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Innovation Patterns under the Magnifying Glass. Firm-level latent class analysis of innovation activities in services.

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Abstract

Innovation is still an obscure concept although many efforts have been made to improve the understanding and measurement of it. The growth of service activities throughout the economy has encouraged scholars, policy makers and executives to explore the determinants and features of the innovation developed by service enterprises. Many empirical studies that form the basis of recent literature on innovation in services have proved the existence of a wide range of innovation patterns, confuting the initial assumption that all services are *supplier-dominated*. In this sense, innovation in services cannot be analysed using a one-size-fits-all concept and that these activities have different innovative trajectories. This paper aims to analyse the real scope of diversity in innovation patterns in services regarding innovation activities and outputs. The empirical analysis is based on the Fourth Community Innovation Survey for Spain. In order to identify clusters with similar behaviour patterns as far as innovation activities and outputs are concerned, we will use the latent class analysis as alternative method of clustering. Firm-level analyses have permitted the in-dept scrutinisation of innovation patterns, beyond the boundary of the traditional standard industrial classification largely applied so far. The empirical results led to create an innovation typology for services, derived from innovation activities and the types of innovation developed, what is composed of four profiles: *Knowledge Creator*, *Knowledge Adopter, Knowledge Creator and Adopter* and *Neither Creator nor Adopter of Knowledge*. From the viewpoint of public innovation policies, the diversity of innovation patterns found encourages the development of tools based on sectoral differences in terms of the nature of the innovation process and the technological opportunities and products.

Keywords

Innovation patterns, Latent Class Analysis, service sector, R&D, training activities.

JEL Classification

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Innovation Patterns under the Magnifying Glass. Firm-level latent class analysis of innovation activities in services

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Abstract

Innovation is still an obscure concept although many efforts have been made to improve the understanding and measurement of it. The growth of service activities throughout the economy has encouraged scholars, policy makers and executives to explore the determinants and features of the innovation developed by service enterprises. Many empirical studies that form the basis of recent literature on innovation in services have proved the existence of a wide range of innovation patterns, confuting the initial assumption that all services are *supplier-dominated*. In this sense, innovation in services cannot be analysed using a one-size-fits-all concept and that these activities have different innovative trajectories. This paper aims to analyse the real scope of diversity in innovation patterns in services regarding innovation activities and outputs. The empirical analysis is based on the Fourth Community Innovation Survey for Spain. In order to identify clusters with similar behaviour patterns as far as innovation activities and outputs are concerned, we will use the latent class analysis as alternative method of clustering. Firm-level analyses have permitted the in-dept scrutinisation of innovation patterns, beyond the boundary of the traditional standard industrial classification largely applied so far. The empirical results led to create an innovation typology for services, derived from innovation activities and the types of innovation developed, what is composed of four profiles: *Knowledge Creator*, *Knowledge Adopter, Knowledge Creator and Adopter* and *Neither Creator nor Adopter of Knowledge*. From the viewpoint of public innovation policies, the diversity of innovation patterns found encourages the development of tools based on sectoral differences in terms of the nature of the innovation process and the technological opportunities and products.

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1. INTRODUCTION AND RESEARCH QUESTIONS

Although many efforts have been made to improve the understanding and measurement of innovation, the definition of innovation is still far from straightforward. The recent advent of the new Service Economy has brought about a debate surrounding the real scope of innovation in different contexts beyond that of the traditional view, embodied in a technological perspective where formal R&D is at the core of the process of creative destruction. The growth of service activities throughout the economy has encouraged scholars, policy makers and executives to explore the determinants and features of the innovation developed by service enterprises.

The first attempts to analyse innovation in services proved that they follow a pattern characterized by the adoption and application of new technologies (Pavitt, 1984; Barras, 1986). However, recent studies have shown services to also be a source of innovation, in contrast to the traditional supposition. Many empirical studies have also proved the existence of a wide range of innovation patterns confuting the initial assumption that all services are *supplier-dominated*. This evidence shows that innovation in services may not be analysed using a one-size-fits-all conception, and that these activities have different innovative performances (Soete & Miozzo, 1989; Den Hertog & Bilderbeek, 1999; Evangelista, 2000; Tether & Hipp, 2000; Miozzo & Soete, 2001; Sundbo & Gallouj, 2000; Hollenstein, 2003; Hipp & Grupp, 2005; de Jong & Marsili, 2006; Miles, 2008; Tether & Tajar, 2008; Vence & Trigo, 2009; Trigo, 2009).

Services are extremely heterogeneous and so innovation is expected to be displayed differently across sub-sectors. It is well known that technological change has been related to the manufacturing sector for a substancial period of time, but it is has also been shown that services innovate too (Miles, 2001, 2005; Tether *et al.*, 2002; Gallouj, 2002a,b; Tether, 2003; Howells & Tether, 2004). Maybe these innovations are not necessarily based on technology, but on different elements of its production process, although technology is an important innovation input in certain service activities such as telecommunication and financial intermediation. Thus, innovation does not necessarily mean purely technological changes. Indeed, the organisational dimension accounts for a great part of the innovation developed in services (see also Tether & Tajar, 2008). Therefore, based on the above arguments and taking into consideration the innovation activities, the following question arises:

(Q1) What drives innovation in services?

Empirical evidences have placed Knowledge Intensive Business Services (KIBS) at the vanguard of innovation issues. Its prominent performance is not only noteworthy due to the high proportion of innovating firms in this sector, but it is also due to the high number of innovating

firms engaged in the majority of innovation activities and other sources of information such as strategic alliances. Conversely, others service industries such as distributive services (transport, wholesale and retail, etc.) and HORECA (hotels, restaurants and catering) present a very low level of innovation.

The study of innovation in services requires the analysis of various dimensions of innovation. Firstly, the heterogeneity of this sector suggests that there is a diversity with regards to innovation patterns, as already stated by other authors. However, the composition of inputs used by each service industry still deserves an in-depth analysis, taking into account the different technological trajectories found in each service industry. The attempt to map the drivers of innovation in services will also permit to answer the following enquiry:

(Q2) Do different innovation performances rely on particular nature of service activities?

Nevertheless, some innovation aspects in services are difficult to be measured, such as R&D activities and other elements of the knowledge-creation process. Indeed, the uneven interpretations of those inputs could lead scholars to misunderstand innovation in services (Tether, 2003); so, innovation should also be examined taking into account the logic of the production process. The analysis proposed here will also allow us to evaluate to what extent innovation surveys are able to identify and measure these inputs. Recent empirical analyses have proved that R&D activities and cooperation endow firms with capacity to introduce more advanced innovations. However, the assumption that specific innovation outputs rely on specific innovation activities still deserves more evidences. This analysis will permit us to scrutinize the association between the innovation activities performed and the types of innovation developed by service firms in order to solve the following question:

(Q3) Do different types of innovation require specific kinds of innovation activities?

The aim of this paper is to analyse the real scope of diversity in innovation patterns in services regarding innovation activities and outputs. The empirical analysis is based on the Fourth Community Innovation Survey for Spain. The statistical technique known as Latent Class Analysis (LCA) has been chosen so as to establish a set of clusters from a set of homogeneous companies with reference to the nature and scope of the innovation activities and innovation outputs. This statistical method permits us to approach the study at a firm-level instead of the traditional sectoral perspective that has been largely applied so far.

2. SYSTEMATIZATION OF INNOVATION IN SERVICES

The literature on innovation in services highlights some specific features present in these activities, among them the high level of interactivity between the users and producers, the intangible nature of its products, the predominance of non-technological innovations and high proportion of incremental innovations, as well as others. Another characteristic which has been highlighted is related to the informality of the innovation process in services, which is reflected by the fact that little importance is placed on R&D activities compared to manufacturing sectors. However, the lack of systematization in the innovation process of services does not represent the reality for all companies involved in the service sector, for example, telecommunications, computer and related activities, financial intermediation, software consultancy or architectural and engineering activities. On the contrary, the innovation in these companies is highly intensive in continuous technology-based R&D activities and high-skilled human resources. In fact, these industries account for almost 85% of expenditure in intramural R&D in the service sector in Spain (INE, 2009).

R&D in services is still underestimated despite the ongoing effort to find accurate indicators to measure R&D beyond technological and scientific fields. In reality, the composition of innovation expenditures in services differs considerably depending on the sub-sector, to a certain extent by the technological level involved throughout the innovation process, the stages of the product life cycle and the degree of human capital participation during the innovation process.

2.1. R&D and services

"Services are ubiquitous, except in R&D statistics" (Den Hertog *et al.*, 2006). Although some exceptions do exist in certain service industries, there is a wide assumption that services rarely engage in R&D activities during their innovation processes. Indeed, "R&D is not the only method of innovating" (Arundel, Bordoy & Kanerva, 2008), particularly in low-tech service industries (see also Howells & Tether, 2004). This evidence raises a number of issues. The first one deals with the interpretation of R&D in the context of service innovation and the traditional (and narrow) definition of R&D activities commonly associated to the existence of a specific department and specific personnel responsible for performing these activities (OECD, 2003; Miles, 2007). This manufacturing-oriented perspective of innovation and R&D normally leads to underestimating the scope of R&D in services given that most of these activities are carried out in less formal circumstances and are more spread among other business areas such as marketing. Miles (2007, 256) observes that research, in most service industries, is commonly denoted as "scanning of the competitive and market environments". Another issue is related to the role of

the public sector in promoting those activities in services through innovation policies. Innovation in services is supported to a less extent by public innovation and R&D programmes than the innovation employed in manufacturing, in part due to the weak ties the service sector has with science and technology (Den Hertog *et al.*, 2006).

Recent cross-country empirical analyses have highlighted that many service industries engage in R&D activities during their innovation process (OECD, 2005a; Den Hertog *et al.*, 2006; SISE, 2005, 2007, European Commission, 2007). Innovation in services has gained prominence and value and so have the elements that fuel that process, such as R&D. Official European Commission Documents focus on innovation as a priority for all member states, as agreed for in the Lisbon Agenda. At the same time, it has been made clear that "achieving substantial growth in Europe's economy – as demanded by the Lisbon strategy – will require a significant contribution from the service sectors" (European Commission, 2004, 2). At the present time, more than 35% of all R&D expenditure in the Spanish business sector is attributable to service firms (INE, 2009). It is worth mentioning that many of the benefits that come from R&D activities carried out by the service sector spread beyond the boundary of this sector.

2.2. Training of human resources as innovation activity

Besides R&D, training activities are another important means by which firms acquire new information and knowledge that enable innovation. Human capital plays an important role in innovation, not only in the manufacturing sphere but also in the service sector (Sundbo & Gallouj, 1998, European Commission, 2004). The prominent role of human resources in productive and innovative dynamics acts as evidence of knowledge-based economies since "knowledge is about people, not databases" (Dougherty, 1999, 262). In fact, the lack of adequately qualified employees can be seen as a barrier in the organisation to innovation for many companies, even low-tech ones (Preissl 1998, Miles & Tether, 2003). The key role of certain innovation activities such as R&D activities or the acquisition of new technologies such as ICT in a service context has been widely discussed, but a consistent and solid innovation performance rely irrefutably on well-trained and skilled human capital in all sectors of the economy.

Staff training is more prevalent in certain service industries, for example, "research and development", "software consultancy", "technical testing and analysis", "architectural and engineering activities", "telecommunications" and "financial intermediation", whose activities are highly associated with science and technology-related fields. This evidence does not only refer to the proportion of firms engaged in training activities but also to the rate between the total

training expenditure and the total turnover of the firms. The high intramural R&D effort undertaken by these services is also worth noting. Although these industries are very dynamic and innovative, they represent a small percentage of the Spanish business sector. In reality, non-innovating firms of those branches also perform considerably well in terms of staff training activities. This evidence, in some way, leads to the conclusion that training plays a wider role in these industries, this is not only associated with the generation of new knowledge for innovation, but also with the day-to-day work of firms.

The analysis of the composition of labour costs in the EU service sector shows a very diverse picture across countries. Whereas Spain, Malta, Latvia, Romania, Belgium, Italy and Greece are at the tail end of the European ranking in this regard, with less than 0,5% of the total labour cost for training activities, UK, France and Hungary are at the top with 2,4%, 1,7% and 1,5% respectively (Eurostat, 2004). The Spanish situation is far from satisfactory: in addition to the low proportion of firms that are engaged in training activities, the percentage of total labour costs designed for training in Spanish service companies is among of the lowest in Europe.

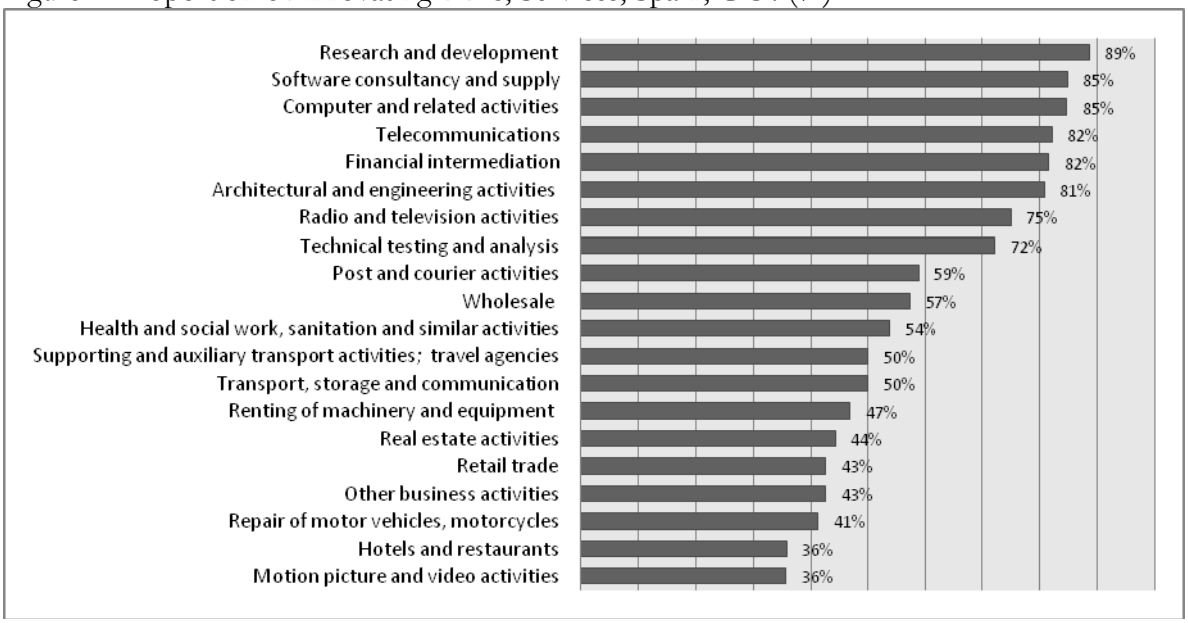
3. EMPIRICAL EVIDENCE: MEASURING THE DIVERSITY IN SERVICES USING THE INNOVATION OUTPUTS

The data used in the empirical analysis derive from the Technological Innovation Panel (PITEC), which is a database developed by the INE (National Institute for Statistics), FECYT (Spanish Foundation for Science and Technology) and COTEC (Foundation for Technological Innovation). The panel, derived from the Spanish Community Innovation Survey, is a statistical tool used for analysing the innovative performance of Spanish enterprises. The number of service enterprises participating in PITEC 2004 was 3.546; among them 2.149 were innovating firms. We consider an innovating firm as one that has implemented any type of innovation during the last two years, as recommended in the Oslo Manual (OECD, 2005b). The classification of the service branches and the proportion of innovation firms are shown in figure 1.

As we observed in the following chart, the service sector shows a different propensity to innovate. The result is quite as expected given that many authors have highlighted the considerable differences in performance among innovative services (Den Hertog & Bilderbeek, 1999; Sundbo & Gallouj, 2000; Tether & Hipp, 2000; Hollenstein, 2003; Hipp & Grupp, 2005, Miles, 2008; Vence & Trigo, 2009; Trigo, 2009). The Business Services (KIBS) is clearly the most innovative sector followed by telecommunications and financial intermediation. However, a set of service activities comprising of hotels, retail, real estate services, motion picture and video

activities, sales and repairs of motor vehicles, among others, present a very low innovative performance. The vast majority of them are personal and distribution services. Their growth was insignificant during the second half of the last century.

Figure 1. Proportion of innovating firms, Services, Spain, CIS4 (%).



Source: Own elaboration.

The results allow us to conclude that the difference in innovative performances is strongly linked to the technological capability, technological opportunities (Dosi, 1982, 1988; Klevorick, Levin, Nelson & Winter, 1995), growth in demand (Arvanitis & Hollenstein, 1996; González, 2007), the life cycle of activities (Robinson, 1998) and the degree of standardisation or customisation of the service (Sundbo & Gallouj, 1998; Sundbo, 1997, 1998, 2000, 2002). Several empirical studies in other European countries have pointed to the existence of a substantial dissimilarity in terms of the innovative performance in services, which serves as a reference to the Spanish case. However, few have attempted to compare these performances (Miles, 2008) [1].

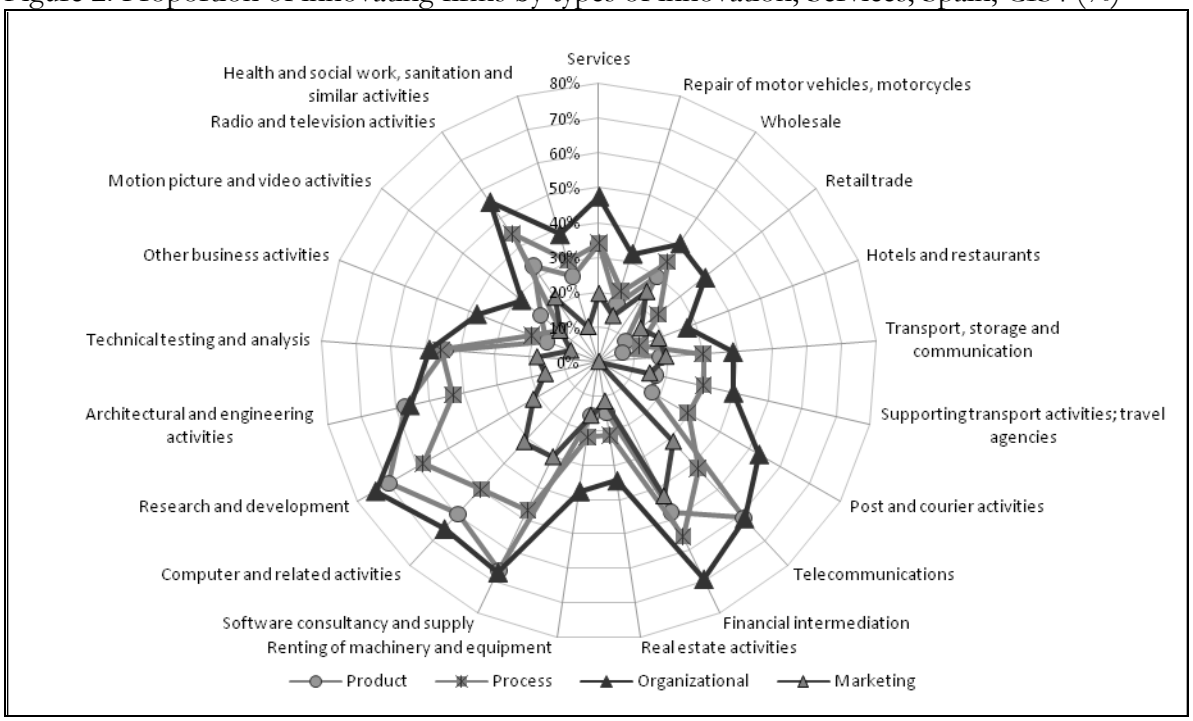
3.1 Product and process innovation versus organisational and marketing innovation

The model of economic production that prevailed throughout the past century has led to the measurement of innovation in enterprises based only on parameters related to manufacturing dynamics (assimilation approach). This way of understanding innovation in services has been widely reported in the literature on innovation under the label of *assimilation approach* (Coombs & Miles, 2000; Sundbo & Gallouj, 2000; Miles, 2001; Salter & Tether, 2006). Because of this, technological change has become the core of any innovation effort. This viewpoint, which has been depicted in manuals published by the OECD, has not taken into account organisational and

[1] See Tether *et al.* (2002), Kanerva, Hollanders & Arundel (2006).

marketing innovations, which were simply called changes. However, the radical process of structural change occurred primarily in developed countries as well as the appreciation of many functions within the enterprise have encouraged scholars and policy makers to perceive these organisational changes as innovation. Since then, the concept of innovation has been based on two major aspects: technological innovations, represented by the product and process innovations, and non-technological ones, such as the organisational and marketing innovations (OECD, 2005b). Furthermore, the discourse in the literature after the boom of the studies on innovation in services has suggested that services tend to innovate more in those areas that are not necessarily related to technology (Sundbo & Gallouj, 1998; Sundbo, 2000; Tether *et al.,* 2002; Tether & Tajar, 2008; Vence & Trigo, 2009)[2]. Thus, innovation in services has been appreciated from a non-technological perspective and highly related to changes in diverse areas of business structure[3].

Figure 2. Proportion of innovating firms by types of innovation, Services, Spain, CIS4 (%)



Source: Own elaboration.

There is a higher tendency for all innovating services to develop organisational innovations. The predominance of this type of innovation in services can be clearly observed in

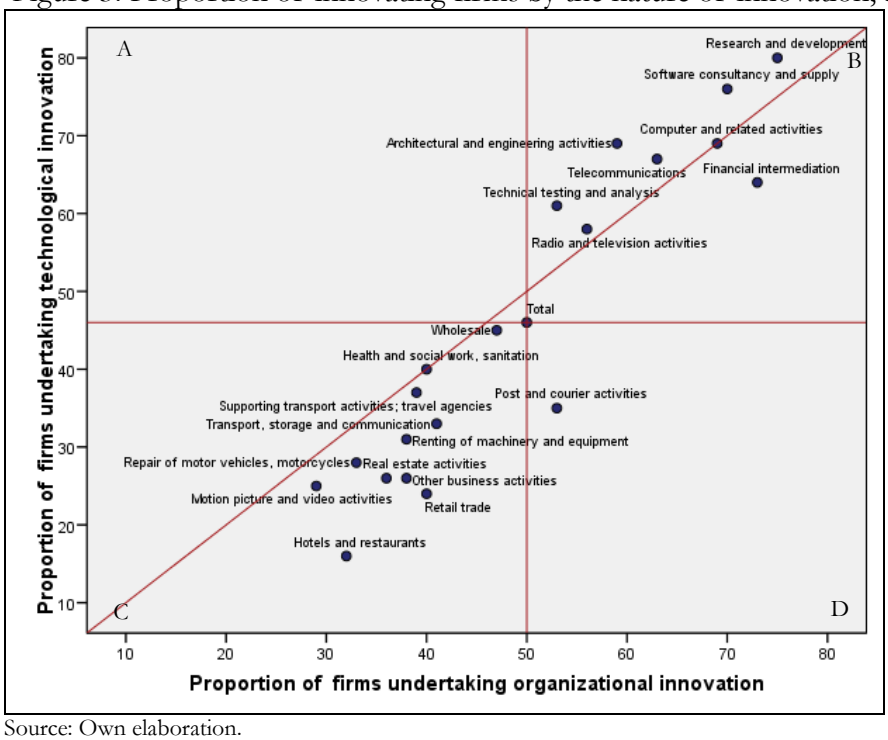
[2] In addition to the classification commonly used to distinguish the field of innovation (product, process, organisational and commercial), recent work revealed some peculiarities of services innovation that identify, in some way, new forms of innovation not covered in the Pavitt's approach, such as innovations from *ad hoc* combinations e.g. (Hauknes, 1998; Galouj, 2002a).

[3] We should observe that product and process innovations not necessarily have a technological nature, especially in the service sphere. Therefore, it would seem appropriate to consider technology as an element that can be directly or indirectly related to innovation, either product, process, organisational or marketing innovation.

the analysis of the Spanish example (Figure 2). As it has been emphasized in reports and empirical studies, "computer-related services", "R&D", "architectural and engineering activities" as well as "technical testing and analysis" (knowledge-intensive services) present the highest percentage with respect to the implementation of strategic or organisational changes, not just in the service sector, but also taking into account all the sectors in general (European Commission, 2004).

However, although services exhibit different propensities to innovate, the type of innovation undertaken is relatively similiar. Figure 3 represents this similarity in terms of shaping innovation patterns. Most of the branches belong to the quadrant "B" or "C", which leads us to the assumption that there is no clear differentiation as far as the nature of innovation is concerned. This evidence reaffirms the results presented by Miles (2008) for British services. According to this industry-level analysis, it seems inconsistent to assert the existence of different tendencies in innovating services as regards the class of innovation outputs. In the same way, the statement that services are primarily organisational innovators and manufacturing firms are basically technological innovators becomes more and more untenable (Miles, 2008; Castellacci, 2008).

Figure 3. Proportion of innovating firms by the nature of innovation, Services, Spain, CIS4 (%).



Source: Own elaboration.

Another interesting conclusion to be drawn from these charts is that the scope of innovation, regardless of the field, follows a pattern in accordance with the innovative performance of the sector. In other words, firms that innovate with regards to both products and

processes are also the most innovative in terms of organisational and marketing aspects. Therefore, taking into account the findings for the Spanish sample, it is reasonable to assert that the type of innovation does not seem to be strongly linked to the nature of economic activities. For instance, we see that software consultancy, financial intermediation and transport tend to innovate in substantially similar areas. The diversity can be seen in the different propensities to innovate in each of these sub-sectors.

This evidence, once again, sheds some light on the debate surrounding the concept of innovation, but above all, the classification used to measure it. These preliminary results lead us to question its meaning and effectiveness for establishing specific patterns on how different sectors of the economy innovate. On the other hand, it confirms what has been disseminated in the literature as the tertiarization of manufacturing and the industrialization of services and their impact on the innovation process. This example, which is the basis of the *synthesis approach* (Sundbo & Gallouj 2000, Coombs & Miles, 2000), attempts to explain the processes of sectoral innovation as being increasingly convergent and similar processes due to the collective integration of all economic activities and productive functions (Tether & Hipp, 2000; Preissl, 2007; Castellacci, 2008, Vence & Trigo, 2009). This new perspective permits the analysing of the innovation process beyond sectoral labels since "any firm or sector is liable to feature a great many of these functions, though the proportions vary markedly" (Coombs & Miles, 2000, 96). In this sense, innovation tends to be analysed similarly throughout the economy.

The measurement of innovation in services still has a great number of difficulties; it is still a challenging concept. The intangibility of services and interaction with users (co-producer of services) blurs the boundaries between different types of innovations that have been developed. Moreover, the different nature of economic activities can lead to erroneous conclusions regarding the types of innovations. For example, process innovation can be considered as product innovation for logistic-related services, in the same way as marketing innovation is for advertising firms. The possible ambiguous interpretation certainly makes the study and measurement of innovation in enterprises more difficult.

The demarcation of boundaries for determining the types of innovation is also obscure because of the overlapping nature of many innovations in services. Therefore, the distinction between certain types of innovation in services is not clear-cut. For example, we have the imprecise distinction of product and process innovations, given that the production, supply and consumption of a range of services can occur simultaneously. Another tricky distinction is that of service innovation and marketing innovation. The answer to many of these classifications is in the understanding of the nature of each economic activity since the marketing functions of an

enterprise may be the main product of others (see also Hipp, Tether & Miles, 2000; Preissl, 2000).

Furthermore, some innovations may be reflected in more than one dimension. The common combination is the product and process innovation. This is the case of significant improvements in the service characteristics and the methods used for such provision (OECD, 2005b). Another possible combination is service innovation and marketing innovation, often using new technologies. A new distribution strategy, for instance, which involves the incorporation of a new logistics system in the enterprise, would be a combination of both process and marketing innovation. These examples demonstrate the innumerable possibilities of combinations. In addition, these combined forms highlight the complementarity of many innovations, and in some ways, the fact that a certain type of innovation can lead to further innovations in different areas.

4. PATTERNS OF INNOVATION IN SERVICES

4.1. Methodology and data analysis: data set and the determination of the model's dimension

Although the study of innovation patterns with regards to services is not a new approach, the analysis proposed here is unique with regards to three aspects. The first is related to the variables chosen to determine the patterns: the innovation-related activities (Table 1). A set of output-related variables composed by the types of innovation developed was also taken into account. The idea behind the analysis is to verify whether different types of innovation rely on a specific type of innovation activity. Secondly, the use of the PITEC database allows twenty different service industries to be analysed. Such a detailed breakdown will certainly lead to a more accurate classification. The third original aspect of this analysis is the use of the Latent Class Analysis (LCA) [4]. The LCA is a multivariate technique based on conditional probabilistic analyses. Its objective is to verify whether the association between a set of observed categorical variables could be explained through a latent typology that is composed by different classes. The variables used in each analysis are summarized in the following table.

[4] More details about the Latent Class Analysis in Heinen (1996) and Hagenaars & McCutcheon (2003).

Table 1. Variables used in the Latent Class Analysis

Indicators		**Type**
innobien	New or significantly improved goods	Binary
innoserv	New or significantly improved services	Binary
innfabri	Implementation of new methods of production	Binary
innlogis	Implementation of new logistic system	Binary
innapoyo	Implementation of new supporting activities	Binary
inorg1	Implementation of advanced management techniques within your enterprise	Binary
inorg2	Implementation of major changes to your organisational structure	Binary
inorg3	Changes in the relationship with other enterprises or public institutions	Binary
incom1	Changes in the good/service design	Binary
incom2	Implementation of new sales methods or delivery	Binary
idin	Intramural R&D	Binary
idex	Extramural R&D	Binary
maqui	Acquisition of advanced machinery, equipment and software	Binary
tecno	Acquisition of other external knowledge	Binary
form	Training	Binary
Covariants		
Service branches		
Size		

Source: Own elaboration.

This statistical technique has many advantages when compared to other methods. One important advantage is the probability distribution of the identified clusters. The elements (in the case of this paper, the economic branches) have different probabilities of belonging to each cluster presented in the model. Consequently, one of the outputs offered by this statistical technique is a classification by groups based on probabilities. Another significant advantage is the determination of numbers of clusters. This is possible due to the existence of rigorous statistical tests that support the choice of the model dimension, for example the number of clusters in the model). Another important attribute is the possibility of using categorical variables. The sample of Spanish enterprises used in the analysis is composed of 2.149 innovating firms.

Table 2. Statistic results of Latent Class Analysis

	LL	**BIC(LL)**	**Npar**	**L^2**	**df**	**p-value**	**Class.Err.**
2-Cluster	-18476,93	37506,27	72	21060,6201	2076	1,4e-3081	0,0763
3-Cluster	-17792,38	36574,46	129	19691,4937	2019	1,5e-2842	0,0989
4-Cluster	-17431,66	**36290,36**	186	18970,0721	1962	3,6e-2730	0,1101
5-Cluster	-17268,16	36400,68	243	18643,0694	1905	1,3e-2694	0,1436
6-Cluster	-17163,61	36628,90	300	18433,9716	1848	3,7e-2682	0,1552

Source: Own elaboration.

The results of the Latent Class Analysis show various solutions, each one with different numbers of classes. The criteria for selecting the most accurate model to fit the data set was the Bayesian Information Criterion (BIC) due to its consistency in comparison with other criteria. Most of the empirical analyses carried out through Latent Class Analysis have chosen such statistical criteria for model selection (see, for instance, Jensen & Vinding, 2003, Vinding & Drejer, 2006, Drejer & Vinding, 2006, Jensen, Johnson, Lorenz & Lundvall, 2007). According to this criteria, the most accurate model is the one which has the lowest value for the BIC (see Kashyap, 1977; Schwartz, 1978). Therefore, the most accurate model with regards to knowledge

generation/incorporation and innovation output consists of four clusters (Table 2).

4.2. Innovation patterns based on innovation activities and innovation outputs

The results suggest that service activities can be classified into four different clusters according to the forms of knowledge creation/incorporation and innovation outputs. This evidence reinforces the assumption that diversity with regards to innovation patterns exists, as supported by various empirical studies (Soete & Miozzo, 1989; Den Hertog & Bilderbeek, 1999; Evangelista, 2000; Tether & Hipp, 2000; Miozzo & Soete, 2001; Sundbo & Gallouj, 2000; Hollenstein, 2003; Hipp & Grupp, 2005; de Jong & Marsili, 2006; Miles, 2008; Vence & Trigo, 2009; Trigo, 2009). The following table shows the probabilistic distribution for each variable analysed.

Table 3. Probability of positive answer, Latent Class Analysis (%)

		Cluster 1 KC	Cluster 2 KA	Cluster 3 KCA	Cluster 4 NCNAK
Innovation activities	Intramural R&D	89%	24%	89%	3%
	Extramural R&D	38%	35%	60%	1%
	Training	43%	45%	87%	4%
	Acquisition of other external knowledge	9%	25%	40%	0%
	Acquisition of advanced machinery and software	34%	70%	74%	1%
Innovation outputs	Goods	49%	15%	64%	0%
	Services	48%	23%	79%	2%
	New methods of production	31%	18%	58%	0%
	New logistic system	7%	20%	33%	0%
	New supporting activities	25%	61%	77%	6%
	Advanced management techniques	39%	55%	92%	71%
	Major changes to the organisational structure	30%	46%	86%	68%
	Relationship with other enterprises or public institutions	19%	17%	55%	26%
	Changes in the good/service design	11%	9%	42%	20%
	Implementation of new sales methods or delivery	11%	16%	42%	23%

Source: Own elaboration.

4.2.1. Knowledge Creator (KC)

As indicated in the table above, the first cluster presents high probabilities of carrying out in-house R&D and training, both of these being activities that are related to the generation of new knowledge in different ways: individual to the product, to the enterprise, as well as to the society. Although this cluster is distinguished by a high probability of carrying out internal R&D compared with other groups, KC seems to be very unlikely to outsource this activity (table 3). Furthermore, the probability of acquiring external knowledge through the purchase or licensing of patents and non-patented inventions, or any kind of know-how, is very low. Both the training and acquisition of advanced machinery, equipment or software does not seem to be as relevant as in-house R&D with regards to innovation contexts. With regard to the types of innovation in this cluster, the probability of developing product innovations is higher than any other kind of innovation. Additionally, the tendency to be a product innovator is also higher than in other clusters. The evidence supports the assumption presented in the literature that a positive

relationship exists between the innovation activities with scientific and technological nature and product and process innovation. D. Foray (2004) emphasizes the role of science as supplier of scientific knowledge, directly applied to technological innovations. On the other hand, the Knowledge Creator profile presents the lowest probability with regards to the development of organisational and marketing innovations. The probability that a Spanish firm belongs to this cluster is 33%. These companies are mostly technology-intensive services and KIBS (figure 4). The main KC branches are "telecommunications", "software", "computer and related activities", "architectural and engineering activities" as well as "engineering and technical testing and analysis". The presence of "wholesale trade" in this profile is worth noting also. In reality, it is a very heterogeneous cluster, and the probability of belonging to cluster 2 is also high. This profile has been identified and named by many authors as *science-based* (Tidd, Bessant & Pavitt, 2001)[5], *specialized technology and science-based suppliers* (Soete & Miozzo, 1989; Miozzo & Soete, 2001), *science and technology-based* (Evangelista, 2000), *professional service pattern* (Sundbo & Gallouj, 2000), *knowledge intensity* (Hipp & Grupp, 2005) and *specialized suppliers* (de Jong & Marsili, 2006) (table 4).

4.2.2. Knowledge Adopter (KA)

The second cluster tends to base innovation mainly around the acquisition of machinery, equipment and software. This approach could be associated with innovation being seen as an effort reduced to the adoption of external knowledge. For this group, in-house R&D does not act as an important source of information in the innovation process and therefore research and development &D activities in this sector place very low value on their innovations. The innovations developed are mainly related to the organisational and process aspects. The probability that a Spanish firm belongs to this cluster is 22%. The branches with the highest probability of belonging to this cluster are "repair of motor vehicles, motorcycles", "transport, storage and communication", "supporting and auxiliary transport activities; activities of travel agencies", "motion picture and video activities" and others (figure 4). Many of these branches are *distributive services* (OECD, 2001) and *scale-intensive physical networks of relationships* (Soete & Miozzo, 1989), highly supplier-dominated and with similar profile to the known *technology users* (Evangelista, 2000). Knowledge Adopters (KA) have also been referred to as *supplier-dominated* (Pavitt, 1984, Bell & Pavitt, 1993; Den Hertog & Bilderbeek, 1999; Tidd, Bessant & Pavitt, 2001, de Jong & Marsili, 2006) and to as *technology users* (Evangelista, 2000) (table 4).

4.2.3. Knowledge Creator and Adopter (KCA)

The third cluster is the most dynamic in terms of innovation activities and outputs. This

[5] Although the well-known Pavitt taxonomy consider services as supplier-dominated.

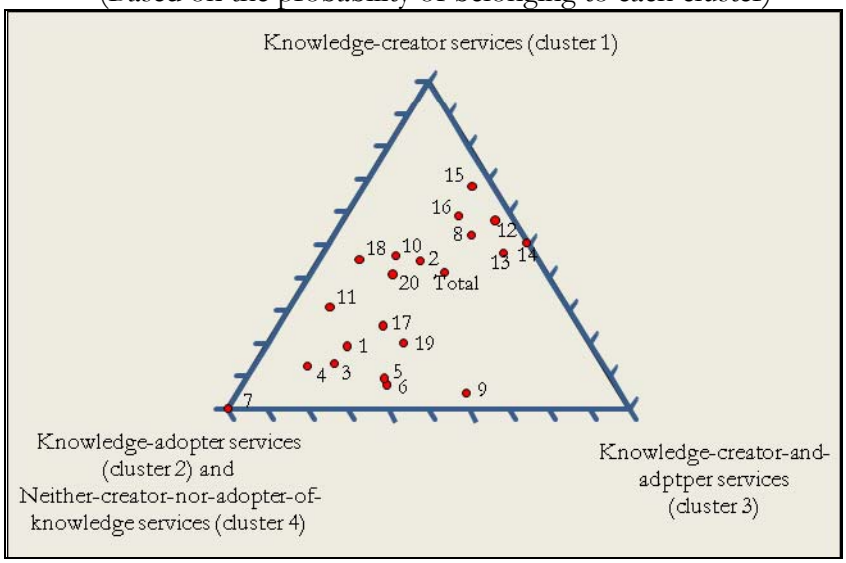
group is characterized by a high probability of carrying out in-house R&D, acquisition of machinery, equipment and software and conducting training of human capital. Therefore, this profile is both a creator and adopter of knowledge. KCA has a relatively low tendency to outsource R&D, but still a higher tendency than all other clusters. It is also characterized by the low probability of acquiring other external knowledge. At the same time, the probability to innovate is clearly higher than in the other clusters, but with similar trends. Companies that combine the two innovative profiles (KC and KA) are more innovative in all areas. This evidence reaffirms the results presented by Jensen, Johnson, Lorenz and Lundvall (2007) who argue that companies that perform different modes of knowledge creation - Science, Technology and Innovation (STI) mode and Doing, Using and Interacting (DUI) mode – are more dynamic and innovative. The probability that a Spanish firm belongs to this cluster is 26%. This group is essentially formed by activities such as "financial intermediation", "research and development" and "software consultancy and supply", although the last two branches have very high probabilities of belonging to other clusters also (figure 4). Evangelista (2000) identified a similar profile to the Knowledge Creator and Adopter that was named *Technical consultancy services* (table 4).

4.2.4. Neither Creator nor Adopter of Knowledge (NCNAK)

The last cluster (cluster 4) displays very a low probability of carrying out any kind of innovation activity or developing innovations. Innovating firms with this profile are fundamentally organisational innovators. Therefore, they are "innovating" firms without any kind of innovation activities. Companies belonging to this cluster can be characterized using an imitator profile, in which innovation is the result of a simply coping what already exists. The probability that a Spanish firm belongs to this cluster is 20%. The branches with the highest probability of belonging to this group are, in essence, distributive and personal services such as "hotels and restaurants", "real estate activities", "other business activities" and "renting of machinery and equipment" (figure 4). This profile has been highlighted in the typology developed by Hollenstein (2003) as *low-profile innovators with hardly any external links* (table 4). The following chart shows the Triplot[6] representation of this typology.

[6] We used the software for Microsoft Excel Triplot developed by David Graham (Loughborough University) and Nicholas Midgley (Liverpool John Moores University), and distributed free of charge. See D. J. Graham & N. G. Midgley (2000). For details, see additional documentation in http://www.lboro.ac.uk/research/phys-geog/tri-plot/index.html.

Figure 4. Triplot representation of innovation patterns, by service industry, Spain, CIS4 (%). (Based on the probability of belonging to each cluster)



Source: Own elaboration.

Legend:

1 Repair of motor vehicles, motorcycles
2 Wholesale
3 Retail trade
4 Hotels and restaurants
5 Transport, storage and communication
6 Supporting transport activities; travel agencies
7 Post and courier activities
8 Telecommunications
9 Financial intermediation
10 Real estate activities
11 Renting of machinery and equipment
12 Software consultancy and supply
13 Computer and related activities
14 Research and development
15 Architectural and engineering activities
16 Technical testing and analysis
17 Other business activities
18 Motion picture and video activities
19 Radio and television activities
20 Health and social work, sanitation

Table 4. Typology of innovation in services based on innovation activities and innovation outputs

	Knowledge Creator	**Knowledge Adopter**	**Knowledge Creator and Adopter**	**Neither Creator Nor Adopter of Knowledge**
Nature of the innovation effort	R&D-intensive	Intensive in acquisition of machinery and software	Intensive in R&D, training and acquisition of machinery and software	Low propensity to engage innovation activities
Innovative intensity	Relatively innovator	Relatively innovator	Highly innovator	Poorly innovator but highly organisational innovator
Most common innovation	Product (goods and services)	Process and organisational	Organisational	Only organisational
Similar typologies	*Science-based* (Pavitt, 1984; Bell & Pavitt, 1993; Tidd, Bessant & Pavitt, 2001) *Specialised technology suppliers and science-based* (Soete & Miozzo, 1989; Miozzo & Soete, 2001) *Science and technology-based* (Evangelista, 2000) *Service professional pattern* (Sundbo & Gallouj, 2000) *Knowledge intensity* (Hipp & Grupp, 2005) *Specialised suppliers* (de Jong & Marsili, 2006)	*Supplier-dominated* (Pavitt, 1984; Bell & Pavitt, 1993; Den Hertog & Bilderbeek, 1999; Tidd, Bessant & Pavitt, 2001; de Jong & Marsili, 2006) *Technology users* (Evangelista, 2000)	*Technical consultancy services* (Evangelista, 2000)	*Artisanal partner* (Sundbo & Gallouj, 2000) *Low profile innovators with hardly any external link* (Hollenstein, 2003)
Typical core sectors	Research and development; Technical testing and analysis; Architectural and engineering activities; Computer and related activities; Software consultancy and supply; Telecommunications; Wholesale.	Repair of motor vehicles, motorcycles; Transport, storage and communication; Supporting transport activities; travel agencies; Post and courier activities; Renting of machinery and equipment; Motion picture and video activities; Radio and television activities; Health and social work, sanitation and similar.	Financial intermediation; Research and development.	Retail trade; Hotels and restaurants; Real estate activities; Other business activities; Renting of machinery and equipment.

Source: Own elaboration.

5. CONCLUSIONS AND POLICY IMPLICATIONS

The diverse context in which innovation takes place in the service sector leads us to wonder what drives innovation in services. The firm-level analysis carried out permits the conclusion that service firms perform differently in terms of knowledge creation and incorporation. Therefore, the assumption of plurality, as demonstrated by other authors, has been confirmed, as far as the nature and the dynamics of innovation activities and innovation outputs are concerned. This evidence objects the growingly untenable hypothesis of a unique pattern of innovation in services. Hence, mapping the drivers of innovation in the service sector, which consists in the first research question (Q1) raised in this paper, is far from a straightforward task given its heterogeneity and complexity. Nonetheless, the use of the statistical technique known as Latent Class Analysis (LCA) has provided relevant contributions.

This analysis has permitted to develop a service taxonomy based on innovation activities and innovation outputs, composed by four patterns: *Knowledge Creator* (KC), *Knowledge Adopter* (KA), *Knowledge Creator and Adopter* (KCA) and *Neither Creator nor Adopter of Knowledge* (NCNAK). The companies that belong to the *Knowledge Creator* profile stand out for being R&D and training-intensive; both activities being related to the generation of knowledge and the creation of new value within the company. A large number of knowledge and technologically intensive business services have been profiled as KC, with the exception of financial intermediation which was outlined as a *Knowledge Creator and Adopter* due to its high intensity of machinery or software employed. *Knowledge Adopters* are characterized by their intensity in activities that represent the incorporation of an established knowledge either through the acquisition of new machinery or software or through the purchase of other external knowledge like patents or other types of inventions. Most of distributive and personal services have been classified as *Knowledge Adopter* or *Neither Creator nor Adopter of Knowledge*, because of its low probability to carry out any kind of innovation activities throughout the innovation processes.

With regard to the enquiry whether different innovation performances rely on specific services' features (Q2), the results also lead to the conclusion that the nature of the economic activities affect both the nature and the intensity of innovation performances. The nature of such activities can be expressed through technological capacity, in other words, the intensity regarding the employment of technologies, the technological opportunities, the growth of demand, the life cycle of the services, which demonstrates the evolution of the sub-sector, as well as the degree of standardisation or customisation of the service activity. While knowledge and technologically intensive business services demonstrate a very forward looking method with regards to variables

analysed are concerned, innovating distributive services (transport, wholesale and retail, etc.) and innovating HORECA (hotels, restaurants and catering) show very low innovative tendencies.

The Spanish innovating SMEs play an important role as knowledge creators in the economy in comparison with large companies. This is not only true for knowledge and technologically intensive business services but also for low-tech and low innovation intensive activities such as distribution services and HORECA. Indeed, the results underline the co-existence of different innovation patterns within the same industry.

The firm-level analysis has permitted to scrutinize in-depth innovation patterns and the boundary of the traditional standard industrial classification that has been largely applied so far. Despite the ongoing debate about which factor, between the sectoral-determinism and strategic-choice, is the most significant one in shaping innovation patterns, the results bring us to the conclusion that the innovation activities performed throughout the innovation processes and the nature of the economic activity are closely connected. However, it is important to stress that, in the same way which the decision to innovate is a strategic-choice, the inclination to use certain information flows is also a choice in terms of management and innovation strategy.

As far as innovation outputs are concerned, services innovate differently although the results indicate that there is no clear relationship between the traditional standard industrial classification and the types of innovation developed. Instead, the use of the Latent Class Analysis at firm level reveals that there is a correlation between the innovation activities carried out and the types of innovation developed. This result corroborates, therefore, the third research question addressed in this paper (Q3). While R&D-intensive firms (*Knowledge Creators*) are more likely to be product innovators, firms intensive on acquisition of machinery, equipment and software (*Knowledge Adopters*) are more prone to develop process and organisational innovations. The outcomes developed by firms that innovate without any kind of innovation activities (*Neither Creator nor Adopter of Knowledge)* comprise essentially organisational aspects. Some issues arise from this evidence: on the one hand, the existence of input-related activities neglected by current innovation surveys, such as learning-by-doing and -using practices and other mechanisms of learning from day-to-day organisational routines. On the other hand, innovation without previous activities might be merely incremental or minor changes in daily work, or purely result of a simple copy of what already exists. On the contrary, *Knowledge Creator and Adopter*, highly intensive in R&D and in machinery or software is the most innovative profile as far as all types of innovation outputs are concerned.

From the point of view of public innovation policies, the diverse patterns of innovation found encourages the development of tools based on sectoral differences in terms of (1) the

nature of the innovation process and (2) the technological opportunities and products. This does not coincide with the traditional and similar incentives for R&D in all sectors. Services are heterogeneous and so are their methods of innovation. The typology suggested in this work has identified groups composed of firms with similar characteristics in terms of innovation activities used throughout the innovation process as well as innovation outputs. On the one hand, the profiles of KC and KCA, which are highly network-intensive, require innovation policies with various orientations, such as fostering cooperation in the field of science and technology, internal R&D, the use of information and communication technologies and other new technologies, and the training and retention of human capital. Although the propensity to carry out training activities is somewhat high in many service branches in Spain, the expenditure on these activities is substantially lower than in other countries. A lower proportion of enterprises are engaged in training than that of the European average. Additionally, investment in terms of the total labour costs is extremely low in Spain.

On the other hand, enterprises profiled as KA or NCNAK, with low technological opportunities and in most cases which have few interactions with other actors, demand innovation policy focused mainly on incorporation of new technologies such as ICT, machinery, equipment and software, as well as mechanisms to fortify interactions with customers and consultants. In both cases, innovation policies for services should take into consideration the close user-producer relationship and, hence, the importance of interface structures to strengthen the ongoing exchange of information. Particularly with regard to the latter group, public policies should also aim to include these activities in the "rail" of the innovation dynamic, led by knowledge- and technological-intensive industries.

It is worth mentioning that public policy should absorb the implications of a sectoral integration process (so-called *synthesis approach* to the analysis of innovation in services) justified due to the interplay between economic sectors as well as the existence of different patterns of innovation within the economic branches. This evidence, which has been focused on in the recent literature with regard to services, endorses the creation of specific policies to foster organisational innovations, which in turn affect the productive and innovative dynamics of sectors such as manufacturing. This requires an effort to incorporate the non-technological aspects in public innovation policies.

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