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The Dynamic Process of Ambidexterity in Eco-Innovation

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Received: 19 February 2020; Accepted: 26 February 2020; Published: 6 March 2020

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Abstract: In recent years, firms' sustainable management has been considered a key factor in the achievement of profits, but few studies analyze the antecedents and effects of eco-innovation. Our study proposes a model to analyze the factors that affect eco-innovation, as well as eco-innovation's effects on dynamic ambidexterity. To pursue this goal, we developed a research model with panel data from 449 firms over five years from the telecom industry and tested the model using structural equations and partial least squares (PLS). Our results demonstrate the influence of R&D expenditure on eco-innovation. They show a slightly ordered sequence of exploration and exploitation results, indicating that some equilibrium between the two orientations is necessary. The study thus shows that eco-innovation facilitates ambidexterity in that exploration and exploitation alternate dynamically in the search for economic profit.

Keywords: eco-innovation; exploration; exploitation; dynamic ambidexterity; economic results

1. Introduction

Consumers are increasingly interested in green products [1], and firms are modifying technologies to provide green products [2,3]. In this context, adopting eco-innovation policies and putting them into practice has become an important area of economic and scholarly interest [4,5]. Despite this increase in academically oriented research, the study of eco-innovation has still produced only a small body of literature, oriented primarily to studying processes prior to the implementation of eco-innovation [6,7]. We would stress that few studies have analyzed the effects of organizational antecedents on the establishment of green practice. One such study is the investigation by Martínez-Pérez and Garcia-Villaverde [8]. Additionally, while the majority of prior studies have focused on the economic impact of eco-innovation policies [9–11], none have evaluated their impact on the evolution of economic results over time based on exploration and/or exploitation activities (dynamic ambidexterity). This is a key issue for firms that are pursuing a sustainable competitive advantage. Nowadays, we need to adapt eco-innovation processes to the new models that dominate the market [12,13].

This study focuses on an analysis of eco-innovation, understood as an innovation in product, service, or business management that reduces environmental impact [14] and achieves sustainable goals and improvements based on transformation of business processes [15]. The study analyzes 449 firms from the telecommunications (telecom) industry over a five-year period. This industry of high technological change requires intensive knowledge that is the result of cooperation among different actors, and eco-innovation can be a consequence of open innovation processes [16,17]. In an increasingly digitalized economic context, the telecom industries influence society greatly [18], while also including other sectors and thus fostering the reduction of environmental impact [19]. Telecom companies can adopt a large number of sustainable initiatives. They can monitor sustainability throughout the supply chain, as they use different electronics and chemicals in the production process. The rapid rise in the use of electronic products in the past two decades requires greater attention to the waste associated with manufacturing and the electronic products manufactured, and should include more recycling inputs. The circular economy is being adopted by firms and studied as part of eco-innovation processes [20,21]. Furthermore, telecom companies can use clean, renewable sources of energy and sustainable packaging, form Green alliances, report on their emissions to all interested stakeholders, etc. According to the OECD, telecommunications is a high-technology industry [22] and thus a sector exposed to continuous dynamic technological changes with high demands for investment and technology [23]. Given the need to apply new technology, we ask how both R&D expenditure and investment affect eco-innovation over time. This study aims to reveal the importance firms attribute to these two variables as antecedents of strategies that focus on eco-innovation.

The exploration-exploitation relationship has been widely studied. Exploration is considered to be the search for new knowledge and/or new markets [24–29]. Meanwhile, exploitation is the capacity to apply actual knowledge to the search for efficiency and/or in developing the actual market [24,25,30–32]. Some authors have proposed that a sequential orientation of exploration and exploitation can be called ambidexterity [33]; others have demonstrated the relevance of ambidexterity's dynamicity [34,35], suggesting the importance of a balanced orientation to exploitation and exploration [36,37]. The relevance of ambidexterity to developing a competitive advantage has hardly been analyzed in the area of sustainability [38], nor have researchers studied how green innovation influences the dynamic results of exploration and exploitation over time. More specifically, our study attempts to reveal the relationship between the results of exploitation and exploration. We are thus interested in understanding when an organization focuses on organizational routines and path dependence [21], stimulating exploitation, and when it is oriented to developing capabilities and creativity, stimulating exploration [22].

Our study contributes to the literature in three ways. First, it provides a dynamic view of ambidexterity in the context of eco-innovation. The literature has not investigated the dynamic effect of eco-innovation on the results of ambidexterity, and this effect is key to understanding firms' adaptation to their environment. Since we analyze the dynamic balanced process of decision-making [34,35], in which ambidexterity is determined by the constant search for economic results, we introduce the study of the dynamicity of ambidexterity, in which the firm strengthens the oscillating substitution of products, taking into account market demands.

Second, the literature on eco-innovation stresses that the positive economic results of eco-innovation for performance are seen in subsequent years [39], since, in this demanding and novel context [40], the effects are not visible in the same year of implementation of the eco-innovation strategies. We analyze the effects of eco-innovation on both the economic results of exploration after one year of implementation and the economic results of exploitation after two years of implementation of the eco-innovation goals (we cannot consider products/services as new to the market after two years). Our study attempts to analyze the processes of exploration vs. exploitation in a long-term time frame of five years in a high-tech sector where processes of substitution and replacement occur with significant rapidity.

Third, there are still only a few studies that have analyzed the antecedents of eco-innovation and, more specifically, R&D expenditure and a firm's investments together. Innovation requirements are balanced between exploration to acquire new technology and exploitation to obtain existing technology [41]. The literature has proposed a relationship between R&D expenditure and innovation [25,26], but has not studied the effects of R&D expenditure on eco-innovation processes. On the other hand, the literature has considered investments in material goods as key to developing innovation [27,28], but fails to determine under which specific conditions in the context of sustainable management that focuses on eco-innovation. Our study models these two antecedents as keys to developing eco-innovation in a highly technified sector.

This text is organized as follows: The next section defines the foundations of our study and develops our hypotheses. It then explains the methodology used, the model, and the research results. The last section discusses the results and proposes theoretical and practical implications.

2. Background

Competitive advantage is achieved over time through the resources a firm possesses, whether physical or financial, and through the firm's capabilities, practices, and routines [42]. Organizational processes for the implementation of green strategies are complex, however, and require profound changes in skills [43]. Prior studies have proposed a "triple bottom line," which relates the firm's sustainable development in three dimensions: social, environmental, and economic [44,45]. The social dimension proposes a balance between society's needs and nature's capabilities [46]. The environmental dimension proposes reducing negative impacts on the environment and achieving efficient use of resources [47]. The economic dimension involves management of financial performance and of the interests of the organization's stakeholders [48]. The combination of these three dimensions means greater complexity in assuming the strategic challenges that eco-innovation requires and thus the need for the firm's eco-adaptation through dynamic capabilities [49]. Dynamic capabilities are defined as "the capacity of an organization to purposefully create, extend or modify its resource base" [50] (p. 4); that is, resources and capabilities are integrated, created, and reconfigured to adapt to environments [51].

For Mousavi et al. [49], eco-innovation requires the application and development of dynamic capabilities. These authors study the dynamicity of transformation of capabilities based on three phases: sensing, seizing, and reconfiguring organizational routines. Through sensing, firms gather information to improve sustainable innovation [52]. In the seizing phase, they develop and mobilize knowledge [53]. In the reconfiguring phase, they transform practices and routines to innovate [51]. Ge et al. [43], in contrast, propose two paths to modify green innovation routines: the behavior of modifying the routine, which gathers and maintains green knowledge, and that of creating the routine, which searches for and brings about change and green innovation. To manage their eco-innovations, firms must modify their routines and dynamize their capabilities [54]. Our study considers the development of dynamic capabilities in the firm as decisions that seek a balance [36]. At times, firms decide to introduce new products to the market and thus to transform their routines; at others, they choose not to modify products and to preserve specific routines while waiting for the right moment to introduce new products.

Oltra and Saint Jean [15] view eco-innovation as an innovation in which processes and results are transformed to benefit the environment. Charter and Clark [55] refine the definition somewhat by proposing eco-innovation as a process for integrating sustainability and the generation of ideas through R&D and commercialization. The most complete definition of eco-innovation, however, and the one we believe is most appropriate to our purpose, is that of Kemp and Pearson [14] (p. 7): "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (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."

2.1. Internal R&D Expenditures and Eco-Innovation

High-tech industry requires great technological innovations [23], which involve significant expenditures and investments. When facing the environmental pressures in the telecom industry, firms attempt to perform innovations to improve competitiveness [56]. R&D can be performed outside the firm, through collaborative processes of open innovation [16,17], or within the firm, through new creative processes and new products [10]. R&D and investment lead to greater innovation [57]. In this study we focus on an internal perspective on R&D.

The literature affirms that eco-innovation is a form of innovation that firms use to increase their competitiveness [58]. Eco-innovation promotes the improvement of organizational processes by implementing new eco-methods and practices [40]. Eco-innovation and eco-technology are thus closely related [59]. External R&D has been shown to have no significant impact, whereas internal R&D influences eco-innovation significantly [60].

Firms must evaluate R&D expenditure by comparing the expected risks and benefits [13]. R&D expenditure is not reflected immediately in the firm's results [61]. Rather, the returns of R&D expenditure are usually uncertain and deferred [62]. According to Boulatoff and Boyer [63], firms that implement green strategies spend more on R&D, and such an increase in R&D expenditure is generally oriented to new projects [64,65]. Innovation in eco-products implies that firms have previously developed improvements in theoretical and material components [66] and have thus allocated greater internal expenditure to R&D.

Based on the arguments presented, we propose the following hypothesis:

Hypothesis 1 (H1). *Expenditure on internal R&D positively and significantly influences eco-innovation.*

2.2. Investments in Material Goods and Eco-Innovation

The literature has shown that economic growth is closely associated with investments in machinery and equipment [67]. It has become imperative to automate processes in the telecom industry in order to respond flexibly to changes and improve performance [68]. Analysis has determined that firms invest more in more uncertain environments [69]. Furthermore, research confirms that uncertainty has a positive effect on investment in competitive sectors [70], as occurs in the telecom industry.

We thus stress that firms that invest in technological innovation can expect greater growth [71]. Investments in green technology activate two types of processes in the organization: an increase in revenues and a reduction in costs [72]. Both processes aim to use current investments to plan the organization's future [73].

Prior studies argue that technological innovation is more complex in eco-innovation than in other innovations [74]. Firms that develop eco-innovation strategies must thus consider investment carefully. Furthermore, firms oriented to eco-innovation strategy stimulate the creation of new eco-technologies and new products for the market [2], changes necessarily involving the redesign of processes, the development of new products [73] and the investment associated with these changes. Investments in machinery and equipment thus promote the implementation of eco-innovation strategies.

Based on the arguments presented above, we formulate the following hypothesis:

Hypothesis 2 (H2). *Investment in material goods positively and significantly influences eco-innovation.*

2.3. Eco-Innovation and Dynamicity of the Results of Exploration and Exploitation

Since the literature has noted the differences between exploration and exploitation [24], stressing the divergences between the two strategies [75], firms tend to specialize in one strategy, minimizing the other [76,77]. Through exploitation, firms manage synergies concerning processes and products already implemented [78]. Exploitation is nourished by existing knowledge, when organizations have sufficient information about the opportunities posed by the environment. Firms that opt for exploration strategies, on the other hand, choose to develop new knowledge, creating new possibilities inside and outside the firm [34]. Researchers view the logic of exploitation as involving less risk for investments than that of exploration, in which firms assume greater risks due to the use of new resources [79]. In a high-tech context, the process of technological change is very rapid [80], and firms that focus on exploitation are at a disadvantage relative to those that focus on exploration.

Govindarajan and Trimble [81] argue that firms with exploitation strategies are oriented to achieving short-term results, which are safer. Organizations that choose the logic of exploration, in contrast, can achieve greater economic returns [82], since they develop processes and products before their competitors do [83].

Chen [34] focuses on finding balances between exploration and exploitation to determine the possibilities for survival both provide. Furthermore, research has considered this combination of strategies as effective for improving performance [84], since the combination produces results that are deferred over time [85]. The firm chooses based on uncertainty, opting for exploitation or exploration in order subsequently to review feedback on its choice of strategy [86]. Eco-innovation enables firms to maintain their competitive position in dynamic environments [11], since product life cycles are shortened by the dynamicity of environments. Lim and Tang [87] analyze the introduction of a new product and successful elimination of the old one, demonstrating the phases and timing of the substitution. Furthermore, through implementation of eco-innovation, firms expand the product's life cycle [88].

Hypothesis 3a (H3a). *Eco-innovation positively and significantly influences short-term exploration results, which are deferred over time by means of new products.*

Hypothesis 3b (H3b). *Eco-innovation positively and significantly influences long-term exploitation results, which are deferred over time when products are no longer new.*

2.4. Eco-Innovation and Dynamic Ambidexterity

Ambidexterity is the firm's capability to explore and exploit simultaneously [84]. Exploitation has been linked to routines, path dependence, and mechanistic structures, whereas exploration is related to improvisation, creativity, and organic structures [24,89]. Ambidexterity proposes the management of both strategies [90]. O'Reilly and Tushman [84] (p. 324) describe ambidexterity as "the ability of an organization to both explore and exploit—to compete in mature technologies and markets where efficiency, control, and incremental improvement are prized and to also compete in new technologies and markets where flexibility, autonomy, and experimentation are needed." With ambidexterity, therefore, the organization aligns the demands of the environment with efficient management [91].

This combination creates difficulties for firms acting with options of exploitation vs. new proposals for exploration, as both strategies require different structures, processes, and contexts [92]. Formal models of ambidexterity have been developed from a fairly static perspective, leading some scholars to attempt to provide explanations with more dynamic contributions [35].

Chen [34] proposes dynamic ambidexterity based on a combination of the three forms of ambidexterity formulated in the literature: contextual, sequential, and structural. Contextual ambidexterity proposes that employees decide on tasks oriented to exploitation or exploration based on demands or opportunities [93]. Sequential ambidexterity suggests the temporal separation of activities by specifically defined periods of time, so that the firm is oriented to either exploring or exploiting [33]. Structural ambidexterity separates the business units, which must be coordinated by the top managers [94]. Chen [34] proposes combining all three types of ambidexterity to develop dynamicity of ambidexterity at three levels: the business unit (contextual ambidexterity), the project (sequential), and the corporation (structural ambidexterity).

This approach enables a firm to create new possibilities by directing the management of exploitation and choosing exploratory strategies [34]. Our study proposes a model to analyze dynamic ambidexterity results through the implementation of eco-innovation strategies, developing products and processes that reduce environmental impact [95]. We analyze the economic results of introducing new eco-innovative projects versus maintaining the firm's established products (sequential ambidexterity).

Various studies support the positive association of eco-innovation policies and performance [11,96], although these results have been evaluated as negative in the short term (less than a year) and positive after two years [39]. We stress that the ambidexterity results are linked to positive results over time [91,97], with dynamic alternation between activities based on exploitation vs. exploration [35].

Based on the arguments presented, we propose the following:

Hypothesis 4 (H4). *Eco-innovation positively and significantly influences the economic results of ambidexterity.*

3. Methodology

3.1. Sample

Our study is based on a sample of 449 firms in the telecommunications sector (NACE codes 32 and 33) from the Spanish Technological Innovation Panel (PITEC)). The PITEC questionnaire is designed by the Spanish Office of Statistics and contains information on 12,000 firms starting in 2003. The data come from the Spanish Community Innovation Survey (CIS), which follows the Oslo Manual [22]. Our study collects panel data on these firms from 2010 to 2016, as such longitudinal data enable the analysis of antecedents and results of eco-innovation in the sector analyzed. Figure 1 presents the theoretical study model.

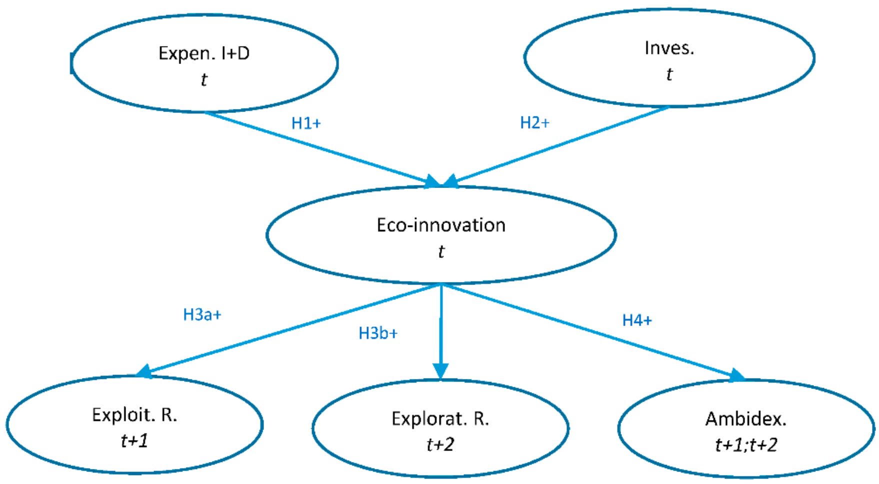

Figure 1. Theoretical model.

According to the PITEC questionnaire, firms oriented to innovations in environmental improvements and eco-innovation goals focus on reduction of environmental impact; improvement and health of employees; and fulfilment of environmental, health, and safety standards. We use eco-innovation goals (ECO-INNO) as a variable whose antecedents are internal expenditure on R&D (GINTID) and gross investment in material goods (INVER).

Our model proposes the following as variables dependent on the goals of eco-innovation: results based on exploitation activities (products that have been on the market for two years) and results based on exploration activities (products that have been on the market for one year). The model considers the antecedent variables and the variable eco-innovation for the year t, and the variables exploration results for the year t+1 and exploitation results for the year t+2. We believe that the variable t_i will affect the variable in the following period [98] because we analyze a new product that is the fruit of exploration activities. The results of exploitation are analyzed two years after implementation of the eco-innovation goals because they can be considered as old products. Horváthová [39] proposes that exploitation results are slower to influence revenue because they require the innovation to be accepted and maintained on the market.

3.2. Measures

The information is drawn from the microdata in the PITEC database, which enables us to identify data from the firms throughout the years included in this study.

Exploration results: measured through the variable business volume of innovations in the firm and the variable business volume of innovations for the market. Since we are analyzing new products, the data collected correspond to the variables NEW-EMP$_{t+1}$ and NEW-MER$_{t+1}$ of the year following implementation of the eco-innovation strategy. The firms were asked about their business volume due to innovations in goods and services that were novel for the firm (NEW-EMP) and business volume due to innovations in goods and services that were novel for the market in which the firm operates (NEW-MER). For example, the use of clean, renewable sources of energy may be new for the firm (NEW-EMP) but not for the market (NEW-MER), and there can be innovations for the whole telecommunications market (NEW-MER), such as 5G. Exploration results are modeled as a formative composite construct, which implies a combination of indicators, as in a recipe [99]. This composite model imposes no restrictions on the covariances, relativizing explanation by a common factor.

Exploitation results: measured by the variable OLD, the business volume corresponding to the firm's products that are unmodified from the previous year. The questionnaire asks about the business volume corresponding to goods and services that were maintained unmodified or that underwent only minor changes. We use the variable OLD$_{t+2}$ after two years of implementing the eco-innovation strategy, while also evaluating the result of the eco-innovation strategy on products that are already mature.

Eco-innovation: measured by the technological innovation goals for environmental impact, safety, and health of employees, and fulfilment of environmental requirements [98]. We use a factor model with reflective constructs, which proposes that the indicators can be explained through a latent variable and random error.

Investment in material goods: we used the variable that explicitly asks firms for their gross investment in material goods during the year.

R&D expenditure: drawn from the data item that indicates expenditure on internal R&D activities during the year. The questionnaire asks about the business cost of compensating R&D researchers, technicians, and assistants, as well as external personnel who have performed R&D activities; cost of materials for performing internal R&D; acquisition of land and buildings for R&D; and cost of specific software and intellectual property products for internal R&D.

Ambidexterity: operationalized by multiplying the variable exploration results t+1 and the variable exploitation results t+2 for each period analyzed [35]. Operationalizing this data item enables the study of the combined data item, as well as analysis of the difference between exploration and exploitation.

4. Analysis and Results

We used the Structural Equations Model technique and PLS estimation method, with SmartPLS software [100]. PLS is congruent with our model, since the variable exploration results were identified as a composite construct. PLS is the recommended method for this type of construct [101,102], and the use of PLS has been tested and found to be appropriate for panel data [103].

Evaluation of the measurement model (external model) showed that it fulfilled the requirements for reliability, internal consistency, and convergent and discriminant validity. Table 1 displays the loadings of the latent variables. All were higher than 0.7. Composite reliability (CR) showed values above 0.7 (Nunnally and Bernstein, 1994), and average variance extracted (AVE) had values over 0.5 [104]. We obtained the following data for model fit: SRMR = 0.08; dULS = 5.92; dG = 2.53; Chi-square = 4911.05; NFI = 0.80.

Table 1. Reliability measurement.

	loadings	Alpha Cronbach	CR	Average Variance Extracted (AVE)
Eco-Inn10		0.933	0.957	0.882
Objet110	0.930 ***			
Objet210	0.951 ***			
Objet310	0.936 ***			
Eco-Inn11		0.946	0.965	0.902
Objet111	0.938 ***			
Objet211	0.957 ***			
Objet311	0.954 ***			
Eco-Inn12		0.943	0.963	0.898
Objet112	0.931 ***			
Objet212	0.958 ***			
Objet312	0.953 ***			
Eco-Inn13		0.941	0.962	0.894
Objet113	0.931 ***			
Objet213	0.953 ***			
Objet313	0.953 ***			
Eco-Inn14		0.955	0.971	0.917
Objet114	0.947 ***			
Objet214	0.960 ***			
Objet314	0.966 ***			

Note: *** $p < 0.001$; $n = 449$.

The variable exploration results were composed of two constructs (new-emp and new-mer) with different weights. Table 2 shows the weights obtained. We observed that innovations on the market were more influential than the innovations performed in the firm, confirming greater market orientation in the data on results.

Table 2. Weights of the variable exploitation results.

	Exploitation R.11	Exploitation R.12	Exploitation R.13	Exploitation R.14	Exploitation R.15
New-Emp11	**5.423**				
New-Mer11	0.137				
New-Emp12		1.196			
New-Mer12		**3.899**			
New-Emp13			0.657		
New-Mer13			**3.316**		
New-Emp14				0.722	
New-Mer14				**2.806**	
New-Emp15					0.504
New-Mer15					**2.892**

To evaluate the structural model (internal model), we used a bootstrapping procedure with 5000 samples. We observed that the majority of the path coefficients were positive, consistent with the hypotheses formulated. As to the coefficients of determination (R^2) and predictive relevance (Q^2), most of the antecedent variables had positive t-values, and the t-values of the variables for exploration results and exploitation results had a significant influence on the economic results for all years studied (see Table 3). We also provided the confidence intervals of the relationships analyzed and included the effect size f^2 as a measure of the impact of the endogenous construct. Effect size was considered small when $f^2 = 0.02$, medium when $f^2 = 0.15$, and large when $f^2 = 0.35$ [105]. To confirm that our model has predictive relevance [106], we show that all Q^2-values are greater than 0, indicating predictive relevance. Furthermore, R^2-values greater than 0.200 for the exogenous variables in the model are considered to have good explanatory power [107,108].

Table 3. Direct effects, f^2, variance explained, R^2, and Q^2 test for endogenous variables.

	Direct Eff.	***t*-Value**	***p*-Value**	R^2	Q^2	f^2	**Confidence Interval (inf. 2.5%; sup. 97.5%)**
H1 Expenditure10-Eco-Inn10	0.137	3.053 **	0.002			0.019	(0.058; 0.232)
H1 Expenditure11-Eco-Inn11	0.051	2.133 **	0.033			0.005	(0.012; 0.106)
H1 Expenditure12-Eco-Inn12	0.044	1.919 *	0.050			0.003	(0.004; 0.095)
H1 Expenditure13-Eco-Inn13	0.081	2.742 **	0.006			0.011	(0.027; 0.144)
H1 Expenditure14-Eco-Inn14	0.076	3.672 ***	0.000			0.011	(0.043; 0.125)
H2 Inves10-Eco-Inn10	0.127	2.242 **	0.025			0.016	(0.005; 0.225)
H2 Inves11-Eco-Inn11	0.021	0.688	0.491			0.001	(−0.050; 0.069)
H2 Inves12-Eco-Inn12	0.019	1.116	0.265			0.001	(−0.016; 0.052)
H2 Inves13-Eco-Inn13	0.012	0.382	0.702			0.000	(−0.031; 0.093)
H2 Inves14-Eco-Inn14	0.084	2.093 **	0.036			0.014	(0.008; 0.164)
H3a Eco-Inn10-Exploitation R.11	0.172	3.586 ***	0.000			0.030	(0.088; 0.273)
H3a Eco-Inn11-Exploitation R.12	0.071	1.881 ^{t}	0.060			0.011	(0.013; 0.161)
H3a Eco-Inn12-Exploitation R.13	0.020	0.516	0.606			0.001	(−0.043; 0.105)
H3a Eco-Inn13-Exploitation R.14	−0.015	0.531	0.595			0.001	(−0.054; 0.066)
H3a Eco-Inn14-Exploitation R.15	0.122	2.487 **	0.013			0.019	(0.021; 0.213)
H3b Eco-Inn10 Exploration R.12	0.216	4.597 ***	0.000			0.028	(0.121; 0.305)
H3b Eco-Inn11-Exploration R.13	−0.005	0.180	0.857			0.000	(−0.065; 0.054)
H3b Eco-Inn12-Exploration R.14	0.102	2.123 **	0.034			0.015	(0.007; 0.197)
H3b Eco-Inn13-Exploration R.15	0.112	2.260 **	0.024			0.022	(0.016; 0.211)
H3b Eco-Inn14-Exploration R.16	0.071	1.432	0.152			0.003	(−0.013; 0.181)
H4 Eco-Inn10-Ambidex.11_12	0.198	4.557 ***	0.000			0.041	(0.106; 0.277)
H4 Eco-Inn11-Ambidex.12_13	0.042	0956	0.339			0.004	(−0.024; 0.149)
H4 Eco-Inn12-Ambidex.13_14	0.088	2.179 **	0.029			0.015	(0.024; 0.181)
H4 Eco-Inn13-Ambidex.14_15	0.061	1.784 ^{t}	0.074			0.006	(0.005; 0.147)
H4 Eco-Inn14-Ambidex.15_16	0.111	2.547 **	0.011			0.019	(0.023; 0.197)
Eco-Inn10				0.042	0.034		
Eco-Inn10-Eco-Inn11	0.712	21.447 ***	0.000			1.029	(0.642; 0.773)
Eco-Inn11				0.526	0.445		
Eco-Inn11-Eco-Inn12	0.667	17.263 ***	0.000			0.786	(0.588; 0.741)
Eco-Inn12				0.464	0.390		
Eco-Inn12-Eco-Inn13	0.617	13.732 ***	0.000			0.622	(0.522; 0.698)
Eco-Inn13				0.402	0.338		
Eco-Inn13-Eco-Inn14	0.694	2.012 **	0.000			0.982	(0.623; 0.758)
Eco-Inn14				0.523	0.451		
Exploitation R.11				0.029	0.020		
Exploitation R.11-Exploitation R.12	0.743	6.774***	0.000			1.258	(0.492; 0.923)
Exploitation R.12				0.579	0.453		
Exploitation R.12-Exploitation R.13	0.732	5.537 ***	0.000			1.117	(0.476; 0.936)
Exploitation R.13				0.542	0.339		
Exploitation R.13- Exploitation R.14	0.829	7.049 ***	0.000			2.114	(0.483; 0.946)
Exploitation R.14				0.684	0.272		
Exploitation R.14-Exploitation R.15	0.557	3.595 ***	0.000			0.463	(0.284; 0.872)

Table 3. *Cont.*

	Direct Eff.	t-Value	p-Value	R^2	Q^2	f^2	Confidence Interval (inf. 2.5%; sup. 97.5%)
Exploitation R.15				0.349	0.167		
Exploitation R.15-Exploration R.16	0.227	1.697 ^{t}	0.090			0.074	(0.049; 0.565)
Ambidex.11_12				0.039	0.032		
Ambidex.11_12-Ambidex.12_13	0.721	5.538 ***	0.000			1.065	(0.386; 0.860)
Ambidex.12_13				0.535	0.454		
Ambidex.12_13-Ambidex.13_14	0.699	5.699 ***	0.000			0.973	(0.405; 0.841)
Ambidex.13_14				0.524	0.433		
Ambidex.13_14-Ambidex.14_15	0.638	6.181 ***	0.000			0.676	(0.365; 0.768)
Ambidex.14_15				0.430	0.388		
Ambidex.14_15-Ambidex.15_16	0.590	5.606 ***	0.000			0.540	(0.352; 0.775)
Ambidex.15_16				0.391	0.361		
Exploration R.12				0.173	0.157		
Exploration R.12-Exploration R.13	0.378	3.757 ***	0.000			0.036	(0.198; 0.594)
Exploration R.13				0.223	0.214		
Exploration R.13-Exploration R.14	0.537	3.824 ***	0.000			0.001	(0.227; 0.766)
Exploration R.14				0.308	0.264		
Exploration R.14-Exploration R.15	0.540	4.689 ***	0.000			0.008	(0.313; 0.762)
Exploration R.15				0.348	0.305		
Exploration R.15-Exploration R.16	0.517	3.321 ***	0.001			0.074	(0.165; 0.753)
Exploration R.16				0.425	0.332		

Note: ^{t} $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; $n = 449$.

Analysis of the model shows that the f^2-values indicate a medium to weak effect size in most of the endogenous and exogenous variables. Following these results, we analyzed the evolution of the coefficients, *t*-value, confidence intervals, and f^2-values to confirm our hypotheses.

Table 3 displays the results of the model estimated. We confirmed H1, which proposes that internal R&D expenditure influences eco-innovation strategies in the five years analyzed. We partially confirmed H2, which proposes that investments in material goods influence eco-innovation, since the results are positive and significant in two of the five years analyzed. H3a proposes the positive and significant relationship of eco-innovation to exploration results. The results indicated that three of the five years were significant. H3b proposes the positive and significant relationship of eco-innovation to exploitation results. The results also showed that three of the five years were positive and significant. We found dynamicity in the results, in that the firm achieved results either through partial mediation or directly. As to H4, which relates eco-innovation to ambidexterity, we observed a positive and significant relationship over four years, suggesting that the empirical analysis supports the hypothesis.

5. Discussion

Although prior results have demonstrated the relationship between eco-innovation and economic results [11,96], we lack studies that analyze the antecedents of eco-innovation while simultaneously analyzing how innovation affects the results of exploration or exploitation and dynamic ambidexterity in firms. Our study used a database with panel data from the Spanish Office of Statistics and a sample of 449 firms from the telecom industry.

Our results suggest that: (a) R&D expenditure shows a tendency toward a positive and significant effect on eco-innovation during all five years in the analysis, while the tendency of investments in material goods to influence eco-innovation is only positive and significant in two of the five years studied; (b) eco-innovation seems to influence exploration and exploitation results dynamically, leading us to conclude that firms have positive economic results for all years studied, whether from exploration or exploitation; and (c) the data suggest the positive impact of eco-innovation strategies on dynamic ambidexterity, and demonstrate the positive and significant relationship deferred over time. We believe that these results support a positive and significant tendency that can be confirmed in subsequent studies.

We now develop the various implications that may be derived from our study:

First, we observed a theoretical tension between exploration and exploitation in demanding sustainable contexts. Although the literature has analyzed exploration vs. exploitation in depth, it has not performed studies that analyze eco-innovation and its effects on the economic results of exploration and exploitation. We stress that certain studies note differences between the strategies of exploration and exploitation [24], while others bid for choosing one strategy and rejecting the other [76,77]. Our study, in contrast, bids for a reconciliation of the two strategies on the assumption that they can benefit the organization's performance in the long term [35,84].

On the other hand, like the existing literature, we demonstrate that positive results are delayed over time when an organization uses both eco-innovation strategies [39]. The firm thus needs more than one cycle of exploitation to determine the economic benefit. Furthermore, the literature has proposed that firms that choose exploitation strategies are oriented to the short term [81] and at a disadvantage in technological and highly competitive environments [80]. Our results add nuance to these arguments. We find that a positive and significant effect of eco-innovation on the results occurs in exploration after one year of implementation and in exploitation after two years. Our findings thus suggest that the firm should tackle the process of dynamicity of exploration vs. exploitation more cautiously. That is, the fact that eco-innovation influences new products after one year and unmodified products after two gives the firm time to substitute products [87].

Furthermore, although the literature argues that firms have better results when they perform exploration [82] and can thus pull ahead of their competitors [83], our analysis of data over five years suggests that firms that perform eco-innovation maintain a balance, focusing on new products in some years and on unmodified products in others.

Second, we find a positive influence of ambidexterity on the organization's results [35], enabling the organization to fit itself to the demands of environments [91]. Our study implies that green strategies influence ambidexterity in the environment of sustainability, making it possible to maintain and/or modify routines and path dependence. Therefore, dynamic capabilities can be sensing, seizing, and reconfiguring through eco-innovation policies [49]. As we observe the tendency toward dynamic movement that organizations achieve in the face of compulsory changes in capabilities and routines, our results suggest that organizations have two dynamic options: modifying routines by exploring and introducing new products, and ensuring that firms give themselves time by preserving those routines, exploiting and maintaining unmodified products until they introduce a new product.

According to our study, this dynamic balance is not constant over the five years analyzed. Rather, the data show alternation of the economic results, as determined by the rhythms at which firms embrace them. This finding indicates a very profound organizational tendency toward dynamic ambidexterity, marked by the goal of maintaining the economic results of established products and by the need to launch new products.

Third, in spite of the interest of eco-innovation for both academics and practitioners, the literature to date has paid little attention to the antecedents that facilitate and promote eco-innovation. This study analyzes two antecedents as drivers of eco-innovation: internal R&D expenditures and investments in material goods. Our data on internal R&D expenditure fit the prior literature and suggest the tendency to bid for using part of the firm's capital for R&D and improving its competitiveness [56], thus also affecting green innovation in sustainable environments [58,63]. Our results seem to show that the firm's expenditures on R&D positively and significantly influence eco-innovation strategies. The literature also supports the argument that investment in material goods and equipment is crucial to innovation [68], especially in high-tech contexts, where environmental uncertainty is very important and investment plays a crucial role [70]. Although green contexts have been considered as contexts with greater innovative difficulty [74], only two of the five years show a tendency for investments in material goods to influence eco-innovation positively and significantly.

Among future lines of research, we would prioritize analysis of eco-innovation strategies and planning of the circular economy as tools to foster better designs and cleaner business planning that explain value creation of eco-innovation with regenerative designs [21]. We also believe it would be interesting for future studies to analyze the generation of innovations derived from collaborative processes and alliances among firms and/or institutions (open innovation) that could provide information about how knowledge that produces eco-innovation is generated [16,17].

Implications for management can also be derived from our study: Our findings suggest that firms orient themselves to exploration and/or exploitation based on market needs. Relative to the literature that proposes a foreseeable sequence of ambidexterity, with predictable dynamicity based on exploration strategies, our data suggest that the firm should not modify organizational routines until the market permits it to change the product. Our data imply that firms should act cautiously, maintaining products that are profitable, on which they base their economic stability, and introducing a new product when they can replace the previous one.

6. Conclusions

Our investigation has two objectives: to study two economic variables as antecedents of eco-innovation and to analyze of the effect of eco-innovation on the financial results of exploration and exploitation. The paper analyzes the dynamic alternation of business volume using longitudinal data (2011–2016).

Very few studies analyze the antecedents of eco-innovation, and even fewer focus specifically on the influence of R&D expenditure on eco-innovation processes or the influence of investment in material goods on eco-innovation. Our results suggest that internal R&D expenditures do influence eco-innovation. Although the literature has shown that investment in material and equipment goods is essential for innovation, our data show that investment in material goods has a positive and significant influence on eco-innovation in only two of the five years studied.

Similarly, our results support previous studies that suggest that the financial performance derived from implementing eco-innovation processes is achieved after two cycles of exploitation. Our results provide evidence of significant effects on both exploration and exploitation. This paper not only analyzes the relationship of eco-innovation to the business volume of exploration and exploitation, but also indicates that dynamic contexts give rise to an alternation in time, suggesting the dynamic ambidexterity of the results for exploration and exploitation.

In future research, we propose deepening the study of the different moments at which sustainable innovation creates market value and attending to the fluctuations that derive from the economic effects. Furthermore, while our study focuses on a highly technological sector that in many cases supports other industries, we recommend future research that studies other sectors to encourage cleaner innovative processes.

Our study thus analyzes the economic effects following implementation of eco-innovation. The results suggest an alternating influence on the economic results of exploration and exploitation over time. We propose that eco-innovation might encourage dynamic ambidexterity in a more dynamic, agile context like that of the telecom industry, since firms in this context balance the economic results of exploration and exploitation to obtain a profit.

Author Contributions: Formal analysis, L.A.-S.; Investigation, L.A.-S. and A.J.V.-J.; Methodology, L.A.-S. and A.J.V.-J.; Resources, L.A.-S.; Supervision, A.J.V.-J. and J.M.G.-G.; Validation, A.J.V.-J. and J.M.G.-G.; Writing—original draft, L.A.-S. and A.J.V.-J.; Writing—review & editing, L.A.-S. and A.J.V.-J. All authors have read and approved the final manuscript.

Funding: This research was funded by the Spanish Ministry of Science and Innovation through project ECO2013-45885R.

Conflicts of Interest: The authors declare no conflict of interest.

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