Received 26 November 2019
Revised 30 October 2020
5 February 2021
30 April 2021
Accepted 6 June 2021

Innovative outcome through exploration and exploitation – Enablers, barriers and industrial property

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Abstract

Purpose – This research aims to study the effect of R&D (research and development) enablers and barriers as well as industrial property on exploration, their influence on exploitation and finally the possible impact on innovative outcome (IO) as a result variable. The IO can be defined as the orientation towards new or improved products, services and processes, as well as towards penetration and greater market share, which the company has obtained as a result of innovative processes.

Design/methodology/approach – For this purpose, a new relationship model is defined, which is empirically contrasted in a quantitative study. We use a sample of large firms from different economic sectors with a high level of investment in R&D.

Findings – The results indicate a close relationship between exploration and exploitation processes, as well as a positive impact on the innovative outcome. Moreover, the type of relationship that R&D enablers and barriers have with exploration is demonstrated and the lack of a positive effect of industrial property on exploration.

Practical implications – These results may lead to new markets opening up and the creation or improvement of new products, services or processes in diverse sectors of highly innovative firms.

Originality/value – This research aims to study the effect of R&D enablers and barriers and industrial property on learning flows and, finally, the possible impact on the innovative outcome. A new theoretical model of relationships is defined, and it is the first time that it is empirically tested.

Keywords R&D enablers and barriers, Industrial property, Exploration, Exploitation, Innovative outcome

Paper type Research paper

The authors are thankful to Spanish Administration and European Union under grant TEC2017-84743-P.

This research is part of the Project ECO 2015-71380-R funded by the Spanish Ministry of Economy, Industry and Competitiveness and the State Research Agency. It was co-financed by the European Regional Development Fund (ERDF).

European Journal of Management and Business Economics
Vol. 31 No. 1, 2022
pp. 40-56
Emerald Publishing Limited
e-ISSN: 2444-8494
p-ISSN: 2444-8451
DOI 10.1108/EJMBE-11-2019-0213

1. Introduction

Innovation is an activity that is difficult to predict. New products or services or the solutions to problems associated with them are developed through complex, indeterminate processes. However, innovations are important for firms involved in technological activity since they have the potential to open up new markets and products, services or processes that are necessary in a competitive environment such as the current one (Maggitti *et al.*, 2013; Ringberg *et al.*, 2019).

In general, firms can produce new products or services because they explore completely new areas that shift away from their current knowledge base or because they turn current knowledge into new knowledge. Today's literature about the search for innovation based on organisational learning is well-known, with two different but complementary focuses: one on exploration and another on exploitation (Wilden *et al.*, 2018).

Through the focus on exploration, the variety of the search extends to new areas, resulting in innovative products or services (Randhawa *et al.*, 2016). However, the expected returns may spread out over time and, as a consequence, the probability of new inventions, too (March, 1991).

On the other hand, by focusing on the exploitation of the firm's current knowledge, the returns for the firm can be relatively high because the value of the knowledge is already known and can, therefore, increase the frequency of creating new products or services (Knight and Harvey, 2015). In summary, when the search is more exploratory, the results will be more innovative but not more reliable, and when the search is more exploitative, the results will be less innovative but more efficient (Wang and Hsu, 2014; Katila and Chen, 2008).

The value of innovative processes focusing on exploration and exploitation processes to obtain an innovative outcome (IO) has been studied. IO has been defined as new products, services or processes (or improvements) that the organisation has obtained as a result of an innovative process (Crossan and Apaydin, 2010; Vargas *et al.*, 2018). Some empirical studies have shown that firms that explore generate new and more innovative technologies in the long term but infrequently (Greve, 2007). On the other hand, firms that exploit generate new technologies in the short term and do so more frequently (Katila, 2002). However, few works have studied the relationship between exploration and exploitation in a direct way.

This paper contributes to an analysis of the relationship between exploration, exploitation and IO in four important ways.

Firstly, previous studies have only partially analysed the relationship between exploration and exploitation (Guisado-González *et al.*, 2017). Some of them have considered both as independent activities with no relationship, for example, Voss *et al.* (2008) or Jansen *et al.* (2009). Other studies accept the existence of a relationship whereby one substitutes the other because they need to compete for the company's scarce resources (Laursen *et al.*, 2010; Lavie *et al.*, 2011). Finally, other authors have considered the two learning flows as complementary with a range of combinations. These combinations are called ambidexterity in much of the literature in this area (Raisch and Birkinshaw, 2008; O'Reilly and Tushman, 2013; Asif and Vries, 2014; Parida *et al.*, 2016; Tian *et al.*, 2020; Wolf *et al.*, 2019). However, in this paper, we present and test the direct relationship between exploration and exploitation, with good results.

Secondly, other works propose theoretical models that are original but which, in the end, are not empirically contrasted in quantitative or qualitative studies. Thus, this area remains a topic of interest in research (Katila and Chen, 2008; Crossan and Apaydin, 2010; Teece, 2012; Vargas *et al.*, 2018; Wilden *et al.*, 2018). In this paper, then, we empirically test our new model in a quantitative study with significant conclusions.

Thirdly, most studies include organisational performance as a final variable (Lubatkin *et al.*, 2006; Raisch and Birkinshaw, 2008; Parida *et al.*, 2016; Arzubiaga *et al.*, 2020). However, we are more specific, and we work with a new variable called IO. (Crossan and Apaydin, 2010; Vargas *et al.*, 2018).

Fourthly, in this paper, we will include other variables such as enablers, R&D barriers and industrial property and study their effect on exploration and exploitation, including the effect on IO as a result variable. For this purpose, a new theoretical model of relationships is defined that is empirically contrasted.

The structure of the paper is as follows. Firstly, the theoretical framework is presented, where exploitation and exploration are defined, as well as the variables that define R&D enablers, barriers, and industrial property and their effect on the IO. Their fundamental relationships are studied and transposed into a theoretical model. Next, the hypotheses to be tested are presented. These hypotheses are tested in a quantitative study in highly innovative firms with high spending on R&D. There are firms in the economic sectors of software and telecommunications, pharmaceuticals, space aeronautics construction and more. Finally, the most relevant results, discussion and conclusions are presented, as well as some of the main limitations and future lines of research.

2. Theoretical background

In this first section, we will develop the theoretical framework and define the variables, which will serve as the basis to build our theoretical model of relationships.

2.1 Exploitation and exploration

The tasks of R&D are characterised fundamentally by their complexity and by the heavy investment they demand. Both aspects require a search for enablers (especially for economic investment), overcoming important barriers and protecting the new knowledge generated. In this context, there is also a need to generate learning flows, both internally and externally, to help transfer technological knowledge (Crossan and Apaydin, 2010). These constant and iterative learning flows in all directions lead to innovative processes that, in the medium or long term, enable the company to increase its competitiveness. In addition, they are a condition for sustained change in the state of knowledge of an individual or an organisation, and they represent the transformation of both the way of thinking about things and how to do them within the organisation. Argyris and Schön (1978) and Crossan *et al.* (1999) define these learning flows as the transfer and dissemination of knowledge within and across the boundaries of the organisation.

On this basis, learning flows allow firms to explore new knowledge and exploit existing knowledge to innovate more and better (Benitez *et al.*, 2018). Two important processes emerge: exploration and exploitation, which involve two different learning activities.

The main objective of exploitation is to take advantage of exploiting local knowledge within the limits of what is known, and the activity is more geared towards the selection and standardisation of successful practices. For this reason, the activity of exploitation does not generate originality but stability and the reinforcement of the routines. The flow of learning related to this flow indicates the way in which institutionalised learning affects individuals and groups. It is the process for taking advantage of what exists, focusing resources on improving products and processes; therefore, it includes aspects such as refinement, choice, production, efficiency, selection, implementation and execution (March, 1991).

Exploration, on the other hand, indicates practices that seek and experiment with new knowledge. In other words, this learning flow is related to the transfer of learning from individuals and groups that becomes embedded or institutionalised in the organisation in the form of systems, structures, strategies and procedures (Hedberg, 1981; Shrivastava, 1983).

Along these lines, some authors recognise the exploitation process as an internal function in the company's main dimension (exploitation of existing resources) and the exploration process as a purpose dimension, a fundamentally external function (Marín-Idárraga *et al.*, 2016). Exploitation also implies refining the internal resources that give rise to more routines and more control. It, therefore, helps a company to innovate more, but it hinders high-impact innovation (Greve, 2007). Exploration, on the other hand, involves research into processes and scientific searches. It allows a company to develop high-impact innovations (Danneels, 2002; March, 1996). This includes elements such as searches, variation, risk-taking, experimentation, play, flexibility, discovery and innovation (March, 1991). These elements are associated with possibilities for development beyond the organisational limits, and therefore, they imply relationships with the environment in which the company seeks to absorb new knowledge (Lavie and Rosenkopf. 2006: Bierly *et al.*, 2009; Lloria and Peris-Ortiz, 2014; Peeters and Martin, 2017).

Exchanges between the two processes are inevitable because the two types of learning require orientations, strategies, capacities but substantially different structures (Bauer and Leker, 2013). Both processes are important in the company, but their presence can generate a dilemma to a greater or lesser degree (March, 1996, 2006).

The central aspect of the distinction between the processes of exploration and exploitation, and their relationship with the IO, lies in whether it is better for the organisation to adopt an orientation. This allows the organisation to use its knowledge in the search for improvements within an established framework (i.e. exploitation) to pursue an orientation based on refreshing knowledge towards exploration.

In conclusion, recognising and managing the tension between exploitation and exploration is not an easy task; they are both critical challenges in the theory of organisational learning (Crossan *et al.*, 1999). Therefore, one key aspect in our research is that an organisation should be involved in sufficient exploitation to guarantee its current viability while devoting sufficient attention to exploration to ensure the organisation's future viability (Levinthal and March, 1993). Some studies have used the notion of ambidexterity to refer to the balance between exploration and exploitation (Simsek *et al.*, 2009; O'Reilly and Tushman, 2013; Hill and Birkinshaw, 2014; D`Souza *et al.*, 2017 and others). Other authors simply suggest that ambidexterity is only an approach to explore and exploit simultaneously (Lavie *et al.*, 2010).

2.2 R&D enablers and barriers, industrial property and their effect on exploration

Having explained the concepts of exploration and exploitation and the need to apply them to some extent simultaneously in organisations, we will now define other variables that will help us create our theoretical model. These independent variables are R&D enablers, R&D barriers, industrial property and IO as a result variable.

The tangible and intangible investment in R&D enablers, such as financial resources, equipment, advanced software and hardware or qualified staff, can be considered to be today's challenges to innovative firms (March, 1991; Lee *et al.*, 2018), yet the high costs of exploratory R&D projects are necessary for exploratory activities. In the same vein, Dominguez and Massaroli (2018) show that exploration processes are affected by the use of information technology systems, the autonomy of researchers and learning culture. There are studies that look into investment as an enabler of R&D and relate investment to the performance of exploratory innovation, concluding that spending on resources, in terms of both finance and qualified personnel, is essential and facilitates the innovative processes (Basu *et al.*, 2011; Lee *et al.*, 2018). Likewise, investment in innovation has been related to exploratory learning outcomes in order to achieve the most efficient method for firms (Battistini *et al.*, 2013). The contemporary vision proposes that R&D enablers provide strong support for success in exploration activities, contributing to the organisation by encouraging the creation of new ideas and knowledge while generating a more innovative context. Finally, innovative activity, when successful, generates profits from internal resources, which allows firms to overcome the barriers associated with financing innovative projects and reduces dependence on external financial sources (Castillo-Merino *et al.*, 2010).

Based on these statements, we propose the first hypothesis of this study.

H1. R&D Enablers have a positive impact on exploration.

During the R&D process, firms are forced to face numerous challenges, impediments and obstacles. These are often called innovation barriers (D'Este *et al.*, 2012; Sandberg and Aarikka-Stenroos, 2014). Research on barriers to innovation has been scarce. However, this approach to barriers is particularly useful since it allows potential specific problems to be identified that can potentially affect innovation, as explained by Hölzl and Janger (2012). Paradoxically, the latter affirms that barriers can be considered advantageous since they filter out the most unrealistic innovation projects and help identify resources for the objectives of the project that is to be carried out.

In Kleijnen *et al.* (2009), infrastructure barriers, financing, qualified training of R&D workers, technological information, state activity in R&D and other factors are considered to be some of the barriers for firms. Nevertheless, the barriers within innovative firms may mostly be economical due to the expense of trying out new solutions and methods (Mancusi and Vezzulli, 2014). Firms that invest in the challenge of innovations generate barriers related to the uncertainty of success. Innovative firms are repeatedly exposed to various types of barriers; hence, the importance of research into the barriers' influence on exploration or exploitation processes is an issue today (Dougherty, 1992; Coad *et al.*, 2016; Das *et al.*, 2017).

Based on these works, we can propose hypothesis 2.

H2. R&D barriers have a negative impact on exploration.

Innovative companies face a fundamental challenge of competitive advantages, which, in the end, is the search, for knowledge entails the propensity to fail, for imitation and mobility. In this environment, industrial property (IP) is a strategic field as a mechanism to protect inventions (Somaya, 2012; Holgersson and Wallin, 2017; Modic *et al.*, 2019).

Innovative firms with patents increase their capacity to attract greater financing or external investment through a re-evaluation of their assets. Patents make it possible or help firms access external resources and foreign markets, for example, through transfer agreements or patent licences (Großmann *et al.*, 2016). Patents could also be interpreted as an intermediate result of R&D expenditure (Hsu and Ziedonis, 2013). The development of new products requires a broad set of highly specialised technologies, knowledge and skills that are difficult to create internally (Iansiti, 1997). IP such as patents is a source of detailed scientific knowledge-sharing, allowing key knowledge to be extracted about the materials, processes, functions, parameters, considerations and restrictions of proven innovations (Shapiro, 2001). Exploration into the applicability of IP for analysis and decisions in the design stages could help reduce the time it takes to analyse new knowledge through the use of existing information processing (Rosenkopf and Nerkar, 2001; Agarwal *et al.*, 2009). Likewise, Wang *et al.* (2017) and Cammarano *et al.* (2017) have identified that IP and exploration activities have a good influence on innovation implementation. Furthermore, a relationship was found between the number of IPs, classified by exploration activities, with R&D costs and their positive influence on the value of the share price (Yu and Hong, 2016). Based on these arguments, we can pose hypothesis 3 of this study.

H3. Industrial property (IP) has a positive effect on exploration.

2.3 Innovative outcome (IO) as a result variable

R&D is a source of corporate competitiveness and, at the same time, a challenge for the company. Today's competition in business is greater (fiercer) and more uncertain than in the past. For large firms, it is almost impossible to have R&D advantages in all fields because, generally, there are limits to their resources, and they cannot neglect the R&D barriers (Xu, 2014). That said, once firms are involved in R&D processes, the IO is the endpoint of those processes, and it can be defined as new products, services or processes (or improvements) that the organisation has obtained as a result of an innovative process (Crossan and Apaydin, 2010; Vargas *et al.*, 2018).

According to the literature, the capacity for innovation is the most important determinant of performance in business profits. It is based on a positive relationship between a firm's innovation and profitability measures in order to generate profits (Ramadani *et al.*, 2017). However, there are a few studies available that have looked quantitatively into the effects of exploration and exploitation on IO (Lavie *et al.*, 2010). Among the studies that consider IO to be a key dependent variable for empirical study are the following: Pati and Garud (2020), Vargas and Lloria (2019), Vargas *et al.* (2018), Guisado-González *et al.* (2017) and Crossan and Apaydin (2010). We have considered these previous works as the background for this research.

Authors such as Ahuja and Katila (2001), Rosenkopf and Nerkar (2001), Wang and Li (2008) and others have stated that the IO has a different effect depending on the exploration or exploitation activities. For their part, Quintana-García and Benavides-Velasco (2008) affirm that IO has a stronger effect on exploration activity than on innovative exploitation activity. However, exploitation also involves development processes and covers the search for technology. This empirical evidence suggests that in technological advances, diversity can mitigate the central rigidities and dependencies of routines. This happens especially when improving innovative solutions that accelerate the rate of invention, which shifts the company away from its past activities. In addition, IO was studied in Ahuja and Lampert (2001), suggesting that the pursuit of original technologies or experimentation with new existing technologies is likely to require slack resources but can generate returns. Several outstanding studies have looked into the effects of flows with organisational performance, particularly the alignment model proposed by Bontis *et al.* (2002) and business performance (Jansen *et al.*, 2006).

However, examples demonstrate a growing interest in the literature in the relationship between exploration, exploitation and innovation and the need to go deeper into their relationships in a more direct way (Guisado-González *et al.*, 2017; Wilden *et al.*, 2018; Tian *et al.*, 2020). For the purpose of this work, IO is analysed with the nine characteristics shown in Table A1. For all of these reasons, we propose the following hypotheses *H4* and *H5*.

H4. Exploration has a positive impact on exploitation.

H5. Exploitation has a positive impact on the innovative outcome.

3. Theoretical model to be tested and summary of the hypotheses

Figure 1 shows the proposed predictive causal model of linear relationships. As independent variables, we consider the R&D enablers and barriers and industrial property. Specifically, we will study how industrial property and R&D barriers and enablers affect exploration then the effect of exploration on exploitation and the latter's effects on the IO as a result variable.

4. Research method

This section gives the characteristics of the sample, the measurement scales and the validation of the measurement scales.

4.1 Characteristics of the sample of firms

The dataset used in this paper contains firm-level data from the Spanish Technological Innovation Panel (PITEC). The survey was carried out by the Spanish Institute of Statistics

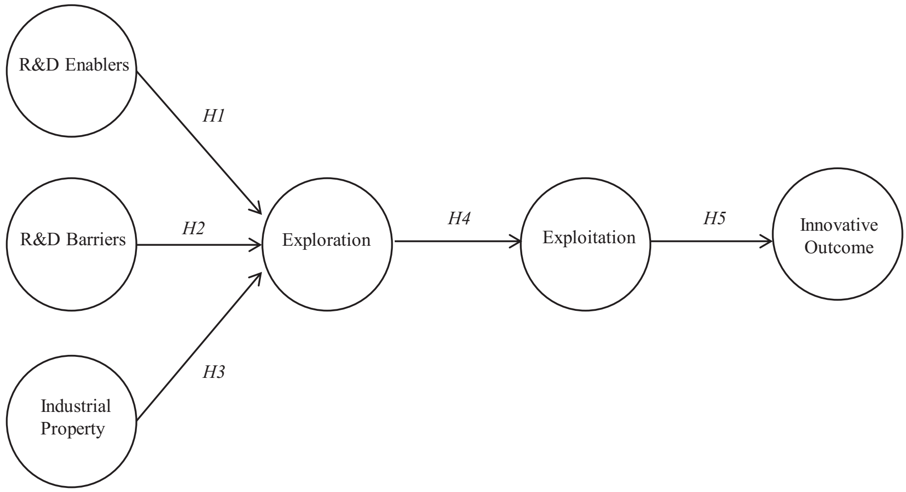

Figure 1.
Theoretical model to be tested

(INE), the Spanish Foundation for Science and Technology (FECYT) and the Foundation for Technological Innovation (COTEC). To create our sample, we selected the sub-samples from the database: (1) large firms with more than 250 employees and more than 50 million euros in turnover (European Commission, May 2003). These are firms that produce differentiated goods with high capital investment and innovation costs. They also have a high concentration of highly qualified workers; (2) firms with high total spending on innovation (above five million euros). In total, the group of firms that met both criteria contained 234 firms. As for the sector, the firms mostly belong to innovative sectors such as the industrial sector of software and telecommunications, pharmaceuticals, and aeronautical and space construction.

The six variables used in the empirical study and their items are shown in Table. The scales of measurements were those used in the questionnaire ite_cues15 called "Survey on Business Innovation 2015 in. All reflective measurements are classified according to the four-point Likert scale (Hair *et al.*, 2017; Vargas and Lloria, 2019). On the other hand, to homogenise the scales of measurement of two variables (R&D enablers and industrial property) with measurements of ratio, where zero represents the absence of the characteristic, a frequency distribution analysis of classes was carried out to group the data into categories and determine the number of classes according to Sturges (1926) and Mason *et al.* (1998).

4.2 Validation of measurement scales

To analyse and validate the data, we used the partial least square (PLS) technique (Wold, 1980, 1985; Fornell and Bookstein, 1982; Bagozzi *et al.*, 1991). Table 1 provides the load (λ) of most of the items. It was found that most of the loads (λ) of the items are greater than 0.7 (Chin, 1998). The results show that all of the reflectively measured constructs' measurements are reliable and valid (Cepeda-Carrion *et al.*, 2018). We examined the values of the variance inflation factor (VIF) and all the values of the items included are below 3.3, verifying the non-collinearity and removing problematic items (Diamantopoulos and Siguaw, 2006). We also include an assessment of convergent validity and internal consistency reliability. Smart PLS 3.0 (Ringle *et al.*, 2015) obtained these values. The evaluation of the quality of the measurement model was carried out by analysing internal consistency, a convergent validity analysis (viable and valid constructs measurements by obtaining the AVE).

Constructs	Items	Loading	VIF	Cronbach's α	Composite reliability	AVE
R&D enablers	EN1	0.822	1.508	0.827	0.878	0.643
	EN2	0.758	2.042			
	EN3	0.851	2.160			
	EN5	0.774	2.035			
R&D barriers	BR5	0.811	2.370	0.848	0.888	0.668
	BR2	0.831	2.111			
	BR3	0.852	1.928			
	BR6	0.702	1.671			
Industrial property	IP1	0.759	1.853	0.750	0.827	0.546
	IP2	0.751	1.538			
	IP4	0.720	1.622			
	IP6	0.803	1.206			
Exploration	EXPLR1	0.913	3.300	0.915	0.940	0.796
	EXPLR3	0.874	3.233			
	EXPLR4	0.898	3.296			
	EXPLR6	0.884	3.022			
Exploitation	EXPLOT1	0.795	1.730	0.834	0.889	0.667
	EXPLOT2	0.813	1.804			
	EXPLOT3	0.802	1.695			
	EXPLOT5	0.884	2.033			
Innovation outcome	IO1	0.793	2.929	0.906	0.928	0.681
	IO3	0.824	3.279			
	IO5	0.812	2.207			
	IO6	0.869	2.972			
	IO7	0.831	2.824			
	IO9	0.823	2.379			

Note(s): EN: R&D enablers; BR: R&D barriers; IP: industrial property; EXPLR: exploration; EXPLT: exploitation; innovative outcome: IO; AVE: average variance extracted; R&D: research and development

Table 1. Assessment of convergent validity and internal consistency reliability

An analysis of discriminant validity was also carried out (Table 2). These analyses show that the results satisfactorily meet the requirements established in the literature.

5. Results

Table 3 shows the results obtained after testing the hypotheses. At first sight, it can be seen that four of the five hypotheses are met with optimal results in the sample of firms analysed (*H1, H2, H4* and *H5*). *H3* is fulfilled but inversely. Each of them is explained below.

Hypothesis *H1* states that the R&D enablers will have a positive impact on exploration: *H1*: β (0.243), R^2 (0.169), and t (2.585**). The results confirm that this hypothesis can be accepted.

Regarding the second hypothesis, *H2*, we stated in the theoretical framework, it is true that the R&D barriers will have a negative impact on exploration: *H2*: β (−0.252), R^2 (0.169) and t (2.215*).

The third hypothesis was that industrial property would have a positive impact on exploration. The results are as follows: *H3*: β (−0.272), R^2 (0.169), and t (3.962 ***). This indicates that the hypothesis is not met with optimal results. Surprisingly, the variable industrial property is strongly related, but negatively, to exploratory activity.

Hypotheses *H4* and *H5* highlight the importance of the IO as a result variable between exploration and exploitation. The results indicate that both hypotheses are met with optimal results: *H4*: β (0.857), R^2 (0.735), and t (27.969 ***) and *H5*: β (0.849), R^2 (0.722) and t (26.246***). Both hypotheses assume the central core of our model, and their results were

	R&D barriers	R&D enablers	Exploitation	Exploration	Industrial property	Innovative outcome
R&D barriers	0.817					
R&D enablers	−0.236	0.802				
Exploitation	−0.174	0.223	0.817			
Exploration	−0.265	0.233	0.778	0.892		
Industrial property	−0.164	0.255	−0.077	−0.169	0.739	
Innovative outcome	−0.172	0.173	0.801	0.808	−0.083	0.826
AVE	0.668	0.643	0.667	0.796	0.546	0.681
Square root AVE	0.817	0.802	0.817	0.892	0.739	0.826

Table 2.
Discriminant validity

Hypothesis	Sample mean (M)	Standardised path coefficient (β)	t-statistics (O/STERRR)	R^2	Q^2 Blindfolding
H1 R&D enablers → exploration	0.243	0.243	2.585**	0.169	0.123
H2 R&D barriers → exploration	−0.252	−0.252	2.215*		
H3 Industrial property → exploration	−0.272	−0.272	3.962***		
H4 Exploration → exploitation	0.857	0.857	27.969***	0.735	0.482
H5 Exploitation → innovative outcome	0.849	0.849	26.246***	0.722	0.487

Note(s): Values estimated using Smart PLS for a bootstrapping sample of 500
Significance: t (0.05; 499) = 1.647345; t (0.01; 499) = 2.585711627; t (0.001; 499) = 3.310124157; Confidence level 95%, 99 and 99.9%. *p < 0.05; **p < 0.01; ***p < 0.001 based on t (499), two-tailed Student's t-test with $n-1$ degrees of freedom

Table 3.
Summary of results

statistically significant. In the sectors studied, the exploration processes offer optimal results in relation to the opening up of new markets and better products, services or processes.

Finally, we used the bootstrapping technique with a recommended sample size of 500 to evaluate the statistical significance of the path coefficients. In Table 3, we show the summary of the results of the hypotheses. The results of the predictive relevance of the dependent constructs, blindfolding Q^2 (Chin, 1998; Tenenhaus *et al.*, 2005) (exploitation: 0.482, exploration: 0.123, innovation outcome: 0.487) are positive, which confirms the predictive relevance of the model (Henseler *et al.*, 2009). We also calculated the Goodness-of-Fit (GoF) index (Tenenhaus *et al.*, 2005), which was 0.602.

Furthermore, we evaluated the model using PLSpredict (Ringle *et al.*, 2015), following the guidelines for predictive model assessment in PLS-SEM of (Shmueli *et al.*, 2019). In the first step, we found that all of the latent variables items outperform the most naïve benchmark (i.e. the training sample's indicator means), as all the items yield $Q^2_{predict} > 0$. Comparing the square root of the average (RMSE) values from the PLS-SEM analysis with the naïve LM benchmark, we found that the PLS-SEM analysis produces lower prediction errors for all the indicators (Evermann and Tate, 2016). We used one repetition (i.e. $r = 1$) when the predictions should be based on a single model (Shmueli *et al.*, 2019). The prediction summary for the latent variables (exploration, exploitation and innovative outcome) is $Q^2_{predict}$ 0.121, 0.105 and 0.144 in terms of RMSE (0.228, 0.125 and 0.268, respectively), the values reveal that the model has good predictive abilities. Finally, the values obtained for these evaluation criteria demonstrate the fit of the proposed model.

6. Conclusions

The main objective of this work was to study the effect of industrial property and R&D enablers and barriers on exploitation and exploration processes, considering the IO as a dependent variable.

Since March published his work in 1991 on the flows of learning, exploration and exploitation, there have been numerous subsequent studies. Even today, it remains an area of knowledge with great potential (Wilden *et al.*, 2018). In this paper, we have explained in an original way how both learning flows behave by introducing the IO variable as a dependent variable. In addition, as drivers or brakes on the innovative process, we have also introduced industrial property and R&D enablers and barriers.

After designing a theoretical framework in which we have defined the main variables and their relationships, we formulated five hypotheses. These hypotheses have been tested in a study of a quantitative nature on a sample of 234 large Spanish firms.

A major effort was made to integrate a construct of six variables measured with a four-point scale and to evaluate the measurement model using the PLS technique (internal consistency, convergent validity and discriminant validity), as well as to evaluate the structural model. The values reveal that the model has good predictive abilities. These scales, when validated, can, thus, be used by other researchers, and the model enables explanation and prediction in a fairly acceptable way. This combined attempt is original and contributes knowledge to exploration and exploitation with innovative outcomes, relating to R&D enablers, R&D barriers and industrial property as independent variables.

Five hypotheses were proposed, of which four have been met. Surprisingly, the one that is not fulfilled is actually met inversely to how it was initially proposed. Thus, we provide the following rationale: The interpretation of our findings involves two central considerations. Firstly, we can see the importance of exploration as a process in which new knowledge is sought and experienced. This allows advantage to be taken of what already exists by designing or improving new products, services or processes. Exploration can be driven by a group of enablers, above all financial and technological resources but inhibited by important barriers such as a lack of funding, information or qualified personnel, among others (Mansfield *et al.*, 1981; Dougherty, 1992; Agarwal and Bayus, 2002; Vargas *et al.*, 2016). Secondly, an inverse relationship is seen between industrial property and exploration. Various arguments have been put forward to explain this. One could be that the high costs of innovation and the competitive advantage it provides in the short term encourage firms to exploit their patents for a long period rather than make innovations. Another explanation may be the possibility of being imitated (Lemley and Shapiro, 2005). The patent requires publication of the innovation, and thereafter competitors could develop complementary innovations more easily, eliminating the possibility of competitive advantage arising from being the first (Shapiro, 2001). For this reason, some firms opt for other forms of protection, such as industrial secrecy (Lee *et al.*, 2017).

The main originality and strength of our model lie in the effect of R&D enablers and barriers and industrial property on the exploration process, the latter's relationship with exploitation and the final effect on IO as a variable of results. In this vein, recognising and managing the tension between exploration and exploitation is not an easy task; they are two critical challenges in the theory of organisational learning (Crossan *et al.*, 1999). Therefore, the key aspect in our research is that an organisation should be involved in sufficient exploitation to ensure its current viability and, at the same time, devote sufficient attention to exploration to ensure the future viability of the organisation (Levinthal and March, 1993). The study confirms these proposals. This indicates that exploration leads to a series of results that, in turn, enhance exploitation. These findings, which may provide an opening to new markets and the creation or improvement of new products, services or processes, can open the doors to standardisation, new routines, efficiency and productivity. Ultimately, managing the tension between exploration and exploitation may give the stability that a company needs to enter new innovative processes in the short, medium and long term.

In terms of the limitations of this investigation, the scope of the sample may be a limiting factor, as the research only included a single country. Recent developments in PLS have emphasised the use of formative models for obtaining good predictive abilities (Chin *et al.*, 2020). However, this is currently an issue under discussion (Shmueli *et al.*, 2019). This work was limited, with a relatively small number of variables and reflective items. The combination of a greater number of new variables related to each other, measured with formative indicators (e.g. cooperation in innovation), would be of interest and is one of our proposals for future research. Furthermore, another model could also be defined based on the exploitation variable in this same data panel and applying new methods developed from the signal-processing framework to the problem proposed in this work (Salazar *et al.*, 2014). Recently, these methods have shown interesting results in data analysis for several applications that could complement the ones obtained by traditional statistical methods.

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Appendix

Variables	Items	Objectives
R&D barriers	BR1	Missing funds within firm
	BR2	Lack of external financing to the firm
	BR3	High innovation cost
	BR4	Missing qualified staff
	BR5	Lack of information technology
	BR6	Lack of information markets
	BR7	Difficulty in finding partners for co-operation in innovation
R&D enablers	EN1	Internal R&D costs: Remuneration researchers, technical and auxiliary, and other trends
	EN2	Acquisition costs of machinery and equipment
	EN3	Acquisition costs of others external knowledge for innovation
	EN4	Acquisition costs of external R&D
	EN5	Introduction cost of innovations in the market cost
	EN6	Training costs for innovation activities
Industrial property	IP1	Spanish patents
	IP2	European patents
	IP3	American patents
	IP4	Patent cooperation treaty
	IP5	Register of utility models
	IP6	Brands
	IP7	Copyright
Exploitation	EXPLT1	Feedback information inside the company or group
	EXPLT2	Feedback supplier information
	EXPLT3	Feedback customer information
	EXPLT4	Feedback competitor information
	EXPLT5	Feedback consultants, laboratories
Exploration	EXPLR1	Share information universities
	EXPLR2	Share public research organisations
	EXPLR3	Share information technology centres
	EXPLR4	Share information conferences, fairs and exhibitions
	EXPLR5	Share information: Scientific journals
	EXPLR6	Share information: Professional
Innovative outcome	IO1	Larger range of goods or service
	IO2	Replacement of outdated products or processes
	IO3	Penetration in new markets
	IO4	Greater market share
	IO5	Higher quality of goods or service
	IO6	Greater flexibility in the production or provision of services
	IO7	Increased production capacity or service provision
	IO8	Lower labour costs per unit produced
	IO9	Fewer materials per unit produced

Table A1.
Variables and indicators

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