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Why does eco-innovation differ in service firms? Some insights from Spain

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Abstract

Although environmental innovation studies have traditionally focused on manufacturing firms, the distinctive features of eco-innovation activities carried out by service firms require special attention. Using the Spanish Community Innovation Survey (CIS), this paper determines which are the main drivers of undertaking eco-innovation and investigates the similarities and differences between service and manufacturing firms within the five sub-groups of services (supplier dominated, scale intensive physical networks, scale intensive information networks, science-based, and others). The results confirm that the main eco-innovation triggers are similar—technological push factor orientation (internal R&D and persistence) and firm size—while the impact of market pull factors and public environmental legislation differ within the services sub-groups. In addition, we find a high degree of heterogeneity within service firms. In contrast to traditional service firms, those in the groups involving R&D activities, information networks, and scale-intensive physical networks exhibit intensive eco-innovation performance and show a high level of green indicators.

KEYWORDS

eco-innovation drivers, sustainable development, environmental policy, service firms, Spain

1 | INTRODUCTION

Increasingly, the differences between developed and developing countries are becoming less tangible. Technological change differences between manufacturing and services, allied to changes in consumption patterns, lead to service firms accounting for a high proportion of total job generation and added value. Nowadays, service activities account for 60–70% of GDP and 70–80% of employment in most OECD and developing countries (see the Gallouj and Savona (2009) review).

Despite new challenges for service firms, it is only in the last two decades that economists became interested in examining the different behaviour of the service sector. This is also true in the field of industrial economy and, particularly, in innovation economy. Most of the theoretical and empirical literature on innovation behaviour among firms focuses on the manufacturing sector which has traditionally been considered "the leader" in innovation, with service firms consequently being "the laggards", secondary innovators on a supplier technology base (Pavitt, 1984). However, these more recent academic studies of innovation focus on analysing the variety of innovative patterns among service firms (Cainelli, Evangelista, & Savona, 2005; Evangelista 2000; Gallouj, Weber, Stare, & Rubalcaba, 2015; Leiponen, 2012; Tether, 2005).

Their main empirical results highlight the fact that the nature of innovation activities differs substantially between manufacturing and service firms, thus discouraging any simple generalization about innovation. Also, the direct adoption of traditional innovation frameworks, which were worked out in the context of the manufacturing sector, underestimates the innovative capacity of the service sector (Gallouj and Savona 2009; Miozzo & Miles, 2003).

Current economies are becoming services economies, or rather, are working towards becoming sustainable development services economies, since environmental and social concerns increasingly aspire to more sustainable and low-carbon economies (Barbieri, Ghisetti, Gilli, Marin, & Nicolli, 2016; Jové-Llopis & Segarra-Blasco, 2018a). A better understanding of the relationship between services and sustainable development is increasingly necessary. However, as del Río, Peñasco, and Romero-Jordán (2016) pointed out in their recent review, the innovation drivers that reduce the environmental impacts and contribute to the transition to sustainable societies are still predominantly those of the manufacturing sector and have not, as yet, been explored in sufficient depth for the service sector.

Since services are conventionally viewed as being immaterial and consequently creating lower direct pressures on natural resources–– an idea recently criticised by Djellal and Gallouj (2016)––the increasing proportion of services in the economy is traditionally seen as positive for its environmental performance. This, however, is not self-evident. Unlike the manufacturing sector, service sector emissions do not always directly impact the environment, and it can be easy to miss the indirect effects and overestimate the sectoral difference. Moreover, many services demand a high volume of industrial inputs; while their direct pressure may be low, it is higher when these transfers are taken into account (EEA 2014). Consequently, from an integrated macro-level perspective, the shift to a service economy may be less green than might be expected (Cainelli & Mazzanti, 2013).

Considering both the central role that the service sector plays nowadays in more developed countries and the need for a greener growth economy, the main purpose of this study is to explore the determinants of Spanish service and manufacturing firms having an environmental orientation. An important challenge when studying how innovation differs between sectors and groups relates to the high degree of heterogeneity between the manufacturing and service sectors and also within the service industry sub-groups (Camacho & Rodriguez, 2008). We analyse both these areas of heterogeneity using the Spanish Community Innovation Survey between 2008 and 2015.

Our results show that manufacturing firms have a higher orientation towards the environment than do service firms and that the drivers affecting the eco-innovative orientation of firms at aggregate level have some similarities (such as internal R&D efforts, firm size and eco-innovation persistence). In contrast, environmental regulations and cooperation play a role for manufacturing firms; service firms seem rather to rely on market pull factors. Service activities based on science and intensive-scale information network services are more likely to involve eco-innovation activities, while this is less likely in traditional service Spanish firms.

This paper contributes to the literature in several ways. First, we study the differences between the eco-innovation drivers in the two sectors[1]. As del Río et al. (2016) and Díaz-García et al. (2015) point out in their recent literature review on eco-innovation, analysis of the main drivers of eco-innovation in sectors other than manufacturing is almost non-existent. Second, with this in mind, we study the heterogeneity among service firms. Third, few papers have focused on Southern Europe countries such as Spain, a country with both a relatively low level of environmental regulation stringency and, as compared to Nordic European countries, a low customer awareness for green products. Finally, the econometric analysis in the eco-innovation literature has mainly been based on small and cross-sectional samples, while there has been almost no use of panel data. We take advantage of an extensive panel database for Spanish firms (PITEC) that allows us to examine long-term relationships between variables and to control for non-observable heterogeneity.

The remainder of this chapter is structured as follows. Section 2 consists of a literature review. Section 3 presents the database, some descriptive statistics and, the econometric methodology. Section 4 shows our main findings. The final section presents our conclusions and consequent policy implications.

2 | DRIVERS OF ECO-INNOVATION STRATEGY

This section focuses on the general innovation approach and environmental issues. Before addressing what factors prompt service firms to carry out eco-innovations, we need to clarify some aspects of innovation activities in manufacturing and services at firm level. Several authors offer evidence that innovation is well defined in the manufacturing sector but that this cannot be transposed to the service activities. In the first place, there is a conceptual problem, given that the bulk of literature adopts the Schumpeter (1934) vision of innovations as the “carrying out of new combinations”.

However, innovation in services is much more eclectic, heterogeneous and intangible. Consequently, many researchers are adopting a concept of service innovation that is distinct from the traditional Schumpeterian conception that emphasises financing, technological profile and the material dimension. This alternative approach focuses on process rather than product, on the participation of clients rather than the exclusive initiative of the innovative firm, and on the intangible dimension as opposed to the material nature of Schumpeterian innovation.

In this context, Hipp and Grupp (2005) and Pires, Sarkar, and Carvalho (2008) argue that the nature and the implementation of innovation differ substantially between the two sectors. From an output perspective, incremental rather than radical innovation predominates in service firms. This innovation is organisational, process or intangible, in contrast to the typical manufacturing technology innovation. From an input perspective, R&D activities—internal, external or cooperative projects—play a different role in research service providers than in other service firms. However, Rubalcaba, Gago, and Gallego (2010) pointed out that technological and non-technological innovation should not be considered independent, but rather reflect a synthesis perspective. The interrelation of service and product innovation supports an integrated neo-Schumpeterian approach, leading to a broadening of the research field and new insights into how firms might manage service innovation (Carlborg, Kindström, Kowalkowski,

[1]In general, the literature uses four different terms to refers innovations that reduce the negative impact on the environment: “green”, “eco”, “environmental” and “sustainable”. In recent years, the term "eco-innovation" has become the predominant term used by literature (Díaz-García, González-Moreno, & Sáez-Martínez, 2015).

2014). Finally, these contributions all agree that one of the difficulties in establishing a typology of innovations in service firms is related to the great heterogeneity of service activities. Consequently, the wide diversity of services and the differences in the role played by technology and innovation means that there is no standard and unique pattern of innovation at the sectoral level.

Considering the above idiosyncrasy of innovation in services, we believe that it is important to examine and shed more insights on the drivers that promote environmental innovation behaviour both between manufacturing and service firms and also within the service sector.

Recently, it has been observed that new environmental challenges create the need to incorporate eco-innovation into firms. The term eco-innovation refers to these innovations that reduce environmental impacts but has not yet been standardised academic level—“eco-innovation”, “green innovation”, “environmental innovation” are all found (EIO 2013; Kemp & Pearson, 2007).[2] Most of firms are not very cognisant of this, and do not see environmental initiatives as distinct from their normal innovation process (OECD, 2008). Environmental innovations differ from more general innovations in that eco-innovations produce both economic and environmental benefits. In an EU-funded research project titled “Measuring Eco-Innovation” (MEI), eco-innovation was defined by Kemp and Pearson (2007) as the: “production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives”.

A crucial question that scholars face is whether eco-innovations can be treated as standard innovations, or whether there is a need for specific management and policy approaches to foster them. Since eco-innovation is characterised by the double externality problem, having both R&D spillovers and environmental externality, there is a need for both innovation and environmental public policies (Rennings, 2000).

In the past decade, a stream of studies has analysed the determinants of eco-innovation among manufacturing firms from different theoretical frameworks (for an overview of the subject see, for example, Aykol and Leonidou (2015) and Hojnik and Ruzzier (2015)).

From the resource-based view (RBV), a firm's ability to eco-innovate is traditionally linked to the role of resources and capabilities and to the pool of knowledge available within the firm. At the same time, the importance of innovation systems, the internal and external factors and the dynamic interaction between different actors and their influences on the innovation process is highlighted by evolutionary perspective (Nelson & Winter, 1982). Taking into account both approaches, the literature has classified the drivers of eco-innovation as internal (resources such as technological capabilities, qualified employees or financial resources) and external factors such as a firm's interaction with other agents through cooperation, networks and market relations (Borghesi, Cainelli, & Mazzanti, 2015; Bossle, Dutra de Barcellos, Vieira, & Sauvée, 2016; Demirel and Kesidou 2011; Hofmann, Theyel, & Wood, 2012; Kieffer, Carrillo-Hermosilla, & del Río, 2019).

In recent years, it has become widely accepted that the main elements of environmental innovation theory include the demand side, supply side, environmental policy influences and firm-specific factors (Horbach 2008; Zubeltzu-Jaka, Erauskin-Tolosa, & Heras-Saizarbitoria, 2018). Following these criteria, we present a vector of determinants of eco-innovation for services that integrate into a single framework both the drivers of innovation for services proposed by Coombs and Miles (2000) and Gallouj and Savona (2009) and the drivers of eco-innovation at the firm level as proposed by Horbach (2008) and Triguero, Moreno-Mondéjar, and Davia (2013). Table 1 summarises our analysis strategy for testing the determinants of eco-innovation in services activities broken their four mains drivers (supply side forces, demand side forces, institutional and political factors, and firms' individual factors).

The main result in the recent literature on the determinants of eco-innovation is that eco-innovations are more dependent on regulation than are other innovations. This idea relies on the Porter hypothesis which postulates that environmental regulation may lead to a win-win situation, where pollution is reduced while profits are increased (Porter & van der Linde, 1995). In this context, regulation can have a significant influence on the direction of innovation. In the manufacturing context, Veugelers (2012) for Belgium and Del Río, Peñasco, and Romero-Jordán (2015) for Spain, identified regulation as an important driver of eco-innovation.

TABLE 1 Determinants of eco-innovation activities in services industries

Supply side factors	**Technology push factors**
	Internal R&D effort
	External R&D effort
	R&D Cooperation
	Eco-innovation persistence
Demand side factors	**Market pull factors**
	New market
	New firm
Institutional and political influences	**Environmental policies**
	Public regulation (pull)
	Public subsidies (push)
Individual characteristics	**Firm characteristics**
	Firm size
	Firm age
	Belonging to a group
	Exports status

Source: Adapted from Horbach (2008) and Triguero et al. (2013) with permission.

[2]The terms eco, environmental and green innovation will be used interchangeably, indicating each time an innovation with a lower detrimental impact on the environment.

Regarding the impact of supply push instruments, such as subsidies for eco-innovation, this is not always clear from the manufacturing firm literature (De Marchi 2012; Triguero et al., 2013). When it comes to service firms, it is expected that, since environmental regulations might reduce investment uncertainty and warn firms of resource-inefficient practices (Cainelli & Mazzanti, 2013), the more emission-intensive sectors such as transport and trade, would be more stimulated by regulations or public funding. In general terms, the lack of specific and properly designed environmental regulation for the services sector due to it being considered to have few environmental impacts might reduce the innovation-induced effects in line with Porter's arguments and might explain the low sustainable progress among services firms (Ambec, Cohen, Elgie, & Lanoie, 2013).

Moreover, technological capabilities (investment in R&D and having qualified employees) play an essential role in the adoption of environmental innovation (Cainelli, De Marchi, & Grandinetti, 2015; Horbach 2008; Mazzanti & Zoboli, 2009). Since service firms are less likely to acquire knowledge and technology through hard sources such as R&D, acquisition of external R&D or the incorporation of new equipment (Segarra-Blasco, 2010), we expected that a firm's ability to carry out eco-innovation is less likely to depend on its technological capabilities.

Eco-innovations are characterised by a high level of uncertainty, novelty and the need to go beyond the firm's core competences and this implies a higher propensity for relying external sources in terms of cooperation and search for new knowledge than does general innovation. De Marchi (2012) and Triguero et al. (2013) show that cooperation with public research institutes and universities becomes more relevant for firms with environmental motivations than it does for other innovators. In parallel, since service firms are more likely to source knowledge and technology through relation with suppliers and customers or cooperation with partners, external sources and cooperation are expected to be an important driver for triggering an eco-innovation strategy (Tether, 2005).

Regarding the demand side, the literature suggests that higher consumer and stakeholder environmental conscience will be transformed—an expected increase in future demand triggering current investment in environmental innovation (Kammerer, 2009). However, the results of empirical studies are mixed. On the one hand, Horbach (2008), using panel data for German firms, shows that customer demand and public pressure are the key drivers of eco-innovation. Similarly, Wagner (2008) shows that market research on green products has a positive effect on a firm's propensity to carry out eco-innovations on central and Nordic European countries. On the other hand, in countries such as Spain with low environmental awareness and low willingness to pay more for environmentally friendly products, a market pull effect will be very low or non-existent (Jové-Llopis & Segarra-Blasco, 2018b).

A related thread in the literature emphasises that the lower visibility of the environmental impacts of service firms as compared to manufacturing firms might explain the low pressure from stakeholders and, consequently, the low eco-innovation pattern (Carballo-Penela & Castromán-Diz, 2015).

Finally, other important, but less frequently reported, drivers are firm characteristics such as its size, age, whether it belongs to a group or export capacity; these variables are usually identified as control variables in the empirical studies.

There is a positive relationship with firm size (Horbach 2016; Triguero et al., 2013), large companies tend to develop and adopt more eco-innovations, since small firms, given their lower innovation capabilities and financial resources, have more difficulties in eco-innovating. Belonging to a multinational group may help a firm to learn about new eco-innovation possibilities, or best practices in other countries, quite apart from the access to capabilities and resources of the parent company. Nevertheless, evidence on the influence of this variable, as well as age and export variable, is still both scarce and inconclusive (Borghesi et al., 2015; Del Río, Romero-Jordán, & Peñasco, 2017; Zubeltzu-Jaka et al., 2018).

3 | DATABASE, VARIABLES AND DESCRIPTIVE STATISTICS

3.1 | Database

The analysis is based on firm level data from the Technological Innovation Panel (PITEC).[3] The main advantage of this dataset is that it contains detailed information on innovation behaviour at the firm level, thus allowing comparison between eco-innovators and non-eco-innovators rather than just analysing eco-innovators. It is compiled from successive Spanish Community Innovation Survey (CIS) waves and, as such, is characterized by its time dimension.

Our final database selection was subject to a process of filtering. The main filters were as follows: 1) the data referred the period 2008–2015, because eco-innovation motivation questions were not included in the survey until 2008; 2) firms from the manufacturing and service sectors were analysed; 3) firms that reported confidentiality issues, mergers, employment incidents and so on were not incorporated in the sample.

3.2 | Some descriptive statistics

We present the descriptive statistics at the aggregate sectoral level. Since the high degree of heterogeneity presents an important challenge, to take this into account we also employ the Camacho and Rodriguez (2008) classification for Spanish services as adapted from Soete and Miozzo (1989). Here, services activities are classified into five clusters considering their high degree of heterogeneity: supplier dominated, scale intensive physical networks, scale intensive information networks, science-based and, other services.[4]

From the innovation output perspective, Table 2 shows that manufacturing firms are more inclined to undertake technological

[3]More information on the dataset is available at the FECYT website: https://icono.fecyt.es/pitec/descarga-la-base-de-datos

[4]See Appendix 1 for a detailed classification of service activities.

TABLE 2 Descriptive statistics. Period 2008-2015

Variable	Manufacturing	Services	Mean differences		Supplier dominated	Scale-intensive physical networks	Scale-intensive information networks	Science-based	Other services
Eco-innovation behaviour (% firms)									
Reduce environmental impacts	43.52	21.24	-22.28***	(0.0037)	0.1276	0.2017	0.2292	0.3097	0.1186
Energy efficiency	37.28	16.59	-20.69***	(0.0036)	0.1047	0.1537	0.2056	0.2331	0.1003
Reactive (regulation)	24.98	11.56	-13.42***	(0.0031)	0.0902	0.1080	0.1337	0.1582	0.0694
Innovation output (% firms)									
Product	56.18	36.79	-19.39***	(0.0041)	0.1936	0.2655	0.5368	0.5630	0.2432
Process	54.81	41.05	-13.76***	(0.0040)	0.3084	0.3747	0.6051	0.4947	0.3242
Organisational	43.43	41.39	-2.04***	(0.0040)	0.3473	0.3554	0.5975	0.5108	0.3226
Marketing	31.88	25.17	-6.71***	(0.0037)	0.1804	0.2469	0.4236	0.2827	0.1970
New market	22.64	16.48	-6.15***	(0.0032)	0.0468	0.0987	0.1649	0.3067	0.0951
New firm	32.98	19.05	-13.93***	(0.0360)	0.0902	0.1291	0.2704	0.3088	0.1179
Innovation inputs (% firms)									
Internal R&D	55.82	34.56	-21.25***	(0.0040)	0.1634	0.2064	0.3423	0.6280	0.1915
External R&D	26.27	16.26	-10.01***	(0.0033)	0.0770	0.1120	0.2162	0.2767	0.0831
Cooperation	30.68	27.37	-3.31***	(0.0037)	0.1495	0.1788	0.4065	0.4467	0.1579
Innovation expenditures per worker (euros)									
Total €	5115.57	8123.60	3008.02***	(277.96)	791.92	1744.41	17499.77	17714.46	2751.13
Internal R&D €	3290.23	5866.86	2576.62***	(159.43)	617.62	1015.34	6979.70	14062.77	2034.30
External R&D €	741.28	1095.23	353.94***	(72.31)	57.99	307.11	1031.68	2634.01	328.60
Public funding's (% firms)									
Subsidies	31.30	24.40	-6.89***	(0.0036)	0.0995	0.1192	0.1632	0.4885	0.1316
Local	17.81	14.23	-3.57***	(0.0030)	0.0530	0.0554	0.0536	0.3114	0.0696
National	20.66	17.74	-2.91***	(0.0032)	0.0669	0.0691	0.1361	0.3760	0.0843
UE	3.76	7.78	4.02***	(0.0018)	0.0215	0.0266	0.0371	0.1817	0.0273
Firms characteristics									
Size (workers)	174.55	637.678	463.11***	(14.035)	726.84	813.60	1360.55	209.03	799.36

(Continues)

TABLE 2 (Continued)

Variable	Manufacturing	Services	Mean differences		Supplier dominated	Scale-intensive physical networks	Scale-intensive information networks	Science-based	Other services
Age	31.62	26.69	-4.9210***	(0.1733)	33.42	30.37	44.97	19.03	24.84
Exports (% firms)	31.54	10.16	-0.2137***	(0.0023)	0.0524	0.1307	0.0741	0.1366	0.0466
Patents (% firms)	12.13	6.45	-5.6.7***	(0.0024)	0.0183	0.0345	0.0341	0.1422	0.0184
Group (% firms)	45.00	48.13	3.13***	(0.0040)	0.4240	0.5405	0.7525	0.4144	0.4566
R&D department (% firms)	52.19	33.24	-18.95***	(0.0045)	0.1544	0.1886	0.3317	0.6127	0.1841
Observations	33,913	26,257			2,882	7,211	1,697	8,625	5,842

Standard deviation in brackets. Comparison of the two samples by the Student t-test. *** Significant at 1%.
Source: Authors derivation from PITEC with permission.

innovations, while organisational and market innovation seem to be quite similar at the aggregate level. From the innovation input perspective, the proportion of innovative firms that invest in internal or external R&D activities is low in the service sector. However, their investment is higher than that of manufacturing firms; this surprising result can only be explained by the heterogeneous nature of services. Finally, regarding eco-innovation behaviour, there are considerable differences. Manufacturing firms have higher environmental orientation than do service firms. It should also be noted that, unlike the industrial sector, in recent years green policies and environmental legislation in the service sector has been almost non-existent, due to the fact that they are considered to have low environmental impact and thus almost no eco-innovative behaviour has been implemented in the service sector. Recently however, in the European context, a long-term strategic vision has been launched to achieve a competitive and neutral climate economy by 2050 (European Commission 2018). This highlights that, to achieve full implementation of this goal, a long-term strategy for the engagement of all the sectors of the economy will be necessary. Consequently, ambitious policies have been agreed at European Union level to promote green practices among services sectors (energy efficiency in buildings, secure and connected net mobility, circular economy, etc.).

In short, the values reflected in the two aggregate sectors, together with the substantial significance of the t-test, suggest that the profile of manufacturing firms differs slightly from that of service firms (Figure 1). In addition, these differences in the innovation indicators also occur within service firms and we pay special attention to the differences between the five clusters.

Supplier-dominated service firms and other service firms are low-innovative and have scarcely any green behaviour. Firms in the scale-intensive physical networks cluster are slightly more innovative than the two previous clusters. However, they rarely apply for public funds and register patents only occasionally. Scale-intensive information networks firms and science-based service firms tend to carry out more output innovations and have higher environmental awareness. The latter firms, in particular, have intense R&D and innovation rates, they are more frequently granted funds by public of R&D and innovation support programmes, they are more inclined to enter into cooperation agreements with partners, and they usually register the patents resulting from their research. To summarise this section, although there is a high degree of heterogeneity eco-innovation patterns, this gap is reduced when the focus is set on science-based services and scale-intensive information technologies.

3.3 | Econometric methodology

Given the binary character of the dependent variable (having an eco-innovation behaviour or not), a dynamic random probit model was specified to further account for endogeneity, by controlling for any unobserved time-invariant heterogeneity in the model. To address concerns of unobserved heterogeneity, we employed a random-effect model rather than a fixed-effect one since our variables of interest

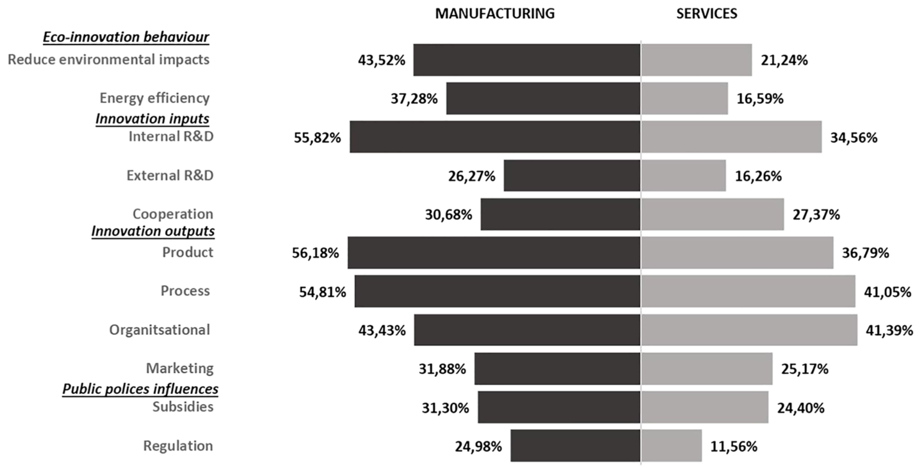

FIGURE 1 **Eco-innovation performance in Spanish manufacturing and services firms (% of firms)** [Colour figure can be viewed at wileyonlinelibrary.com]

Source: Authors own derivation from PITEC.

show little variation over time and our sample was drawn from a large population and included data for only a few years. In addition, the Hausman specification tests do not support the use of fixed effects.

Based on our research interest, the following equation was estimated:

$y_{it} = \beta_1 y_{it-1} + \beta_2 X_{it-1} + \alpha_i + \varepsilon_{it}$ Eq. [1]

where $i = 1 \ldots N$ indexes the firms, $t = 1 \ldots T$ the years, and where y_{it} is a binary outcome variable that takes the value 1 if firm i states that an eco-innovation orientation has been of high or medium importance between t and t-2. The variable y_{it-1} is an indicator for eco-innovation during the previous period and captures the previous eco-innovation experience and (X_{it}) refers to the explanatory variables.

We introduce a set of independent variables that the empirical literature lists as determinants of eco-innovation orientation in capturing factors related to: (1) technology-push factors, (2) market-pull factors, (3) regulatory factors, and finally, (4) a set of firm characteristics (among others, see Horbach (2008); Doran and Ryan (2016); and Hojnik and Ruzzier (2015)).[5] To mitigate the potential omitted variables bias in our econometric estimations, we also include an industry dummy to control technological conditions and a time dummy to control macro differences over time. Finally, α_i represents the time-invariant unobserved individual effects and ε_{it} is the idiosyncratic error term. In the regression analyses, we lag explanatory variables one period to mitigate endogeneity problems deriving from reverse causality.

When using dynamic random probit models, one needs to handle the initial conditions carefully to mitigate estimator's inconsistency and also the overestimation of the state dependence effect. The literature on nonlinear dynamic panel data models proposes various estimation techniques to mitigate (Skrondal & Rabe-Hesketh, 2014; Wooldridge, 2005). Specifically, Wooldridge (2005) suggests a conditional maximum likelihood approach, where the individual effect is assumed to depend on the initial conditions of the dependent variable (y_{it0}), and all lag values of the time-varying explanatory variables (excluding the initial value). In practice, researchers often use a constrained version of the model where the lags of exogenous variables are replaced by the time average of each exogenous variable $\bar{x}_i$ namely:

$\alpha_i = \delta_0 + \delta_1 y_{i0} + \delta_2 \bar{X}_i + \mu_i$ Eq. [2]

where $\bar{X}_i$ represents the means of time-variant exogenous variables, y_{i0} pertain to the first available observation for each firm. δ_1 capture the dependence of the individual effects on the initial conditions. μ_i is assumed to be distributed $N(0, \sigma_u^2)$ and independently of the explanatory variables, the initial conditions, and the idiosyncratic error term ε_{it}.[6]

Substituting Equation [2] into Equation [1] gives:

$y_{it}^* = \beta_1 y_{it-1} + \beta_2 X_{it-1} + \delta_0 + \delta_1 y_{i0} + \delta_2 \bar{X}_i + \mu_i + \varepsilon_{it}$ Eq. [3]

4 | RESULTS

This section presents the principal results of the dynamic random probit model. Table 3 gives the results the probability of designing an eco-innovation strategy for both aggregate samples. Then, considering the high heterogeneity within service activities, Table 4 shows the estimations for the five services clusters proposed in this analysis.[7]

To show the importance of accounting for individual effects and handling the initial conditions problem, we report the estimation of the dynamic random effect probit model considering the unobserved individual heterogeneity, and assuming the initial conditions to be exogenous (first pair of columns) from the model with individual effects correlated with the initial conditions (second pair of columns). The results indicate that, when the initial conditions are taken to be exogenous, the coefficients of the lagged dependent variable are

[5] Appendix 2 summarises the list of variables.

[6] The approach considered in Eq. [2] allows the individual effects to be correlated with the regressors. However, because of the lack of variation over time (within variation) in our variables, we were unable to identify δ_2. Consequently, we followed the strategy adopted by Raymond, Mohnen, Palm, and Schim Van Der Loeff (2010) and assumed that the unobserved individual effects are correlated only with the initial values of y_{ti}.

[7] In Appendix 3 the results of the probability of designing an eco-innovation strategy aimed at reducing environmental impact and reducing energy consumption are also reported.

TABLE 3 Results of the probability of designing an eco-innovation strategy (manufacturing and service firms)

	Eco-innovation strategy (EI + EE)				Reduce environmental impacts (EI)				Energy efficiency (EE)			
	Manufacturing firms		Service firms		Manufacturing firms		Service firms		Manufacturing firms		Service firms	
	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions
Technology push factors												
Internal R&D effort $_{t-1}$	0.0280*** (0.0037)	0.0297*** (0.0055)	0.0301** (0.0055)	0.0342*** (0.0077)	0.0264*** (0.0036)	0.0274*** (0.0040)	0.0344*** (0.0057)	0.0344*** (0.0063)	0.0188*** (0.0038)	0.0190*** (0.0041)	0.0214*** (0.0055)	0.0224*** (0.0060)
External R&D effort $_{t-1}$	0.0068 (0.0041)	0.0101 (0.0061)	0.0102 (0.0056)	0.0071 (0.0079)	0.0097* (0.0040)	0.0095* (0.0044)	0.0163** (0.0053)	0.0156* (0.0063)	0.0031 (0.0040)	0.0038 (0.0043)	0.0058 (0.0057)	0.0044 (0.0062)
Cooperation $_{t-1}$	0.0729** (0.0281)	0.0418 (0.0401)	-0.0758* (0.0381)	-0.123* (0.0509)	0.0748** (0.0270)	0.0651* (0.0295)	-0.00934 (0.0388)	-0.0215 (0.0427)	0.0358 (0.0273)	0.0388 (0.0292)	-0.108** (0.0397)	-0.107* (0.0428)
Market pull factors												
Sales new market $_{t-1}$	0.0006 (0.0005)	-0.0002 (0.0007)	0.0019** (0.0007)	0.0014 (0.0009)	0.0009* (0.0004)	0.0008 (0.0005)	0.0012 (0.0007)	0.0009 (0.0007)	-0.0001 (0.0004)	-0.0002 (0.0005)	0.0021** (0.0007)	0.0023** (0.0007)
Sales new firm $_{t-1}$	-0.0006 (0.0003)	-0.0010 (0.0005)	0.0003 (0.0005)	-0.0008 (0.0007)	-0.0004 (0.000380)	-0.0006 (0.000412)	0.0006 (0.000603)	-0.0004 (0.0006)	-0.0002 (0.0003)	-0.0004 (0.0004)	-0.0001 (0.0006)	-0.0005 (0.0006)
Policies influences												
Regulation $_{t-1}$	0.295*** (0.0291)	0.199*** (0.0400)	0.117** (0.0409)	-0.0134 (0.0544)	0.149*** (0.0308)	0.140*** (0.0333)	0.0296 (0.0454)	-0.00760 (0.0495)	0.140*** (0.0320)	0.142*** (0.0339)	0.0498 (0.0471)	0.0345 (0.0506)
Subsidies $_{t-1}$	0.0510 (0.0279)	0.00111 (0.0396)	0.0724 (0.0427)	0.00379 (0.0580)	0.0410 (0.0269)	0.0423 (0.0294)	0.0523 (0.0435)	0.0440 (0.0480)	0.0187 (0.0272)	0.0182 (0.0290)	0.0947* (0.0439)	0.0876 (0.0476)
Firm characteristics												
Size $_{t-1}$	0.141*** (0.0138)	0.171*** (0.0255)	0.0767*** (0.0131)	0.110*** (0.0224)	0.143*** (0.0134)	0.153*** (0.0155)	0.0861*** (0.0133)	0.0987*** (0.0158)	0.135*** (0.0137)	0.147*** (0.0154)	0.0600*** (0.0126)	0.0696*** (0.0145)
Young $_{t-1}$	-0.116 (0.0942)	-0.225 (0.143)	-0.102 (0.0985)	-0.181 (0.142)	-0.0938 (0.0918)	-0.102 (0.102)	-0.125 (0.100)	-0.159 (0.112)	-0.140 (0.0937)	-0.151 (0.101)	0.122 (0.0974)	0.0941 (0.107)
Group $_{t-1}$	0.00138 (0.0304)	-0.0348 (0.0528)	-0.0177 (0.0397)	0.0233 (0.0638)	-0.0237 (0.0293)	-0.0157 (0.0341)	-0.0313 (0.0403)	-0.0192 (0.0472)	0.0298 (0.0304)	0.0139 (0.0340)	-0.0421 (0.0405)	-0.0387 (0.0459)
Exports $_{t-1}$	-0.0387 (0.0320)	-0.0382 (0.0493)	-0.0125 (0.0374)	-0.0324 (0.0554)	-0.0113 (0.0312)	0.0144 (0.0348)	-0.0194 (0.0380)	-0.0295 (0.0435)	-0.0225 (0.0320)	-0.0144 (0.0348)	-0.0603 (0.0375)	-0.0634 (0.0417)
Persistence												
y_{it-1}	1.319*** (0.0341)	0.575*** (0.0390)	1.417*** (0.0460)	0.728*** (0.0518)	1.388*** (0.0367)	1.070*** (0.0389)	1.489*** (0.0531)	1.132*** (0.0562)	1.379*** (0.0310)	1.120*** (0.0329)	1.420*** (0.0465)	1.126*** (0.0493)
y_{i0}		2.837*** (0.0834)		2.947*** (0.116)		0.685*** (0.0414)		0.900*** (0.0682)		0.610*** (0.0395)		0.762*** (0.0665)

(Continues)

TABLE 3 (Continued)

	Eco-innovation strategy (EI + EE)				Reduce environmental impacts (EI)				Energy efficiency (EE)			
	Manufacturing firms		Service firms		Manufacturing firms		Service firms		Manufacturing firms		Service firms	
	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions
Complementarity												
EI									0.147*** (0.0327)	0.118*** (0.0347)	0.221*** (0.0487)	0.197*** (0.0521)
EE					0.171*** (0.0265)	0.138*** (0.0288)	0.114** (0.0404)	0.103* (0.0441)				
Constant	-1.292*** (0.216)	-2.372*** (0.431)	-1.271*** (0.149)	-1.831*** (0.259)	-1.680*** (0.203)	-1.895*** (0.243)	-1.452*** (0.148)	-1.671*** (0.177)	-1.465*** (0.212)	-1.718*** (0.244)	-1.714*** (0.0878)	-1.902*** (0.0996)
Log likelihood	-8996.5	-7286.5	-5344.4	-4472.2	-9320.1	-9130.5	-4949.1	-4823.7	-9748.5	-9593.2	-4851.0	-4761.7
Wald test of χ^2	4280.5	2494.8	2361.9	1566.9	4873.3	4831.9	2485.2	2392.3	4029.7	4351.4	1612.2	1904.7
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
σ_α	0.4180 (0.0318)	1.2177 (0.0413)	0.5408 (0.0419)	1.2492 (0.0531)	0.3812 (0.0334)	0.5844 (0.0289)	0.5115 (0.0458)	0.7351 (0.0420)	0.4605 (0.0295)	0.6100 (0.0274)	0.5381 (0.0429)	0.7187 (0.0416)
Rho	0.1487 (0.0192)	0.5972 (0.0163)	0.2263 (0.0271)	0.6094 (0.0202)	0.1269 (0.0194)	0.2546 (0.0187)	0.2073 (0.0293)	0.3508 (0.0260)	0.1750 (0.0185)	0.2712 (0.0178)	0.2245 (0.0277)	0.3406 (0.0260)
Observations	20,383		11.750		20.383		11.750		20.383		11.750	

Estimations control for time and industry dummies. Robust standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

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TABLE 4 Results of the probability of designing an eco-innovation strategy (5 services clusters)

	Supplier dominated		Scale-intensive physical networks		Scale-intensive information networks		Science based		Other services	
	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions
Technology push factors										
Internal R&D effort $_{t-1}$	0.0112 (0.0210)	-0.00733 (0.0287)	0.0508*** (0.0104)	0.0578*** (0.0160)	0.0161 (0.0180)	0.0105 (0.0272)	0.0279** (0.00864)	0.0294* (0.0119)	0.0301* (0.0136)	0.0440* (0.0184)
External R&D effort $_{t-1}$	-0.0632* (0.0260)	-0.0706* (0.0336)	0.0131 (0.0115)	0.0131 (0.0170)	0.0158 (0.0199)	0.0024 (0.0287)	0.0260** (0.0081)	0.0168 (0.0115)	-0.0055 (0.0162)	0.0049 (0.0214)
Cooperation $_{t-1}$	-0.0701 (0.127)	-0.0023 (0.159)	-0.0355 (0.0703)	-0.165 (0.102)	-0.183 (0.125)	-0.0881 (0.172)	0.00352 (0.0617)	-0.0596 (0.0831)	-0.0880 (0.0949)	-0.159 (0.124)
Market pull factors										
Sales new market $_{t-1}$	0.0058 (0.0036)	0.0039 (0.0046)	0.0002 (0.0014)	-0.0011 (0.0020)	0.0017 (0.0031)	0.00028 (0.0042)	0.0024* (0.00098)	0.0029* (0.0013)	0.0012 (0.0018)	0.0014 (0.0024)
Sales new firm $_{t-1}$	0.0001 (0.0019)	-0.0023 (0.0023)	0.0001 (0.0010)	-0.0013 (0.0015)	-0.0010 (0.0019)	-0.0052 (0.0028)	0.00017 (0.00097)	0.0002 (0.0013)	0.0007 (0.0014)	0.0002 (0.0019)
Policies influences										
Regulation $_{t-1}$	0.314* (0.130)	0.242 (0.158)	0.0660 (0.0804)	-0.0639 (0.114)	-0.00911 (0.139)	0.00822 (0.202)	0.224*** (0.0647)	0.0559 (0.0873)	0.113 (0.105)	-0.157 (0.137)
Subsidies $_{t-1}$	0.156 (0.157)	0.179 (0.198)	0.103 (0.0784)	0.0404 (0.117)	0.108 (0.162)	-0.281 (0.235)	0.128 (0.0667)	0.0368 (0.0896)	0.0132 (0.109)	-0.0618 (0.147)
Firm characteristics										
Size $_{t-1}$	-0.0267 (0.0409)	0.0155 (0.0625)	0.0910*** (0.0202)	0.117** (0.0390)	0.0943* (0.0404)	0.131 (0.0707)	0.0777** (0.0257)	0.117** (0.0448)	0.0919** (0.0303)	0.151** (0.0473)
Young $_{t-1}$	-0.337 (0.380)	-0.306 (0.525)	-0.224 (0.342)	-0.379 (0.500)	0.188 (0.385)	0.392 (0.643)	0.0158 (0.124)	-0.120 (0.179)	-0.269 (0.309)	-0.150 (0.432)
Group $_{t-1}$	0.289* (0.118)	0.258 (0.173)	-0.0243 (0.0655)	0.137 (0.121)	-0.0438 (0.164)	-0.0700 (0.266)	-0.0569 (0.0664)	-0.0954 (0.109)	-0.136 (0.0980)	-0.0469 (0.148)
Export $_{t-1}$	0.246 (0.163)	0.245 (0.221)	-0.0251 (0.0628)	-0.0667 (0.106)	-0.150 (0.149)	-0.342 (0.247)	-0.0232 (0.0586)	-0.0154 (0.0852)	-0.0437 (0.0976)	-0.0239 (0.139)
Persistence										
y_{it-1}	1.087*** (0.155)	0.566*** (0.167)	1.485*** (0.0881)	0.739*** (0.110)	1.725*** (0.154)	0.847*** (0.191)	1.418*** (0.0742)	0.718*** (0.0818)	1.496*** (0.112)	0.843*** (0.127)
y_{i0}		2.052*** (0.335)		2.646*** (0.217)		3.658*** (0.487)		3.522*** (0.205)		2.757*** (0.278)

(Continues)

TABLE 4 (Continued)

	Supplier dominated		Scale-intensive physical networks		Scale-intensive information networks		Science based		Other services	
	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions	Exogenous initial conditions	Correlated with initial conditions
Constant	-0.820*	-0.849	-1.544***	-2.236***	-1.066**	-1.686*	-1.625***	-2.304***	-1.740***	-2.300***
	(0.372)	(0.545)	(0.225)	(0.430)	(0.369)	(0.664)	(0.223)	(0.385)	(0.315)	(0.493)
Log likelihood	-468.1	-426.4	-1364.1	-1170.0	-429.8	-347.3	-2214.2	-1745.4	-868.0	-750.0
Wald test of χ^2	117.2	119.1	707.8	402.2	206.8	137.8	813.4	634.5	317.8	264.1
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
σ_α	0.3801	0.9025	0.2918	1.1998	0.5309	1.3068	0.6670	1.4216	0.5564	1.1858
	(0.1554)	(0.1583)	(0.1015)	(0.1070)	(0.1532)	(0.1907)	(0.0696)	(0.0913)	(0.1011)	(0.1263)
Rho	0.1262	0.4489	0.0784	0.5901	0.2199	0.6307	0.3079	0.6690	0.2364	0.5844
	(0.0902)	(0.0868)	(0.0503)	(0.0431)	(0.0990)	(0.0679)	(0.0445)	(0.0284)	(0.0656)	(0.0517)
Observations	883		2.839		998		5.075		1.955	

Estimations control for time dummies. Robust standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

overestimated, hence the hypothesis of exogenous initial conditions leads to an overestimation of the degree of persistence. Although, the estimation results of both model variants are very similar, they demonstrate that taking into account the assumption of the initial conditions correlated with the unobserved individual effects is important in estimating the probability of a positive outcome (eco-innovation behaviour).

At the aggregate level, the results of the estimation exhibit some similarities and differences between sectors. First looking at the similarities, the findings show how internal R&D efforts and firm size are crucial for triggering eco-innovation behaviour (EI, EE) in Spanish manufacturing and service firms.

Note also that, in both sectors, the external R&D investment is positively correlated to reducing environmental impacts, but not to improving energy efficiency. Moreover, after accounting for individual effects and correctly handling the initial conditions, the empirical analysis reveals that past eco-innovation behaviour is an essential driver of current eco-innovation status for either type of environmental innovation strategy (EI, EE) or sector analysed. These results are consistent with an empirical study of the Spanish automotive industry carry out by Peiró-Signes and Segarra-Oña (2018). Finally, the results also point to the existence of complementarities between reducing environmental impacts and reducing energy consumption strategies across Spanish manufacturing and service firms.

Regarding the differences between service and manufacturing firms, the results highlight that the variable *cooperation* is positively correlated for manufacturing firms looking at reducing environmental impacts and has no effect on energy efficiency strategy. In contrast, for service firms the relationships with other partners in the value chain, such as clients or suppliers, and the support of associations or universities do not promote a green orientation.

Other differences between manufacturing and service sectors rely on environmental policies influences and market pull factors. In general, regarding the effects of public policy, the literature highlights regulations as a driver for enhancing eco-innovation strategy. In line with other contributions in the literature, our results show that environmental regulations matter for promoting green behaviour in manufacturing firms (De Marchi 2012; Del Río et al., 2015; Demirel and Kesidou 2011; Horbach, Oltra, & Belin, 2013).

However, the negligible role of regulations in service firms is not surprising, since services are usually subject to less strict environmental regulations and economic instruments because of the perception of services as being less environmentally harmful than material goods. Moreover, service firms seem more closely related to market pull proxies such as high volume of sales in products new to the market than manufacturing are firms.

Table 4 reports the probability of designing an eco-innovation strategy for five specific service sectors. Note that in all service clusters, persistence is positively correlated with being a more sustainable green firm. Then, starting with supplier dominated (sale and repairs, hotels and restaurants, and health, social and community) services, we observe the absence of eco-innovation drivers in the area of technology push factors, which is also the case for the scale-intensive information networks cluster. In contrast, environmental regulations seem to somewhat drive supplied-dominated service firms, indicating a reactive attitude of this group of firms towards the environment.

For scale-intensive physical networks (trade and transport, the most polluting services) and other services, the crucial drivers for pursuing an eco-innovation strategy are the investment in R&D activities and the size of the firm, which suggest that larger firms have higher innovation capabilities and financial resources to overcome difficulties in eco-innovating than do smaller firms. Finally, for the science-based cluster, the roles played by internal and external R&D are significant for the eco-innovation strategy. Regulation, market pull factors, and firm size are also significant.

Usually, empirical studies based on the CIS data on innovation among services firms fail to reveal striking differences between manufacturing and service firms. However, we found clear differences in the effects of eco-innovation drivers between the five services clusters considered in this paper. The most relevant economic results regarding the eco-innovation behaviours among Spanish innovative firms are summarised in Table 5. Several considerations apply to the information synthetized here.

First, the drivers of eco-innovation among manufacturing and service firms are especially oriented towards technological push factors, while the impacts of the market pull factors and environmental public legislation differ among manufacturing and services sectors. The propensity of Spanish firms to undertake energy efficiency actions or reduce environmental impacts are more markedly pull-oriented in service firms; in contrast, Spanish manufacturing firms are more public regulation oriented.

Secondly, firm size plays a vital role in the capacity of Spanish firms to perform eco-innovation, both in manufacturing and in services, while others individual traits such as firm age, internationalisation capacity, or to belonging to a group show weak effects.

Third, when we compare the five groups of service activities in detail, the differences are remarkable. Service activities based on science and intensive-scale information network services are more likely to involve eco-innovation activities, while Spanish firms that operate in traditional services activities are less inclined to engage in eco-innovation.

Finally, a crucial dimension of the eco-innovation strategies among Spanish firms is their high dependence on the trajectory and their strong complementarity feedback In short, eco-innovation is more likely to be carried out in the future, and, also, firms that carried out energy efficiency activities are more likely to reduce their environmental impacts, and vice versa.

TABLE 5 Summary of the main empirical results

	Aggregate sectors		Services activities				
Drivers	Manufacturing	Services	Supplier dominated	Scale-intensive physical networks	Scale-intensive information networks	Science based	Other services
Technology push factors							
Internal R&D effort	+++	+++		+++		++	+
External R&D effort			-	+			
Cooperation	++	-					
Persistence and complementarity							
Persistence	+++	+++	+++	+++	+++	+++	+++
Complementarity (EI-EE)	+++	+++			+++		
Market pull factors							
Sales new market		++				+	
Sales new firm							
Environmental Policies influences							
Regulations	++		+			+++	
Subsidies							
Firm characteristics							
Size	+++	+++		+++	+	+++	++
Young							
Group							
Export							

This table extracts the result of Tables 3 and 4 in terms of significance and sign for the drivers of eco-innovation strategy. +++, ++, + indicate positive significance at a 1%, 5% and 10% level, respectively. - indicates negative significance at a 10% level. An empty space means no significant effect.

5 | DISCUSSION AND CONCLUDING REMARKS

Previous empirical studies have analysed the relationship between the determinants that influence the uptake of eco-innovation behaviour among manufacturing firms. However, despite the growing importance of services in current economic activity, the literature on environmental sustainability has under-investigated service innovation. To fill this gap, the current paper uses an extensive sample of Spanish innovative service firms, thus contributing to the better understanding of the similarities and the differences between manufacturing and service firms when engaging in eco-innovation initiatives. The analysis also pays special attention to the high degree of heterogeneity among service firms.

Results show that manufacturing firms are more oriented towards the environment than are service firms. However, they highlight that the drivers affecting the probability of designing an eco-innovation strategy among both sectors are quite moderate. The main differences in eco-innovation behaviour appear when we split service firms into the five previously mentioned clusters. For this case, we observe that important dissimilarities appear both in the eco-innovative capacity of firms and in drivers and obstacles that influence the green innovative orientation of service firms.

At the aggregate level, the main similarities for triggering eco-innovation behaviour are internal R&D efforts, firm size and eco-innovation persistence. In contrast, while environmental regulations and cooperation have a relevant role for manufacturing firms, service firms seem to rely on market pull factors. Second, analysing the similarities and dissimilarities within service activities, again past eco-innovation behaviour is an important driver for current eco-innovation status in all five service clusters. Internal R&D impacts in the regression (aggregate) and is found to matter for some sectors. However, the lack of significance for supplier-dominated and scale-intensive information networks poses questions for policy makers.

Considerable differences are also found within service clusters. Whereas service firms belonging science-based and scale intensive information networks clusters present intensive eco-innovation performance and exhibit high green indicators, traditional service activity firms exhibit moderate eco-innovation behaviour. Consequently, the strengths and weaknesses of each service cluster should be considered by both policymakers and firm managers.

This paper has several implications for firms, scholars and public policymakers. On the one hand, current economies are becoming service economies and, at the same time, environmental and social concerns for more sustainable and low-carbon economies are gaining more attention every day. Therefore, both fields, sustainability and services, should be tacked together and in-depth research and analysis of the service economy is required. However, to undertake future analysis there is a need access new data that combine both fields. Although PITEC is a valuable data source, and one that has been previously used in analyses of eco-innovation in Spain, it was not specifically established to analyse environmental innovation, and consequently variables of interest to us, such as market demand for green products or different environmental policy instruments, are not reported.

From the scholars' perspective, this study contributes to the literature as it sheds light on the differences and similarities between innovative manufacturing and service firms regarding the determinants of pursing an eco-innovation strategy. This study shows a high persistence in eco-innovation orientation which reinforces the idea that environmental behaviour is a long-term issue based on firms building their own capacities and creating a green culture. This path could be explained by the existence of sunk costs, learning effects or dynamic economies of scale. The results are of considerable interest for any public policy targeting innovation and eco-innovation. Government agencies or other institutions could provide incentives to engage in eco-innovation activities, but stability in eco-innovation activities over time is required to produce persistent and stable eco-innovators.

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APPENDIX 1. SECTORAL CLASSIFICATION

Sector	CNAE 2009
Manufacturing industries	10-33
Services industries	45-96
Supplier dominated	
Sale and repairs	
Hotels and restaurants	
Health, social and community services	
Scale-intensive physical networks	
Wholesale trade	
Transport	
Scale-intensive information networks	
Financial Intermediation	
Telecommunications	
Science-based	
Software	
R&D	
Engineering and technical services	
Technical testing and analysis	
Other services	
Retail trade	
Other transport	
Post	
Real estate	
Renting of machinery and equipment	
Other computer activities	
Other business services	
Movies and video	
Radio and television	

APPENDIX 2. DEFINITION OF VARIABLES

Dependent variables	Variable definitions
Eco-innovation strategy	Dummy variable that takes a value equal to 1 if the firm innovation objective has a high or medium orientation towards reducing environmental impact or energy consumption per unit produced; 0 if not
Green strategy	Dummy variable that takes a value equal to 1 if the firm innovation objective has a high or medium orientation towards reducing environmental impact; 0 if not
Energy efficiency strategy	Dummy variable that takes a value equal to 1 if the firm innovation objective has a high or medium orientation towards reducing energy consumption per unit produced; 0 if not
Independent variables	
Policy influences	
Regulation	Dummy variable that takes a value equal to 1 if the firm innovation objective has a high or medium orientation towards meet regulatory requirements; 0 if not
Subsidies	Local subsidies: dummy variable that takes a value equal to 1 if the firm receives any public financial support for innovation activities from local authorities; 0 if not
	National subsidies: dummy variable that takes a value equal to 1 if the firm receives any public financial support for innovation activities national authorities; 0 if not
	EU subsidies: dummy variable that takes a value equal to 1 if the firm receives any public financial support for innovation activities from the EU; 0 if not
Technology push factors	
Internal R&D effort	Expenditures in internal R&D activities per worker
External R&D effort	Expenditures in external R&D activities per worker
R&D Cooperation	Dummy variable that takes a value equal to 1 if the firm cooperates with other agents during the activity; 0 if not
Market-pull factors	
New market	% of turnover in new or improved products that were new to the market
New firm	% of turnover in new or improved products that were new to the firm
Firm characteristics	
Size	Log of the total number of employees of the firm
Young	Dummy variable that takes a value equal to 1 if the firm is less than seven years old since its creation; 0 if not
Group	Dummy variable that takes a value equal to 1 if the firm belongs to a group; 0 if not
Exports	Dummy variable that takes a value equal to 1 if the firm sells its product on international markets; 0 if not

APPENDIX 3. DISAGGREGATE RESULTS OF ECO-INNOVATION BEHAVIOUR BY FIVE SERVICE CLUSTERS

Table A.3.1 Results of the probability of reducing environmental impacts strategy (5 services clusters)

	Supplier dominated		Scale-intensive physical networks		Scale-intensive information networks		Science based		Other services	
Technology push factors										
Internal R&D effort $_{t-1}$	0.0044	0.00048	0.0454***	0.0456***	0.0289	0.0307	0.0282**	0.0292**	0.0307*	0.0398*
	(0.0201)	(0.0212)	(0.0107)	(0.0122)	(0.0174)	(0.0196)	(0.0087)	(0.0099)	(0.0146)	(0.0164)
External R&D effort $_{t-1}$	-0.0613*	-0.0623*	0.0235*	0.0195	0.00464	0.00661	0.0305***	0.0298**	-0.0021	-0.00111
	(0.0261)	(0.0270)	(0.0118)	(0.0135)	(0.0188)	(0.0211)	(0.0079)	(0.0091)	(0.017)	(0.019)
Cooperation $_{t-1}$	0.0634	0.0669	0.0652	0.0358	-0.258*	-0.260	0.0878	0.0691	-0.0551	-0.0874
	(0.122)	(0.127)	(0.0719)	(0.0813)	(0.127)	(0.139)	(0.0612)	(0.0697)	(0.100)	(0.111)
Market pull factors										
Sales new market $_{t-1}$	0.0083*	0.0084*	0.0009	0.0004	0.0002	0.00052	0.0009	0.0009	0.0006	0.0005
	(0.0034)	(0.0035)	(0.0014)	(0.0016)	(0.0030)	(0.0033)	(0.0009)	(0.0011)	(0.0019)	(0.0021)
Sales new firm $_{t-1}$	0.0023	0.0020	0.0008	0.0003	-0.0047*	-0.0058*	-0.0006	-0.0008	-0.0001	-0.0003
	(0.0018)	(0.0019)	(0.0010)	(0.0012)	(0.0020)	(0.0022)	(0.0009)	(0.0011)	(0.0016)	(0.0017)
Policies influences										
Regulation $_{t-1}$	0.197	0.176	0.0384	0.0151	0.0185	-0.0203	0.0767	0.0101	-0.0088	-0.0732
	(0.139)	(0.144)	(0.0896)	(0.100)	(0.144)	(0.162)	(0.0695)	(0.0783)	(0.124)	(0.135)
Subsidies $_{t-1}$	0.0491	0.0244	0.0948	0.0830	0.166	0.129	0.0986	0.102	-0.00094	-0.0334
	(0.153)	(0.159)	(0.0800)	(0.0907)	(0.156)	(0.177)	(0.0664)	(0.0754)	(0.116)	(0.129)
Firm characteristics										
Size $_{t-1}$	0.0008	0.0117	0.0832***	0.0985***	0.115**	0.129**	0.0909***	0.102**	0.0925**	0.119**
	(0.0381)	(0.0412)	(0.0213)	(0.0263)	(0.0394)	(0.0454)	(0.0245)	(0.0310)	(0.0320)	(0.0379)
Young $_{t-1}$	-0.335	-0.311	-0.0795	0.0474	0.326	0.235	0.0246	-0.0667	-1.312*	-1.366*
	(0.402)	(0.422)	(0.350)	(0.394)	(0.359)	(0.410)	(0.120)	(0.138)	(0.581)	(0.629)
Group $_{t-1}$	0.369**	0.370**	-0.0188	0.0324	-0.142	-0.141	-0.0782	-0.0774	-0.147	-0.128
	(0.113)	(0.119)	(0.0693)	(0.0849)	(0.155)	(0.182)	(0.0633)	(0.0787)	(0.104)	(0.122)
Export $_{t-1}$	0.150	0.169	-0.0132	-0.00308	-0.0717	-0.125	-0.0638	-0.0800	-0.0363	-0.0345
	(0.154)	(0.163)	(0.0659)	(0.0784)	(0.139)	(0.163)	(0.0568)	(0.0675)	(0.106)	(0.121)

(Continues)

	Supplier dominated		Scale-intensive physical networks		Scale-intensive information networks		Science based		Other services	
Persistence										
Eco $_{t-1}$	1.291***	1.159***	1.437***	1.037***	1.793***	1.493***	1.609***	1.134***	1.533***	1.167***
	(0.171)	(0.182)	(0.103)	(0.113)	(0.173)	(0.196)	(0.0832)	(0.0869)	(0.138)	(0.147)
Eco $_{t0}$		0.286		0.858***		0.727**		1.180***		1.009***
		(0.163)		(0.124)		(0.240)		(0.120)		(0.188)
Complementarity										
Reduce EE	0.127	0.139	0.0595	0.0566	0.204	0.147	0.140*	0.131	0.183	0.152
	(0.135)	(0.139)	(0.0742)	(0.0829)	(0.142)	(0.158)	(0.0621)	(0.0700)	(0.110)	(0.120)
Constant	-1.356***	-1.430***	-1.495***	-1.764***	-1.600***	-1.728***	-1.858***	-2.137***	-1.767***	-2.119***
	(0.280)	(0.299)	(0.156)	(0.189)	(0.280)	(0.322)	(0.138)	(0.170)	(0.227)	(0.268)
Log likelihood	-417.5	-415.7	-1322.2	-1286.4	-393.2	-387.0	-2058.9	-1980.2	-766.0	-745.0
Wald test of χ^2	174.9	183.7	611.4	607.8	265.2	241.0	935.6	1000.2	251.8	302.6
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
σ_α	0.1883	0.3026	0.3540	0.6361	0.3587	0.6061	0.5488	0.8646	0.5694	0.8006
	(0.2456)	(0.1780)	(0.0949)	(0.0795)	(0.1755)	(0.1519)	(0.0784)	(0.0705)	(0.1153)	(0.1113)
Rho	0.0342	0.0838	0.1113	0.2880	0.1140	0.2686	0.2314	0.4277	0.2448	0.3906
	(0.0862)	(0.0904)	(0.0530)	(0.0513)	(0.0988)	(0.0985)	(0.0508)	(0.0399)	(0.0749)	(0.0665)
Observations	883		2839		998		5075		1955	

Estimations control for time dummies. Robust standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

Table A.3.2 Results of the probability of reducing energy consumption strategy (5 services clusters)

	Supplier dominated		Scale-intensive physical networks		Scale-intensive information networks		Science based		Other services	
Technology push factors										
Internal R&D effort $_{t-1}$	0.00639	0.0122	0.0323**	0.0330**	0.00163	0.000808	0.0256**	0.0262**	0.0159	0.0126
	(0.0227)	(0.0249)	(0.0110)	(0.0120)	(0.0188)	(0.0216)	(0.0091)	(0.0097)	(0.0142)	(0.0159)
External R&D effort $_{t-1}$	-0.0616*	-0.0676*	0.00173	0.0021	0.0150	0.0149	0.0119	0.0097	-0.0068	-0.0054
	(0.0279)	(0.0300)	(0.0123)	(0.0132)	(0.0205)	(0.0233)	(0.0081)	(0.0087)	(0.0172)	(0.0190)
Cooperation $_{t-1}$	-0.0272	-0.0450	-0.0738	-0.0898	-0.124	-0.0749	-0.125	-0.109	-0.129	-0.130
	(0.138)	(0.148)	(0.0753)	(0.0808)	(0.135)	(0.153)	(0.0640)	(0.0680)	(0.102)	(0.112)
Market pull factors										
Sales new market $_{t-1}$	0.0063	0.0055	-0.0003	-0.0002	0.0025	0.0022	0.0026**	0.0029**	0.0036	0.0038
	(0.0036)	(0.0039)	(0.0015)	(0.0016)	(0.0033)	(0.0038)	(0.0009)	(0.0010)	(0.0018)	(0.0020)
Sales new firm $_{t-1}$	-0.0002	-0.0008	-0.00080	-0.0012	0.0003	-0.00005	0.0003	-0.0003	0.0001	-0.0002
	(0.0020)	(0.0022)	(0.0011)	(0.0012)	(0.0021)	(0.0024)	(0.0010)	(0.0010)	(0.0015)	(0.0017)
Policies influences										
Regulation $_{t-1}$	0.120	0.107	-0.0329	-0.0337	-0.142	-0.169	0.110	0.0958	0.0729	0.00520
	(0.155)	(0.164)	(0.0941)	(0.100)	(0.166)	(0.187)	(0.0730)	(0.0774)	(0.129)	(0.142)
Subsidies $_{t-1}$	0.0590	0.0621	0.0607	0.0481	0.223	0.184	0.0924	0.0712	0.0940	0.132
	(0.169)	(0.181)	(0.0829)	(0.0891)	(0.169)	(0.194)	(0.0695)	(0.0743)	(0.115)	(0.127)
Firm characteristics										
Size $_{t-1}$	-0.0109	0.0187	0.0934***	0.102***	0.0522	0.0567	0.0397	0.0416	0.0727*	0.0983**
	(0.0433)	(0.0504)	(0.0224)	(0.0251)	(0.0416)	(0.0508)	(0.0253)	(0.0285)	(0.0314)	(0.0372)
Young $_{t-1}$	-0.0879	-0.0581	-0.149	-0.176	0.0878	-0.154	0.174	0.159	0.0993	0.0441
	(0.388)	(0.430)	(0.380)	(0.411)	(0.404)	(0.482)	(0.121)	(0.131)	(0.306)	(0.341)
Group $_{t-1}$	0.259*	0.264	-0.0976	-0.0764	-0.0486	-0.0329	-0.0264	-0.0559	-0.126	-0.0864
	(0.128)	(0.145)	(0.0720)	(0.0806)	(0.176)	(0.210)	(0.0664)	(0.0739)	(0.103)	(0.119)
Export $_{t-1}$	0.244	0.246	-0.0181	-0.0207	-0.102	-0.189	-0.108	-0.0982	-0.108	-0.0889
	(0.171)	(0.188)	(0.0686)	(0.0757)	(0.160)	(0.193)	(0.0591)	(0.0642)	(0.103)	(0.117)

(Continues)

	Supplier dominated		Scale-intensive physical networks		Scale-intensive information networks		Science based		Other services	
Persistence										
EE $_{t-1}$	1.339***	1.079***	1.518***	1.312***	1.887***	1.452***	1.272***	0.994***	1.633***	1.257***
	(0.185)	(0.191)	(0.0830)	(0.0946)	(0.162)	(0.191)	(0.0735)	(0.0747)	(0.119)	(0.134)
EE $_{t0}$		0.742**		0.445***		0.972***		0.837***		0.896***
		(0.236)		(0.113)		(0.276)		(0.105)		(0.184)
Complementarity										
Reduce EI	-0.0534	-0.0925	0.136	0.116	0.279	0.267	0.289***	0.261**	0.208	0.238
	(0.168)	(0.177)	(0.0961)	(0.102)	(0.176)	(0.198)	(0.0754)	(0.0798)	(0.130)	(0.142)
Constant	-1.501***	-1.686***	-1.723***	-1.862***	-1.810***	-2.018***	-1.641***	-1.795***	-1.914***	-2.326***
	(0.316)	(0.358)	(0.167)	(0.186)	(0.318)	(0.386)	(0.142)	(0.158)	(0.236)	(0.283)
Log likelihood	-397.0	-390.3	-1239.1	-1229.6	-352.3	-343.4	-2112.9	-2069.7	-689.7	-672.6
Wald test of χ^2	99.73	122.3	558.9	567.8	215.2	205.7	601.8	743.0	325.5	343.4
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
σ_α	0.4058	0.5797	0.3751	0.5408	0.5024	0.7860	0.6420	0.7960	0.4827	0.7058
	(0.1750)	(0.1543)	(0.0868)	(0.0831)	(0.1641)	(0.1624)	(0.0660)	(0.0640)	(0.1117)	(0.1119)
Rho	0.1414	0.2515	0.1233	0.2263	0.2015	0.3819	0.2918	0.3879	0.1890	0.3325
	(0.1047)	(0.1002)	(0.0500)	(0.0538)	(0.1051)	(0.0975)	(0.0425)	(0.0381)	(0.0709)	(0.0704)
Observations	883		2839		998		5075		1955	

Estimations control for time dummies. Robust standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.