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**Exploration, exploitation and innovation performance: Disentangling environmental dynamism**

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**Abstract**

Environmental dynamism has recently attracted the attention of scholars studying the relationships between exploration and exploitation strategies and innovation performance. Surprisingly, although extant research has already acknowledged its multidimensional character, it has only been analyzed in an aggregate fashion. In this paper, we distinguish two components of environmental dynamism, the pace of market evolution and the pace of technology evolution, and we elaborate on their different impacts in the context of exploration and exploitation strategies. More precisely, we argue that while a rapid pace of technology evolution has opposite impacts on the relationships between exploration (positive), exploitation (negative) and innovation performance, a rapid pace of market evolution positively affects both exploration and exploitation. Our findings provide substantial support for our prediction using a large panel of Spanish innovating firms for the period 2008-2012.

**Keywords**

Exploration; Exploitation; Environment; Technology; Market

**JEL Classification**

O31 O32 O33

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Environmental dynamism has recently attracted the attention of scholars studying the relationships between exploration and exploitation strategies and innovation performance. Surprisingly, although extant research has already acknowledged its multidimensional character, it has only been analyzed in an aggregate fashion. In this paper, we distinguish two components of environmental dynamism, the pace of market evolution and the pace of technology evolution, and we elaborate on their different impacts in the context of exploration and exploitation strategies. More precisely, we argue that while a rapid pace of technology evolution has opposite impacts on the relationships between exploration (positive), exploitation (negative) and innovation performance, a rapid pace of market evolution positively affects both exploration and exploitation. Our findings provide substantial support for our prediction using a large panel of Spanish innovating firms for the period 2008-2012.

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## 1. INTRODUCTION

The study of how exploration and exploitation strategies affect innovation performance has become a popular topic in strategic management literature (Rothaermel and Deeds, 2004; Greve, 2007). In recent years, our knowledge has evolved from the stream of research that analyzes the relationships between exploration, exploitation and innovation performance (Faems, Van Looy and Debackere, 2005) to a more recent line that suggests that these relationships should be studied from a contingency perspective (Jansen, Van Bosch and Volberda, 2006; Yang and Li, 2011).

Our point of departure is to consider that, given their opposite natures, the factors explaining the relationships between exploration and exploitation and innovation performance are not necessarily the same (Jansen et al, 2006). This has opened a new line of research focused on a more granular and individual study of exploration and exploitation strategies (Yamakawa, Yang and Lin, 2011; Yang and Li, 2011).

Most recent research has addressed the contingent nature of exploration and exploitation strategies. For instance, organizational age has been taken into consideration by scholars analyzing the different impact of exploration and exploitation strategies on innovation performance (Rothaermel and Deeds, 2004; Yamakawa, Yang and Lin, 2011). The literature has also referred to the size of the firm as a factor that enables organizations that develop exploration or exploitation strategies to obtain a different innovation performance (Cao, Gedajlovic and Zhang, 2009).

The environment is one of the dimensions that have recently attracted the interest of scholars (Auh and Menguc, 2005; Yang and Li, 2011), especially its dynamism (Jansen et al., 2006; Kim and Rhee, 2009). In the literature, there is a consensus that environmental dynamism is positive for the development of exploration processes while

it is detrimental to the implementation of exploitation strategies (Jansen et al., 2006; Kim and Rhee, 2009).

The literature on exploration and exploitation has acknowledged the multidimensional character of environmental dynamism, in which mainly changes in technologies and fluctuations in demand play an important role (Jansen et al., 2006; Yang and Li, 2011). Therefore it is surprising that extant research has mostly analyzed environmental dynamism in an aggregated fashion (Jansen et al., 2006; Wang and Li, 2008; Yang and Li, 2011), neglecting the different influences that each of its components may have. The main assumption of this stream of research is to consider that the impact of environmental dynamism is equivalent to the sum of its different components (Jansen et al., 2006; Kim and Rhee, 2009; Yang and Li, 2011).

In this paper, we will distinguish two components of environmental dynamism, namely, the pace of technology evolution and the pace of market evolution, to analyze their moderating influence on the relationships between exploration, exploitation and innovation performance. We build on technology and strategic management literatures that have considered that environmental dynamism is a multidimensional concept (McCarthy, Lawrence, Wixted and Gordon, 2010). We argue that the paces of market and technology evolution have different impacts (Katz and Shapiro, 1992; Suárez and Lanzolla, 2007) and they deserve to be studied separately. Our contention is that the pace of market evolution strengthens the relationship between exploration and exploitation and innovation performance, while the pace of technology evolution boosts the innovation performance associated with exploration strategies, but inhibits that of exploitation strategies.

We test our hypotheses within the Technological Innovation Panel database (PITEC), which contains information about the innovative activity of Spanish

companies. This database is particularly useful for the purposes of our work for at least for two reasons. First, it provides information about companies belonging to different sectors. This means that there is sufficient variability in the two components of environmental dynamism for our purposes. Second, it allows us to identify exploration and exploitation strategies over a time frame of five years.

Our contribution to the literature is twofold. First, it extends our knowledge on the impact of environmental dynamism on exploration and exploitation strategies by considering two components, market and technology evolution. To the best of our knowledge, there are no previous attempts, either theoretical or empirical, to analyze environmental dynamism in a more granular way. Given the opposite influences that the paces of market and technology evolution may have, some of the previous findings in the literature could be threatened (Jansen et al., 2006; Wang and Li, Yang and Li, 2011). Second, we offer a much-needed longitudinal perspective in the analysis of the impact of environmental factors (Auh and Menguc, 2005). The literature on exploration and exploitation has conceptualized and measured environmental conditions as static variables (Jansen et al., 2006; Yang and Li, 2011) although they clearly have a dynamic nature (McCarthy, Lawrence, Wixted and Gordon, 2010). Several studies postulate that any structural change that modifies the conditions of competition does not occur at a particular moment in time, but encompasses a longer period (Agarwal, Sarkar and Echambadi, 2002). Based on this contention, the consideration of environmental attributes as static prevents us from perceiving the full extent of their effects. Consequently, the inclusion of the time factor allows us to address the impact of the two dimensions more rigorously.

## **2. THEORETICAL BACKGROUND**

### **2.1 Exploration, exploitation and innovation performance**

The concepts of exploration and exploitation are generally used to describe activities that are essential for organizations in sustaining and ensuring their competitive advantages (Isobe, Makino and Montgomery, 2004). In his seminal paper, March (1991) describes exploitation and exploration as two different forms of learning activities between which firms have to balance their attention and resources. Exploration strategies are associated with search, discovery, experimentation and development of new knowledge, while exploitation involves activities that seek the refinement and extension of existing knowledge and is associated with convergent thinking (March, 1991; Levinthal and March, 1993).

Exploration and exploitation strategies are different types of innovation strategies (Faems et al., 2005) and their impact on innovation performance has recently attracted the attention of researchers (Rothaermel and Deeds, 2004; Jansen et al., 2006). At first, researchers focused on whether the development of each of these strategies was related to innovation performance (Faems et al., 2005). These studies have obtained somewhat conflicting results (Lavie, Stettner and Tushman, 2010). Whereas most researchers find positive innovation performance effects for exploration (Yalcinkaya, Calantone and Griffith, 2007) and exploitation strategies (Faems et al., 2005), others find no relationship (Amason, Shrader and Tompson, 2006) or even a negative association (Yalcinkaya et al., 2007; Rothaermel and Alexandre, 2009). These non-conclusive results could be related to the drawbacks of each strategy. In this vein, researchers like Rosenkopf and Nerkar (2001) have shown that too much exploration, overexploration, leads organizations to focus on long-term performance, renouncing short-term outcomes. They also show that too much exploitation, overexploitation, generates

rigidity problems because it prevents organizations from being able to break out of their technological trajectory and thereby, to compete in the long-term (Wang and Li, 2008).

Another possible reason for these conflicting results is the risks that each strategy entails. Scholars like Auh and Menguc (2005) have argued that, given that exploitation strategies aim at creating and commercializing improved products and services (Benner and Tushman, 2003), innovating firms are familiar with innovation outcomes which involve lower risk. Furthermore, because organizations developing exploitation strategies often obtain high synergies with the knowledge they already have (Mueller, Rosenbusch and Bausch, 2013), economies of scale and scope will increase innovation performance (Auh and Menguc, 2005). Moreover, and given that these organizations apply their prior knowledge, they can also benefit from learning curve effects, leading to a positive effect on innovation performance (Morgan and Berthon, 2008; Mueller et al., 2013). However, because these low-risk strategies do not allow the creation of products with a high degree of novelty, many firms may develop similar products and, hence, not reap the benefits that they expect from their innovation processes, which could even result in a negative impact (Mueller et al., 2013).

Meanwhile, exploration strategies are considered to be high-risk because their implementation requires a large amount of resources and, to be successful, firms must be able to allocate these resources to high-risk projects whose outcomes are unpredictable (Rosenkopf and Nerkar, 2001).

## **2.2 Exploration, exploitation and environmental dynamism**

In a context of exploration and exploitation strategies, researchers have started to address the importance of the opportunities and threats that come from the environment (Wang and Li, 2008; Yamakawa et al., 2011). Based on the fact that exploration and exploitation strategies require different structures, processes and resources (March,

1991; Levinthal and March, 1993), several researchers have proposed that the effect of the environment in each of these strategies might not be the same (Jansen et al., 2006; Yang and Li, 2011).

Levinthal and March (1993) and Lewin, Long and Carroll (1999) suggest that environmental dynamism is likely to moderate the effect of exploration and exploitation strategies on innovation performance. Other recent studies suggest that the development of exploration strategies seems to be optimal in dynamic environments while the implementation of exploitation strategies may be detrimental to innovation performance (Jansen et al., 2006; Kim and Rhee, 2009). Firms developing exploration strategies have a broader knowledge that enables them to satisfy the new requirements created by a dynamic environment (Uotila, Maula, Keil and Zahra, 2009).

In the same vein, Lumpkin and Dess (2001) claim that a proactive attitude, such as that resulting from the development of exploration strategies, helps reduce the threat of obsolescence in an environment characterized by dynamism. They also suggest that the search for opportunities is more likely to succeed in environments where the risk associated with novelty and originality can be recovered more easily through the capture of new market niches. On the contrary, in an environment characterized by low dynamism, in which only small modifications of the products and the existing services are required, the development of exploitation strategies is more appropriate (Li, Lin and Chu, 2008). In such contexts, organizations can rely on their existing knowledge and the skills and processes that they have already developed (Jansen et al., 2006).

Research on exploration and exploitation seems to adopt a unanimous position on the effect of dynamism on the relationship between exploration and exploitation strategies and innovation performance (Jansen et al., 2006; Kim and Rhee, 2009). Most of these studies, although defining dynamism as a multidimensional concept, have

analyzed it from a unidimensional approach (see, for example, Jansen et al., 2006 and Yang and Li, 2011).

In this paper, we decompose environmental dynamism into two components in accordance with existing literature (McCarthy et al. 2010; Suárez and Lanzolla, 2007), namely, the pace of technology evolution and the pace of market evolution, and we elaborate on the idea that they evolve independently with respect to the relationships between exploration and exploitation strategies and innovation performance. Our starting point is that each of these dimensions could have a different impact on the relationships stated above. To our knowledge, there is no theoretical or empirical work that analyzes environmental dynamism taking into account its different components (Wang and Li, 2008; Yang and Li, 2011; Uotila et al, 2009).

### **3. HYPOTHESES**

#### **3.1 The pace of technology evolution**

One element that affects firms' behavior is the rate at which technology evolves in the environment in which they operate (Tushman and Anderson, 1986). Traditionally, the literature has used this factor to explain the speed at which the products and services that have been introduced into an industry become technologically obsolete (Zahra, 1996; Zahra and Bogner, 1999). Following Zahra (1996), we understand the pace of technology evolution as the level of change that technology undergoes in a specific period of time.

A rapid pace of technology evolution means that existing products and services cannot satisfy market needs (Tushman and Anderson, 1986; Zahra, 1996). This is because technology evolution has created new technology requirements, a fact that prompts organizations to develop new products and services to meet this lack (Zahra, 1996; Wind and Mahajan, 1997; Sorensen and Stuart, 2000). However, firms are not yet

aware of market preferences. Given this uncertainty, firms have to turn to experimentation if they want to introduce a dominant technological standard (Zahra, 1996; Zahra and Bogner, 1999). The more numerous the product design alternatives resulting from this process, the more likely these firms will satisfy the unmet needs (Zahra, 1996; Fleming and Sorenson, 2001).

Therefore, it seems that the implementation of strategies whose dynamic has its origin in trial and error and which are based on the constant development of innovations with a high degree of novelty, could be an appropriate response to a context of rapid technology evolution. This is precisely the nature of exploration strategies, whose starting point is the search for information outside the boundaries of the organization (Atuahene-Gima, 2005). As a result, firms implementing exploration strategies obtain a wider-ranging knowledge that fosters the constant introduction of new products and services (Benner and Tushman, 2003; Atuahene-Gima, 2005). Because an environment characterized by rapid technology evolution allows the introduction of multiple product designs (Zahra and Bogner, 1999), firms developing exploration strategies can more easily place the innovations that they have introduced. Accordingly, firms' investments associated with novelty will be more useful (Lumpkin and Dess, 2001).

In addition, firms developing exploration strategies could more easily capture returns from innovations because, as technological requirements are renewed quickly, competitors will not be able to imitate the innovations introduced (Zahra, 1996; Zahra and Bogner, 1999). Therefore, the organizations that have created the innovations may acquire an advantage over their competitors, a fact that could be particularly beneficial for organizations that develop exploration strategies because they have invested abundant resources and assumed a high risk (Atuahene-Gima, 2005).

Consequently, organizations developing exploration strategies may have above-normal returns. Therefore, a context like this could enhance the effect of exploration strategies on innovation performance. In accordance with this, we propose our hypothesis as follows:

**HYPOTHESIS 1a:** *Rapid technology evolution positively moderates the relationship between exploration and innovation performance.*

On the contrary, an environment characterized by rapid technology evolution might not be equally favorable for organizations that develop exploitation strategies. Firstly, because the satisfaction of the needs of emerging markets seems more likely through the constant introduction of innovations with a high degree of novelty (Jansen et al, 2006; Kim and Rhee, 2009). Nevertheless, as is well known, the dynamic of the organizations that develop exploitation strategies does not support this type of innovative behavior (Benner and Tushman, 2003; Atuahene-Gima, 2005). As a result, organizations that develop exploitation strategies could find it difficult to place the innovations that they have introduced. Consequently, the investments in innovations they have made may not prove as profitable as they expected.

Secondly, rapid technology evolution could be particularly unfavorable for firms whose technological trajectory is maintained over time (Jansen et al., 2006). This is because their new creations, being very close to those developed previously, become obsolete even faster (Zahra, 1996). Given that organizations that develop exploitation strategies follow this dynamic, they are especially vulnerable in this context (Zahra and Bogner 1999).

With these arguments in mind, it seems logical to consider that an environment characterized by rapid technology evolution is not optimal for the development of

exploitation strategies. Based on all the above arguments, we propose the following hypothesis:

**HYPOTHESIS 1b:** *Rapid technology evolution negatively moderates the relationship between exploitation and innovation performance.*

### **3.2 The pace of market evolution**

The pace of market evolution is another environmental attribute that may affect organization dynamics (Raisch and Hotz, 2008). The market evolution of an industry is usually characterized by an initial period of slow growth. This phase is followed by an intense increase and a later phase of market maturity and decline (Suárez and Lanzolla, 2007). Thus, rapid market evolution implies that fluctuations in product demand are high while, if the market grows slowly, the demand will follow the same path (Raisch and Hotz, 2008).

If the market is evolving rapidly, the continuous fluctuations in product demand could have two fundamental implications. First, the risk involved in carrying out innovation investments could be minimized (Lumpkin and Dess, 2001). In this type of context, if the products or services developed do not meet the needs of a market segment, excess demand will accommodate them (Klepper, 1997). This could be especially beneficial for organizations that develop exploration strategies, for which the loss of their investments, given its magnitude, could seriously undermine their innovation performance (Lavie et al., 2010). Organizations of this type experiment with new knowledge and their dependence on the knowledge they already had is reduced (Zahra, 1996), a fact that explains why their investment in innovation is high (Zahra and Bogner, 1999; Atuahene-Gima, 2005). However, this means that they have to assume a high level of risk, generally considered as one of the impediments to their development

(Lavie et al, 2010; Mueller et al, 2013). If this risk could be reduced by high demand, these firms will be able to take advantage of the investments they have made.

Second, the competitive conditions of the industry could be modified precisely by this high demand that makes the market more attractive (Lumpkin and Dess, 2001). Thus, more firms could be interested in entering the market (Raisch and Hotz, 2008). However, due to the high demand that characterizes the industry, the firms in this industry will have sufficient resources and the competition will exert less pressure (Lumpkin and Dess, 2001). Therefore, these organizations are not obliged to set low prices to compete (Jansen et al., 2006). This could be especially beneficial for organizations that develop exploration strategies because their implementation involves high costs to be recovered (Lavie et al, 2010). As competition gives a greater clearance in the pricing (Jansen et al., 2006), organizations that develop exploration strategies could recover their investment in innovation by setting a price in accordance with the characteristics of the product they offer.

In addition, and because of the possibility of charging higher prices, the competition will focus on offering products and services that better satisfy the emerging market requirements (Schmidt and Calantone, 1998). In this context, where the growth in demand explains why there will be unsatisfied market niches, it seems logical that organizations which anticipate the future demand will be able to satisfy customer needs better than the rest. As is well known, exploration strategies are based precisely on the discovery of new knowledge and resources that enable companies to move away from the path previously followed (Atuahene-Gima, 2005). Thus we might think that organizations that develop exploration strategies will be trained to meet the needs of emerging markets.

For all the reasons above, we consider that rapid market evolution is attractive for the development of exploration strategies. Consequently, the innovation performance that results from these strategies could experience a boost. Accordingly, the following hypothesis is formulated:

**HYPOTHESIS 2a:** *Rapid market evolution positively moderates the relationship between exploration and innovation performance.*

Likewise, rapid market evolution could be beneficial for the development of exploitation strategies. This is because it is an environment characterized by high demand and, thus, by multiple market segments with very different needs (Lumpkin and Dess, 2001). The high growth of demand may mean that even the introduction of innovations that only improve the existing products and services will be accommodated (Lumpkin and Dess, 2001; Raisch and Hotz, 2008). As a result, organizations that develop exploitation strategies may find a place in an environment characterized by volatile market shares and be able to increase their efficiency and their cash flow (Lumpkin and Dess, 2001). In this way, they could take advantage of their innovation processes. In this type of context, where it is optimal not to do better than the competitors, but to do what is best for the company (Armstrong and Collopy, 1996), the development of exploitation strategies could succeed.

Moreover, and given the possibility of setting higher prices, organizations developing exploitation strategies will be able to obtain a substantial margin. Because of the presence of scale economies, firms developing exploitation strategies can concentrate on cost reduction and get the most out of their existing resources (Porter, 1980) without making large investments (Lavie et al., 2010) and they do not have to assume a high risk. Hence, although their prices are similar to those of their competitors, they will be able to capture important benefits because the costs they will

have to recover are not as high as those made by organizations that incorporate a higher level of risk.

In sum, it seems logical that the conditions of an environment characterized by rapid market evolution are appropriate for the development of exploitation strategies. Given that the high demand and the competition conditions allow organizations that focus on exploitation strategies to make above-normal profits, we might think that rapid market evolution potentiates the effect of the implementation of these strategies on innovation performance. As a consequence of all the arguments set out above, the following hypothesis is proposed:

**HYPOTHESIS 2b:** *Rapid market evolution positively moderates the relationship between exploitation and innovation performance.*

#### **4. SAMPLE AND VARIABLES**

##### **4.1 Sample**

To test our hypotheses, we use the Technological Innovation Panel database (PITEC). This database provides annual information about the innovation activities of a large sample of Spanish manufacturing and service firms from 2003 to 2012. The data are collected by the National Institute of Statistics (INE) with the support of the Spanish Foundation for Science and Technology (FECYT) and the Spanish Foundation for Technological Innovation (COTEC). PITEC is based on the Community Innovation Survey (CIS) framework, which is a valid tool for studying innovation and is one of the most frequently used datasets in this context.<sup>1</sup> Finally, it is important to highlight that these data have been previously used for several purposes (see for instance Vega

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<sup>1</sup> The dataset, the questionnaire and the description of each variable is available at the website: [http://icono.fecyt.es/PITEC/Paginas/por\\_que.aspx](http://icono.fecyt.es/PITEC/Paginas/por_que.aspx). In order to avoid the identification of the firms, some variables are “anonymized”. López (2011) shows that the expected biases due to this anonymization are small through the comparison of regressions that use original and harmonized data alternatively.

Jurado, Gutierrez Gracia and Fernandez de Lucio, 2009; De Marchi, 2012 or Barge-Gil and López, 2014).

PITEC is particularly appropriate for the purposes of this work. First, it provides information about the innovation objectives of each firm. With this information in mind, and following the logic of previous papers (see, for example He and Wong, 2004 and Archibugi, Filippetti and Frenz 2013), we are able to characterize exploration and exploitation strategies. Second, PITEC contains information for firms operating in very different industrial settings. This means that we have sufficient variability in both the paces of market evolution and technology evolution for our purposes. Finally, and as argued before, the dataset has a longitudinal dimension, spanning information from 2003 to 2012. Although the information is provided from 2003 on, due to the availability of the information we need<sup>2</sup>, we use the time frame 2008-2012. In addition, since we are analyzing the differences in the innovation performance of the organizations that develop exploration and exploitation strategies, our analysis is restricted to firms engaging in innovative activities (He and Wong, 2004; Laursen and Salter, 2006).<sup>3</sup> After excluding non-innovation firms, those belonging to agriculture and construction, firms with no information on the main variables, those that have suffered problems associated with mergers and acquisitions and those that are public or newly created, we have a sample of 23,028 observations.

Tables 1 and 2 offer descriptive statistics of our final sample by industry (manufacturing vs service), technological level (high vs low)<sup>4</sup> and size.<sup>5</sup>

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<sup>2</sup> For building the exploration and exploitation variables, information is only available from 2008, which limits the final observation window to the period 2008-2012.

<sup>3</sup> Innovators are firms that have developed product or process innovation.

<sup>4</sup> We have used the OECD (2005)'s classification of industries to create the high-tech and low-tech groups. Additional information is available at the website: <http://www.ine.es/daco/daco43/notaiat.pdf>.

<sup>5</sup> Classification carried out in accordance with the criteria established by the European Commission Regulation (CE) N° 800/2008 of 6 August 2008 (DOUE L214/3 of 9 of August, 2008), which defines the requirements for three categories of companies: microenterprise, comprising those which employ fewer

**Table 1. Distribution of firms by industry and technological level**

<b>Manufacturing</b>	Number of firms	%
<b>High technology</b>	6,635	28.81
<b>Low technology</b>	7,926	34.42
<b>Total</b>	14,561	63.23

  

<b>Services</b>	Number of firms	%
<b>High technology</b>	2,508	10.89
<b>Low technology</b>	5,959	25.88
<b>Total</b>	8,467	36.77

**Table 2. Distribution by size of the firms in the sample**

	N	%
<b>Micro-enterprises</b>	2,100	9.12
<b>Small enterprises</b>	8,903	38.66
<b>Medium enterprises</b>	7,429	32.26
<b>Large enterprises</b>	4,596	19.96

## 4.2 Variables

### *Dependent variable*

In order to measure innovation performance, we have used the fraction of the firm's total turnover related to the firm's new products. This measure has been previously used with very similar purposes (see, for example, Laursen and Salter, 2006; Bauer and Leker, 2013) and is considered a good proxy not only for a firm's ability to introduce new products but also for its commercial success (Woerter and Roper, 2008; Tsai, 2009).

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than 10 workers, small business, which includes those which employ 10 to 49 workers and medium enterprises, those that employ between 50 and 249 workers.

*Independent variables*

Following previous papers (see, for example, He and Wong, 2004 and Archibugi et al., 2013), we measure exploration and exploitation through ten Likert-scale items to measure how firms divide attention and resources between innovation activities with explorative versus exploitative objectives in the last three years of the sample. Factor analysis (see Table 3) is used to reduce the ten items to two factors, exploration and exploitation strategies, with acceptable Cronbach alphas (0.886 and 0.896) respectively). In addition, and based on Rothaermel and Alexandre (2009) and Yang and Li (2011), these variables will be included in the model in their quadratic form in order to control the impact of overexploration and overexploitation on innovation performance.

**Table 3. Factor Analysis**

Objectives for undertaking innovation projects (From 1=not important to 7=very important)	<b>Exploitation</b>	<b>Exploration</b>
Extend product range	0.1068	<b>0.8267</b>
Introduce new generation of products	0.3151	<b>0.6476</b>
Open up new markets	0.1926	<b>0.8427</b>
Improve market share	0.2369	<b>0.8568</b>
Improve existing product quality	0.3054	<b>0.7553</b>
Improve production flexibility	<b>0.7499</b>	0.1899
Improve capacity of production or service delivery	<b>0.7787</b>	0.2315
Reduce labor costs per unit produced	<b>0.8349</b>	0.2402
Reduce material per unit produced	<b>0.8063</b>	0.2230
Reduce energy per unit produced	<b>0.8087</b>	0.2063
<b>Cronbach alpha</b>	<b>0.8862</b>	<b>0.8964</b>

Notes. Extraction method: Principal component analysis

Rotation method: Varimax with Kaiser normalization

*Moderating variables*

The pace of technology evolution and the pace of market evolution are the moderating variables in this paper. In line with Uotila et al. (2009), we measure

technology evolution through the intensity of R&D in the industry, calculated as the industry's total R&D expenses divided by total industry sales.

Consistent with previous studies (Cao et al., 2009) the pace of market evolution is measured through industry sales growth, which reflects the opportunities of the environment. To measure industry sales growth, we have to obtain industry sales, calculated as the sum of the sales of the firms in the same industry. Industry sales growth is obtained from the ratio of industry sales in year  $t$  and industry sales in year  $t-1$ .

#### *Control variables*

In addition to the independent variables and moderators, we control for a variety of variables that are classified into two groups: firm and industry variables.

Several papers suggest that there is a positive relationship between firm size and innovation performance (Cassiman and Veugelers, 2006; Lavie and Rosenkopf, 2006). Following Yang and Li (2011), we have measured firm size as the number of employees. It is also necessary to control for the innovative intensity of the firms, because if it is high, the results from innovation strategies will increase. Following the literature that measures innovative intensity through the ratio of total firm R&D and firm size (Laursen and Salter, 2006), we use this measure to proxy the variable. Furthermore, we need to control whether the firm operates in an international context. Several papers have pointed out that firms that operate internationally are more innovative (Galende and Suarez, 1999; Cassiman and Veugelers, 2006). We proxy this variable through the ratio between exports and sales (Nieto and Santamaría, 2007). As in previous papers, we expect a positive relationship between innovation performance and export activity. Researchers also think that the participation of foreign capital affects the propensity of organizations to innovate. This is because their ownership

structure can facilitate a more effective knowledge transfer (Love and Roper, 2001; Desai, Foley and Hines, 2004). Some investigations have measured this variable through a dummy variable that takes the value 1 if the firm has foreign capital participation and 0 otherwise (Sadowski and Sadowski-Rasters, 2006) and this is how our paper is going to measure it.

The innovative activity of organizations is, in turn, affected by factors related to the sector to which the firm belongs (Miotti and Sachwald, 2003; Auh and Menguc, 2005). To measure this effect, this work has included a dummy variable that classifies the firms under study by sector, in accordance with the CNAE 2009 code.

### **4.3 Descriptive Statistics**

Table 4 shows the descriptive statistics of the sample as well as the correlation matrix. Our sample consists of a total of 23,028 observations which are used in the model. The mean of the dependent variable is 0.205, which indicates that an average of 20% of the turnover of the companies comes from the introduction of innovations new to the firm or new to the market.

With respect to the independent variables, Table 4 shows that the average scores that firms have given to the objectives that define exploration are lower than the average scores that they have given to the exploitation innovation objectives. Researchers like Archibugi et al. (2013) have obtained similar results for companies in the UK. Their results show that, on average, companies give higher scores to exploitation than exploration.

Finally, the correlation matrix shows that, generally, the variables have low correlations between them. This means that there will be no problems of multicollinearity if we include them in the same regression.

**Table 4. Descriptive statistics and correlation matrix**

Variables	n	Mean	Std. Dev	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Innovation performance	23,028	0.201	0.253	0	0.693	1								
Exploration	23,028	-0.001	0.999	-2.746	1.839	0.202*	1							
Exploitation	23,028	0.004	0.999	-2.114	2.467	0.019*	0.001	1						
Technology evolution (000)	23,028	4.187	8.382	0.0099	78.79	0.045*	0.092*	0.017*	1					
Market evolution	23,028	0.949	0.169	0.524	1.838	-0.029	0.026*	-0.007	-0.023*	1				
International activity	23,028	0.240	0.308	0	1	0.058	0.114*	0.098*	0.077	-0.017	1			
Participation of foreign capital	23,028	0.135	0.342	0	1	-0.013	-0.017*	0.062*	0.033	0.021*	0.156*	1		
Innovation intensity (000)	23,028	5.758	13.47	0	470.79	0.119*	0.178*	0.011	0.370*	0.013*	0.066	-0.018*	1	
Size (000)	23,028	0.324	1.616	1	40.585	-0.009*	-0.013*	0.043*	-0.032*	0.017*	-0.038	0.088*	-0.041*	1

- $p < 0.05$

## 5. RESULTS

Table 6 shows Tobit<sup>6</sup> estimates for the relationship between exploration and exploitation strategies and innovation performance. First, it should be noted that the literature has found that the variables that reflect the innovation performance of organizations may present problems of asymmetry and deviation from normality (Filippucci, Drudi and Papolia, 1996; Laursen and Salter, 2006). Based on this idea, we have calculated the logarithmic transformation of the dependent variable. Second, and following previous literature (He and Wong, 2004), both the independent and the moderating variables have been lagged one period.<sup>7</sup> The variables have been centered on their means to simplify the interpretation of the coefficients (Aiken and West, 1991; Yang and Li, 2011).

We have run three nested models. Model 1 is the based model that only includes the control variables. Model 2 introduces the direct effects of exploration and exploitation and their quadratic form. Finally, Model 3, the full model, includes the pace of technology and the pace of market evolution and their interactions with exploration and exploitation. It is important to note that, if we compare the models through the Wald test –shown at the end of the table–, the complete model has the greatest explanatory power.

In Model 1, we observe that the development of international activities has a positive and significant effect on innovation performance. Similarly, higher innovation intensity is positively and significantly related to a superior innovation performance. This is in line with Nieto and Santamaría (2007). Firm size also has a positive and a significant influence on innovation performance. This is consistent with previous

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<sup>6</sup> The innovation performance variable is a doubled censored variable. It represents the percentage of sales of new products that, by definition, ranges between 0 and 100. Accordingly, the applicable methodology is a Tobit regression (Greene, 2000).

<sup>7</sup> This explains why our number of observations declines from the 23,028 showed in the descriptive statistics to 15,299.

findings that maintain that innovation strategies can be affected by size through economies of scale and scope (Cassiman and Veugelers, 2006). Our results show that the participation of foreign capital has no significant effect on innovation performance. The dummy variables capturing time-specific influences and the effect of the industry are globally significant. With regard to our control variables, it is important to note that the sign and significance of all of them are highly stable in Models 2 and 3.

In Model 2, we observe that the development of exploration and exploitation strategies is positive and significantly related to innovation performance. Moreover, the effect that exploration has on innovation performance ( $\beta = 0.0717$ ;  $p < 0.001$ ) is higher than the effect of exploitation ( $\beta = 0.00995$ ;  $p < 0.05$ ).<sup>8</sup> This is in line with previous findings such as Archibugi et al. (2013). They observed that, in the UK and for 2008, the effect of the development of exploration strategies on innovation performance was superior to that of exploitation strategies. Interestingly, our results reveal that there is a negative and significant relationship between the quadratic version of the exploration variable and innovation performance ( $\beta = -0.0243$ ;  $p < 0.001$ ). This means that the relationship between exploration and innovation performance has an inverted U-shaped. In other words, it seems that low and high levels of exploration have a negative impact on innovation performance. This finding is consistent with Yang and Li (2011), who postulated a negative relationship between the development of low and high levels of exploration and innovation performance. On the contrary, our data shows a positive and significant relationship between the quadratic version of exploitation and our dependent variable ( $\beta = 0.0116$ ;  $p < 0.001$ ). This means that the relationship between exploitation strategies and innovation performance is U-shaped. This result is also consistent with the literature. For instance, Atuahene-Gima and Murray (2007) found that the

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<sup>8</sup> We have used a Wald test to test whether the differences between the coefficients of exploration and exploitation are statistically significant. The result shows that they are, which leads us to reject the null hypothesis of equal coefficients.

relationship between low and high levels of exploitation and innovation performance is positive.

Model 3, the full model, incorporates the pace of technology and the pace of market evolution variables together with their interactions with exploration and exploitation strategies. The data shows that the pace of technology evolution positively moderates the relationship between exploration and innovation performance ( $\beta = 0.00000172$ ;  $p < 0.05$ ), which is consistent with Hypothesis 1a. This means that exploration processes seems more appropriate in a context characterized by rapid technology evolution. On the contrary, our results show that the pace of technology evolution has no significant effect on the relationship between exploitation and innovation performance. This does not support Hypothesis 1b. As for the pace of market evolution, our results show that this variable positively moderates the relationship between exploration and innovation performance ( $\beta = 0.0460$ ;  $p < 0.10$ ), which supports Hypothesis 2a. We also observe that the pace of market evolution has a positive and a significant effect on the relationship between exploitation and innovation performance ( $\beta = 0.0352$ ;  $p < 0.10$ ), which is in line with Hypothesis 2b.

**Table 5. Relationship between exploration and exploitation and innovation performance**

	(1) Innovation performance	(2) Innovation performance	(3) Innovation performance
Exploration		0.0717*** (15.20)	0.0749*** (15.38)
Exploitation		0.00995** (2.48)	0.0115** (2.79)
Exploration*Exploration		-0.0243*** (-6.13)	-0.0256*** (-6.40)
Exploitation*Exploitation		0.0116*** (3.38)	0.0116*** (3.38)
Technology evolution (000)			-0.0000640 (-0.06)
Technology evolution*Exploration (000)			0.00172** (2.56)
Technology evolution*Exploitation (000)			0.000407 (0.86)
Market evolution			0.0130 (0.42)
Market evolution*Exploration			0.0458* (1.79)
Market evolution*Exploitation			0.0356* (1.67)
International activity	0.0522*** (3.62)	0.0399** (2.80)	0.0394** (2.76)
Participation of foreign capital	0.00336 (0.24)	0.00751 (0.56)	0.00709 (0.53)
Innovation intensity (000)	0.00168*** (5.59)	0.00108*** (3.64)	0.00108*** (3.64)
Size (000)	0.00699** (2.23)	0.00574* (1.88)	0.00566* (1.86)
Constant	-0.0860 (-0.33)	-0.127 (-0.50)	-0.128 (-0.51)
Temporal dummies	Yes ***	Yes ***	Yes ***
Sectorial dummies	Yes ***	Yes ***	Yes ***
N	15,299	15,299	15,299
Log Likelihood	-9,342.42	-9,356.06	-9,118.55
Wald chi-square	685.62***	1,122.79***	1,100.65***
Test vs. 1		425.82***	432.76***
Test vs. 2			13.71**
AIC	18,782.84	18,356.96	18,355.1

\* p < 0.10, \*\* p < 0.05, \*\*\* p < 0.01

## 6. CONCLUSION AND DISCUSSION

The main purpose of this investigation has been to disentangle the impact of the environmental dynamism on the relationships between exploration, exploitation and innovation performance. Although some scholars have studied this impact, to our knowledge they have always considered environmental dynamism in an aggregate fashion (Jansen et al., 2006; Wang and Li, 2008). This is somewhat surprising given that management literature has understood environmental dynamism as a multidimensional construct (Katz and Shapiro, 1992; Suárez and Lanzolla, 2007). Our paper has covered this gap by distinguishing two components of the environmental dynamism, namely, the pace of market evolution and the pace of technology evolution, to analyze whether they have different impacts on the relationships between exploration and exploitation and innovation performance.

Our results reveal that, in an environment characterized by rapid technology evolution, firms that develop exploration strategies can obtain better innovation performance. On the contrary, we find that rapid technology evolution does not have any significant effect on the relationship between exploitation and innovation performance.

We also find that, when the market is evolving rapidly, the development of exploration and exploitation strategies leads to better innovation performance. Accordingly, the pace of market evolution seems to reward exploration and exploitation strategies equally. As is well known, rapid market evolution implies that there is always a demand to be satisfied (Raisch and Hotz, 2008). We argue that there will be both market segments that demand radical innovations (exploration) as well as market segments that require only improvements in the products and the services introduced (exploitation). Consequently, the innovations resulting from the development of

exploration and exploitation strategies can both be accommodated in an environment characterized by rapid market evolution.

Our results contribute to the existing empirical evidence (Archibugi et al., 2013) that the impact of exploration strategies on innovation performance exceeds that of exploitation strategies, although both effects are positive. The reason for this result is that developing innovations that involve a break with the current technological trajectory offers a higher and more sustainable advantage compared with introducing small improvements (Jansen et al., 2006).

Our paper also aims to contribute to the exploration and exploitation literature (Rothaermel and Deeds, 2004), more precisely to the stream of research that analyzes the boundary conditions on the relationship between these strategies and innovation performance (Jansen et al., 2006; Yang and Li, 2011). By decomposing environmental dynamism into two elements, the pace of market evolution and the pace of technology evolution, we offer a much more nuanced picture of how environmental dynamism is related to both exploration and exploitation. Moreover, we believe that by developing a more granular analysis of environmental dynamism, the literature on exploration and exploitation will follow the same path as other streams of research that have understood environmental dynamism as a multidimensional construct (McCarthy et al., 2010).

The paper also has important implications for practitioners. Based on our results, firms operating in environments characterized by rapid technology evolution may benefit from the development of exploration strategies. On the other hand, firms that operate in a context characterized by rapid market evolution will be aware that the development of exploration and exploitation strategies is going to be related to a higher performance. Organizations will also know that, if they are developing exploration strategies, their innovation performance could be higher.

In spite of the contribution of our research to disentangling the impact of the two components of environmental dynamism on the relationship between exploration, exploitation and innovation performance, several issues will require additional attention. One is that, given that our database provides information about Spanish firms, our results are only representative of the behavior of the organizations operating in this country, a fact that prevents us from generalizing our findings. Thus, as a future research line, we propose the extension of this analysis to other countries. Checking whether this phenomenon occurs in different scenarios could give a greater consistency to our findings.

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