, are far fewer (see Van de Vrande et al., 2009; Verbano et al., 2015). The extent to which the size differences that characterise large firms and SMEs can be applied to small and medium-sized firms is unclear (Prajogo et al., 2013). In general, the effects of size on innovation practices have been found to not be linear and it appears that various thresholds exist for certain innovation practices (Barge-Gil, 2010a; Cassiman and Veugelers, 2002). Having said that, multi-actor alliances and networks in SMEs are used to help them achieve critical size to access key resources and the technology needed for innovation (Lee et al., 2010). Huizingh (2011) and Spithoven et al. (2013) highlight the fact that SMEs may be specifically interested in opening up their innovation processes to overcome their limited resources, that is, as a means "to overcome their liability of smallness" [Gassmann et al., (2010), p.216]. The empirical evidence on size differences in studies of open innovation profiles in SMEs is mixed (Van de Vrande et al., 2009; Verbano et al., 2015).

Gassmann et al. (2010), West et al. (2014) and Vanhaverbeke et al. (2014) recognise the need for further study on how open innovation applies specifically to smaller firms. The first aim of this article is to research which open innovation profiles apply to SMEs and the extent to which size is important within the SME category regarding said profiles.

2.2 Country as an evolving policy factor in open innovation

Innovation policies in the EU are implemented at different levels: regional plans coexist with national and European strategies, constituting a multilevel approach to the promotion of innovation in Europe (Balaz et al., 2005; García Manjón, 2010). Efforts have been made to coordinate these policies (European Council, 2000; Hollanders et al., 2016) whilst taking the overall technological position of each country into account (Izsak et al., 2015). Some of these policies specifically target SMEs, chief among them those aimed at entrepreneurship and access to finance (Muller et al., 2014).

The EU has also taken the initiative to specifically boost open innovation European-wide (Curley and Salmelin, 2013; European Commission, 2013, 2016). At the same time, several studies (Curley, 2015; Debackere et al., 2014; De Jong et al., 2008; European Commission, 2016) recognise that there is significant heterogeneity in Europe with regards to the performance, output and impact of open innovation. To set out a coherent whole of policy recommendations on open innovation, it is important that actions are coordinated at the EU level while simultaneously considering the specificities of the status of open innovation in the various member states. In order to do so it is critical to not only develop monitoring systems to measure the development and progress of open innovation in these states, but also to ensure that the data used for monitoring comes from official sources like the Eurostat Community Innovation Survey (CIS) to facilitate comparison (García Manjón, 2010). In this respect, open innovation has for some time been recognised as having many facets and typologies, rather than as being an open versus closed dichotomy (e.g., Verbano et al., 2015). For all the above reasons, innovation measures that focus on some form of overall level in the country must be interpreted with caution as they could mask subtle but important differences. The same policy mix may work well in countries with very different distances from the technology frontier; while on the contrary, country idiosyncrasy could explain why the same policies fail to work in places with similar distances from the technology frontier.

In this study we compare the open innovation profiles of SMEs in Spain and Portugal. The decision to compare these countries is based on the fact that SMEs constitute more than 95% of the business world in these economies (Muller et al., 2014). According to the European Innovation Scoreboard (European Commission, 2009, 2017), both Spain and Portugal fall into the category of moderate innovators with innovation indexes between 10% and 50% below the EU average. The second aim of this article is to raise awareness of potential country idiosyncrasies in open innovation profiles beyond the overall innovation indexes by comparing two countries included in the same category. According to the same European Commission report (2009), the differences between the two countries lie in the detailed indicators: at that time, Spain was clearly ahead of Portugal regarding intellectual assets, economic effects and financial support, while Portugal was significantly ahead of Spain in firm investments and innovators.

Open innovation can also be regarded as a multi-stage process wherein some practices, such as consumer involvement as a source of information (e.g., Van de Vrande et al., 2009), appear earlier than cooperation (e.g., Westerlund and Leminen, 2011). Poot et al. (2009) find that the use of external information is generally embraced earlier than cooperation, and that even at later stages, cooperation with competitors and especially with universities is achieved by just a small number of firms. This explains why public policy mixes also evolve over time (Iszak et al., 2015). The third aim of this article is to

depict the evolution of open innovation profiles and, to this end; we combine three waves of the CIS survey.

2.3 Empirical quantitative studies of open innovation in SMEs in Europe

Recent years have seen an increase in the number of empirical studies using large-scale data concerned with open innovation activities in Europe. Of these, we will focus on the articles that either centre on SMEs or include them. Table 1 summarises the main works published on this subject. The data source of the articles is included to highlight those that use CIS data.

The CIS questionnaire draws on a long tradition of innovation research and is used extensively in most European countries (Laursen and Salter, 2006). The European-wide availability of CIS data has contributed to the surge of empirical work on open innovation (Abramovsky et al., 2009; Barge-Gil, 2010b; Cassiman and Veugelers, 2002; Frenz and Ietto-Gillies, 2009; Grimpe and Sofka, 2009; Laursen and Salter, 2006; Poot et al., 2009; Spithoven et al., 2013). Key advantages of using CIS data are their large sample sizes, their country representativeness, their comparability across countries and the use of best survey research practices ensured by the resources and know-how of the countries' statistical offices. Conversely, the questions included in the survey fail to cover the full spectrum of open innovation practices, especially regarding outbound innovation, which is why single-country open innovation research has tended to use primary data and tailored questionnaires and inbound open innovation in SMEs is reported to be far more diffuse than outbound open innovation (Enkel et al., 2009; Van de Vrande et al., 2009).

The articles included in Table 1 that are most closely related to this study are those that use cluster analysis. They are Lichtenthaler (2008), who classifies a firm's strategic approach to open innovation with two global measures: external technology acquisition and external technology exploitation; Van de Vrande et al. (2009), who classify open innovation practices from a range of open innovation activities; Brunswicker and Vanhaverbeke (2015), who construct a typology of five strategic types of external knowledge sourcing; and Verbano et al. (2015), who focus on three variables related to cooperation: number of partners, variety of partner typology and variety of phases in the innovation process in which partners are involved. None of these studies compare country results, and they all use just one wave of data. Studies that apply cluster analysis and related techniques to official, multi-country samples of SMEs and use data from more than one year are thus promising.

3 Data and methods

3.1 Data

Data from the last three available waves of the Eurostat CIS survey (2004, 2006 and 2008) carried out in Spain and Portugal were used. The sample included firms with ten or more employees from all manufacturing and service industries. The analysis, however, included only the SMEs. The data of all three waves were pooled in one single data set.

Table 1 Empirical studies on open innovation in Europe that use large-scale data and include small and/or medium-sized firms

Author	*Country*	*Firm size*	*Data*	*Sector*	*Quantitative methodology*
Hochleitner et al. (2017)	Spain	SMEs	CIS (2004–2006)	All (the manufacturing and service industries)	Logit models
Verbano et al. (2015)	Italy	SMEs	Web survey (2010–2011)	Manufacturing	Cluster/typologies
Brunswicker and Vanhaverbeke (2015)	Various European countries (not specified and not compared)	SMEs	Database various European countries (2007–2009)	Biotechnology, food, electrical, knowledge intensive services, machinery, space and textiles	Cluster/typologies
Van de Vrande et al. (2009)	The Netherlands	SMEs	DACST database (2005)	All (the manufacturing and service industries)	Cluster/typologies
Lichtenthaler (2008)	Germany, Austria and Switzerland	Medium and large	Licensing Executives Society (LES)	Technology firms	Cluster/typologies
Colombo et al. (2014)	Finland, Germany, Italy, Portugal and Spain	SMEs	ELISS II directory (2004–2005)	Open source	Poisson regression model
Spithoven et al. (2013)	Belgium	SMEs and large	CIS 4 (2002–2004)	All (excluding the public sector)	Probit and logit models
Parida et al. (2012)	Sweden	SMEs	Affarsdata (2008)	High-tech	Hierarchical regression model
Love et al. (2011)	UK	SMEs and large	Telephone survey (2009)	Services sector	Instrumental-variable Tobit model
Leiponen and Helfat (2010)	Finland	SMEs and large	R&D survey (1996–1998) and CIS (1994–1996)	All (manufacturing sector)	Probit and Tobit models
Frenz and Ietto-Gillies (2009)	UK	SMEs and large	CIS 2 and CIS 3 (1998–2000)	All (excluding the public sector)	Heckit model
Poot et al. (2009)	The Netherlands	SMEs and large	CIS 2, CIS 3 and CIS 4	All (excluding the primary sector)	Generalised linear model
Laursen and Salter (2006)	UK	SMEs and large	CIS 3 (2000)	All (excluding the public, retail, hotel and restaurant sectors)	Tobit models

Numerous studies use the variable 'number of employees' to measure firm size. This category, however, varies from country to country and according to the reference source (see Lee et al., 2010; Spithoven et al., 2013; Van de Vrande et al., 2009; Zeng et al., 2010). The Oslo Manual's classification (OECD, 2005), which distinguishes between small firms (10–49 employees) and medium-sized firms (50–249 employees), was used in this study.

Our initial pooled sample was made up of 97,208 Spanish and Portuguese SMEs. Of those surveyed only innovative firms that answered the questions related to innovation practices were considered. Firms belonging to a business group were excluded as transference between companies from the same group could lead to distortion of the concepts of open and closed innovation.

Having thus filtered the sample and excluded the missing values, 31,003 firms were identified who stated that they had initiated at least one innovation activity related to their products or services between 2004 and 2008 and that this process had either been concluded, was still in progress or had been initiated but later abandoned. 84% of these firms were located in Spain and 16% in Portugal; 71% were small firms and 29% medium-sized firms.

3.2 Variables

We used the 20 variables of inbound innovation activities shown in Table 2. First, we considered the variables in-house R&D and external R&D as overall closed and open innovation activities (Spithoven et al., 2013).

Two variables of activities related to acquisition were also used

1 the acquisition of machinery, equipment and software

2 the acquisition of external knowledge (Laursen and Salter, 2006; Spithoven et al., 2013).

These variables allow us to identify how often SMEs acquire embedded technology (machinery and equipment) and non-embedded technology (knowledge) as innovation practices, as these are also indicators of openness (Barge-Gil, 2010a; West and Bogers, 2014).

Ten variables related to information sources were also considered (Laursen and Salter, 2006). One of these variables was internal, or within the firm, and nine were external. Of these nine external variables, four were classified as market sources (suppliers, customers, competitors and consultants), two were classified as institutional sources (universities and the government) and three were classified as other sources (associations, trade fairs and exhibitions, and scientific journals). As different studies have shown, external sources of knowledge are becoming an important competitive advantage for firms (Brunswicker and Vanhaverbeke, 2015; Henkel, 2006; Laursen and Salter, 2006; Spithoven et al., 2013), due mainly to the complexity of the innovation processes. This means that firms, SMEs included, look to acquire knowledge and skills from outside their company structure to complement their internal capabilities (Barge-Gil, 2010a; Cassiman and Veugelers, 2002; West and Bogers, 2014).

Table 2 Frequencies of innovation activities*

Variables	*Small* (*n = 22,023*)	*Medium* (*n = 8,980*)	*Total* (*n = 31,003*)
In-house R&D	43.4%	49.8%	45.3%
External R&D	20.5%	24.8%	21.8%
Acquisition of external knowledge	7.2%	8.4%	7.6%
Acquisition of machinery and equipment	44.4%	44.1%	44.3%
Information sources from within the enterprise	69.7%	73.7%	70.8%
Information sources from suppliers	57.0%	59.7%	57.8%
Information sources from customers	47.8%	49.6%	48.3%
Information sources from competitors	35.5%	37.7%	36.1%
Information sources from consultants	23.2%	27.9%	24.6%
Information sources from universities	15.3%	18.2%	16.1%
Information sources from government	12.5%	14.7%	13.2%
Information sources from trade fairs	35.9%	39.1%	36.8%
Information sources from scientific journals	29.6%	31.0%	30.0%
Information sources from associations	23.4%	25.3%	24.0%
Cooperation suppliers	9.1%	13.2%	10.3%
Cooperation customers	6.8%	8.2%	7.2%
Cooperation competitors	4.5%	5.9%	4.9%
Cooperation consultants	5.1%	7.8%	5.9%
Cooperation universities	7.2%	9.5%	7.8%
Cooperation government	5.9%	7.9%	6.5%

Note: *% of 'yes' or 'medium/high' answers.

Last, six variables of cooperation activities were considered: suppliers, customers, competitors, consultants, universities and/or the government (e.g., Laursen and Salter, 2006; Spithoven et al., 2013). Various studies have shown that a firm's decision to cooperate with innovation is motivated by the fact that cooperation is an effective way to improve the innovation projects' chances of success (Barge-Gil, 2010b; Becker and Dietz, 2004; Pisano and Verganti, 2008; Spaeth et al., 2010) and to benefit from a higher level of innovative performance (Laursen and Salter, 2006; Ragatz et al., 2002; Zeng et al., 2010). Other studies also demonstrate that cooperation activities with external

partners give firms the chance to access complementary resources, build synergies, access the market more easily, reach economies of scale and diversify risks by sharing the cost of the innovation project (Colombo et al., 2014; Spaeth et al., 2010; Van de Vrande et al., 2009). Cooperation with innovation activities can be considered as the utmost sign of openness and has been referred to as coupled open innovation (Gassmann and Enkel, 2004).

Unlike in Lichtenthaler (2008), Van de Vrande et al. (2009), Brunswicker and Vanhaverbeke (2015) and Verbano et al. (2015) some closed innovation variables (in-house R&D and information sources from within the enterprise) are included in this study, serving to distinguish between firms that are innovative overall and firms that are innovative with an open profile, which were not distinguished in the cited previous studies. The inclusion of these variables is further justified by their link with absorptive capacity by which in-house innovation activities help assimilate external knowledge (Cohen and Levinthal, 1990). It is also justified by their relationship with relevant innovation outcomes, even in the open innovation era (Hochleitner et al., 2016). Unlike in Lichtenthaler (2008), Brunswicker and Vanhaverbeke (2015) and Verbano et al. (2015) a wide range of open innovation activities that have shown predictive validity regarding the open development of innovations (Hochleitner et al., 2017) are included in this study.

These 20 variables cover both pecuniary and non-pecuniary aspects of inbound innovation. It is true that the CIS surveys do not include outbound innovation indicators (even though cooperation could be considered both inbound and outbound; see Enkel et al., 2009). Nonetheless, we believe that a quality classification of open and closed innovation profiles can be achieved after contrasting the available variables for the study with the literature about open innovation (Huizingh, 2011; Van de Vrande et al., 2010; West and Bogers, 2014).

3.3 Statistical methods

First, we converted all the variables into binaries so that those with more categories did not have a greater influence on the final results (Le Roux and Rouanet, 2010). The variables in-house R&D, external R&D, acquisition of machinery and acquisition of external knowledge were already binary in the CIS survey. For the information sources, the categories ‘nothing’ and ‘little’ were grouped together, as were the categories ‘medium’ and ‘high’. This grouping aimed to identify a substantial rather than anecdotal use of the sources. For the cooperation variables, the category ‘yes’ included any cooperation regardless of geographical location.

Before carrying out the classification analysis, the qualitative variables were converted into a smaller number of numerical dimensions by means of a multiple correspondence analysis (e.g., Le Roux and Rouanet, 2010). Contrary to principal component analysis (the method used by Van de Vrande et al., 2009), multiple correspondence analysis is suited to binary variables indicating innovation activities. Three dimensions were interpretable, which together explained almost all the corrected inertia (Benzécri, 1979): 87.3%, 10.6% and 1.5%.

The cluster analysis was carried out on these three dimensions, which had previously been standardised. The size of the sample meant that hierarchical methods were not viable, so the method used was k-means (e.g., Everitt et al., 2001). To avoid local optima, which is the main weakness of the k-means method, the classification was repeated

50 times, choosing firms from the sample at random to be the initial cluster centres. The best solutions between three and eight clusters were examined with the following percentages of variance explained by the set of dimensions: 46.6% (3), 59.9% (4), 65.4% (5), 68.3% (6), 73.8% (7) and 76.7% (8). Each additional cluster up to five revealed an innovation profile with significant qualitative differences with respect to the previous classification. The SPSS v19 programme was used to carry out all the analyses.

4 Results

4.1 Innovation activities of small and medium-sized enterprises

The analyses were carried out on the 20 innovation activities (Table 2) undertaken by the SMEs during the study period. Regarding firm size, the results show that both small and medium-sized firms are tending to look towards using open innovation activities in their innovation processes (mainly external R&D, acquisition of machinery and external sources of knowledge).

4.2 Three innovation dimensions

In the multiple correspondence analysis (Table 3), we identify three dimensions which represent the overall degree of innovativeness and the openness profiles of the innovation process and we interpret them according to the sign of the coordinates of the variables with large absolute contributions.

Table 3 Multiple correspondence analysis

Variables	*Category*	*Coordinates*			*Absolute contributions*		
		Dim 1	*Dim 2*	*Dim 3*	*Dim 1*	*Dim 2*	*Dim 3*
In-house R&D	No	0.424	0.045	0.184	0.022	0.000	0.013
	Yes	–0.512	–0.054	–0.222	0.027	0.001	0.015
External R&D	No	0.225	0.102	0.079	0.009	0.004	0.003
	Yes	–0.807	–0.365	–0.283	0.032	0.013	0.012
Acquisition of external knowledge	No	0.067	–0.009	–0.089	0.001	0.000	0.005
	Yes	–0.820	0.115	1.084	0.012	0.000	0.061
Acquisition of machinery and equipment	No	0.068	–0.176	–0.461	0.001	0.008	0.082
	Yes	–0.086	0.221	0.579	0.001	0.010	0.103
Information sources from within the enterprise	No/low	0.585	–0.321	–0.002	0.023	0.014	0.000
	Medium/high	–0.241	0.132	0.001	0.009	0.006	0.000
Information sources from suppliers	No/low	0.340	–0.471	–0.408	0.011	0.043	0.049
	Medium high	–0.248	0.345	0.298	0.008	0.031	0.036
Information sources from customers	No/low	0.473	–0.368	–0.128	0.026	0.032	0.006
	Medium/high	–0.505	0.393	0.137	0.028	0.034	0.006

Notes: Dim 1: overall innovativeness. Dim 2: cooperation versus external information absorption. Dim 3: public versus private sources and partners.

Table 3 Multiple correspondence analysis (continued)

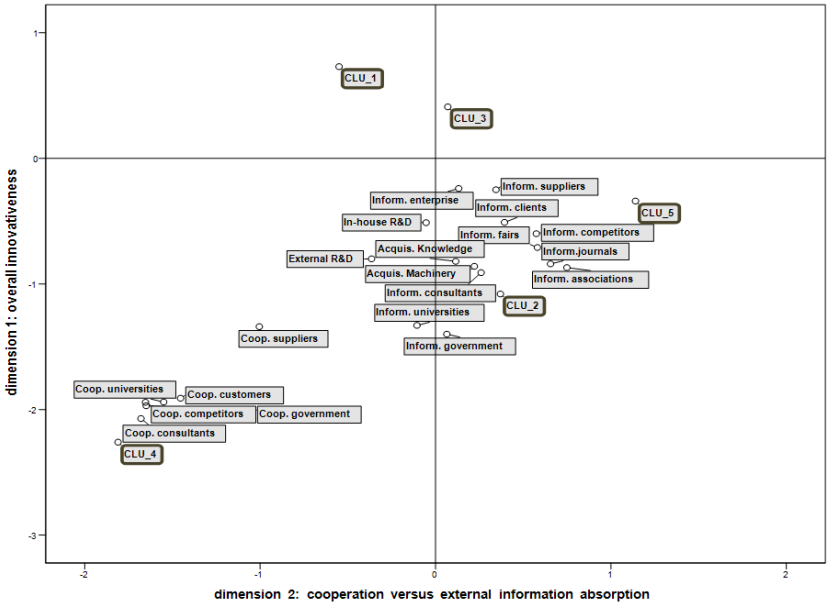
Variables	*Category*	*Coordinates*			*Absolute contributions*		
		Dim 1	*Dim 2*	*Dim 3*	*Dim 1*	*Dim 2*	*Dim 3*
Information sources from competitors	No/low	0.339	–0.325	–0.070	0.017	0.031	0.002
	Medium/high	–0.601	0.575	0.125	0.030	0.054	0.004
Information sources from consultants	No/low	0.295	–0.085	0.124	0.015	0.002	0.008
	Medium/high	–0.906	0.260	–0.381	0.046	0.008	0.025
Information sources from universities	No/low	0.255	0.020	0.200	0.012	0.000	0.023
	Medium/high	–1.325	–0.106	–1.040	0.064	0.001	0.120
Information sources from government	No/low	0.212	–0.010	0.176	0.009	0.000	0.019
	Medium/high	–1.401	0.064	–1.160	0.059	0.000	0.122
Information sources from trade fairs	No/low	0.411	–0.338	–0.033	0.024	0.033	0.000
	Medium/high	–0.706	0.581	0.057	0.042	0.057	0.001
Information sources from scientific journals	No/low	0.360	–0.280	0.011	0.021	0.025	0.000
	Medium/high	–0.841	0.655	–0.025	0.048	0.059	0.000
Information sources from associations	No/low	0.273	–0.236	0.020	0.013	0.019	0.000
	Medium/high	–0.867	0.749	–0.064	0.041	0.061	0.001
Cooperation suppliers	No	0.154	0.115	–0.143	0.011	0.043	0.049
	Yes	–1.345	–1.005	1.247	0.008	0.031	0.036
Cooperation customers	No	0.148	0.113	–0.099	0.005	0.005	0.006
	Yes	–1.908	–1.454	1.270	0.060	0.070	0.080
Cooperation competitors	No	0.101	0.086	–0.057	0.002	0.003	0.002
	Yes	–1.942	–1.653	1.104	0.042	0.062	0.042
Cooperation consultants	No	0.130	0.105	–0.038	0.004	0.005	0.001
	Yes	–2.072	–1.679	0.614	0.057	0.076	0.015
Cooperation universities	No	0.165	0.132	0.033	0.006	0.007	0.001
	Yes	–1.942	–1.550	–0.383	0.067	0.086	0.008
Cooperation government	No	0.136	0.114	0.023	0.004	0.006	0.000
	Yes	–1.969	–1.650	–0.336	0.057	0.080	0.005

Notes: Dim 1: overall innovativeness. Dim 2: cooperation versus external information absorption. Dim 3: public versus private sources and partners.

In dimension 1, the negative values correspond to carrying out any of the 20 innovation activities, while the positive values correspond to failing to undertake any activity. Therefore, this dimension does not relate to openness, but to global innovation, which we call *overall innovativeness*.

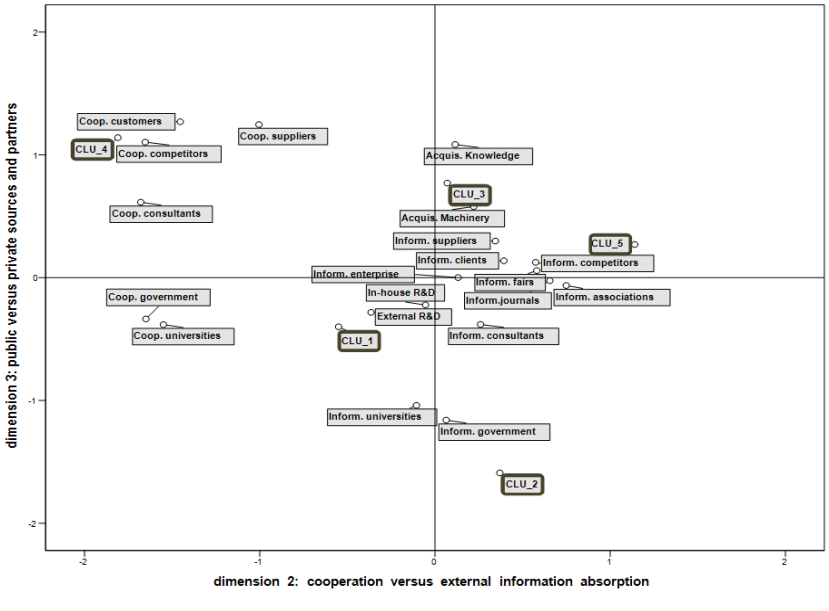
In dimension 2, the positive values correspond to the open innovators in the sense of using information from trade fairs, associations, journals, competitors, customers and suppliers. The negative values correspond to the open innovators in the sense of cooperating with external partners. We call this dimension *cooperation versus external information absorption*.

Figure 1 First and second dimensions



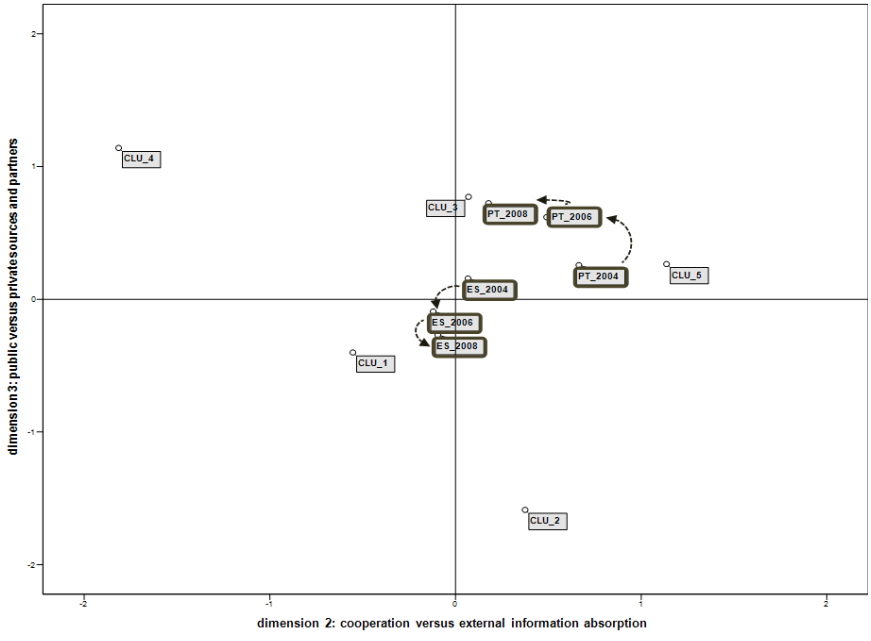
Notes: 'Yes' and 'medium/high' categories of the 20 innovation activities and cluster centres*.
*CLU_1 to CLU_5 show cluster centres.

Figure 2 Second and third dimensions



Note: 'Yes' and 'medium/high' categories of the 20 innovation activities and cluster centres*.
*CLU_1 to CLU_5 show cluster centres.

Figure 3 Second and third dimensions



Notes: Cluster, country and year centres.
*CLU_1 to CLU_5 show cluster centres. PT_2004 and ES_2004 show the centres of Portuguese and Spanish firms in the 2004 CIS wave; PT_2006, ES_2006, PT_2008, and ES_2008 show the same in 2006 and 2008.

In dimension 3, the positive values correspond to the open innovators, in the sense of acquiring knowledge, machinery and/or equipment and cooperating with suppliers, customers and competitors. The negative values correspond to the open innovators in the sense of using information from the government and universities. We call this dimension *public versus private sources and partners*.

In short, dimensions 2 and 3 correspond to the distinct closeness and openness profiles with which the SMEs undertake their innovation activities. Given that this is one of the key aims of this study, we focus on dimensions 2 and 3, even though the cluster analysis is carried out on the three dimensions. Figures 1 and 2 show the categories 'yes' and 'medium/high' of the variables in dimensions 1 to 3.

4.3 Five distinct openness profiles

Figures 1 and 2 include the cluster means as additional points, clearly showing the pattern of innovative practices of the five identified clusters. These practices vary according to the openness of the innovation activities, ranging from firms with conservative innovation practices (closed innovators) to firms with different openness profiles. Table 4 shows the mean values of the three dimensions for each cluster. R-squared values show that the classification properly captures all the dimensions. We base interpretation on said mean values, with the assistance of Figures 1 and 2. Accuracy was checked by means of all possible contingency tables between clusters and innovation activities (not shown for the sake of simplicity).

Table 4 Relationships between dimensions, clusters, firm size, year and country

	Dim 1	*Dim 2*	*Dim 3*
Cluster			
1	.73	–.55	–.40
2	–1.08	.37	–1.59
3	.41	.07	.77
4	–2.26	–1.81	1.14
5	–.34	1.14	.27
ANOVA R-square	0.730	0.625	0.608
ANOVA Welch test sig.*	0.000	0.000	0.000
Firm size			
Small	0.05	0.01	0.00
Medium	–0.11	–0.03	0.00
ANOVA R-square	0.005	0.001	0.000
ANOVA Welch test sig.	0.000	0.001	0.882
Country			
ES	0.07	–0.07	–0.11
PT	–0.38	0.38	0.58
ANOVA R-square	0.027	0.027	0.063
ANOVA Welch test sig.	0.000	0.000	0.000
Year × country			
2004 ES	–0.04	0.07	0.16
2006 ES	0.16	–0.12	–0.09
2008 ES	0.04	–0.10	–0.27
2004 PT	–0.55	0.66	0.26
2006 PT	–0.30	0.49	0.62
2008 PT	–0.33	0.18	0.72
ANOVA R-square	0.034	0.038	0.090
ANOVA Welch test sig.	0.000	0.000	0.000

Notes: Means and one-way ANOVAs with heteroskedasticity robust Welch tests.
*This significance cannot be interpreted because it relates clusters with the same variables on which the classification is based.
Dim 1: overall innovativeness. Dim 2: cooperation versus external information absorption. Dim 3: public versus private sources and partners ES: Spain; PT: Portugal.

- *Cluster 1: closed innovators*. This group is located close to the origin of the coordinates in Figure 2. It contains the largest number of firms (34.4%) and includes the 'traditional' or 'closed' innovators whose innovations were developed mainly through their own efforts. That is, closed innovators are firms that use internal information and internal R&D to carry out their innovation activities. It is also the least innovative group (highest positive coordinate in the first dimension, see Figure 1).

- *Cluster 2: absorbers of specialised knowledge*. This group represents a profile of open innovators and includes 12% of the firms analysed, with a negative coordinate in dimension 3. These firms use mainly specialised sources of information to carry out their innovation activities: universities, government, consultants and associations. It is also the second most innovative group (substantial negative coordinate in the first dimension).
- *Cluster 3: acquirers*. This group is the second largest in terms of the number of firms (25.1%) and has a positive coordinate in dimension 3. Its openness profile is characterised by the acquisition of machinery and external knowledge and by external sources of information, especially from suppliers.
- *Cluster 4: co-operators*. This is the group with the smallest number of firms (6.7%) and has negative coordinates in dimension 2 and positive coordinates in dimension 3. These firms seek specialised collaboration with customers, suppliers, consultants, competitors and, to a lesser extent, with universities and the government. It is also the most innovative group, all things considered (lowest coordinate in the first dimension).
- *Cluster 5: absorbers of industry knowledge*. This group represents another open innovation profile. It comprises 21.9% of the firms and has positive coordinates in dimension 2. The most characteristic feature of the firms in this group is their use of sector-specific information to carry out their innovation activities: information obtained from customers, suppliers, trade fairs, competitors, journals and associations.

Table 5 Relationships between clusters, firm size, year and country

	Cluster 1	*Cluster 2*	*Cluster 3*	*Cluster 4*	*Cluster 5*
Total	34.4%	12.0%	25.1%	6.7%	21.9%
Firm size*					
Small	35.0%	11.7%	25.7%	6.0%	21.6%
Medium	33.0%	12.6%	23.6%	8.4%	22.5%
Country**					
ES	38.4%	12.4%	24.4%	5.6%	19.2%
PT	12.9%	9.8%	28.8%	12.5%	36.1%
Year × country***					
2004 ES	27.9%	10.6%	32.5%	6.4%	22.6%
2006 ES	42.6%	9.6%	24.0%	5.1%	18.6%
2008 ES	40.0%	16.1%	20.4%	5.6%	17.9%
2004 PT	6.4%	19.8%	19.8%	9.9%	44.0%
2006 PT	11.6%	5.9%	31.1%	9.7%	41.6%
2008 PT	16.8%	6.5%	32.1%	15.1%	29.4%

Notes: Row percentages, Cramér's V measures of association and Pearson's χ^2 tests for contingency tables.
*Cramér's V = 0.051; χ^2 sig. = 0.000; **Cramér's V = 0.233; χ^2 sig. = 0.000;
***Cramér's V = 0.149; χ^2 sig. = 0.000; ES: Spain; PT: Portugal.

4.4 Size and country differences in openness profiles

There is no substantial relationship between firm size and any of the three dimensions. Even if two of the relationships are statistically significant in table 4 (Welch test significance), R-squared values are negligible and the means are extremely close to the origin of the coordinates. Table 5 shows the cross tabulation of the classification by firm size and tells the same story: statistically significant (χ^2 test significance), albeit practically insignificant, differences in cluster composition by firm size (low Cramér's V statistic and small differences in row percentages).

Conversely, there is a substantial relationship between country and the three dimensions (especially the third). Table 4 shows the dimension means by country and reveals how many Spanish firms (ES) rely on public sources and partners compared to Portuguese firms (PT). Accordingly, Table 5 shows a higher presence of clusters 3 and 5 in Portugal and a higher presence of Cluster 2 in Spain. Portuguese firms also seem to have higher overall innovativeness (a negative coordinate in dimension 1, as shown in Table 4) and there is a corresponding higher presence of cluster 4 and a lower presence of cluster 1 (Table 5).

4.5 Evolution of openness profiles over time

The last rows of Tables 4 and 5 are concerned with the combinations of year (2004, 2006, and 2008) and country (ES, PT), which are related to the dimensions and the cluster compositions, respectively. Figure 3 shows the means of said combinations together with cluster centres in the same coordinate space of Figure 2.

Over the course of the study period, Portuguese SMEs' innovation strategies evolved from using mainly basic sources of information in 2004 to mainly acquiring complementary resources (knowledge, machinery and/or equipment) in 2008 (upward trend to the left in Figure 3). Accordingly, the importance of clusters 3 and 4 in Portugal is tending to increase over time and the importance of clusters 2 and 5 to decrease (Table 5).

Spanish SMEs have evolved quite differently from their Portuguese counterparts. They gradually stopped using the basic sources of information in their innovation processes that they were using in 2004 and by 2008 were using specialised sources of information, especially from universities and the government (downward trend in Figure 3). In Spain, clusters 1 and 2 have tended to increase in size over time and clusters 3 and 5 to decrease. By 2008, clusters 1 and 2 had become comparatively more important in Spain and clusters 3 and 4 in Portugal (Table 5).

Regarding overall innovativeness, stagnation and even a small decline is observed. The coordinate in the first dimension tends to increase slightly over time in both countries (Table 4) and the size of the least innovative cluster 1 increases in both countries (Table 5).

5 Discussion and conclusions

5.1 Implications for practice

In this article, a classification of the innovative practices of SMEs was established by means of analysing the inbound innovation activities they had engaged in:

1 closed innovators

2 absorbers of specialised knowledge

3 acquirers

4 co-operators

5 absorbers of industry knowledge.

The group of closed innovators contains the largest number of firms (34.4%), which are characterised by their use of internal information from their own R&D departments and their use of hardly any external innovation sources. In this study, this cluster is also the one with the lowest overall innovativeness. Lichtenthaler (2008) finds a much larger percentage of closed innovators (67.5%), while Brunswicker and Vanhaverbeke (2015) find a lower percentage (19.7%). The remaining cited studies of open innovation typologies do not identify any pure closed cluster.

The absorbers of specialised knowledge use mainly specialised sources of information such as universities, the government and, to a lesser extent, consultants and associations. The use of these sources of information is also reported to be important by Brunswicker and Vanhaverbeke (2015), Laursen and Salter (2006) and Leiponen and Helfat (2010). All things considered, this group is the second most innovative.

The acquirers are firms that acquire technology, be it embedded technology (machines and equipment) or non-embedded technology (knowledge), to innovate. This cluster contains the second largest number of firms (25.1%). See Brunswicker and Vanhaverbeke (2015) and Spithoven et al. (2013) regarding the importance of acquisition in open innovation.

The co-operators are the firms that have the boldest attitude towards open innovation activities because they generate and develop them through seeking to collaborate with customers, suppliers, consultants, universities, the government and competitors [see also Barge-Gil (2010b), Gassmann and Enkel (2004) and Narula (2004), with regards to the importance of cooperation]. All things considered, this group is the most innovative.

The absorbers of industry knowledge use mainly sector-specific sources of information such as customers, suppliers, trade fairs and competitors to innovate. These SMEs (21.9%) appear to be fairly open as on average they tend to draw on more than three relevant sources of knowledge and they seem to have an explicit search strategy for new knowledge. These firms are customer driven and so rely heavily on understanding customers' needs as a source of their innovations. These sources of knowledge are also found to be relevant in Brunswicker and Vanhaverbeke (2015), Laursen and Salter (2006) and Leiponen and Helfat (2010).

The clusters obtained in this study provide profiles on how SMEs use open innovation practices that only partially mirror those identified previously by Lichtenthaler (2008) for medium-sized and large manufacturers and by Van de Vrande et al. (2009) for small and medium-sized manufacturers and service firms. As in Van de Vrande et al.

(2009), openness profiles are identified here that go beyond the classic inbound/outbound distinction. Unlike in Lichtenthaler (2008), Brunswicker and Vanhaverbeke (2015) and Verbano et al. (2015), a wide range of innovation activities are considered in this analysis. The results also show that SMEs do adopt open innovation practices in their innovation processes (65.6% of companies belonging to clusters 2 to 5).

Practically no differences were found between the innovation profiles of small and medium-sized firms, which show that there is no threshold hindering small firms from benefiting from open innovation. After all, both small and medium-sized firms often lack the resources to develop and commercialise new products in-house and so may be inclined or forced to collaborate with other organisations (Gassmann et al., 2010; Huizingh, 2011; Spithoven et al., 2013). In the empirical literature, Verbano et al. (2015) drew the same conclusion for Italy as we do for Spain and Portugal, while Van de Vrande et al. (2009) found that medium-sized firms in the Netherlands engage in certain open innovation activities more frequently than do small enterprises.

5.2 Implications for policy makers

Evidence of country differences regarding open innovation profiles is still scarce (Bogers et al., 2017). Garcia-Martínez et al. (2014) found no differences in open innovation typologies in the UK, Spain and Italy, using data from firms of all sizes. This paper shows that the differences in the open innovation profiles of SMEs in Spain and Portugal are considerable.

Furthermore, said differences between Spain and Portugal are shown to increase over the study period. Portuguese SMEs follow the path established by the literature (Poot et al., 2009; Van de Vrande et at., 2009; Westerlund and Leminen, 2011). Cluster 5, which contains consumer involvement as an information source, decreases in size and cluster 4, which contains cooperation, increases. Portuguese firms are increasingly focusing on acquiring machinery and/or equipment and external knowledge and on cooperation [known as pecuniary and coupled open innovation activities, respectively, see Dahlander and Gann (2010) and Gassmann and Enkel (2004)]. Spanish SMEs, on the other hand, are increasingly characterised by their use of specialised sources of information, such as universities and the government. Although the two countries have similar SME share and overall innovation performance (European Commission, 2009, 2017), and despite the differences in performance observed prior to 2008 (European Commission, 2009), over the years Portugal has overtaken Spain in terms of financial support and has caught up in terms of intellectual assets, while Spain has gained advantage with respect to human resources (e.g., doctorate graduates; European Commission, 2017).

Both the country and the time differences in this study may be relevant for the design of European Commission policies aimed at boosting open innovation (Izsak et al., 2015). In the period 2004 to 2008, the term ‘open innovation’ was far from universally used in policy making. Nonetheless, EU member states’ traditional innovation policies already reflected some aspects of open innovation policies, for instance knowledge transfer, spill overs and cooperation fostering. Having said that, open innovation provides opportunities for broadening the set of policy instruments (De Jong et al., 2008) and SMEs deserve and will continue to deserve special attention. Regarding specific policies, one of the actions recommended by the independent expert group on open innovation and knowledge

transfer [Debackere et al., (2014), p.52] is to "adopt appropriate incentive schemes for academics, scientists and knowledge-transfer-organization staff to engage in co-creation processes with the users of academic knowledge", which could foster a path of open innovation profiles similar to Spain's. Another recommended action [Debackere et al., (2014) p.28] is to 'make the intellectual property regime fit for open innovation 2.0', which might foster paths like Portugal's. These recommendations must be interpreted with the utmost care, as causal effects of such policies remain largely unproven.

5.3 Limitations and future research

To the best of our knowledge, this is the first study on the evolution of open innovation profiles over time. Key precedents are the static studies by Brunswicker and Vanhaverbeke (2015), Verbano et al. (2015), Lichtenthaler (2008) and Van de Vrande et al. (2009). Regarding contributions, this article explicitly combines more than one country, compares the profiles of small and medium-sized firms and, contrary to previous studies, explicitly includes closed innovation practices, thereby distinguishing between overall innovativeness and openness.

Regarding limitations, while the study considers a wide range of innovation activities in the analysis, it does ignore the purely outbound type. This limitation is related to using CIS official statistics data, whose range of variables is not controlled by the researcher. Another important limitation regarding the data used is that they are based on the experiences of Spanish and Portuguese SMEs, and the more we believe in country specificities, the more the results are specific to these countries. We expect the innovation practices of firms in other countries to be significantly different, and even more so if countries with larger differences in innovation performance are compared (European Commission, 2017).

To verify the above conjecture, future research could use data on SMEs from other countries with both the standard comparable secondary data provided by the CIS and richer data from tailor-made questionnaires. Once evidence from several countries is gathered, the factors contributing to these differences can be unveiled. Following the recommendation of one anonymous reviewer, complementary qualitative research on the reasons firms give for employing certain practices and for changing practices would provide further insight into the reasons for country differences and variations over time, as at the moment a thorough explanation for said differences and their evolution is elusive.

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