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## SECTORAL DETERMINISM FOR (INBOUND OPEN) INNOVATION PATTERNS?

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*The purpose of the present paper is to categorise the innovation processes of individual organizations by drawing attention to their open innovation strategies from an integrated view that combines both manufacturing and service firms. The study is based on firm-level data from the 2004 Spanish Community Innovation Survey (CIS) and uses multivariate exploratory techniques in the search to clarify the (dis-)similar innovation patterns amongst a set of 7,597 innovative organizations from 26 different industries. The results lead only to consider two services-predominant categories: i) supplier-dominated and ii) science-based.*

## 1. Introduction

Literature on open innovation, that is on the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively (Chesbrough, 2006), has profusely increased over the last decade. However, the rapid adoption of the term among innovation scholars from very different disciplines seems not to lie on the complete novelty of its claims (Cassiman and Valentini, 2013; Trott and Hartmann, 2009; Christensen et al., 2005; Gann, 2005), but on its capacity to embrace and connect the internal and external organization of the innovation process of firms under a sole umbrella and, thus, on the meta-capacity of the term for conceptual integration.

Back in the 70s and 80s, innovation was already considered a collective process to a certain extent (Rothwell et al., 1974; Tushman, 1977; Allen, 1983), partially conducted outside firms' boundaries (Teece, 1988). As a matter of fact, as firms have always relied on outflows and inflows of knowledge (Hargadon, 2003) and rarely innovated in isolation from the economic system (Christensen and Lundvall, 2004), some authors (e.g., Monwery, 2009) have suggested that the innovating-in-isolation approach might have been the exception in a history characterized mostly by open innovation practices. Nevertheless, the decreasing tendency in the productivity of the innovation process (e.g., increased cost of R&D, shorter product life cycles) in addition to other relevant developments (e.g., the rise of new information and communication technologies, the increasing mobility of knowledge workers, etc.) are supporting a recent intensification of the open innovation practices. Open innovation has proved to be a valuable concept for so many firms and in so many contexts, that it is on its way to become innovation (Huizingh, 2011).

Whether this is the case, an important and prevalent debate in service innovation and related literature concerns the issue of whether or not the (open) innovation process in services differs to that in manufacturing (Gallouj and Windrum, 2009). Along with the transformation of advanced societies into service-based economies, a number of taxonomies emerged in order to categorise services' innovation endeavours. From Pavitt's (1984) seminal classification, which conferred services a supplier-dominated role in the innovation process – not as true innovators but as dependent on external sources for the supply of technology –, different works distinguished and characterised a variety of innovation patterns among economic activities (i.e., Evangelista, 2000; Archibugi, 2001; Hollestein, 2003; Hipp and Grupp, 2005; De Jong and Marsili, 2006; Castellacci, 2008; Camacho and Rodriguez, 2008; Theter and Tajar, 2008; Miles 2008; and Trigo and Vence, 2012). However, despite some pertinent exceptions (i.e., De Jong and Marsili, 2006), most of studies considered services in isolation from the manufacturing sector, leading to a fragmentation between manufacturing and service innovation studies (Castellacci, 2008) and failing to provide an integrated perspective that enable us to gain greater insight into the differences between innovation patterns prevailing in the two sectors (Hollestein, 2003). Additionally, even though, in a technology-based taxonomy, firms should be classified according to their intrinsic characteristics (e.g., sources of innovation, etc.), and independently from an output-based (industry) classification (Archibugi, 2001), most taxonomies on service innovation have been built at the sectoral level.

The openness of the innovation process can differ across technologies and industries (Christensen et al., 2005; Gassman, 2006; Poot et al., 2009). Given the distinct nature of the offerings of manufacturing and services firms, differences in the adoption of open innovation may be plausible (Van de Vrande et al., 2009). However, as the initial discussion of open innovation placed the focus on product and technology innovation (Chesbrough, 2011), service innovation is being almost completely overlooked within the open innovation literature. Accordingly, the purpose of the present paper is to categorise the innovation processes of individual organizations by drawing attention to their open innovation strategies from an integrated view that combines both manufacturing and service firms. As service and manufacturing activities are becoming increasingly more intertwined there is an increasing need for approaching a common framework, instead of maintaining the dichotomy between both industries. Finally, few studies explored openness using large-scale datasets covering a variety of different industries (Dahlander and Gann, 2010). The present study is based on firm-level data from the 2004 Spanish Community Innovation Survey (CIS). The work uses multivariate exploratory techniques in the search to clarify the (dis-)similar innovation patterns amongst a set of 7,597 innovative organizations from 26 different industries.

The work is organised as follows. After this introduction, Section 2 briefly reviews some literature on service innovation processes. Section 3 discusses on the studies that have built taxonomies to categorise service innovation patterns. Then, we present the data and set the methodological framework. After reporting the results, we conclude with some final remarks.

## 2. Patterns of service innovation

The attempts in literature for disentangling particular patterns of innovation development across sectors share a cognitive basis, related to the notion of technological-regimes (Nelson and Winter, 1977) and technological-trajectories (Dosi, 1982). On the one hand, a technological regime can be defined as the technological and knowledge environment in which firms operate (Malerba, 2002). This environment sets the context (e.g., opportunities, constraints, etc.) for developing innovation activities in the different sectors of the economy, and is generally composed by the level of technological opportunities, appropriability conditions, cumulativeness of technological knowledge, and the characteristics of the relevant knowledge base (Malerba and Orsenigo, 1996). Thus, the innovation strategies of firms vary substantially across sectors because industries have different characteristics of their technological regimes.

On the other hand, the technological regime indicates the directions or paths in which innovation is possible, that is, the technological-trajectories. According to Pavitt (1984), different principal activities generate different technological trajectories, which can be usefully be grouped into categories or taxonomies of innovation. Based on the technological competences of firms, Pavitt proposed a four-type taxonomy in order to describe their behaviour, predict their actions and suggest policy implications. The basic unit of analysis was the innovating firm due to the importance of their cumulative technological trajectories. The analysis, which included data on 2,000 innovations and innovating firms (manufacturers and services) in Britain from 1945 to 1979, was based upon three main characteristics (sources of technology, users' needs, and means of appropriating benefits) that differentiated across sectors. The taxonomy grouped into: i) supplier-dominated firms (dependent on providers of equipment and materials for innovation, i.e., many professional, financial and commercial services); ii) large-scale producers (i.e., glass, steel, etc.); iii) specialised suppliers (i.e., machinery, instruments); and iv) science-based firms (reliant on their own R&D activities for innovation, i.e., chemical and electrical sectors). In a later version, another category was added to classify emerging information-intensive firms using advanced data processing such as banking or retailing (Pavitt et al., 1989).

Inspired by Pavitt´s contribution, a number of studies sought to understand the diverse modes of innovation within service activities. In this respect, Den Hertog and Bilderbeek (1999) carry out, by means of a conceptual and qualitative analysis, a typology of seven service innovation patterns, which are grouped on the basis of the diverse role played by suppliers of inputs, the (innovating) service firm, and the client of the innovative product (final or intermediate). Another relevant contribution is the Miozzo and Soete (2001) categorisation that splits service sectors into four main groups, based on their technological linkages with manufacturing and other service sectors. These categories are namely: i) large-scale physical networks (i.e., transport and wholesale trade); ii) informational networks (i.e., finance, insurance and communications); iii) specialised suppliers and science-based firms (i.e., software and specialised business services); and iv) supplier-dominated firms (i.e., personal, public and social services).

By plotting technological innovation versus organizational innovation by sectors for the case of the UK, Miles (2008) shows that some service organizations behave very much like high-technology manufacturing (e.g., Technological-Knowledge Intensive Business Services). The author argues that, firstly, more technologically innovative sectors tend to be more organizationally innovative and, secondly, that the correlation is imperfect with manufacturing focused on technological innovation and services on organizational innovation. Beyond those categories observed by Miozzo and Soete classification, Miles (2008) introduces three further innovation styles: i) professional knowledge-based (adopters of new IT, but mainly supplier driven, i.e., producer KIBS); ii) public services (public organizations with suitable links with universities and higher shares of professional staff than most of supplier-dominated firms); and iii) interactive firms (closely cooperative with clients in the production or co-production of innovation).

Castellacci's (2008) taxonomy combines manufacturing and services within the same system of innovation, although it follows a (neo-schumpeterian) sectoral categorisation by stressing vertical linkages and inter-sectoral knowledge exchanges between economic activities. According to the position of each industry in the vertical chain and to the technological content of each industry, the author identifies a four-type taxonomy: i) advanced knowledge providers (with great technological and knowledge capabilities towards other economic sectors, i.e., suppliers of machinery, equipment and instruments, as well as R&D, software and consultancy services); ii) mass production goods (including science-based and scale-intensive manufacturing); iii) supporting infrastructural services (less knowledge-intensive intermediate services, including network and physical infrastructure services); and iv) personal goods and services (supplier-dominated activities at the final stage of the value chain). The conceptual exercise is confirmed ex-post on the basis of descriptive results for the Fourth CIS (2000-2004) at the industry level for a sample of 24 European countries and OECD data.

Anyhow, firm-level analyses increased during last decade. An example is Hollestein (2003), who uses cluster techniques to detect five innovation modes in the Swiss service sector: i) science- based high-tech firms with full network integration (i.e., R&D and business services); ii) IT-oriented network-integrated developers (i.e., IT services, banking, etc.); iii) market-oriented incremental innovators with weak external links (i.e., distributive trades); iv) cost-oriented process innovators with strong external links along the value chain (i.e., its structure is close to service sector average); and v) low-profile innovators with hardly any external links (i.e., hotels and restaurants, personal services, etc.). On the other hand, Hipp and Grupp (2005) explore the case for 513 service firms from the German Innovation Survey 2000 by means of a probit analysis. Their results suggest that the Miozzo and Soete taxonomy adjust to specific firms of their dataset, but cases of each style are found in every sector examined. Accordingly, the authors regard a four-innovation-modes taxonomy, namely: i) knowledge intensity (firms with close links with customers and universities); ii) network basis (firms that use technological systems, data processing software, etc.); iii) scale intensity (firms that generate standardized services); and iv) supplier dominance (firms that declare innovation being developed outside).

Camacho and Rodriguez (2008) undertake a non-hierarchical cluster analysis using data on 1,193 innovating service firms from the Spanish Innovation Survey 2000 and they identify five different service innovation clusters: i) firms with production efficiency strategies (product and process innovation oriented and interactive firms); ii) product innovating firms (based on acquisition of machinery and technology); iii) low innovative supplier-dominated firms; iv) high innovative low integrated firms (innovative but non-interactive firms); and v) innovative highly integrated firms (R&D is relevant as well as collaboration with others). Some correspondence can be observed with respect to Miozzo and Soete's (2001) and Hollestein (2003) classifications. Again, no single pattern of innovation is found for each industry, that is, intra-sectoral diversity exists. However, Tether and Tajar (2008) conclude that service firms often perform 'soft' innovation, which involves organizational and relational changes within supply-chains or networks. Using firm-level data for 2,500 organizations from the European Innobarometer, the authors suggest three different modes of innovation: i) product- research mode; (mostly large and high-technology firms); ii) process-technologies (mostly low-technology manufacturers); and iii) organizational-cooperation (more likely amongst small services firms).

More recently, Trigo and and Vence (2012) explore and group, through latent class analysis, 2,148 Spanish innovating firms from twenty service sub-sectors. The authors identify six different clusters that are reduced into three broad profiles, namely: i) firms which are intensive in techno-scientific flows of information; ii) firms with intensive interactions with clients; and iii) lonely innovators. The results confirm that diverse cooperation patterns within the same industry co-exist and a direct relationship between cooperation and innovation performance: both embrace a positive feedback loop. However, it is stated that the probability that a service firm innovates in isolation is around 60%.

All previous works follow a particular approach and, thus, reach to different taxonomies, which, in occasions, keep some correspondence. As previously mentioned, some of them followed a sectoral approach, whilst others undertook firm-level analyses. In addition, we find hardly any studies that develop taxonomies of innovation considering manufacturing and service firms together. Among them, De Jong and Marsili (2006) is the only one based on micro-data analysis. By means of clustering techniques, they build a taxonomy specifically for micro and small enterprises (below 100 employees) in the Netherlands. Besides the supplier-dominated, specialised suppliers and science-based categories, already identified by Pavitt (1984), they find a fourth cluster of resource-intensive firms. In this latter category the degree of innovativeness is relatively higher and the role of suppliers less pronounced than in supplier-dominated type. They also show that patterns of innovation in services are at least as broad as that of manufacturing firms; and that both sectors share many common patterns. In fact, results do not show a clear-cut relationship between industrial sectors and clusters of firms.

Input and output innovation-related variables is another matter of heterogeneity among studies and different methodologies have been also explored, i.e., multiple correspondence analysis, factor analysis, hierarchical and non-hierarchical cluster analysis, latent class analysis, binary logistic regressions, probit estimations, etc. Finally, the multiplicity of taxonomies differ as regards their study’s object and focus: innovation-cooperation strategies, innovation orientation (i.e., technological vs. non-technological results), objectives of the innovation activity, managerial attitudes, technological regimes and trajectories, etc.). Therefore, input innovation-related variables and databases used for the empirical strategies also differ among the different works.

# 3. Data and methodology

The empirical analysis investigates the innovative behaviour of a range of manufacturing and service industries by using longitudinal firm-level data, based on the 2004 Spanish CIS, which is collected and compiled by the Instituto Nacional de Estadística (Spanish Statistical Institute). The main statistical unit is the enterprise and the target population is defined by those firms with 10 or more employees whose principal economic activity may be classified in one of the categories of NACE 10 to NACE 74. Following previous considerations on this matter (e.g., Tether, 2002), for the sake of simplicity, no attempt has been made to adjust the response to make it representative of businesses in Spain. Thus, the study analyses the data as a simple sample. The final sample consists of 7,597 innovative firms grouped into three different firm-size categories – small (10-49 employees), medium (50-250 employees) and large (>250 employees) – for which a wide and complete set of innovation-related data are available.

Even though business innovation process is assumed to be multi-faceted and influenced by a broad range of variables, in identifying open innovation patterns within and between industries we limit our analysis to specific attributes and characteristics at firm-level, leaving apart other potential influential factors such as those explicated in the National Innovation System discipline (e.g., Malerba, 2002, 2004; Cooke et al., 1997). On the one hand, despite the logic that supports an internally-oriented and centralised approach to R&D may remain obsolete (Chesbrough, 2003), the dual role of R&D (Cohen and Levinthal, 1989; 1990) and other knowledge attainment activities to create the absorptive capacity to track and evaluate developments outside firm boundaries and to become more attractive patterns for collaboration (Rosenberg's, 1990) lead to consider firms' engagement in innovation activities (IAC) a key open innovation dimension.

On the other hand, as inter-organisational networking relationships become fundamental instruments within the innovation process (Perkmann and Walsh, 2007), by considering openness as "the level of different sources of external knowledge that each firm draws upon in its innovative activities" (Laursen and Salter, 2006), the analysis also accounts for firm's attainment of information and knowledge from external market and institutional sources (SOU) and firms' cooperation arrangements with other organisations (COP). Accordingly, and for the sake of clarification, even though open innovation is about both sides of the R&D market (Chesbrough and Euchner, 2011), the analysis focusses on the inbound (vs. outbound) open innovation dimension (Gassmann and Enkel, 2006), that is, on how firms acquire (pecuniary) and source (non-pecuniary) knowledge and expertise in the marketplace (Dahlander and Gann, 2010; Asakawa et al., 2010).

Multivariate exploratory techniques are, then, applied to detect and then to analyse (dis)similarities in firms' open innovation patterns. Firstly, a Principal Component Analysis is undertaken in order to condense the information contained within the previously regarded 24 open innovation indicators into a smaller set of dimensions with minimum loss of information, as well as to identify a set of factors (Fj, j = 1,…, p) as linear combinations of the initial variables. The analysis leads to the detection of the structure in the relationships among the various variables, thus explaining these variables by means of their shared underlying dimensions (Hair et al., 1992).

Secondly, Cluster Analysis is applied, as it offers a sophisticated statistical tool for the creation of taxonomies and is specifically designed for classifying observations on behalf of their relative similarities with respect to a multidimensional array of variables (Peneder, 2005). The clustering exercise is applied from an overall and partial perspective. On the one hand, a hierarchical cluster analysis is used to detect a general pattern. The square Euclidean distance (Ward's method) measure is applied to calculate the closeness (distance) between two entities. On the other hand, non-hierarchical cluster analysis is applied to reach a final solution. For each number of groups (k), we perform a k-means cluster analysis. In addition, an agglomerative classification method is used, which relies upon the weighted pair-group average linkage. This rule is introduced to take into consideration differences in cluster sizes. A predetermined classification is not imposed and established ex-ante.

Finally, in the definition of suitable metrics to assess open innovation patterns, the research is guided by the 'subject' approach, which is based on an analysis of firms' own perceptions of their innovative activity (Hughes, 2000), instead of the 'object' approach, which draws attention on business rights appropriation settings or specific innovation developments. Accordingly, as occurred in other academic works in the service innovation discipline (e.g., Tether and Tajar, 2008) the empirical investigation has been influenced by the quality of the available data. This means that some concepts and definitions used throughout the analysis are survey-fixed, such as the sort of manufacturing and service industries, which strictly relates to the Statistical Classification of Economic Activities in the European Community (NACE), or the definition of innovation inputs, which comes delimited by the exploration of existing innovation survey data.

## 4. Clustering of firms

The structure in the relationships among the 24 original indicators, observed through the Pearson correlation matrix, shows the existence of significant correlation among some of these indicators. By applying the Principal Component Analysis and, after checking the right output from the covariance matrix and the Bartlett test (p(Bartlett)<0.001), a five-dimensional solution was obtained that account for 51.6% of total variance explained.1 To determine the number of components the analysis applies the latent root criterion (eigenvalues > 1.0). In order to obtain a better interpretation of the results, a varimax normalized rotation was realized. In addition, the evaluation of the communalities suggests that the all components provide an acceptable explanation for almost every variable in the analysis.

The first component reflects the sourcing of knowledge from industry agents, also including professional conferences and fairs, industry associations and publications. The second factor clearly matches with the whole set of cooperation for innovation related indicators. The third factor presents major loadings as regards the non-R&D related activities undertaken by firms (i.e., the acquisition of machinery and equipment, the purchasing of intellectual property rights, the training of personnel, the implementation of procedures and technical preparations). The fourth factor relates to the internal attainment of knowledge either by the development of in-house R&D activities or by the sourcing of knowledge from within the own firm or enterprise group. Finally, loadings for factor five are particularly relevant as regards the acquisition of extramural R&D and the sourcing of knowledge from specialized knowledge providers (i.e., universities, public and private R&D institutes) outside firms' boundaries.

[1] See Table A.3 in the Appendix.

Even though the aim behind the PCA exercise is basically to reduce the number of dimensions contained within the broad set of input indicators, the results make the components feasible to be interpreted and labelled: i) Sourcing of knowledge from industry agents (SOUIND); ii) Engagement in cooperation activities (COOPER); iii) Engagement in non-R&D related innovation activities (IACNON); iv) Engagement in internal R&D related activities (IACR&D); and v) Sourcing (and acquisition) of knowledge from external specialized providers (SOUSPE).

**Table 1**: Intensity of use of innovation inputs by cluster

| *Indicators* | *C1* | *C2* | *C3* | *C4* | *C5* | *C6* | *C7* | *C8* | *C9* |
|---|---|---|---|---|---|---|---|---|---|
| $IAC_1$ | 5 | 4 | 1 | 4 | 2 | 3 | 4 | 5 | 5 |
| $IAC_2$ | 2 | 3 | 1 | 4 | 1 | 3 | 3 | 4 | 5 |
| $IAC_3$ | 1 | 5 | 5 | 4 | 4 | 2 | 3 | 4 | 4 |
| $IAC_4$ | 1 | 4 | 3 | 4 | 1 | 1 | 1 | 5 | 4 |
| $IAC_5$ | 2 | 5 | 2 | 4 | 2 | 1 | 2 | 5 | 4 |
| $IAC_6$ | 3 | 5 | 1 | 4 | 1 | 1 | 1 | 5 | 4 |
| $IAC_7$ | 2 | 5 | 1 | 4 | 1 | 1 | 1 | 5 | 4 |
| $SOU_1$ | 5 | 5 | 1 | 5 | 4 | 4 | 5 | 5 | 5 |
| $SOU_2$ | 4 | 5 | 4 | 3 | 5 | 1 | 5 | 5 | 5 |
| $SOU_3$ | 5 | 5 | 1 | 2 | 5 | 1 | 5 | 5 | 5 |
| $SOU_4$ | 4 | 5 | 2 | 2 | 5 | 1 | 5 | 5 | 5 |
| $SOU_5$ | 2 | 3 | 1 | 2 | 3 | 1 | 5 | 5 | 5 |
| $SOU_6$ | 1 | 1 | 1 | 2 | 1 | 2 | 5 | 5 | 5 |
| $SOU_7$ | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 5 | 4 |
| $SOU_8$ | 4 | 4 | 2 | 2 | 4 | 1 | 5 | 5 | 5 |
| $SOU_9$ | 3 | 4 | 1 | 2 | 3 | 1 | 5 | 5 | 5 |
| $SOU_{10}$ | 3 | 3 | 1 | 1 | 3 | 1 | 5 | 5 | 4 |
| $COP_1$ | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 5 |
| $COP_2$ | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 5 |
| $COP_3$ | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 5 |
| $COP_4$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 |
| $COP_5$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 |
| $COP_6$ | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 5 |
| $COP_7$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 |

Note: The intensity of use ranges from 5 (very high) to 1 (very low).

The five factors' scores are used as a basis for the cluster exercise. As exhibited in Table 1, firms in cluster 9 are those making use of innovation inputs to the greater extent. Even though these group of firms heavily rely on internal development and external acquisition of knowledge, they are mostly characterized by a relative prominent use of cooperative arrangements with the rest of actors in the innovation system. Firms in cluster 8 are also major users of inputs for innovation development. However, in comparison to cluster 9, they more actively concentrate on non-R&D related innovation activities (i.e., acquisition of machinery and equipment and computer hardware or software, purchasing or licensing of patents), whereas their involvement in cooperation arrangements for innovation is much more limited. Clusters 2 and 7 include firms with a relatively moderate use of innovation inputs. However, differences between these two groups can be perceived. Accordingly, while firms in cluster 2 more profusely engage in non-R&D oriented activities (i.e., technology acquisition, training, market research or procedures implementation), firms in cluster 7 more greatly rely on the knowledge sourced by specialized knowledge providers (i.e., universities, public and private R&D institutes).

Firms in clusters 1, 4 and 5 present relative lower levels of involvement in knowledge attainment practices in their respective innovation processes. Firms in cluster 1 seem to primarily follow an internally-focused innovation strategy, as their innovation inputs mostly come from in-house R&D investments and the sourcing of information from within the organization or enterprise group. Cluster 5 contains a group of firms whose main source of knowledge comes from other industry organizations (e.g., suppliers, clients and competitors). Firms in cluster 4 mostly base their innovation inputs on the undertaking of R&D and non-R&D related innovation activities, with a relative low use external sources of knowledge. Finally, firms in clusters 3 and 6 are those more poorly involved in innovation practices, either by means of knowledge acquisition or sourcing. On the one hand, cluster 3 includes firms that merely rely on technology acquisition (i.e., machinery, equipment and computer hardware or software) and on information from suppliers in their innovation processes. On the other hand, firms in cluster 6 mostly base their innovation processes on internal information (i.e., employees).

**Table 2**: Firms in every cluster by sector and size

| *Cluster (n=)* | *C1 (1,006)* | *C2 (1,076)* | *C3 (858)* | *C4 (596)* | *C5 (918)* | *C6 (913)* | *C7 (897)* | *C8 (877)* | *C9 (456)* |
|---|---|---|---|---|---|---|---|---|---|
| % Manufacturing | 74.6 | 69.89 | 58.6 | 68.8 | 63.7 | 68.3 | 72.5 | 67.7 | 60.1 |
| % Services | 25.4 | 30.1 | 41.4 | 31.2 | 36.3 | 31.7 | 27.5 | 32.3 | 39.9 |
| *Sector difference (p-value)* | 0,0000 | 0,1480 | 0,0000 | 0,5804 | 0,0148 | 0,7142 | 0,0035 | 1,0000 | 0,0008 |

We also looked into the distribution of clusters in order to better understand whether differences across industries can be perceived. The share of firms within each cluster by sector (manufacturing vs. services) is exhibited in Table 2. We undertake difference tests between two means (cluster mean vs. population mean). Results show that more than half of clusters are not industry-dependent. That is, industry classification seems no to be a suitable criterion base for innovation processes clustering for around 58% of the sample. However, manufacturing firms represent the prevailing sector in clusters 1 and 7. In the same vein, service firms in clusters 3 and 7 have a relative dominant position with respect to the sample average, although different service categories prevail within these two service-oriented clusters.

On the one hand, cluster 3 is mainly formed of small firms in traditional services, including: retail trade, sale and maintenance, wholesale trade, hotels and restaurants, transport, and auxiliary transport activities (Table 3). The result is in accordance with most literature on service innovation taxonomies as this group clearly matches the 'supplier-dominated' services category, which basically relies on technology acquisition and on information from suppliers in the development of innovations. On the other hand, large firms in the R&D services sector prevail in cluster 9. This group has been identified by previous works as the 'science-based' category, and, as previously identified, represent the group of firms that more extensively undertake open innovation practices.  Nevertheless, although service activities are overrepresented in clusters 3 and 7, both groups are also characterized by including specific representative manufacturing. On the one hand, manufacturing activities such as wood and paper, printing and reproduction, and tanning and luggage are well represented in cluster 3. On the other hand, an important share of knowledge-intensive manufacturing activities (i.e., chemicals, machinery, vehicles and transport, equipment) follow a similar pattern to those knowledge-intensive services (i.e., R&D, telecommunications) included in cluster 9. As suggested by Miles (2008), together with their fundamental processes and market relations, knowledge intensity is one of the three key ways in which industries vary, with high significance for their innovative activities.

**Table 3:** Clusters correspondence with industry categories

| *Cluster* | *Sector orientation* | *Most representative sub-sectors* | *Category* |
|---|---|---|---|
| 1 | Manufacturing | Machinery; Vehicles & Transport; Equipment; Textiles | Intramural-oriented |
| 3 | Services | Retail Trade; Sale & Maintenance; Wholesale Trade; Hotels & Restaurants; Transport; Auxiliary Transport; Renting | Supplier-dominated |
| 7 | Manufacturing | Basic metals; Food and Tobacco; Metal products | Information-networked |
| 9 | Services | R&D; Post and telecommunications | Science-based |

## 5. Conclusions and discussion

The debate on whether services innovate differently from manufacturing firms has typically concentrated around the assimilation, demarcation and synthesis discussion (e.g., Coombs and Miles, 2000). The demarcation approach, which embraces service-specific modes of innovation, emerged in response to the assimilation perspective in an attempt to examine distinctive features of service innovation and to develop context-specific concepts for service innovation in order to underline those limitations of traditional innovation studies' focus. These context-specific concepts served to direct the attention towards features that were perceived as distinctive for service innovation, implicitly stating that these features do not apply to manufacturing – at least not to the same extent (Drejer, 2002). As result of the high content of intangible, informative and interactive elements associated with service products and processes, as well as to the higher relevance of non-incorporated innovation, service innovation comprised and exhibited particular characteristics, conducts and needs (i.e., Gallouj, 1994; Gallouj and Gallouj, 1996; Gadrey et al., 1995; Sundbo, 1998; Gallouj, 2000; Gadrey, 2000; Djellal and Gallouj, 2001; Tether, 2003; Rubalcaba, 2006; Green et al., 2001; Miles, 1999; Howells and Tether, 2004; den Hertog, 2000).

Based on the service-specific characteristics many different service innovation groups have been discerned in literature (depending on the data and methodology used). However, our results lead only to consider two services-predominant categories: i) supplier-dominated and ii) science-based. Even though the supplier-dominated category does apply, the results suggest that this pattern is not restricted to traditional services, as some manufacturing activities are also well-represented within this cluster (i.e., wood and paper, printing and reproduction, tanning and luggage). In addition, the results show how some of the initially claimed peculiarities of service innovation (e.g., the interaction with their clients in the production or coproduction of innovations) are not exclusively associated with services. To this respect, although some knowledge-intensive services (i.e., financial services, computer and related activities, R&D) are major absorbers of information from their clients, manufacturing activities such as machinery, vehicles and transport, and equipment also make a great use of this knowledge source. As suggested by Drejer (2002), these service specific peculiarities do also apply – admittedly to a varying degree – to manufacturing.

Inter-sectorial patterns are observed to a certain extent. As a matter of fact, the analysis accounts for a combination of open innovation forms, depending on the firm's business model but also partly related to the sectoral breakdown. While some firms still primarily follow an internally-oriented innovation strategy (i.e., firms in cluster 1), others apply different forms of openness by jointly undertaking knowledge acquiring and sourcing strategies, as well as engaging in cooperation arrangements (i.e., clusters 9). However, intra-sectorial differences matter and may be more plausible. In some respects there is greater variation in innovation activity within manufacturing and services than between the two groups of sectors (e.g., Hughes and Wood, 2000). Additionally, much has been said about the heterogeneity of the service sector, but innovation in manufacturing may not be as homogeneous as typically considered. Therefore, these results are in accordance with previous evidence (i.e., de Jong and Marsili, 2006), as patterns of innovation in services are at least as broad as that of manufacturing firms. New boundaries have to be drawn across service and manufacturing sectors (Preissl, 2000), as differences of service and manufacturing innovation were blurred in recent years, being now of degree rather than of substance Hollestein (2003). The increased blurring lines between manufacturing and services made the 'services-oriented' approaches less relevant, bringing to the forefront moderate and integrative views such as the synthesis approach, where innovation is interpreted as a multidimensional phenomenon both in services and manufacturing (Gallouj and Weinstein, 1997; Gallouj, 1994; Boden and Miles, 2000; Gallouj, 2002; Tether and Metcalfe, 2004).

Nevertheless, despite considerable progress has been made in the measurement and monitoring of innovation processes in the service sector, statistical sources that facilitate the analysis of service innovation activity in the economy are scarce and generally adopt a methodological approach which is more applicable to manufacturing than to services. The traditional innovation measurement framework (based on subordinate surveys) has historically focused on a technological innovation-based perspective. However, as suggested by Tether and Tajar (2008), this perspective remained imperfect as it applied a 'manufacturing mindset' to innovation, which could be problematic for studying services and service innovation. The difficulties encountered in the evaluation of service innovation performance call for more specific approaches and the use of new indicators that consider indirect impacts and intangible gains.

The service sector nowadays accounts for the largest part of advanced economies. This stylised fact poses a major challenge to those economies striving to achieve economic growth. However, the magnitude of this figure contrasts with the fact that innovation policies have traditionally been aimed at manufacturing industries. Understanding whether particular features of service innovation can be identified may benefit not only firms' innovation management and strategies but also the design and implementation of policy instruments that effectively tackle the needs of service and manufacturing innovative activities. The case for special policies designed for service innovation may lose credibility if no particular strategies are recognised. The present paper represents a small contribution to this debate.

The paper must include an abstract in English or French of no more than 10 lines (style "Abstract"). There is no page break either before or after the abstract.

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