Scarpellini, S., Marín-Vinuesa, L.M., Portillo-Tarragona, P., Moneva, J.M.. 2018. Defining and measuring different dimensions of financial resources for business eco-innovation and the influence of the firms' capabilities Journal of Cleaner Production. Vol. 2014. 258-269. Post-ptint version of: doi: https://doi.org/10.1016/j.jclepro.2018.08.320

Defining and measuring different dimensions of financial resources for business eco-innovation and the influence of the firms' capabilities

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Keywords: Eco-innovation**,** Financial resources management, Cleaner production Corporate finance, Resource-Based View, Circular economy

ABSTRACT

Despite the growing number of studies on eco-innovation, the measurement of the specific financial resources applied to the eco-innovation process by firms and its internal management have not been thoroughly elucidated to date. Therefore, the main objectives of this study is to define, classify, and measure different dimensions of financial resources applied to eco-innovation by firms and to analyse

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the influence of business' technological and environmental management capabilities in the efficient allocation of these resources to undertake investments in eco-innovation. Resource amounts and their quality, availability and public nature are measured using a novel approach that addresses the study of their different aspects as a whole. A partial least square structural equation model (PLS-SEM) on a sample of Spanish companies shows that different dimensions of financial resources influence the eco-innovative investment and the internal management of eco-innovation.

1. INTRODUCTION

In recent years, interest in eco-innovation among policy makers, academics, and practitioners has fomented a growing number of studies on the subject because it is a relevant instrument in the search for solutions to optimise the use of natural resources in industrial production (Coenen and Díaz López, 2010; Díaz-García et al., 2015). Nonetheless, the internal management of eco-innovation and its conceptualisation remain under investigation due to its multifaceted character (Garcés Ayerbe et al., 2016; Kiefer et al., 2017).

In the micro field, the factors that influence companies' commitment to the environment—such as complexity, compatibility with existing production processes, capital life cycle or the high initial direct costs of investment—have been analysed for eco-innovation in business (Del Río González, 2009). Internal factors, such as the resources and capabilities related to eco-innovation, have been an object of analysis in terms of their conceptualisation (Del Río et al., 2016, 2012; Demirel and Kesidou, 2011; He et al., 2018), and firm resources and capabilities are demonstrated to be relevant for the success of investments in eco-innovation (Díaz-García et al., 2015).

The management of eco-innovation and the interrelationships that these investments have with corporate finance have not been extensively investigated to date within the theoretical framework of the Resource-Based View (RBV). To the best of our knowledge, a broad investigation remains open about the definition and measurement of different dimension of financial resources for eco-innovation

(Cai and Li, 2018; Johnson and Lybecker, 2012; Lee and Min, 2015), although financial aspects are considered today as one pillar of the business model (Gallo et al., 2018).

A number of the studies conducted within this framework analyse resources or capabilities jointly or separately, without offering total clarity concerning the resources required to finance eco-innovation or how these resources complement the capabilities necessary for their application to investments (Amit and Schoemaker, 1993; Carrillo-Hermosilla et al., 2010; Halila and Rundquist, 2011; Kraaijenbrink et al., 2010; López and Montalvo, 2015; May et al., 2012; Ramanathan et al., 2016). In general terms, financial resources, technical and environmental management capability and eco-innovative business have been addressed in literature, but these concepts have not been combined with eco-innovation investments in the same analytical framework.

Therefore, this study's main objectives are to define, classify, and measure different dimensions of financial resources applied to eco-innovation by firms and to analyse the influence of business' technological and environmental management capabilities in the efficient allocation of these resources to undertake investments in eco-innovation.

In this context, corporate finance aspects in private companies are affected, as they require their active collaboration in classifying and measuring the specific resources and capabilities that are applied to perform investments in eco-innovation. Thus, a model of the cause-and-effect relationship between the level of eco-innovation and the factors that favour its implementation has been developed using least squares structural equation modelling (PLS-SEM).

The model was tested in a sample of 87 Spanish companies that demonstrate a pro-active profile in eco-innovation. These companies actively participated in a campaign to promote this type of innovation in the framework of a collaborative R&D project, which is described in the methodology section of this paper after a review of the literature. Finally, based on the results obtained in this research, the primary conclusions and contributions achieved within the RBV framework are summarised to improve the eco-innovation management of financial resources and the specific technological and environmental capabilities for cleaner production in business and its measurement.

2. Theoretical background

Kemp and Pearson (2007) define eco-innovation 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 that results, throughout its life cycle, in a reduction in environmental risk, pollution, and other negative impacts of resource use (including energy use) compared to relevant alternatives.

Broadly speaking, eco-innovations are considered those aimed at eco-design (Smith et al., 2010), the development of new technologies focused on reducing and controlling pollution, technologies of renewable and sustainable processes, the implementation of processes for waste reduction, or the improvement of sustainable transport technologies (Kemp and Pontoglio, 2011).

Specifically, the internal dimension of eco-innovation can be analysed using RBV theory, in which a company’s competitive advantage is considered to lie in a set of resources, not easily substitutable and expensive to imitate, that characterizes it (Barney, 1991; Hart, 1995), being the resources used by companies through their hardly imitable competitive capabilities (Penrose, 1959).

In previous studies, the RBV was considered to provide an appropriate theoretical basis for analysing the resources and capabilities necessary for eco-innovation (Aragon-Correa and Leyva-de la Hiz, 2016; Carrillo-Hermosilla et al., 2010; Cai and Li, 2018; Colin et al., 2014; Cheon and Urpelainen, 2012; Dangelico and Pujari, 2010; De Marchi, 2012; Halila and Rundquist, 2011; Kesidou and Demirel, 2012; Lee and Kim, 2011; Lee and Min, 2015; Menguc and Ozanne, 2005; Peiró-Signes et al., 2011).

In addition, Lee and Min (2015) pointed out that in the RBV framework, the resources (valuable, rare and imperfectly imitable) and capabilities to deploy resources can be related to achieve a competitive advantage that constitutes the basis for eco-innovation holistically. Although scholars seem to agree on the relevance of firm resources and capabilities in eco-innovation systemic processes, currently, no univocal studies exist about how to implement resources to achieve a competitive advantage within a changing external environment (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013; Albertini, 2013; Hart, 1995).

When analysis resources and capabilities are applied to innovative processes, some authors show an overlap between innovation and eco-innovation processes (Aragon-Correa and Leyva-de la Hiz, 2016; Ramanathan et al., 2016); therefore, the detailed classification of firm internal financial resources and capabilities for specific investments in eco-innovation is a complex task that cannot be performed without considering corporate strategy and the company's environmental commitment. In addition, most of the available studies refer to firm internal resources and capabilities that are not specific to eco-innovation, and the resources and capabilities that are applied to environmental activity are often not internally differentiated (Lee and Min, 2015).

However, the in-depth study of the resources and capabilities that enables the creation of value and competitive advantage continues to be a subject of debate, particularly with regard to financial resources and their application to eco-innovation. Given the high difficulty that is posed by this field of analysis, few authors enter into the measurement of specific resources and capabilities that facilitate the organisation's alignment with the changes in its environment (Cockburn et al., 2000; Helfat and Peteraf, 2009; Teece et al., 1997), in particular those resources that are needed to implement the investments in eco-innovation. In summary, in this study, the RBV is applied to explain why some companies manage eco-innovation better than others through the analysis of internal financial resources as engines of sustainable competitive advantage and those technical and environmental management capabilities applied by business to the management of eco-innovative investments

(Ketata et al., 2014; Kraaijenbrink et al., 2010; Zhang and Walton, 2017). Thus, analyses of eco-innovation in the RBV framework can help industries develop unique resources and capabilities that may increase their financial and environmental performance (Ketata et al., 2014).

Accordingly, our proposal focuses on differentiating the financial resources and the technical and environmental management capabilities that are specifically applied to eco-innovation and on analysing their main dimensions and their relationship with the eco-innovation performed by companies to offer innovative results in the corporate finance framework for cleaner production.

2.1 Specific financial resources for eco-innovation

The relationship between financial resources and business eco-innovation has been previously studied (Table 1). However, the following table shows that in the literature to date the different dimensions of financial resources have not been analysed as a whole or with the scope and degree of detail proposed in this study:

Main Objective of Analysis	Authors
Risk of operations to be financed and eco-innovation (negative relation with activities in eco-innovation)	Ciccozzi et al. (2003); Ghisetti et al. (2017)
Relationship between accessibility to financial resources and eco-innovation (positive relation with eco-innovation activities)	Noci and Verganti (1999); Biondi et al. (2002); Del Brío and Junquera (2003); Fleiter et al. (2012); Rohdin et al. (2007)
Relationship between short-term objectives and eco-innovation (Negative relation with eco-innovation activities)	Biondi et al. (2002); Del Brío and Junquera (2003); Noci and Verganti (1999); Ghisetti et al. (2017)
Relationship between public incentives and eco-innovation (Positive relationship with eco-innovation activities)	Aschhoff and Sofka (2009); De Marchi (2012); Doran and Ryan (2012); Galia et al. (2015); Ghisetti and Rennings (2014); Ketata et al. (2014); May et al. (2012); Sierzchula et al.(2014); Veugelers (2012
Relationship between the level of indebtedness and eco-innovation (Positive relationship with eco-innovation activities)	Lee and Min (2015); Scarpellini et al. (2016)
Relationship between the level of indebtedness and eco-innovation (Negative relation with eco-innovation activities)	Przychodzen and Przychodzen (2015)
Relationship between internal financing and innovation (Positive relationship with innovation activities)	Przychodzen and Przychodzen (2015)
Relationship between R&D activities and environmental R&D (Positive relationship with eco-innovation activities)	Ding (2014); Ketata et al. (2014); Lee and Min (2015); Parthasarthy and Hammond (2002)
Relationship between the size of the company and eco-innovation (Positive relationship with eco-innovation activities)	Dong et al. (2014); Galia et al. (2015); Hojnik and Ruzzier (2016); Leitner et al. (2010); Pereira and Vence (2012); Rehfeld et al. (2007); Roda-Llorca et al. (2015); Triguero et al. (2014, 2013); Wagner (2007)

Table 1. Main contributions analysed for the analysis of financial resources applied to business eco-innovation

Although the relationship between financial resources and eco-innovation has been explored, the influence of different parameters inherent to these resources on eco-innovative investments may be considered in more dimensions, such as the volume, the availability and other qualitative aspects of financing, as well as the allocation of public subsidies to promote these investments.

The literature has analysed as endogenous resources financial resources (Cruz-Cázares et al., 2013; Halila and Rundquist, 2011; Lee and Min, 2015; Paraschiv et al., 2012b; Triguero et al., 2015); access to capital through credit institutions, venture capital, capital increase, or individual funds; and the availability of public funds for the company's environmental improvement (Johnson and Lybecker, 2012).

The volume of investment in environmental R&D provides a competitive advantage to companies in eco-innovation (Ghisetti et al., 2017; Lee and Min, 2015; Ociepa-Kubicka and Pachura, 2017; Parthasarthy and Hammond, 2002; Triguero et al., 2017). The level of investment in R&D has been considered a relevant resource for eco-innovation (Ding, 2014; Ketata et al., 2014; Lee and Min, 2015; Triguero et al, 2017), leaving the field of research open on the specificity of the environmental resources devoted to R&D such as eco-innovation, rather than contemplating the level of R&D investment in an aggregate manner.

Company size has been analysed as has a company characteristic relevant for innovation (Segarra-Oña et al., 2011) based on the hypothesis of Schumpeter (1942), according to which market concentration and company size positively affect innovation (Leitner et al., 2010). These studies indicate that larger companies would have higher levels of external finance for the eco-innovation. In contrast, Magri (2009) observes a greater weight for internal financial resources, to the detriment of external financing, in more innovative and smaller companies. The own-financing model would allow companies to approach their strategies with greater independence, especially when investments require long periods of time to offer an adequate return (De Massis et al., 2018). In this line, the studies by Friend and Lang (1988), Hall (1992; 2010), and O'Brien (2003) show a clear negative correlation between R&D intensity and leverage; thus, companies with greater R&D intensity maintain lower debt levels.

Moreover, in García Pérez De Lema et al. (2013), a positive and significant relationship is shown between the use of external financing, mainly banking, and innovative activity in comparison with capital increases or other internally generated funds, and the effect of long-term investors appears to be generally consistent over time (Harford et al., 2017). Bartoloni (2013) analyses the capital structure of Italian companies and indicates that although companies that present higher profitability tend to introduce increased internal funding, when a company's innovative effort is greater, its need for external financing, specifically the use of debt, also is greater. Other authors have demonstrated a significant and positive relationship between used credit lines and R&D investments (Guney et al., 2017).

Amore and Bennedsen (2016) point to financial constraints and the high dependence of external capital on certain sectors as explanatory factors for the decrease in eco-innovation as measured by the number of registered green patents identified by Durán-Romero and Urraca-Ruiz (2015), especially in sectors with high levels of R&D investment and in stages of the life cycle (Johnson and Lybecker, 2012). Therefore, funding is relevant to eco-innovation. For this reason, financial resources are analysed in this study by measuring the volume of funds (quantity) allocated to eco-investments by companies.

In previous studies, other aspects related to the financing such as the company debt and the debt structure have been considered as explanatory variables of the company's eco-innovation behaviour through their relationship with financial performance (Elsayed and Paton, 2005; Lee and Min, 2015; Przychodzen and Przychodzen, 2015; Scarpellini et al., 2016; Wagner, 2005).

Przychodzen and Przychodzen (2015) assess the relationship between eco-innovation and the financial performance of Polish and Hungarian companies, introducing debt as an indicator of financial risk; they show that eco-innovative companies have lower profiles of exposure to financial risk (less debt). The information asymmetries could imply that the cost of financial resources increases and spreads due to a worsening in profitability from the higher risk level of the investments in eco-innovation (Przychodzen and Przychodzen, 2015).

In addition, the uncertainty implies a higher level of collaterals for the granting of loans related to high risk investments (Kim et al., 2016), and it reduces the flow of funds towards this type of investment (Polzin et al., 2017). This effect is particularly true in those economic systems dominated by banks and institutional investors exposed to the regulatory reactions of supervisory entities in favour of safe investments. From the perspective of risk in financing projects, in Schäfer et al. (2004) studied German innovative small and medium enterprises (SMEs) and found that an increased risk in the project to be financed implies a greater orientation towards internal financing because lenders tend to demand a higher cost and collateral, and these are more difficult to meet in certain profiles.

In this framework, the individual characteristics of the financial system in which businesses perform their activities can also influence the resources that are used to finance innovation. In countries such as Spain and Italy, the degree of banking intermediation is high; therefore, the small capitalization of micro and small business prevents them from entering the market (Aloise and Macke, 2017). In that setting, a greater number of financial resource providers come from the banking system compared to other external financing alternatives (Bartoloni, 2013; Casasola-Martinez and Cardone-Riportella, 2009). The circumstances surrounding the process of risk assessment allow resources to be assigned in these types of channels, which have followed traditional criteria for the risk assessment of operations to finance, mainly based on solvency criteria, both of the debtor and of the project itself, which can undermine investments in environmental innovation (Ciccozzi et al., 2003; Polzin et al, 2017). Thus, qualitative aspects of the financial resources companies apply to eco-innovation must be introduced into the analysis.

Previous studies have also emphasised public subsidies as an element that facilitates research, development, and innovation activities (Pereiras and Huergo, 2006). Regarding the environmental sphere, Triguero et al. (2017) pointed out the positive effect of public subsidies on environmental R&D as a driver for eco-innovation. Similarly, Ghisetti and Rennings (2014) highlighted the importance of public financial incentives for adopting eco-innovation in companies, particularly in projects that would not be profitable for these companies. From another perspective, the relation must be considered between innovation and the level of takeover provisions (Becker-Blease, 2011).

Business interest in eco-innovation is largely driven by the market, which determines innovation funding (Johnson and Lybecker, 2012). Moreover, measures related to the reduction of rates and taxes promote the adoption of more sustainable behaviours, such as in the energy field in the automotive sector (Sierzchula et al., 2014). Hitaj (2013) affirmed that public incentives are a driver for the development of renewables such as wind energy, even from the consumer perspective, to increase market share, such as for hybrid vehicles (Chandra et al., 2010) or solar energy (Lasco Crago and Chernyakhovskiy, 2017). The existence of public and sustainable incentives facilitates the change from polluting to clean technologies over time (Veugelers, 2012). Thus, subsidies or grants available for companies as a resource for environmental investments have been measured (Aschhoff and Sofka, 2009; De Marchi, 2012; Doran and Ryan, 2012; Galia et al., 2015; Ketata et al., 2014; May et al., 2012). Considering these premises, the level of public financing of the eco-innovative investments is analysed in this study.

In general terms, the lack of financial resources has been identified as an element that limits the level of eco-innovativeness in European countries (Ociepa-Kubicka and Pachura, 2017), in addition to its influence in the development of an environmental strategy for SMEs (Noci and Verganti, 1999) and in sectors especially sensitive to the development of eco-innovation within the EU, such as manufacturing (Ghisetti et al., 2017), given the higher level of risk associated with this type of investment.

The availability of financial resources maintains a close relationship with R&D; thus, the possible restrictions to which resources may be exposed would particularly affect these types of investments (Brown et al., 2009; Lee et al., 2015). The higher level of uncertainty, complexity and specificity of eco-innovation in comparison to conventional innovation (Zhang and Walton, 2017) implies that the information asymmetries related to this type of investment hinder access to the needed financial resources (Polzin, 2017). Companies will make these investments if they can access sufficient financing at a reasonable cost, and this availability of funds depends on their risk related to the characteristics of each company, such as sector, size, or finance. Thus, the availability of financial resources becomes a strategic element for eco-innovation (Ociepa-Kubicka and Pachura, 2017; Zulfiqar and Thapa, 2018) analysed in this study.

2.2 Capabilities related to eco-innovation investments

Concerning the capabilities of organisations for eco-innovation, we can find numerous theoretical perspectives in the literature that address the study of company capabilities for eco-innovation, such as technological (Kemp and Pearson, 2007; Kemp and Soete, 1992; Pereira and Vence, 2012; Raven, 2005; van der Laak et al., 2007) and the organisational capabilities (Horbach, 2008; Kesidou and Demirel, 2012). Firm size has been often considered a necessary characteristic for innovation (Grimsey and Lewis, 2002; Leitner et al., 2010; Schumpeter, 1942; Segarra-Oña et al., 2011).

In line with Triguero et al. (2014), firms with high technological and managerial capabilities as environmental management systems are more likely to adopt eco-innovation in the RBV framework, because the innovation process is linked to firms' technological and managerial capabilities. Other authors corroborate the positive influence of technological capabilities on clean technologies (Hammar and Löfgren, 2010), and the implementation of environmental management systems has been analysed by several authors (Horbach, 2008; Horbach et al., 2012; Kesidou and Demirel, 2012; Rave et al., 2011; Wagner, 2008), as has the implementation of certifications such as the ISO 14001 or EMAS (Demirel and Kesidou, 2011; Mazzanti and Zoboli, 2006).

Business management shapes and gives the company characteristics that can favour or hinder the obtaining of the necessary resources and their management to implement eco-innovation (Lee and Min, 2015). Related to this capability, managers' environmental responsibility must be analysed for the implementation of green practices (Hamann et al., 2017), as should the leadership for environmental changes (Ar, 2012; Paraschiv et al., 2012a), such as for the achievement of public financial resources that are invested in R&D to expand the company's technological knowledge applied to eco-innovation (Plank and Doblinger, 2018). Muller et al. (2005) noted that firms' abilities to combine several process innovations (productive efficiency) or to produce different innovative products is relevant when developing eco-innovations (Oltra and Jean, 2005), as is their capability to anticipate regulation changes (Taylor et al., 2005). In summary, managers' environmental awareness could improve firms' application of resources and capabilities to eco-innovation development (Bossle et al., 2016; Pacheco et al., 2017).

With these premises, technological and environmental management capabilities have been considered in this study to deepen the subject. However, the literature shows no clear consensus regarding the influence of the technological capabilities in the eco-innovation process (Díaz-García et al., 2015), and the causality between these firm capabilities and eco-innovation has not been thoroughly elucidated to date (Cainelli et al., 2011; Cuerva et al., 2014; Díaz-García et al., 2015; Nill and Kemp, 2009; Petruzzelli et al., 2011; Ziegler and Seijas Nogareda, 2009).

2.3 Business eco-innovation and research questions

Nonetheless, several authors have incorporated environmental R&D costs as an indicator of eco-innovation to measure the level of a company's investment in eco-innovation in a more specific and accurate manner (Aragón-Correa et al., 2008; Kesidou and Demirel, 2012).

The variables for measuring the economic-financial results of eco-innovation should also be considered. In general, a company's level of eco-innovation can be defined by measuring the improvements achieved in environmental terms or the goals pursued by the company (Carrillo-Hermosilla et al., 2010; Díaz-García et al., 2015). Thus, we can observe the results, whether they consist of financial profitability or of competitiveness projects, which have been infrequently employed in previous studies because they require access to information on the investments made by companies and confidential data (Fleiter et al., 2012; Kemp and Pearson, 2007; Scarpellini et al., 2016).

Therefore, this study incorporates this measurement as a variable of the resources applied by companies rather than adopting the eco-innovative result as a measurement.

On this basis, the research questions proposed here are as follows:

> *R.1. Which aspects of financial resources can companies apply specifically to eco-innovative investments, and how can they be measured?*
>
> *R.2. Is there a relationship between companies' levels of eco-innovation, the financial resources allocated to eco-innovation and the technical and environmental management capabilities for eco-innovative investments?*
>
> *R.3. To what extent are financial resources, in their different dimensions and application, factors that increase the levels of business eco-innovation?*

To answer these questions, we chose a quantitative methodology described in the following section.

3. Methodology and sample description

3.1 Sample and data collection

To achieve the objective proposed in this research study, the analysis is performed through surveys designed for this purpose and proposed to channel active cooperation in this investigation on eco-innovative companies that express interest in eco-innovation by participating in a collaborative campaign that promotes eco-innovation in north-eastern Spain. Overall, the extent to which including non-eco innovative firms in the sample would bias the results is difficult to quantify. Thus, the analysis was conducted on a sample of eco-innovative business to have a more homogeneous matching process for innovation (Becker-Blease, 2011). As a premise of the study, radical innovations that contemplate completely disruptive products with respect to existing ones, eco-design, and incremental product improvements are assimilated within the term eco-innovation or existing processes (Kemp et al., 2007) due to the empirical phase's main objective.

The population was selected to have a sample of eco-innovative companies or companies with high motivation for eco-innovation to launch a collaborative action in the Spanish regions of Aragon, Catalonia, Navarre, and the Basque Country, as the regional target of the R&D project carried out. Considering that size increases the possibilities for undertaking eco-innovation (Dong et al., 2014; Rehfeld et al., 2007; Roda-Llorca et al., 2015; Triguero et al., 2015; Wagner, 2007), selected were companies with 50 or more workers that operate in the sectors of greatest potential for eco-innovation, such as those related to technologies referred to in the documents as "BREFs" of the "Best Available Techniques"[2]. Specifically, the selected sectors were industrial, transport and logistics, and waste, whose NACE 09 codes correspond to the extractive industry (05-09); the manufacturing industry (10-33); electricity, gas, steam, and air conditioning supply (35); water supply, sewerage, waste management, and remediation activities (36-39); and transporting and storage (49-53). Although some eco-innovative companies may have been excluded, this selection criterion allowed the vast majority of firms that were the object of study to be selected, in line with Ding (2014).

Finally, a population sample of approximately 1000 companies was obtained, which were contacted by e-mail and to which the survey on their eco-innovation activity to adhere to the collaborative campaign was sent. Firms accepted to actively participate in the collaborative initiative were 87, and these comprised the sample. This study's main objective required the collection of data from eco-innovative business or from companies that expressed an interest in this type of innovation. Although the sample does not consist of a large number of companies, the companies are identified with their VAT ID number, and these are not anonymous surveys, ensuring the commitment of companies to this

[2]See http://www.prtr-es.es/documentos/documentos-mejores-tecnicas-disponibles (accessed June 2016).

research and the quality of the answers provided. The collaboration with the firms means a smaller number of valid observations, but the identification of the companies in the sample allows us to integrate the study variables with the companies' economic-financial data and their main characteristics. Regarding the sectors that participated in this research, the largest percentage (73.3%) was comprised of firms that corresponded to the manufacturing industry, followed by those industries involved in transport and storage (19.8%); water-supply, sewerage, waste management and remediation activities (3.5%); and the extractive industry (3.5%). The sample companies are distributed as shown in Table 2.

Spanish Region	42.5% Aragon,17.2% Navarre, 6.9% Bask Country, 33.3% Catalonia
Age	Means=35.91 Deviation=23.73 Minimum=7.11, Maximum=115.10
Total assets (thousand euros)	Means=925104.2 Deviation=5600435.4 Minimum=3243.9 Maximum=50072051
Total turnover (thousand euros)	Means=294259.6 Deviation=1103196.7 Minimum=4743.7 Maximum=8805300
Number of employees	Means=513.17 Deviation=1592.41 Minimum= 50 Maximum=12.671
ROA	Means=0.041 Deviation=0.086 Minimum= -0.26 Maximum= 0.36
ROE	Means=0.056 Deviation=0.57 Minimum= -3.24 Maximum= 2.93
Liab-LT	Means=0.35 Deviation=0.22 Minimum= 0.006 Maximum= 0.92
% Environmental R&D investments financed with own funds	19.5%=0%, 14.9%=1%-5%, 39.08%=6%-10%, 1.1%=11%-20%, 13.8%=21%-30%, 11.5%= more than 30%
% Environmental R&D investments financed with public subsidies	37.99%=0%, 50.57%=1%-5%, 5.7%=6%-10%, 1.1%=11%-20%, 4.6%=21%-30%, 0% =more than 30%
% Environmental R&D investments financed with foreign funds	54%=0%, 36.78%=1%-5%, 0%= 6%-10%, 2.3%=11%-20%, 1.1%=21%-30%, 5.7%=more than 30%

Table 2. Sample characteristics

3.2 Measurement and variables

Using a series of indicators that measure the level of eco-innovation achieved by the surveyed companies throughout the past three years, a set of variables was designed. To select these variables, those used in other studies were taken as a starting point, in addition to the specific financial variables selected for this study. Next, the questionnaire was validated by a panel of experts consisting of the authors and representatives of the public administration, business association, R&D Institute and private sector that are experts in the field of environmental management and innovation. The participants were asked to assess the clarity and relevance of each of the survey items. Expert feedback was included in a revised version of the questionnaire.

This process permits us to assess the questionnaire's content and validity, integrated in three sections. This study is based on the questionnaire's first section, focused on the measurement of eco-innovation through 16 items (Table 3). In particular, the financial resources applied are measured, including the amount and typology, technology and environmental management capabilities as well as other variables such as the organisation's age and size. Table 3 provides the scale items of the eco-innovation construct. Based on data from the company's survey respondent, some of the items allow us to quantify the level of investments and eco-innovative activities performed by the firms in recent years in terms of savings in emissions and resources, the replacement of raw materials and components, and the investments made to decrease the environmental impact of products and companies. These resource types have scarcely been analysed due to the need for company financial data.

These items were measured on 6-point Likert scales (0= "0%", 1="1%-5%", 2="6%-10%", 3="11%-20%", 4="21%-30%", and 5="more than 30%")[3]. Other items used to quantify the extent to which activities carried out in eco-innovation or innovation were or were not related to resources, capabilities or other factors were measured on 6-point Likert scales (0 = "in no measure" to 5 "in large measure").

The economic-financial variables obtained from the SABI[4] database through the companies' VAT identification numbers were added to the other variables collected through the survey. In this respect, three items were used to measure the size of the company, the number of its assets, its income and the

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3 Although the respondents evaluated the level of the different investments and activities of eco-innovation type using percent scales, these were transformed into 6-point Likert scales for the statistical analysis.

4 Balance Sheets Analysis System (SABI) [online database]. 2014. Madrid.

number of its employees corresponding to the last year available at the time the data analysis (year 2014).

Construct/items	Construct / Items description	Analysed References
Construct: ECOi	**Eco-innovation level**	
ECOi1	% of components of the product or service that have been replaced by innovative ones to comply with environmental regulations.	(Bartlett and Trifilova, 2010; Cole et al., 2005; De Marchi, 2012; Ding, 2014; Dong et al., 2014; Doran and Ryan, 2015; Issa et al., 2014; Klewitz, 2012; Ziegler and Seijas Nogareda, 2009)
ECOi2	% of the total amount of the company's R&D investments is invested in environmental R&D, eco-design or similar.	(Ding, 2014; Ketata et al., 2014; Lee and Min, 2015; Triguero et al., 2017)
Construct: FR	**Financial resources quantity**	
FR1	% of the company's total revenues invested in environmental R&D (internal or external) for eco-innovating.	(Ghisetti et al., 2017; Lee and Min, 2015; Ociepa-Kubicka and Pachura, 2017; Parthasarthy and Hammond, 2002; Segarra-Onã et al., 2014; Triguero et al., 2017)
FR2	% of the company's total revenues invested in innovative equipment/machines to reduce the company's environmental impact.	(Scarpellini et al., 2017a)
FR3	% of the investments in environmental R&D, eco-design or similar that are financed with the company's own funds.	(De Massis et al., 2018; Friend and Lang, 1988; Hall, 2010, 1992; Magri, 2009; O'Brien, 2003)
Construct: FRQ	**Financial resources quality**	
FRQ1	Level of higher collateral (guarantees) required for the company to finance eco-innovation compared to that required for other investments.	(Ciccozzi et al., 2003; Kim et al., 2016; Polzin et al., 2017)
FRQ2	Level of costs of the external funds for eco-innovation higher than those necessary for the company's other investments.	(Lee et al., 2015; Przychodzen and Przychodzen, 2015; Schäfer et al., 2004)
Construct: PFR	**Public financial resources**	
PFR1	% of environmental R&D investments, eco-design or similar that are financed through public funds (subsidies, tax deductions, incentives, bonuses, etc.).	(Aschhoff and Sofka, 2009; De Marchi, 2012; Doran and Ryan, 2012; Galia et al., 2015; Ghisetti and Rennings, 2014; Hitaj, 2013; Ketata et al., 2014; May et al., 2012; Triguero et al., 2017)
Construct: AFR	**Financial Resources Availability**	
AFR1	Level to which the availability of the company's financial resources determines eco-innovation's implementation.	(Ghisetti et al., 2017; Ociepa-Kubicka and Pachura, 2017; Polzin et al., 2017; Zulfiqar and Thapa, 2018)
Construct: TC	**Technological and sectorial capabilities**	
TSC1	Range of possibilities for eco-innovation offered by the company's products or services.	(Carrillo-Hermosilla et al., 2010; Del Río et al., 2016; Kemp et al., 2007; Scarpellini et al., 2017b)
TSC2	Level to which eco-innovations' reduction of environmental impact, even if unnecessary, allow the company to compete better in the market.	(Hellström, 2007; Scarpellini et al., 2017a)
Construct: EMC	**Environmental management capabilities**	

EMC1	Level of the managers' personal linkage with the eco-innovation activities' implementation.	(Bossle et al., 2016b; Hamann et al., 2017; Lee and Min, 2015; Pacheco et al., 2017; Plank and Doblinger, 2018)
EMC2	Environmental and certification standards (ISO 14001, EMAS, ISO 50001, ISO 14006)	(Daddi et al., 2017; Park et al., 2017; Rehfeld et al., 2007)
Construct: S	**Firm Size**	
S1	Total Assets	(Dong et al., 2014; Revell et al., 2010; Scarpellini et al., 2016; Segarra-Oña et al., 2011)
S2	Total turnover	
S3	Total employees	

Table 3. Constructs, items and main references related to the selected variables

To measure the levels of eco-innovation implemented in companies, this study applies variables for the replacement of a component or of raw materials (Bartlett and Trifilova, 2010; Cole et al., 2005; Ding, 2014; Dong et al., 2014; Doran and Ryan, 2015; Ziegler and Seijas Nogareda, 2009) and the decrease in the use of raw materials or energy resources (De Marchi, 2012; Dong et al., 2014; Issa et al., 2014; Klewitz, 2012).

Concerning company technical and environmental management capabilities (Georg et al., 1992; Kemp and Soete, 1992; Winn and Roome, 1993), the size (Segarra-Oña et al., 2014), and, in particular, the R&D management are also subjects of this study (Horbach, 2008). The capability related to the environmental management systems and environmental certifications have been introduced into the list of variables (Daddi et al., 2016).

3.3 Statistical analysis

To test the research objectives, a sequential process was followed. First the factors comprising the measurement scales were tested by means of exploratory factor analysis. Second, the measurement model was assessed by testing the reliability and validity of the measurement scales. Lastly, partial least squares structural equation modelling (PLS-SEM) was used to test whether a cause-and-effect relationship existed between eco-innovation level measure and enterprise resources and capabilities measures. SmartPLS 3.0 software was chosen for this end because it was less sensitive to the violation of assumptions of data normality (Chin, 1998; Ram et al., 2014).

4. Primary Results and Discussion

First, participants were asked about the level of investments and eco-innovative activities carried out by companies. Regarding the improvements in terms of innovative component replacement to comply with environmental regulations, the percentage of substituted components ranges from 1% to 10%, based on respondents' average response. In terms of investments in R&D aimed at eco-innovation, eco-design or similar, the average levels are from 1%-10%.

The investments in eco-innovation, eco-design or similar that are financed with the firms' own funds have an average score from 6% to 10%. Investments financed through public incentives (subsidies, tax deductions, bonuses, etc.) are between 1% and 5%, and the foreign funds are between 1% and 5% and less than 1%.

Environmental management and technology capabilities of companies have average scores slightly higher than 3 on a 6-point scale. These capabilities reflect the extent to which managers in the company are personally involved in eco-innovation implementation processes (3.4), the extent to which the company's products or services offer clear possibilities for eco-innovative changes or environmental improvements (3.3) and the extent to which a complete change of design for environmental impact reduction, even when unnecessary, improves the competition level (3.01).

With regard to respondents' perception of the extent to which the collateral (guarantees) and the cost of external financing supporting the implementation of eco-innovation are higher than for other activities, the average scores (2.1 and 1.8) suggest that these guarantees influence the eco-innovation activities. The availability of financial resources also greatly influences the development of eco-innovation, reflected in the average score achieved (3.0). Finally, the companies in the sample count on average between 1 and 2 environmental standards (ISO 14001, EMAS, ISO 50001, ISO 14006).

4.1. Assessment of the structural model

In the first stage, an exploratory factor analysis was carried out to verify the factors formed from the observable variables (i.e., the measurement scales). The value of the Kaiser-Meyer-Olkin sample adequacy index (KMO) and the Bartlett sphericity test show the appropriateness of the analysis performed. The results for the eco-innovation (ECOi), financial resources quantity (FR), financial resources quality (FRQ), technological and sectorial capabilities (TC), environmental management capabilities (EMC) and size (S) scales are formed, in all cases, by a single factor with a high explained variance: ECOi= 72.79% (KMO=0.5), FR = 54.55% (KMO=0.621), FRQ = 81.5% (KMO=0.5), TC = 68.9% (KMO=0.5), EMC =57.3% (KMO=0.5) and S=63.2% (KMO=0.5). Bartlett's sphericity tests reflect a significance level of less than 0.001 for all the aforementioned scales.

In the second stage, we assessed the structural model. To ensure the adequacy of the selected indicators, we examined the variables' standardized loadings. For all of the variables, standardized loadings were greater than 0.7 and significant (see Table 3 and Fig. 1). All constructs also showed very high values for composite reliability, in all case higher than 0.7, and in some cases near or higher than 0.8 (Table 4). Convergent validity is tested by calculating the average variance extracted (AVE), which determines whether the construct variance can be explained by the indicators selected. The minimum value recommended is 0.5 (Bagozzi and Yi, 1988), which means that over 50 per cent of the construct variance is due to its indicators. The last column in Table 4 displays the values obtained, which satisfied the criteria for all constructs.

Discriminant validity means that each construct must be significantly different from the remaining constructs to which it is not related. This criterion was also met: (1) the square root of the AVE was larger than the correlations among constructs (see Table 3) and (2) the model loadings were larger than the cross loadings (see Table 4).

Bootstrapping with 5000 resamples was used to assess the significance of the path coefficients (Hair et al., 2011). Fig. 1 shows the overall model results, namely, the R^2 in the dependent variable and the path coefficients. Results show that empirical support was found for five of the seven cause-effect relations (Fig. 1 and Table 5). Specifically, the construct we term eco-innovation is positively related with the application of financial resources, their availability, public incentives and the company's size. Likewise, a negative relationship exists between financing costs and the collateral required to finance activities with the level of eco-innovation. Empirical support was not found on the following relations: environmental management capabilities/eco-innovation and technological capabilities/eco-innovation. These relations were non-significant, and the 95% confidence interval included zero.

The explanatory power of the proposed model was high because the variance explained (R^2) was 62.8% (see Fig. 1). Stone-Geisser's cross-validated redundancy Q2 (0.231) confirms the model's predictive relevance (i.e., Q2 > 0). These results show that the model was highly predictive of the eco-innovation level.

	ECOi	**AFR**	**FR**	**FRQ**	**EMC**	**PFR**	**S**	**TC**
ECOi1	0.685	0.204	0.412	0.050	0.163	0.259	0.340	0.079
ECOi2	0.766	-0.056	0.478	-0.357	0.089	0.310	0.041	0.262
AFR1	0.090	1.000	-0.052	0.366	-0.022	0.036	0.074	0.061
FR1	0.480	0.012	0.747	0.169	0.289	0.463	0.036	0.200
FR2	0.390	-0.092	0.729	0.102	0.057	0.065	-0.063	0.143
FR3	0.476	-0.047	0.735	-0.161	-0.110	0.074	-0.220	0.270
FRQ1	-0.246	0.339	0.039	0.952	0.237	-0.224	0.022	0.153
FRQ2	-0.142	0.326	0.044	0.846	0.268	0.106	0.108	0.008
EMC1	0.116	-0.104	0.194	0.217	0.701	0.076	0.146	0.285
EMC2	0.140	0.056	-0.009	0.198	0.808	0.010	0.551	0.155
PFR1	0.393	0.036	0.285	-0.113	0.052	1.000	0.054	-0.019
S1	0.229	-0.065	-0.099	-0.060	0.409	0.005	0.721	0.149
S2	0.150	0.108	-0.100	0.114	0.406	0.052	0.878	-0.026
S3	0.176	0.173	-0.061	0.122	0.294	0.079	0.733	0.024
TC1	0.198	0.004	0.290	-0.009	0.334	0.040	0.078	0.824
TC2	0.204	0.096	0.181	0.189	0.135	-0.071	0.056	0.836

Table 4. Outer model loadings and cross loadings

	ECOi	**AFR**	**FR**	**FRQ**	**EMC**	**PFR**	**S**	**TC**	**Composite reliability**	**AVE**
ECOi	*0.727*								0.710	0.528
AFR	0.090	*1.000*							1.000	1.000
FR	0.614	-0.052	*0.737*						0.781	0.543
FRQ	-0.228	0.366	0.045	*0.900*					0.895	0.811
EMC	0.170	-0.022	0.110	0.272	*0.756*				0.727	0.572
PFR	0.393	0.036	0.285	-0.113	0.052	*1.000*			1.000	1.000

S	0.249	0.074	-0.113	0.059	0.484	0.054	*0.781*		0.823	0.609
TC	0.243	0.061	0.282	0.110	0.281	0.019	0.081	*0.830*	0.816	0.689
Diagonal elements (in italics) are the square root of the AVE and off-diagonal elements are the correlations among the constructs										

Table 5. Construct reliability, convergent validity and discriminant validity

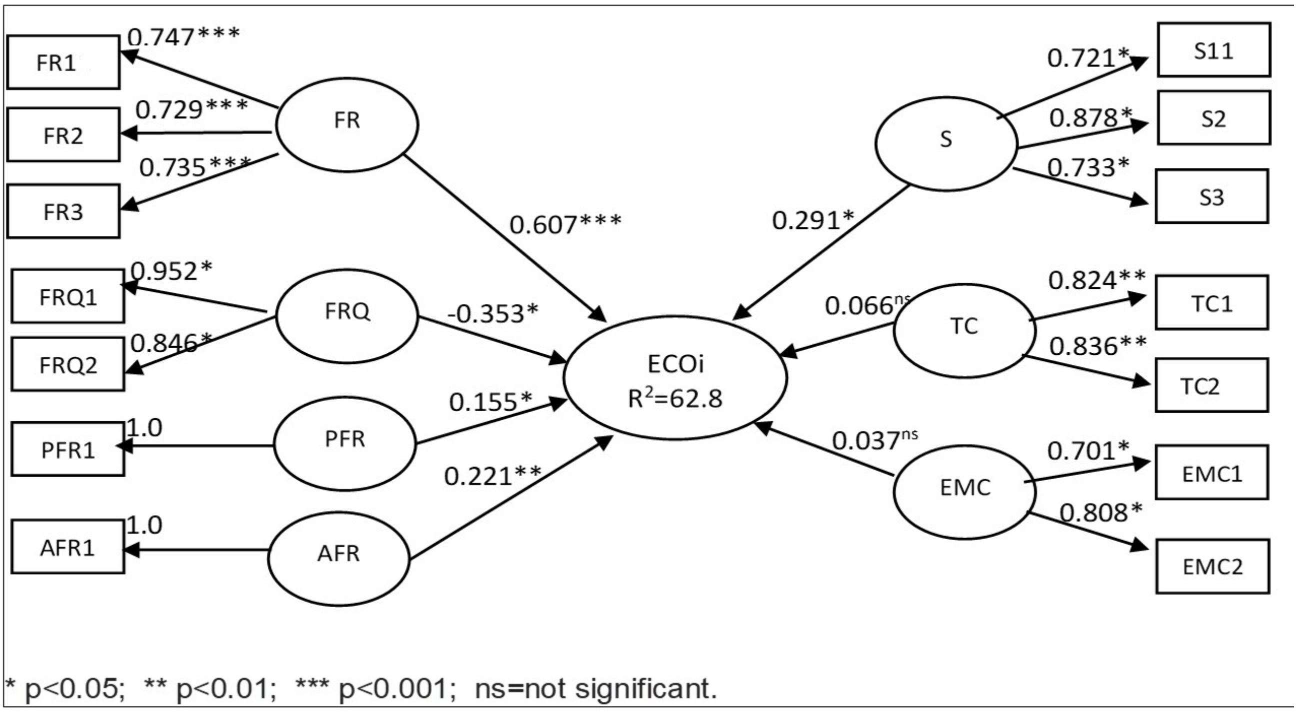

Figure 1. Structural model results

Relations	**Path coefficients**	**t-values**	**Percentile bootstrap 95% confidence levels**	
			Lower	**Upper**
AFR => Ecoinnovation	0.221**	2.577	0.028	0.360
Financial resources quantity => Ecoinnovation	0.607***	7.062	0.425	0.763
Financial resources quality => Ecoinnovation	-0.353*	2.187	0.052	0.183
Environmental management capabilities => Ecoinnovation	0.037 ns	0.437	-0.130	0.202
Public financial resources => Ecoinnovation	0.155*	2.034	0.003	0.299
Size => Ecoinnovation	0.291*	1.986	0.074	0.508
Technological and sectorial capabilities=> Eco-innovation	0.066 ns	0.793	-0.108	0.225
Based on a one-tailed t(4,999 distribution) *p<0.05; **p<0.01; ***p<0.001; ns=not significant				

Table 6. Structural model results

4.2 Discussion and implications on sustainability

In answer to one of the main research questions, financial resources were measured through the amount of resources applied to eco-innovation by companies, also measuring the quality of these resources and their availability.

The analysis shows that both the availability of the financial resources and their type influence the eco-innovative activity. The level of eco-innovation carried out by companies shows a positive and significant relation with the quantity of financial resources applied to the eco-innovative investments, in line with the conclusions found by Ghisetti et al. (2017) because the volume of certain resources, such as investment in environmental R&D, offers an advantage to companies in eco-innovation. In the previous studies analysed, no unidirectional results have been found about the relationship between the indebtedness of companies and their levels of eco-innovation, since this type of innovation is carried out both by companies characterized by more indebted profiles (Scarpellini et al. al., 2016; Lee and Min, 2015; García Pérez de Lema et al., 2013) and by firms with lower levels of debt (Przychodzen and Przychodzen, 2015).

In this study a negative and significant relationship is demonstrated between eco-innovation and higher levels of collateral and costs due to financing, through which qualitative aspects of financial resources are measured to understand whether the collateral and the cost of the external financial resources for eco-innovation are higher than that required for other investments of the company.

Also in line with previous studies, public funds generate a positive effect on the environmental R&D (Triguero et al., 2017), favouring the change towards clean technologies. In this analysis, a positive relationship is found between public incentives and eco-innovation; therefore, subsidies would reduce the risk related to these investments, improving their profitability.

A positive relationship is also found between eco-innovation and the availability of financial resources in companies, in line with previous results achieved by Ociepa-Kubicka and Pachura (2017) and by Zulfiqar and Thapa (2018) that pointed out the lack of financial resources as a limit of the level of eco-innovation in European countries. A positive relationship of eco-innovation with the size of the companies was indicated by Leitner et al. (2010).

Regarding the consideration that endogenous resources can by themselves explain the eco-innovation, we must emphasize the need to complement the analysis of the quality of financial resources with the analysis of those external aspects that could also influence the process, such as the conditions of the financial market in which the companies operate, in line with Cainelli et al. (2015), who suggest the relevance of complementing the analysis of internal resources with external factors triggering eco-innovations. Therefore, companies that obtain and manage financial resources that respond to a set of characteristics of quality, source, quantity and availability achieve a higher level of eco-innovation and improve the rates of competitiveness that innovation provides them.

Although, as indicated in Hamann et al. (2017), companies' technological and environmental capabilities can influence the management of the resources allocated to eco-innovation, the relations between eco-innovation and environmental management and technological cannot be considered significant through the empirical methodology applied. Thus, the debate about the relationship between the capabilities and the eco-innovation remains open, because it is demonstrated in this study, but it is not shown to be significant (Cainelli et al., 2015; Petruzzelli et al., 2011). Generally, the definition of a possible specific capability that is inherent in the optimum use of financial resources for eco-innovation also remains unaddressed (Del Río et al., 2016; Kammerer, 2009).

5. Conclusions

Eco-innovation can be considered a relevant instrument to make compatible economic growth and environmental protection. However, to be viable, eco-innovative investments require adequate financial resources in terms of quantity, quality, typology and availability.

Based on the results obtained through an empirical analysis on a sample of 87 Spanish companies, the dimensions of financial resources and the level of eco-innovation achieved by companies are closely related. Business must have an adequate framework to obtain a minimum quality of financial resources in terms of volume and costs to diversify the risk of operations among a greater number of investors. This fact discriminates against them favouring others with lower risk, allowing them to finance the company’s environmental investments.

One of the conclusions reached in this paper allows us to reflect on the specificity of financial resources devoted to eco-innovation in companies, highlighting their identification and measurement in terms of quantity, availability and quality. Although eco-innovation cannot be conclusively demonstrated to require exclusive resources, we can observe that some resources are specifically applied to investments in eco-innovation, differentiated from those applied to other innovative processes by companies. The relevance of the environmental management capabilities of the companies for eco-innovation processes can be observed, although their relationship with the level of business eco-innovation cannot be empirically demonstrated.

For eco-innovative companies, the availability of financial resources and their quality influence the activity’s development and they determine the choice of resources to finance the investments. For this reason, financial sources that are not explicitly penalized are preferred, with the consequent impact on the differentials applied and the collateral demanded as well as the importance of the public financial incentives that allow a reduction in the risk exposure and the provision of profitability to certain projects, which otherwise could not be developed by companies. The obtained results allowed us to delve into the measurement and allocation of specific financial resources for eco-innovation investments.

Those financial resources are relevant specifically to eco-innovation for these processes as a contribution of this work that gives a greater degree of knowledge in this field. Based on the literature review summarised in this paper taking a theoretical approach to firms’ financial resources and capabilities, we make progress in the knowledge of the management of the endogenous factors for business eco-innovation within the RBV.

Based on the resource-based view, this paper represents a contribution to the literature in the different aspects of specific resources and capabilities that are measured as a whole from a novel approach. The influence of companies' technological and environmental management capabilities in the allocation and management of the financial resources means a contribution to the knowledge about the decision-making process for eco-innovation investments in the corporate finance field for sustainability.

This study is not free of limitations, related to the size and the geographical location of the company sample analysed, which has not allowed us to achieve irrefutable empirical results regarding the causal relationship between the capabilities of the companies and the eco-innovation. This inconclusive result is probably related to the condition of proactive companies in eco-innovation of the sample that does not allow the detection of evidence of a behaviour with respect to the less proactive companies in eco-innovation.

However, these issues have been mitigated through the use of longitudinal data on the economic-financial variables obtained and by the specificity of the variables provided by the companies with regard to the financial resources specifically applied to eco-innovation.

6. ACKNOWLEDGEMENTS

This study was made possible owing to funding from the Ministry of Economy, Industry and Competitiveness, Project "Reco-inno", Ref. ECO2013-45599-R and it has been partially co-financed by the project "Conta-Circular" ECO2016-74920-C2-1-R. The authors are particularly grateful for the contribution of the companies that participated in the project ECO2013-45599-R and that provided the necessary data for this research.

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