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Exploration, Exploitation, and Firm Age in Alliance Portfolios

Abstract

We analysed the relationship between explorative-oriented and exploitative-oriented alliances. Through the complementarity approach, three possible relationships were analysed: complementarity, substitutability, and no relationship. We use Technological Innovation Panel data for Spanish manufacturing firms for 2005-2013. The econometric technique that we used to estimate the coefficients was population-averaged OLS. Our findings suggest that alliance portfolios formed by explorative-oriented and exploitative-oriented alliances achieve worse innovation performance than specialized exploration or exploitation portfolios. In addition, we found that a single class of alliance has different impacts on innovation performance depending on whether it is implemented by a young company or a mature company.

Keywords: Exploration, Exploitation, Firm age, Alliances, Complementarity approach

Research paper

JEL Codes: C12, D24, L24, O32

1. Introduction

Regarding the nature of the relation between exploration and exploitation, the economic literature recognizes the existence of three perfectly differentiated streams. The first stream, which encompasses a large part of the studies carried out, considers that the process of learning new knowledge can be represented by a continuous line, at the ends of which are the exploration and exploitation activities, respectively (e.g. Lavie et al., 2010; Rosenkopf and McGrath, 2011). Between the two ends there is a linear continuum of both learning activities' combinations. With this conception exploration and exploitation struggle for the scarce resources of organizations, so conflict between the two learning patterns is inevitable (March, 1991).

This linear conception presupposes the existence of a substitution relationship between exploration and exploitation insofar as the two forms of learning compete to hoard companies' scarce resources (Gupta et al., 2006; Cao et al., 2009, Lavie et al., 2010, Lavie et al., 2011).

"Compared with the returns from exploitation, the returns from exploration are systematically less certain, more remote in time, and organizationally more distant from the locus of action and adaptation" (March, 1991). Therefore, it is expected that the exploitation activities will provide companies with high and safe short-term performances (He and Wong, 2004; Gupta et al., 2006), while the development of exploration activities will offer low short-term performances and uncertain long-term performances (Levinthal and March, 1993; Lewin et al., 1999). In this sense Abernathy (1978) already conjectured that short-term efficiency and long-term adaptability are inherently incompatible.

However, the short-term maximization of performance may be the seed for long-term failure (Tushman and Nadler, 1986), since environmental conditions often change and the survival of firms requires the possession of new knowledge and the implementation of different policies and technologies from the current ones. Consequently, companies must find a balance in the development of their exploration and exploitation activities, which should provide them with sufficient returns and reasonable chances of survival.

The second stream considers the relationship between the exploration–exploitation continuum and firms' performance to be of a negative quadratic nature (inverted U-shape) (e.g. Rothaermel and Alexandre, 2009; Uotila et al., 2009; Lavie et al., 2011). This implies the assumption that there is a reduced range of exploration and exploitation combinations in which the company achieves the highest performance (ambidexterity) (Gupta et al., 2006; Rosenkopf and McGrath, 2011). In general, ambidexterity is defined as the ability of a company to develop exploration and exploitation activities simultaneously while at the same time achieving high performance (Duncan, 1976; March, 1991; Gibson y Birkinshaw, 2004; O'Reilly y Tushman, 2004, 2008; Raisch y Birkinshaw, 2008; Raisch et al., 2009; Lavie et al., 2011). Therefore, for this second stream, the relationship between exploration and exploitation is complementary; that is, the performance that is obtained from the simultaneous implementation of both activities is higher than the achievement from the sum of their isolated implementations.

Finally, there is a third stream that argues that exploration and exploitation activities are not induced by the same causes and do not share similar characteristics (e.g., Gupta et al., 2006), so the two learning patterns are conceived as independent activities (e.g., He and

Wong, 2004; Voss et al., 2008; Jansen et al., 2009). Within this stream, exploration and exploitation activities are not conceived as complementary or substitutive. The two activities are independent, that is, there is no relation between them, since they are considered to be differentiated phenomena, the analysis of which must be undertaken separately.

The results of the empirical investigations carried out to analyse each of the three indicated streams have not been conclusive. Thus, while some studies have found the existence of ambidexterity (e.g., Gibson and Birkinshaw, 2004; He and Wong, 2004; Lubatkin et al. 2006; Sidhu et al., 2007), others have discovered substitution relations (e.g., Atuahene-Gima, 2005; Lavie et al., 2011) or have not found a relationship between the two forms of learning (e.g., Venkatraman et al., 2007; Cao et al., 2009).

The main objective of this study is to analyse which of the three streams of thought is dominant in the alliance portfolio of the companies insofar as the purpose of the alliances is pooling partners' resources together with the intention of jointly undertaking exploration or exploitation activities (Das and Teng, 2000; Rivkin and Siggelkow, 2003; Park et al., 2004).

In this study we are interested in finding empirical evidence that allows us to verify whether the alliance portfolio of the companies must be formed simultaneously by exploration-oriented alliances and exploitation-oriented alliances or simply be formed by alliances of the same nature. That is, we try to determine whether the composition of the alliance portfolio, in terms of exploration/exploitation, influences the innovation performance of the companies.

To find the answer to this question, we analyse whether the relationships between exploration-oriented alliance and exploitation-oriented alliance are complementary, substitutive, or independent. If the relationships are complementary, it means that the simultaneous implementation of exploration-oriented alliance and exploitation-oriented alliance generates a greater innovation performance than the sum coming from the separate implementation of the two types of alliances; that is, there is ambidexterity. If so, the alliance portfolio of the companies must be formed by both types of alliances.

On the contrary, if the relationship between the two types of alliances is substitutive, it means that the coexistence in the same portfolio of exploration-oriented alliances and exploitation-oriented alliances diminishes the innovation performance of the companies.

Finally, if the test reveals that there is no relation between exploration-oriented alliance and exploitation-oriented alliance, it means that the coexistence of exploration-oriented alliances and exploitation-oriented alliances in the same alliance portfolio has no additional positive or negative impact on the innovation performance of companies.

Likewise, in this study we are interested in checking how the age of companies influences the choice of exploration/exploitation alliances in their alliance portfolio. Regarding this issue, it should be noted that the literature on innovation suggests that age is an important indicator of the resources and capacities accumulated by firms (Yamakawa et al., 2011) and that many strategic decisions and performance can be affected by this indicator (Sutton, 1997; Sorensen and Stuart, 2000).

It should be emphasized that the empirical research on these issues generally remains scarce. Our study extends the empirical research on ambidexterity, focusing the analysis not only on inter-firm relationships but also on the relationships existing within alliance portfolios. Another of the novelties of our study is that it analyses these relations using the so-called complementarity approach. This approach has its foundations in the lattice theory of Topkis (1978) and was used first in the economic sphere by Milgrom and Roberts (1990). In addition, our study focuses on the entire Spanish manufacturing sector and not on a single industry, like many previous studies (e.g., Park et al., 2002). Likewise, we want to emphasize that our study tried to overcome the so-called unobserved heterogeneity present when cross-sectional data are used. In this study we used panel data. In addition, it should be highlighted that the use of panel data is essential in the exploration variable analysis, since the analysis of exploration only makes sense in the long term.

Finally, we note that this study extends the technology views (distinctive view and integrative view) (e.g., Damanpour et al., 2009). The distinctive view argues that the antecedents of product and process innovations are different, so it predicts that there is no relationship between the two types of innovation or that this relationship is substitutive; on the contrary, the integrative view considers that the two types of innovation share antecedents, so the relationship is complementary. In this sense the parallels are evident, since the innovation literature often associates product innovation with exploration and process innovation with exploitation (e.g. He and Wong, 2004).

2. Framework and hypothesis

Most of the literature on innovation considers that firms often do not establish hybrid alliances, but tend to establish specialized alliances in either exploration or exploitation (e.g., Koza and Lewin, 1998; Colombo et al., 2015). In this sense there are studies that emphasize the differentiation of the two types of alliances (Raisch et al. 2009) or the separation of exploration and exploitation into different domains (Gupta et al. 2006). Therefore, one wonders how companies achieve a better innovation performance: with alliance portfolios specializing in either exploration or exploitation or with alliance portfolios containing both types of alliances.

Generally, it is very difficult for companies to act with two opposing cultures at the same time (Porter, 1980). We intuit that this can also happen with companies that combine exploration and exploitation alliances in the same alliance portfolio. This combination is likely to generate inefficiencies, so that in this type of portfolio neither the exploration-oriented alliances nor the exploitation-oriented alliances achieve their best potential results. In fact, Stettner and Lavie (2014) suggested that firms can pursue ambidexterity by balancing exploration and exploitation across different modes of action, such as exploiting internally and exploring externally or vice versa. Likewise, Zhang (2016) points out that firms tend to compensate for their exploration in one dimension by performing exploitation in the other. Finally, there are authors who have described the coexistence of exploration and exploitation in the same organizational entity but at different points in time (Gupta et al., 2006; Boumgarden et al., 2012; Volery et al., 2015). Based on the above arguments, we propose the following hypothesis:

Hypothesis 1: The relationship between exploration-oriented alliances and exploitation-oriented alliances within the alliance portfolio is substitutive.

On the other hand, numerous studies have pointed out that the relationships between exploration, exploitation, and innovative performance are also affected by the age of enterprises (e.g. Sorensen and Stuart, 2000). With age, as time passes, surviving firms increase their knowledge and efficiency, thus reinforcing their ability to produce new innovations (Stinchcombe, 1965; Cohen and Levinthal, 1990). However, the structural inertia of firms increases over the years (Hannan and Freeman 1984), resulting in rooting of the acquired routines. In these conditions it may be difficult for firms to adjust the adopted routines to changing environments. Therefore, as firms' age increases, they tend to exploit their existing technological competencies rather than exploring new and unfamiliar technologies (Sorensen and Stuart, 2000).

Thus, young firms are in a better position than mature firms to explore beyond the limits of their existing areas of competence to cope with and adapt to the changes in the environment (Hannan and Freeman, 1984). This implies that the probability of maintaining explorative behaviour is much higher in young companies than in mature firms. Therefore, the probability of synergies between the development of exploration activities and young firms is high, so we expect that the interaction between exploration and young firms will lead to the emergence of complementarities.

Therefore, in accordance with the aforementioned foundations, we formulate the following hypothesis:

Hypothesis 2: The relationship between exploration-oriented alliances and young firms within the alliance portfolio, and in the context of companies that do not engage in exploitation-oriented alliances, is complementary.

However, there are companies that simultaneously implement exploration-oriented alliances and exploitation-oriented alliances. Thus, in this case the positive synergistic effects of the exploration-oriented alliances–young firms relationship can be counteracted by the negative synergistic effects produced by the exploration-oriented alliances–exploitation-oriented alliances relationship (hypothesis 1). Therefore, in the aforementioned conditions, we formulate the following hypothesis:

Hypothesis 3: Within the portfolio alliance, and in the context of the companies that engage in exploitation-oriented alliances, there is no relationship between exploration-oriented alliances and young firms.

On the other hand, with aging, companies tend to change exploration for exploitation, or vice versa. However, this transit is expensive, because the creation of new skills requires large investments. Therefore, to the extent that existing capabilities still produce good results in terms of efficiency, older firms rely on their existing capabilities in a growing manner (Sorensen and Stuart 2000). All this leads to older firms preferring their existing area of expertise to new areas, that is, focusing on the realization of exploitation activities. Therefore, the relationship between exploitation and firm age is expected to be positive.

On the contrary, young companies have not yet had sufficient time to define their current competencies clearly, nor do they have strong operational routines rooted in their behaviour. As a result, they are much less constrained and subject to less inertia than mature companies and therefore have a greater proclivity to develop exploration activities. Consequently, we expect young companies to develop many more exploration than exploitation activities. In line with the arguments, and in relation to the formation of alliances between companies that do not form exploration-oriented alliances, we propose the following hypothesis:

Hypothesis 4: Within the portfolio alliance, and in the context of companies that do not engage in exploration-oriented alliances, there is no relationship between exploitation-oriented alliances and young firms.

However, when the complementarity test is carried out between companies that form exploration-oriented alliances, we expect the result to be quite different, since the sub-sample analysed contains portfolios in which exploration-oriented alliances and exploitation-oriented alliances are implemented simultaneously. According to hypothesis 1, when both types of alliances coincide in the same portfolio, we expect negative synergistic effects to occur, so in this case we propose the following hypothesis:

Hypothesis 5: The relationship between exploitation-oriented alliances and young firms within the alliance portfolio, and in the context of the companies that form exploration-oriented alliances, is substitutive.

3. Data, methodology, and variables

Data

We use Technological Innovation Panel (PITEC) data for Spanish manufacturing firms for 2005-2013. After removing the observations with missing values and those that had some sort of impact on the variables of interest, we obtained 38726 observations for the whole data database. Our panel data are strongly balanced.

Methodology

In relation to the complementarity approach (Milgrom and Roberts, 1990), suppose that there are two activities X_i and X_j, and Z is a vector of exogenous variables in an objective function $F(X_i,X_j,Z)$. Assume that X_i and X_j are dichotomous choices that take the value 1 if they are adopted by the firm and the value 0 if they are not. The complementarity approach regresses an objective on exclusive combinations of activities:

$$F(X_i, X_j, Z) = \beta_{00}(1 - X_i)(1 - X_j) + \beta_{10}X_i(1 - X_j) + \beta_{01}(1 - X_i)X_j + \beta_{11}X_iX_j + \beta_z Z + e$$

where β_{11} measures the cross-partial returns of choosing X_i and X_j jointly; β_{10} of choosing only X_i; β_{01} of choosing only X_j; and β_{00} of choosing none of them.

Then, the objective function $F(X_i,X_j,Z)$ is supermodular and X_i and X_j are complementary if:

$$\beta_{11} + \beta_{00} - \beta_{10} - \beta_{01} > 0$$

Obviously, the objective function $F(X_i,X_j,Z)$ is submodular and X_i and X_j are substitutes if:

$$\beta_{11} + \beta_{00} - \beta_{10} - \beta_{01} < 0$$

In the complementarity approach two different methods are used to test the hypotheses: Mohnen and Röller (2005) uses as null hypothesis H0: $R\beta > r$, and as alternative hypothesis H1: $R\beta \leq r$. Belderbos et al. (2006) uses H0: $R\beta = r$ vs H1: $R\beta \geq r$.

Ballot et al. (2015) call the first test, unconditional complementarity, and the second, conditional complementarity. However, the unconditional test often offers abundant inconclusive results (Ballot et al., 2015), while the conditional test offers more information, mainly important when analyzing the complementarity of more than two variables. Therefore, Ballot et al. (2015) proposes to use the conditional test. Consequently, we focus on conditional tests.

We analyse the complementarity/substitutability relationships between the variables exploration-oriented alliance, exploitation-oriented alliance, and firm age. Following the complementarity approach, the relationship between variables is tested pairwise. For example, if we want to test the conditional complementarity between exploration-oriented alliance and exploitation-oriented alliance, we have to test the two following non-trivial inequalities:

$$\beta_{110} + \beta_{000} - \beta_{100} - \beta_{010} > 0 \qquad \text{(test carried out among mature firms)}$$
$$\beta_{111} + \beta_{001} - \beta_{101} - \beta_{011} > 0 \qquad \text{(test carried out among young firms)}$$

As we need to test for the two other pairs of variables, we also have to test for conditional complementarity between exploration-oriented alliance and firm age and between exploitation-oriented alliance y firm age, in the presence and absence of the third variable (exploitation-oriented alliance and exploration-oriented alliance, respectively).

The econometric technique that we used to estimate the coefficients of the models is population-averaged OLS.

The estimation of the coefficients of all the dummies relative to the eight possible exclusive combinations of the three variables of interest (firm age, exploitation-oriented alliance and exploration-oriented alliance) is necessary to implement complementarity tests. However, the model cannot be estimated due to the perfect multicolineality that is generated by the eight exclusive variables that have presence in it. Consequently, we proceed to eliminate the model constant in order to avoid this perfect multicollinearity. Likewise, the estimation of the model is carried out by the Stata® software. This software provides five different model estimators for panel data and linear models, three of which (random-effects generalized least squares, between effects and fixed effects) do not allow to suppress the model constant and only use "within" variation for the data (variation in time for a given company). As a consequence, these estimators prevent the estimation of models with time-invariant regressors. In addition, we include industry dummies at the two-digit cassification level in order to control the differences among manufacturing industries. These dummy variables are time invariant.

Therefore, our analysis cannot be carried out with any of these three estimators, as they are unable to estimate the coefficients of the eight exclusive variables that make up our model.

However, the constrains of these three estimators are not present in the remaining two that Stata offers (population-average and maximum likelihood random-effects), as they use both inter-firm variability (between) and temporal variability (within) while allowing us to suppress the constant of the model. Our analysis shows the same results for the complementarity test regardless of whether we use the maximum likelihood random-effects estimator or the population-average one. In this paper we have chosen to show the results obtained by the population-averaged OLS estimator.

Variables

It should be noted that, to apply the complementarity approach, it is necessary to use a measure of company performance as a dependent variable (Cassiman and Veugelers, 2006). We are analyzing the interaction between exploration-oriented alliances and exploitation-oriented alliances. Therefore, it is logical to use as a dependent variable some indicator of the effectiveness of innovation strategies. In this sense, there are studies on alliances that use patent activity as a measure of innovative outcome (e.g., Ahuja, 2000; Stuart, 2000). However, some studies have questioned if the amount of patent activity is a good measure of innovation effectiveness (Deeds and Hill, 1996; Levin et al., 1987), since in many cases patents are inputs in the product development process and not an output (Faems et al, 2005), and also the result of many innovations is not patentable (Teece, 2002). Therefore, there are studies that use the percentage of sales generated by new or substantially improved products as a measure of the effectiveness of innovation strategies, since creating new technologies is related with the percentage of turnover attributed to new products, and the further development of existing technologies is usually associated with the percentage of turnover attributed to improved products (Faems et al., 2005). Consequently, in this study we use the percentage of sales generated by new or substantially improved products (Innovative performance) as dependent variable, in the same way as in the previous researches (e.g., Faems et al., 2005).

Previous research has emphasized that alliances with clients and suppliers tend to reinforce both the existing resources and the existing core competences (Brown and Eisenhardt, 1995). Consequently, these alliances develop activities within a given value chain (Tripsas, 1997). For this reason this type of alliance is considered to be oriented towards the development of exploitation activities (Faems et al., 2005).

On the other hand, alliances with universities and research institutes are considered to be oriented towards the development of exploration activities, since the main objective of these alliances is the generation of new knowledge and not the exploitation of existing knowledge (Wheelwright and Clark, 1992; Faems et al., 2005).

The PITEC asked companies whether they have implemented alliances with customers and alliances with suppliers. If the company has implemented one or both types of alliance, the variable exploitation-oriented alliance takes the value 1; if it has not implemented any type of alliance, the variable takes the value 0. In addition, the PITEC asked companies whether they have implemented alliances with universities and research institutes. If the company has implemented one or both types of alliance, the variable exploration-oriented alliance takes the value 1; if it has not implemented any type of alliance, the variable takes the value 0.

Furthermore, we consider that a company is young when the time that has elapsed since its birth is equal to or less than ten years (Coad et al., 2016; Wagner, 2004). When this is true, the variable young firm takes the value 1; otherwise, the company is considered to be mature, and the young firm variable is set to 0.

The population under analysis is very broad and is made up of manufacturing companies with very different characteristics, so that, to control the aforementioned diversity, we incorporate a set of control variables to which the literature attributes a certain degree of influence on innovation performance:

Research personnel intensity: number of researchers in internal R&D/number of employees of the company.

Number exploration-oriented alliances: number of exploration-oriented alliances. Rescaled between 0 and 1.

Number exploitation-oriented alliances: number of exploitation-oriented alliances. Rescaled between 0 and 1.

Formal protection methods: sum of the scores (number between 0 (not used) and 1 (used)) of formal protection methods for innovations (patents, registration of design, trademarks, and copyright). Rescaled between 0 (not used) and 1 (highly important).

Size: logarithm of the number of employees.

In relation to the importance of research staff, the literature on innovation has pointed out that this type of staff is especially important for the development of new knowledge (Smith et al., 2005) and for the absorption, combination, transformation, and integration of knowledge acquired from external sources (Cohen and Levinthal, 1990). In addition, much empirical research has found that innovation performance is positively related to the number of alliances of a firm (e.g., Rothaermel, 2001), the use of formal protection methods for innovations (Ballot et al., 2015; Guisado-González et al., 2015), and the firm size (e.g., Rothaermel and Deeds, 2004).

In addition, we include industry dummies at the two-digit industry classification level to take into account the influence of the singularity of each sector in innovation performance.

In this study we estimate two models. In model I we incorporate the dummy variables exploration-oriented alliance, exploitation-oriented alliance, and young firms, besides the set of control variables defined previously. The determination of the coefficients of these variables will allow us to analyse globally the influence of the exploration-oriented alliance, exploitation-oriented alliance, and young firm on innovative performance.

In model II we transform the three dummies (exploration-oriented alliance, exploitation-oriented alliance, and young firm) into eight different exclusive categories. For example, the exclusive category (110) represents a mature enterprise that simultaneously implements exploration-oriented alliance and exploitation-oriented alliance. The coefficients of these eight unique categories are essential for complementary tests.

4. Results and discussion

A summary of the descriptive statistics of the variables used in this study can be found in table 1. On average the firms attributed 23.03% of their sales to new or substantially improved products. It is also verified that all the independent variables of the model are significantly correlated with the dependent variable. On the other hand, one can notice that the young firm variable is not correlated with exploitation-oriented alliances or with number exploitation-oriented alliances, which is an indication that there is no complementarity between the exploitation-oriented alliance and the young firm variable.

Please, insert table 1

Table 2 shows the results of the regression of the variable proportion of turnover new/improved products on the set of independent variables of models I and II. In relation to the control variables, it verifies that in both models all the variables have a positive and statistically significant influence except for the variable number of explorative-oriented alliances, the influence of which is negative and not significant.

Please, insert table 2

In model I we found that the exploration-oriented alliances variable is significant and positively associated with proportion of turnover new/improved products and that the exploitation-oriented alliances variable is also positively associated but with a much lower innovation performance impact and it is not significant. In short, we found that both exploration and exploitation alliances have a positive effect on proportion of turnover new/improved products, as other studies have previously noted (e.g. Faems et al., 2005; Leung et al., 2015).

On the other hand, in model I we verified that the young firm variable is significant, strong, and positively associated with innovation performance. This is a strong indication that firms' strategic choices in terms of exploration and exploitation and their innovation performance are contingent upon their age (Yamakawa et al., 2011). To confirm or reject this and the other indications mentioned above, it is necessary to carry out the corresponding complementarity tests from the results of model II.

Table 3 presents the output of the complementarity tests performed.

Please, insert table 3

Hypothesis 1 investigates whether alliance hybrid portfolios (formed simultaneously by exploration-oriented alliances and exploitation-oriented alliances) achieve better innovation performances than portfolios focused on either exploration-oriented alliances or exploitation-oriented alliances. We found that the relationship between the two types of alliances is substitutive in the field of both young and mature companies. Therefore, we can affirm that the relationship between exploration-oriented alliances and exploitation-oriented alliances, within the alliance portfolio of companies, is substitutive. That is, the portfolios that simultaneously implement both types of alliances achieve an lower performance innovation to the one derived from the sum of the implementation of each type of alliance separately. According to the results obtained, ambidexterity in the formation of the alliance portfolio cannot be achieved in the same space of time, since the companies obtain better results if they first focus on one type of alliance and then on the other.

The literature on innovation has pointed out that exploration and exploitation require two distinct sets of organizational abilities (Miotti and Sachwald, 2003; Pinto et al., 2011), which implies that their impacts on the performance of companies are also different (Puhan, 2008). This suggests that companies that simultaneously develop exploration and exploitation activities are obliged to create and maintain dual structures (Lavie and Rosenkopf, 2006; McNamara and Baden-Fuller, 2007), and it is extremely difficult and costly to balance the two types of innovation activities (Levinthal and March, 1993; Gibson and Birkinshaw, 2004; Faems et al., 2008).

However, the difficulty of balancing exploration and exploitation to achieve greater innovation performance is increased when the search for and creation of new knowledge is carried out by establishing cooperation agreements with other companies. In this case companies must share the added value of joint activities in addition to having to make additional investments in the area of coordination and in the prevention of opportunistic behaviour by their partners (Das and Teng, 1998; Faems et al., 2008). Obviously, the activities of coordination and defence against the opportunistic behaviour of the partners are substantially different depending on whether they are exploration-oriented alliances or exploitation-oriented alliances. When both types of alliances are implemented simultaneously, the reconciliation of all the dual structures created is extremely difficult and costly. In these circumstances there is a high probability that the relations between the two types of alliance will be substitutive; that is to say, far from achieving the ambidexterity pursued, the companies achieve a performance innovation smaller than the one that would be obtained from the sum of the separate implementations of each alliance class. In short, it is likely that the simultaneous implementation of exploration-oriented alliances and exploitation-oriented alliances hinders the development of companies' ability to appropriate the full value of shared activities (Lavie et al., 2007). In this sense the alliance literature has suggested that in most cases a focused alliance is better than a hybrid alliance (e.g. Branstetter and Sakakibara, 2002; Rothaermel and Deeds, 2004). Likewise, Stettner and Lavie (2014) pointed out that many companies achieve better performance from exploring via alliances and exploiting via internal organization; that is, they obtain better results if the alliances are focused on a strategy.

Concisely, there is a literature on innovation that has pointed out that hybrid alliances (combining exploration and exploitation in the same alliance) and the implementation of exploration-oriented alliances and exploitation-oriented alliances in the same portfolio lead to worse results than the implementation of specialized exploration or exploitation alliances.

The results of the complementarity test that we carried out are consistent with the suggestions provided by the aforementioned literature. In addition, the test results indicate that the substitutability between exploration-oriented alliances and exploitation-oriented alliances depends neither on the age of the companies nor therefore on the different propensities to implement exploration and exploitation activities that generally differentiate young companies from mature ones.

In hypotheses 2 and 3 we argue that the relationship between exploration-oriented alliances and young firms is conditional complementarity. This argument is supported by the results of the complementarity test. Thus, among firms that do not carry out exploitation-oriented alliances, the relationship between exploration-oriented alliances and young firms is complementary, while there is no relationship between companies that engage in exploitation-oriented alliances. This happens because the subsample analysed contains companies that simultaneously implement both types of alliances; we have already verified that this produces a reduction in innovation performance (hypothesis 1). Very few studies have attempted to analyse the relationship between explorative/exploitative behaviour and firm age. In this sense the study by Sorensen and Stuart (2000) has been considered as pioneering on this topic. In their study Sorensen and Stuart (2000) found that the innovations of older firms are more likely to be incremental than radical. Therefore, young companies are more likely to develop radical innovations (exploration). As a consequence, this is an indication that the existence of complementarity in the field of the implementation of exploration activities can only be found among young companies. Similar evidence has been provided by studies such as Choi and Phan (2014), Coad and Guenther (2013), and Voss and Voss (2013).

However, to our knowledge the only study that has examined the complementarity between alliance portfolio and firm age found that it is more beneficial for younger firms to form exploitation alliances than exploration ones (Yamakawa et al. 2011). The argument that supports this behaviour refers to the fact that young companies, although preferably they are dedicated internally to the development of exploration activities, must have alliances in the field of exploitation, since this kind of alliance allows them to make more efficient use of their scarce resources and capabilities. In our view this result is counterintuitive and, of course, contrary to the findings of our study. It is counterintuitive because companies focused on the internal development of exploration activities will obviously have a great ability to absorb knowledge of an exploratory nature and little capacity to absorb knowledge of an exploitative nature. The more similarities that corporations have, both organizational and cultural, the easier it will be to absorb the knowledge of the partners (Cohen and Levinthal 1990; Van den Bosch et al. 1999). Logic therefore points out that only in the field of exploratory alliances do young companies have a real chance of recognizing, absorbing, and assimilating close and complementary knowledge. The complementarity test between young firms and exploration-oriented alliances performed in this paper supports this hypothesis. The discrepancy in the results probably comes from the different focuses adopted. In this regard Yamakawa et al. (2011) focused on only 95 companies and 5 industries, while our study investigates about 4306 companies, 38726 observations, and the entire manufacturing industry. Furthermore, Yamakawa et al. (2011) use return on assets (ROA) as dependent variable and we use the percentage of sales generated by new or substantially improved products.

Hypotheses 4 and 5 indicate that the relationship between exploitation-oriented alliances and young firms is conditional substitutive. This argument is supported by the results of the complementarity test.

Obviously, the experience of young firms is more associated with the development of explorative than exploitative activities. Therefore, it is not expected that young companies focused solely on the implementation of exploitation-oriented alliances will have a positive additional impact on innovation performance. The complementarity test between young firms and exploitation-oriented alliances carried out between companies that do not implement exploration-oriented alliances verifies this behaviour. Hypothesis 4 is confirmed.

On the contrary, if the previous analysis is performed on the subsample of companies that implement exploration-oriented alliances, the complementarity test indicates that the young firm and exploitation-oriented alliance variables are substitutive. This substitutability has previously been argued (hypothesis 4). In this case, in addition to the previously accumulated organizational and cultural distance (young firms probably do not have the necessary experience to take proper advantage of the knowledge that can be obtained from the implementation of exploitation-oriented alliances), it must be stated that the simultaneous implementation of exploration- and exploitation-oriented alliances is of a substitutive nature (hypothesis 1). In this sense the complementarity test indicates that the relationship is substitutive, and therefore hypothesis 5 is confirmed.

5. Conclusions

Our findings suggest that the alliance portfolios formed by exploration-oriented alliances and exploitation-oriented alliances achieve worse innovation performance than the portfolios focused only on exploration or only on exploitation, since exploration-oriented alliances and exploitation-oriented alliances are substitutes, meaning that there is substitutability between the two types of alliances, both in young companies and in mature companies. This result agrees with the suggestions defending the distinctive vision in terms of the relations between product innovation (exploration) and process innovation (exploitation).

In addition, our findings suggest that the innovation performance achieved by focusing on an alliance class (explorative or exploitative) depends on the age of the company, since the implementation of the same class of alliance has different impacts on innovation performance when implemented by a young company or a mature company. Young companies achieve superior innovation performance when they implement only exploration-oriented alliances. In addition, young companies do not achieve superior innovation performance with the implementation of exploitation-oriented alliances, as they have no significant additional impact on innovation performance (between companies that do not implement exploration-oriented alliances) or their impact reduces the innovation performance (among companies that implement exploration-oriented alliances).

The lessons learned from these findings are illuminating: as far as possible, the simultaneous implementation of exploration-oriented alliances and exploitation-oriented alliances should be avoided, since their joint action diminishes the innovation performance, so no ambidexterity is generated. This ambidexterity can be achieved through the successive implementation, in different periods of time, of alliances focused on exploration and alliances focused on exploitation. On the other hand, these different time periods correspond to the dichotomy of young companies/mature companies, as young companies achieve better performances with the implementation of exploration-oriented alliances and mature companies with the implementation of exploitation-oriented alliances.

These findings may be an important guide in the decision making of managers. In addition, they can be useful to policymakers in their task of designing innovation promotion policies that make use of public aid for the development of R&D activities, as public administrations generally grant part of this aid under the condition that the subsidized enterprises establish R&D cooperation agreements (Broekel and Graf, 2012; Czarnitzki et al., 2007). In this sense our findings suggest that among young firms exploration-oriented alliances should be subsidized, and among mature firms the alliances that should be subsidized are the exploitation-oriented ones. In this way companies and society together achieve better innovation performances.

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Table 1. Descriptive statistics

Variable	Mean	Stand. deviat.	Correlations								
			1	2	3	4	5	6	7	8	9
1. Innovative performance	23.031	0.1761	1								
2. Exploration oriented alliance	0.133	0.0017	0.093***	1							
3. Exploitation oriented alliance	0.169	0.0019	0.092***	0.437***	1						
4. Young firm	0.117	0.0016	0.061***	0.013**	0.001	1					
5. Research personnel intensity	0.039	0.0004	0.164***	0.179***	0.106***	0.177***	1				
6. Number exploration oriented alliances	0.024	0.0003	0.080***	0.863***	0.429***	0.008*	0.168***	1			
7. Number exploitation oriented alliances	0.037	0.0005	0.096***	0.441***	0.824***	0.005	0.103***	0.492***	1		
8. Formal protection methods	0.107	0.0013	0.101***	0.156***	0.116***	0.013**	0.076***	0.180***	0.129***	1	
9. Size	1.752	0.0030	0.029***	0.168***	0.196***	-0.13***	-0.25***	0.193***	0.215***	0.129***	1

*** $p < 0.01$.; ** $p < 0.05$.; * $p < 0.1$.

Table 2. Results of regressions for the **percentage of sales generated by new or substantially improved products (Innovative performance)**

VARIABLE	MODEL I	MODEL II
Exploration-oriented alliance	4.754*** (1.0362)	-
Exploitation-oriented alliance	1.00060 (0.829)	-
Young firm	4.460*** (0.636)	-
Research personnel intensity	41.090*** (2.550)	40.574*** (2.554)
Number exploration-oriented alliances	-6.01833 (5.283)	-3.138 (5.323)
Number exploitation-oriented alliances	8.640** (3.390)	10.520*** (3.406)
Formal protection methods	5.711*** (0.651)	5.678*** (0.651)
Size	5.413*** (0.532)	5.441*** (0.532)
(111)	-	10.458*** (3.569)
(000)	-	5.565** (2.711)
(110)	-	9.255*** (3.019)
(101)	-	22.178*** (3.336)
(011)	-	10.154*** (3.159)
(100)	-	11.115*** (2.933)
(010)	-	8.0173*** (2.850)
(001)	-	9.822*** (2.777)
Constant	5.734** (2.714)	-
Industry Dummies	Included	
Model	Wald Chi^2 = 972.56***	Wald Chi^2 = 5913.73***
Number of observations	38726	38726

*** $p < 0.01$.; ** $p < 0.05$.; * $p < 0.1$.
Standard errors are in parentheses

Table 3. Complementarity tests

		Chi2	P-value
Exploration alliance – Exploitative alliance	Young firm = 0		
	T1: $\beta_{110}+\beta_{000}-\beta_{010}-\beta_{100}=0$	12.60	0.0004
	T2: $\beta_{110}+\beta_{000}-\beta_{010}-\beta_{100}\leq 0$		0.9998
	Complements/Substitutes/No relation	**Substitutes**	
	Young firm = 1		
	T1: $\beta_{111}+\beta_{001}-\beta_{011}-\beta_{101}=0$	16.73	0.0000
	T2: $\beta_{111}+\beta_{001}-\beta_{011}-\beta_{101}\leq 0$		0.9999
	Complements/Substitutes/No relation	**Substitutes**	
Exploration alliance – Young firm	Exploitation-oriented alliance = 0		
	T1: $\beta_{101}+\beta_{000}-\beta_{100}-\beta_{001}=0$	11.51	0.0007
	T2: $\beta_{101}+\beta_{000}-\beta_{100}-\beta_{001}\leq 0$		0.0003
	Complements/Substitutes/No relation	**Complements**	
	Exploitation-oriented alliance = 1		
	T1: $\beta_{111}+\beta_{010}-\beta_{110}-\beta_{011}=0$	0.13	0.7156
	T2: $\beta_{111}+\beta_{010}-\beta_{110}-\beta_{011}\leq 0$		
	Complements/Substitutes/No relation	**No relation**	
Exploitation alliance – Young firm	Exploration-oriented alliance = 0		
	T1: $\beta_{011}+\beta_{000}-\beta_{010}-\beta_{001}=0$	1.57	0.2102
	T2: $\beta_{011}+\beta_{000}-\beta_{010}-\beta_{001}\leq 0$		
	Complements/Substitutes/No relation	**No relation**	
	Exploration-oriented alliance = 1		
	T1: $\beta_{111}+\beta_{100}-\beta_{110}-\beta_{101}=0$	13.30	0.0003
	T2: $\beta_{111}+\beta_{100}-\beta_{110}-\beta_{101}\leq 0$		0.9998
	Complements/Substitutes/No relation	**Substitutes**	