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THE EFFECT OF THE DIVERSITY OF INTERORGANIZATIONAL PARTNERS ON PRODUCT INNOVATION

El efecto de la diversidad de socios de relaciones interorganizacionales en la innovación de productos
Efeito da diversidade de parceiros de relações Interorganizacionais na inovação de produtos

Ángeles Montoro-Sánchez[1] | mangeles@ccee.ucm.es | ORCID: 0000-0003-0575-4568

Youseline Garavito-Hernández[2] | ygaravito2@udi.edu.co | ORCID: 0000-0002-1644-9959

Ana M. Romero-Martínez[3] | amromero@ucm.es | ORCID: 0000-0001-7419-554X

[1]Universidad Complutense de Madrid, Facultad de Ciencias Económicas y Empresariales, Departamento de Organización de Empresas y Marketing, Madrid, Spain

[2]Universidad de Investigación y Desarrollo, Facultad de Ciencias Administrativas, Económicas y Contables, Bucaramanga, Santander, Colombia

[3]Universidad Complutense de Madrid, Facultad de Ciencias Económicas y Empresariales, Departamento de Organización de Empresas y Marketing, Madrid, Spain

ABSTRACT

This paper analyzes the impact on product innovation of different types of interorganizational relationship partners. An empirical contrast with data taken from the Spanish Technological Innovation Panel (based on Eurostat's Community Innovation Survey) shows that diversity in the types of partners involved in interorganizational relationships has a positive effect on product innovation. In particular, increased benefits can be achieved in the innovation of goods when there is diversity in the relationships that exist between business partners (customers and suppliers); and in service innovation when there is diversity in the relationships between non-industrial partners (consultants, universities and research entities). Finally, given the results it is not possible to state that a lot of diversity reduces the returns on innovation.

KEYWORDS | Product innovation, diversity, interorganizational relationships, goods innovation, service innovation.

RESUMEN

El objetivo de este estudio es analizar el impacto de la diversidad del tipo de socios en las relaciones interorganizacionales en la innovación de productos. La contrastación empírica con datos del Panel de Innovación Tecnológica de España muestra que la diversidad de tipos de socios en las relaciones interorganizacionales influye positivamente en la innovación de productos. En concreto, se pueden obtener mayores beneficios en la innovación de bienes cuando hay diversidad de relaciones entre socios comerciales (clientes y proveedores); y en la innovación de servicios con diversidad de relaciones entre socios no industriales (consultores, universidades y entidades de investigación). Finalmente, los resultados no permiten afirmar que mucha diversidad produce rendimientos decrecientes en la innovación.

PALABRAS CLAVE */ innovación de producto, diversidad, relaciones interorganizacionales, innovación de bienes, innovación de servicios.*

RESUMO

O objetivo deste estudo é analisar o impacto da diversidade do tipo de parceiros nas relações interorganizacionais em inovação de produtos. A aplicação empírica com dados do Painel de Inovação Tecnológica da Espanha mostra que a diversidade de tipos de parceiros nas relações interorganizacionais influencia positivamente a inovação de produtos. Em particular, pode-se ter maiores benefícios para a inovação em bens quando existem relações diversas entre parceiros comerciais (clientes e fornecedores); e inovação em serviços quando a diversidade de relacionamentos ocorre entre parceiros não industriais (consultores, universidades e entidades de pesquisa). Finalmente, os resultados não permitem afirmar que muita diversidade produz retornos decrescentes de inovação.

PALAVRAS-CHAVE */ inovação de produtos, diversidade, relacionamentos interorganizacionais, inovação de bens, inovação de serviços.*

INTRODUCTION

To survive and be competitive, companies must innovate (Belderbos, Gilsing, Lokshin, Carree, & Sastre, 2018). As not all of them have the resources, capabilities or knowledge internally to do so (Schoenmakers & Duysters, 2006), they resort to interorganizational relationships (IRs) to acquire them (Beers & Zand, 2014; Belderbos *et al.*, 2018; Das & Teng, 2000). IRs are collaboration agreements that a company maintains with different strategic partners with the purpose of exchanging or sharing resources. The literature shows that these have a positive and significant effect on product innovation (PI), allowing companies to combine and complement their resources and capabilities with those of their partners (Faems, Looy, & Debackere, 2005). Hence, there is a growing interest in studying IRs and their impact on PI (Belderbos, Carree, Lokshin, & Sastre, 2015; Silva & Leitão, 2009).

In order to innovate, companies need to cooperate with different types of partners, such as clients, suppliers, competitors, companies in the same group, and research institutions in order to achieve different objectives through the mutual transfer of various types of knowledge (Arranz & Arroyabe, 2008). However, each type of partner contributes to innovation in different ways (Belderbos, Carree, & Lokshin, 2004; Bogers, Afuah, & Bastian, 2010; Leeuw, Lokshin, & Duysters, 2014; Nieto & Santamaría, 2007; Story, O'Malley, & Hart, 2011). Recent literature highlights the importance of collaborating with different types of partners, and of appropriately managing the company's alliance portfolio (Hagedoorn, Lokshin, & Zobel, 2018). Most of the previous studies have focused on how diverse the partners are and looked at the variety or wide range of partners simply regarding their difference in numbers (Belderbos *et al.*, 2018; Kobarg, Stumpf-Wollersheimb, & Welpe, 2019; Nieto & Santamaría, 2007). The diversity among these partners has hardly ever been analyzed from a perspective that focuses on their heterogeneity.

In this study, IR diversity refers to the degree of heterogeneity between the different types of strategic partners with which companies interact (Hagedoorn *et al.*, 2018). This heterogeneity depends on the differences between the partners, which is derived from whether the relationship is vertical or horizontal, competitive or complementary, or on the objective of the company for having a relationship with each type of partner (Beck & Schenker-Wicki, 2014; Beers & Zand, 2014; Belderbos *et al.*, 2018). A key factor when assessing the effect of IR diversity on innovation, therefore, is knowing the types of partners with which the company cooperates (Lee, Kirkpatrick-Husk, & Madhavan, 2017; Nieto & Santamaría, 2010). The empirical evidence for this, however, in addition to being scarce, is inconclusive (Hagedoorn *et al.*, 2018; Lee *et al.*, 2017). Some studies find that the degree of diversity of the types of partners has a positive influence on innovation, while in others it is seen as negative, or non-linear (Beck & Schenker-Wicki, 2014; Beers & Zand, 2014; Kobarg *et al.*, 2019; Leeuw *et al.*, 2014; Meyskens & Carssrud, 2013).

Given the high-level importance of cooperation with different types of partners in product innovation (Hagedoorn *et al.*, 2018), and the need to provide more specific knowledge and empirical evidence of the effect of the diversity of these partners on innovation, the objective of this study is to analyze the impact of the diversity of types of IR partners on PI. With this in mind, the main novel aspects of this work are, its study of the effect of IR diversity on PI with respect to the heterogeneity between the different types of partners, and the proposal that there are three groups of strategic partners. These are: non-industrial partners (research institutions and consultants); industrial partners (companies in the same group, and competitors); and commercial partners (customers and suppliers) (Ardito, Petruzzelli, & Albino, 2015; Silva & Leitão, 2009). Companies choose their strategic partners depending on the type of knowledge they want to acquire, and each of these partner groups contributes different knowledge to PI (Ardito *et al.*, 2015; Story *et al.*, 2011; Wagner & Hoegl, 2006). With this analysis of the impact of

the diversity of the different types of strategic partners on PI, this work first provides a foundation and evidence for the literature on IR diversity in the absence of any conclusive results therein (Hagedoorn *et al.*, 2018; Lee *et al.*, 2017). Second, it studies not only the linear relationship in innovation, but also the inverted U-shaped relationship that exists between IR diversity and innovation for each of the strategic partner groups (Beck & Schenker-Wicki, 2014; Kobarg *et al.*, 2019; Leeuw *et al.*, 2014). This means that even though IR diversity is favorable to innovation, as it increases the company may not obtain the expected positive results (Hagedoorn *et al.*, 2018; Lee *et al.*, 2017). Finally, this study also provides additional new empirical evidence using the Spanish Technological Innovation Panel.

To achieve the research objective a literature review is first presented, followed by the methodology and variable measurements. Finally, the results and conclusions, future research lines, and the study's limitations are set out.

THEORETICAL FRAMEWORK AND HYPOTHESES

An important source of competitive edge is a company's ability to create and maintain valuable IRs (Lavie, 2006) in order to access knowledge from its partners, thus improving its innovative activities and developing new products and services (Das & Teng, 2000; Martinez-Noya & Narula, 2018; Miotti & Sachwald, 2003; Schoenmakers & Duysters, 2006).

PI is a knowledge-intensive activity that requires going beyond the company's walls to acquire the necessary insights (Ozer & Zhang, 2015). If a company has relationships with different types of strategic partners (customers, suppliers, competitors, and research institutions), it will be able to obtain the new and complementary knowledge, information, and synergies (Beers & Zand, 2014; Nieto & Santamaría, 2007) that favor learning and the development of new products, as well as their introduction in the market (Kobarg *et al.*, 2019; Lavie, 2009). Having access to more knowledge because of partner diversity and mutual collaboration provides the company with the skills needed to innovate and improve its competitive edge (Beck & Schenker-Wicki, 2014; Burg, Berends, & Raaij, 2014; Kobarg *et al.*, 2019; Lee *et al.*, 2017; Meyskens & Carssrud, 2013). Conversely, when there is little diversity and the interrelationships are always with the same partners, the consequent isomorphism reduces access to new opportunities (Uzzi, 1997). With Hypothesis 1, therefore, we propose that the degree of diversity of the partners with which the company collaborates (Beers & Zand, 2014; Duysters & Lokshin, 2011; Jiang, Qingjiu, & Santoro, 2010) will have a positive effect on innovation.

H1: Partner diversity in IRs favors PI.

The type of partner is of great relevance (Nieto & Santamaría, 2010; Tether, 2002). The company seeks to benefit from diversity by choosing those partners that make it easier for it to innovate (Leeuw *et al.*, 2014), so they choose their strategic partners based on certain factors (Miotti & Sachwald, 2003; Tether, 2002), such as knowledge and skills complementarity (Mowery, Oxley, & Silverman, 1996), previous experience (Wagner & Hoegl, 2006), strategic compatibility – the affinity of their strategic and competitive objectives - and organizational compatibility – similar management styles, company culture, etc. (Emden, Calantone, & Droge, 2006). The literature classifies partner types into three categories: business partners (customers and suppliers), industrial partners (competitors and companies in the same group**),** and non-industrial partners (consultants, universities and other research institutions) (Ardito *et al.*, 2015; Arranz & Arroyabe, 2008; Belderbos *et al.*, 2018; Silva & Leitão,

2009). Each of them contributes different knowledge to PI (Ardito *et al.*, 2015; Story *et al.*, 2011; Wagner & Hoegl, 2006). Previous literature has only studied the effect of cooperating with each one of them individually, or in the previously mentioned groups in innovation (Nieto & Santamaría, 2007). Our objective is to investigate how the degree of diversity in each group affects PI.

Previous literature recognizes that IRs with business partners (customers and suppliers) (Mowery *et al.*, 1996) make it easy to access the new technologies, experiences, and knowledge that are needed to develop new products. (Bogers *et al.*, 2010; Romijn & Albaladejo, 2002; Tether, 2002). Customers can offer insights into new market trends and potential new product applications (Burg *et al.*, 2014; Ozer & Zhang, 2015). This type of relationship favors PI because the company obtains or gathers more information to better satisfy their specific tastes and needs (Miotti & Sachwald, 2003), especially if these products are new to the market (Ashok, Narula & Martínez-Noya, 2016; Belderbos *et al.*, 2004; Nieto & Santamaría, 2007; Tether, 2002). On the other hand, supplier relationships can be beneficial because of the operational knowledge they offer, as well as access to specialized and complementary assets, which are important aspects that help improve product quality and efficiency, protect innovative technologies or designs, and improve production processes and costs, and reduce risks (Burg *et al.*, 2014; Faems *et al.*, 2005; Ledwith & Coughlan, 2005; Miotti & Sachwald, 2003; Nieto & Santamaría, 2007; Ozer & Zhang, 2015). Likewise, for companies, maintaining relationships with both strategic partners (customers and suppliers) allows their new products to be marketed quicker and more efficiently, thereby increasing sales and leading to further innovations (Rosenzweig, Roth, & Dean, 2003). The following hypothesis analyzes the positive effect of diversity when maintaining IRs with business partners (customers and suppliers) in innovation:

> H1a: The diversity of the IRs with customers and suppliers favors IP.

Regarding those partners with which a corporate or competitive connection is shared (companies in the same group or competitors, respectively), the diversity of the IRs becomes beneficial because it enables uncertainty, research costs and risks to be shared, whilst at the same time allowing for easier access to necessary complementary assets, resources, and knowledge (Belderbos *et al.*, 2004; Burg *et al.*, 2014; Emden *et al.*, 2006; Nieto & Santamaría, 2007) for achieving a better position in the market (Ardito *et al.*, 2015; Belderbos *et al.*, 2018). One can learn about the characteristics, design and marketing of new alternative products from rivals (Ozer & Zhang, 2015). Cooperating with companies in the same group helps with complementary information from the same or related sectors when there is a complementary and horizontal type of relationship (Belderbos *et al.*, 2004; Tether, 2002). With Hypothesis 1b we explore the positive effect of this diversity of relationships:

> H1b: The diversity of the IRs with the same group of companies and competitors favors PI.

Finally, there are those partners that provide the company with knowledge that cannot be acquired in the market from the competition, or even from companies in the same group. These are consultants, universities, public research organizations, and technology centers (non-industrial partners) (Mowery *et al.*, 1996; Wagner & Hoegl, 2006). These partners contribute to innovation by providing scientific knowledge and advice that favors the creation of new ideas and an improvement in R&D activity (Dowling & Helm, 2006; Frenz & Ietto-Gillies, 2009). Thus, IRs with consultants help when it comes to sharing experiences, defining specific innovation needs, and contributing new and complementary ideas (Bessant & Rush, 1995; Bruce, Leverick, Littler, & Wilson, 1995); Relationships with universities and research centers allow access to scientific knowledge, key personnel in technical teams who focus on innovation, such as professors or researchers, or even new technological options,

which favor new product development (Frenz & Ietto-Gillies, 2009). With Hypothesis 1c we explore the positive effect of the diversity of IRs with non-industrial partners.

H1c: The diversity of the IRs with consultants, universities, public research organizations and technology centers favors IP.

Not all the previous evidence, however, shows there to be a positive relationship between diversity and innovation (Kobarg *et al.*, 2019; Luo, 2002; Nieto & Santamaría, 2010). There is previous evidence of this in this relationship, but with no conclusive results (Beck & Schenker-Wicki, 2014; Meyskens & Carssrud, 2013). Some authors argue that it is an inverted U-shaped relationship (Beck & Schenker-Wicki, 2014; Duysters & Lokshin, 2011; Haans, Pieters, & Zi-Lin, 2016; Kobarg *et al.*, 2019; Laursen & Salter, 2006; Leeuw *et al.*, 2014; Vasudeva & Anand, 2011). This is because companies need internal resources to exploit the knowledge acquired from their different strategic partners (Faems, Janssens, Madhok, & Looy, 2008); without them, it is difficult to implement the acquired knowledge (Leeuw *et al.*, 2014). Their exploitation can also generate problems and coordination costs due to the complexity of managing diverse knowledge (Hagedoorn *et al.*, 2018; Jiang *et al.*, 2010; Wuyts & Dutta, 2014). Companies can also count on these resources as long as they are worth exploiting considering the cost-benefit ratio, and the input of information with new ideas occur at the proper time Companies can also count on these resources but it is not compensated to exploit them because of the cost-benefit ratio or because the entry of information with new ideas does not occur at the right time.

(Chen, Chen, & Vanhaverbeke, 2011; Knudsen & Mortensen, 2011; Nieto & Santamaría, 2007). For PI to be successful, it is necessary to integrate and implement interrelated, external and internal knowledge in the company (Ozer & Zhang, 2015). Another reason for the inverted U-shaped effect of IR diversity in PI is the lack of control over the exchange of information or the trust between partners. This can lead to opportunistic behaviors (Santamaría, Nieto, & Miles, 2012) and critical technical knowledge spillovers (Burg *et al.*, 2014), which affect the effectiveness of IR diversity for acquiring the relevant knowledge needed for developing innovation (Das & Teng, 2000). With Hypothesis 2 we explore whether the effect of the diversity of partners in IRs indicates an inverted U-shaped relationship:

H2: The effect of IR diversity on PI results in an inverted U-shaped relationship.

If we focus on each of the groups of strategic partners, there are few studies that contrast whether the effect of the diversity of IRs on PI results in an inverted U-shaped relationship (Hagedoorn *et al.*, 2018; Martinez-Noya & Narula, 2018) in each of these groups (Ardito *et al.*, 2015).

Most authors conclude that the diversity of the relationships between business partners allows companies to access broader and more diverse experiences and knowledge, all of which are necessary for creating new models, improving existing designs, and developing new products (Bogers *et al.*, 2010; Romijn & Albaladejo, 2002). As the diversity of the relationships between business partners increases, exploiting these resources in the company can be difficult. This is because the more diverse the knowledge acquired, the greater the difficulty in coordinating and integrating it. Therefore, there may be a reduction in the benefits of maintaining a diversity of relationships with business partners (Jiang *et al.*, 2010; Wuyts & Dutta, 2014). Hypothesis 2a explores the effect of relationship diversity with business partners on increasing positive innovation until it reaches the inflexion point where it begins to decrease.

H2a: The effect of IR diversity with customers and suppliers on PI results in an inverted U-shaped relationship.

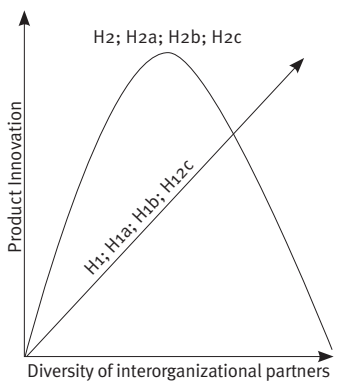
Regarding industrial partners, although the diversity of the relationships with these partners allows companies to have easier access to complementary knowledge for innovating (Belderbos *et al.*, 2004; Emden *et al.*, 2006; Nieto & Santamaría, 2007), increasing relationship diversity can make it riskier. Knowledge between partners may also be redundant, leading to mistrust between partners, opportunistic behaviors, or even the misappropriation of capabilities. Therefore, cooperation may become unstable, or even dissolve and not generate the desired positive effect on product development (Dussauge, Garrette, & Mitchell, 2000; Gimeno, 2004; Monteiro, Mol, & Birkinshaw, 2017). With Hypothesis 2b we explore the effect of relationship diversity with industrial partners on increasing positive innovation until it reaches an inflexion point where it begins to decrease.

> H2b: The effect on PI of IR diversity with companies in the same group and competitors results in an inverted U-shaped relationship.

Finally, the literature recognizes that diversity in relationships with non-industrial partners, such as consultants, universities, and research entities, contributes to PI by providing knowledge that favors continuous improvement in R&D activities (Frenz & Ietto-Gillies, 2009). The increase in external knowledge because of this type of IR diversity, however, can generate R&D activities that are not in line with the company's research strategies (Numprasertchai & Igel, 2005), and therefore will not have the expected positive impact on PI. The success of the diversity of relationships with non-industrial partners lies in identifying the extent to which this diversity is favorable. Hypothesis 2c explores whether the effect on innovation of the diversity of relationships with non-industrial partners is positive and grows until it reaches a point where it begins to decline.

> H2c: The effect of IR diversity with consultants, universities and research entities on PI results in an inverted U-shaped relationship.

Figure 1. **Research hypothesis**



METHODOLOGY

Population and sample

The information source used in this study was the Technological Innovation Panel of Spain (Eurostat Community Innovation Survey) prepared by the National Institute of Statistics. Data from 2011 and 2012 were considered to

use the innovation values for the 2010-2012 period and the cooperation values for the 2009-2011 period (years with free and open access data). The 2011 values were used for the independent variables, while those of 2012 were used for the dependent variable. With regard to the control variables, for internal and external innovation expenses in R&D, the values of 2011 were used, while data from 2012 were used for the size, age, and sector variables.

For sample selection, three criteria were considered: operational companies with more than 10 employees that, having answered the question of cooperation with other companies, had cooperated with at least one type of strategic partner. The final sample consisted of 2,141 companies: 34.89% are less than 20 years old, and 65.11% are more than 20 years old. According to the European Commission's recommendation of May 6, 2003 with regard to the number of employees, 33.49% are small companies (10-49 employees), 38.81% are medium-sized (50-249 employees), and 27.70% are large companies (more than 250 employees). Manufacturing companies represent 62.21% of the sample, while service companies account for 37.78%s. With regard to innovation, 67% of all companies carry out PI (1,433 companies), of which 56% (1,280 companies out of 2,141) innovate in goods and 33% (713 companies) in services.

Variable Measurement

PI is involved in the development of new goods or services. According to the Technological Innovation Panel, PI (in goods or services) results in the commercialization of a new or significantly improved product as far as its capabilities, ease of use, components or subsystems are concerned. Product innovations (new or improved) should be new for the company, but they do not have to be new to the market. PI is often separated between the innovation of goods (GI) (a good is generally a tangible object, such as a smartphone, furniture or packaged software; downloadable software, music and movies are also goods), and services (SI) (a service is usually intangible, such as retail, insurance, educational courses, air travel, consulting, etc.). According to the Panel's information and the innovation measures used in previous studies (Simonen & McCann, 2008), we have used three dichotomous variables that have a value of 1 if the company has innovated; first, a measure that represents PI as a single global measure, and second, two indicators that represent GI and SI.

With regard to the independent variables, to measure the diversity of types of partners in IRs we used the Blau index. This is considered the most reliable and consistent index of heterogeneity for measuring IR diversity (Meyskens & Carsrud, 2013). It is calculated as $B = 1 - \sum_{i=1}^{k} \left(pi \right)^2$, where B is the Blau index and p is the percentage of members in each *i-th* class of the existing k. The higher the value of B, the greater the degree of diversity, with the values of B varying between 0 and (k-1)/k. In this way we calculated total diversity and the diversity for each of the three groups of partners that were considered in the theoretical framework (Arranz & Arroyabe, 2008).

There are eight categories in the total diversity of partner types, and the following IR alternatives were considered: customers, suppliers, competitors, companies in the same group, consultants, universities, public research organizations and technology centers (Beck & Schenker-Wicki, 2014). Since K = 8 for the IR diversity variable, the maximum diversity will be attained when B reaches 0.875.

In the diversity of partner types for IRs between customers and suppliers, and the diversity of IRs between companies in the same group and competitors, since there are two categories in each group, diversity will be at its highest when B reaches the value of 0.5, with K = 2 in this case. Finally, for diversity of partner types in the IRs

between consultants, universities, public research organizations and technology centers, since K = 4, there will be maximum diversity when *B* reaches the value of 0.75.

To calculate diversity using this index, we took Panel data, which by means of dichotomous variables allowed us to identify whether or not the company has cooperated with each of the eight types of partners considered. Total diversity and the diversity of the three groups were then calculated. Finally, to analyze the inverted U effect of IR diversity on innovation, the IR diversity variables were squared.

We also included five control variables: size (Napierian logarithm of the number of employees), company age (number of years since its foundation), sector (dichotomous variable that has the value of 1 when it is a purely service company), and the amount allocated to internal and external R&D expenses. R&D expenses means the total percentage of internal and external expenses spent on R&D, which is the way in which the database allows access to a reference of the total R&D expenses for both categories, and on a relative scale that allows a more suitable comparison between companies (Galende & Fuente, 2003; Order, Riding, & Manley, 2006; Pérez-Luño, Cabello-Medina, Carmona-Lavado, & Cuevas-Rodríguez, 2011).

RESULTS AND DISCUSSION

The descriptive statistics of the 2,141 companies show that 67% engage in PI (1,433 innovate with regard to products; 708 do not), 56% undertake goods' innovation (1280 companies; 933 do not innovate), and 33% undertake service innovation (713 companies; 1428 do not innovate). For this reason, we thought it appropriate to use two balanced samples (considering the same number of companies that innovate as those that do not) to contrast hypotheses, thus allowing for greater robustness in the regression models, and avoiding errors related to atypical observations. (Chambers, 1986). Thus, the total sample for the PI analysis is 1,416 companies (708 do not innovate; 708 do), the GI sample size is 1,866 companies (933 do not innovate; 933 do), and the SI sample size is made up of 1,426 companies (713 do not innovate; 713 do). Table 1 shows the descriptive statistics, the collinearity and the correlations of each of the balanced subsamples. The PI variables, goods innovation and service innovation, are significantly correlated in all of them with the types of partner diversity variables in the IRs, and with the diversity of other types of partners (IRs with consultants, universities, public research agencies and technology centers), although only innovation of goods is also correlated with partner diversity in relationships with customers and suppliers, and in relationships with same group companies and with competitors.

To contrast the hypotheses, four binomial logistic regression models were calculated (the backward Wald method provides a solution with the variables that have a higher level of significance) for each indicator of the dependent variable (PI, goods innovation, and service innovation). Model 1 enables Hypothesis 1 (effect of total diversity on PI) to be contrasted, and Model 3 enables Hypotheses 1a, 1b and 1c (the effect of the diversity of each of the three groups on PI) to be contrasted. Model 2 enables Hypothesis 2 (inverted U effect of total diversity on PI) to be contrasted, while Model 4 enables Hypotheses 2a, 2b and 2c (inverted U effect of the diversity of each of the three groups on PI) to be contrasted. Although the correlations of the diversity variables of the different groups with total diversity are low in Models 2 and 4, we decided to split the contrast into two regression models. Tables 2, 3 and 4 show the results of the binomial logistic regression models for PI (Table 2), goods (Table 3) and service (Table 4).

Table 1. **Means, standard deviations, collinearity statistics, and Pearson's correlation coefficients**

	Mean	Standart Deviation	Frequency	VIF	Correlations									
					1	2	3	4	5	6	7	8	9	10
Product Innovation - N = 1416														
1. Interorganizational relationship diversity	0.360	0.302		5.034	1									
2. Customer-Supplier diversity	0.077	0.175		1.673	0.271**	1								
3. Same group company-competitor diversity	0.037	0.123		1.657	0.336**	0.341**	1							
4. Other partner types diversity	0.147	0.230		3.254	0.656**	0.174**	0.314**	1						
5. Company size	4.661	1.477		1.226	0.165**	0.122*	0.020	0.163**	1					
6. Company age	31.923	23.725		1.253	0.023	0.023	-0.037	0.001	0.295**	1				
7. Sector			1=535 /0=881	1.205	0.020	-0.104*	0.026	0.062*	-0.004	-0.197*	1			
8. Internal R&D expenses	60.597	38.541		1.459	0.197**	0.006	-0.013	0.118**	-0.068*	-0.096**	-0.026	1		
9. External R&D expenses	13.682	23.514		1.416	0.015	0.067	0.020	-0.015	0.087**	0.024	-0.064*	-0.327**	1	
10. Innovation			1=708 0=708		0.207**	0.097	0.044	0.161**	0.078**	0.019	-0.05	0.180**	-0.04	1
Goods Innovation - N =1866														
1. Interorganizational relationship diversity	0.370	0.299		4.802	1									
2. Customer-Supplier diversity	0.083	0.179		1.587	0.291**	1								
3. Same group company-competitor diversity	0.034	0.117		1.533	0.322**	0.293**	1							
4. Other partner types diversity	0.153	0.232		3.185	0.654**	0.202**	0.301**	1						
5. Company size	4.713	1.514		1.291	0.184**	0.100*	0.036	0.180**	1					
6. Company age	31.887	23.259		1.313	0.037	0.032	-0.015	0.022	0.326**	1				
7. Sector			1=618 /0=808	1.134	0.018	-0.051	0.004	0.049*	-0.010	-0.205**	1			
8. Internal R&D expenses	62.625	36.804		1.407	0.167**	0.024	0.001	0.086**	-0.100**	-0.113*	-0.013	1		
9. External R&D expenses	13.390	22.348		1.333	0.032	0.032	0.001	0.002	0.068**	0.046*	-0.064**	-0.329**	1	
10. Innovation			1=933 /0=933		0.190**	0.120**	0.061*	0.140**	0.076**	0.034	-0.207**	0.166**	-0.006	1
Service Innovation - N =1426														
1. Interorganizational relationship diversity	0.394	0.296		4.395	1									
2. Customer-Supplier diversity	0.083	0.178		1.590	0.320**	1								
3. Same group company-competitor diversity	0.038	0.123		1.571	0.333**	0.355**	1							
4. Other partner types diversity	0.163	0.238		2.866	0.655**	0.205**	0.291**	1						
5. Company size	4.766	1.578		1.313	0.182**	0.128**	0.048	0.181**	1					
6. Company age	31.256	23.606		1.355	0.037	0.033	-0.035	0.007	0.356**	1				
7. Sector			1=535 /0=881	1.144	0.012	-0.021	-0.006	0.069*	-0.029	-0.195**	1			
8. Internal R&D expenses	64.737	35.302		1.563	0.158**	-0.040	-0.008	0.089**	-0.119**	-0.120**	-0.022	1		
9. External R&D expenses	13.099	21.642		1.464	0.045	0.065	0.019	-0.006	0.059*	0.026	-0.044	-0.357**	1	
10. Innovation			1=713 /0=713		0.180**	0.057	-0.031	0.170**	0.138**	-0.017	0.269**	0.092**	-0.048	1

Table 2. Product innovation regressions

Product Innovation	Model 1				Model 2				Model 3				Model 4			
	B	Wald	Sig	Exp (B)	B	Wald	Sig	Exp (B)	B	Wald	Sig	Exp (B)	B	Wald	Sig	Exp (B)
Constant	-1.477	33.046	0.000	0.285	-1.477	33.046	0.000	0.285	-0.002	0.00	0.99	0.998	-0.76	2.13	0.14	0.463
Company size	0.088	5.295	0.021	1.092	0.088	5.295	0.021	1.092	0.095	1.12	0.29	1.099	0.138	2.83	0.09	1.148
Company age	0.000	0.008	0.928	1.000	0.000	0.003	0.955	1.000	-0.001	0.01	0.91	0.999	-0.00	0.05	0.81	0.999
Sector	0.223	3.816	0.051	0.800	0.223	3.816	0.051	0.800	0.140	0.27	0.59	1.151	0.189	0.48	0.48	1.208
Internal R&D expenses	0.008	31.368	0.000	1.008	0.008	31.368	0.000	1.008	0.008	5.03	0.02	1.008	0.010	6.54	0.01	1.010
External R&D expenses	.000	.002	.961	1.000	0.000	0.003	0.955	1.000	-0.006	0.79	0.37	0.994	-0.00	0.79	0.37	0.994
Interorganizational relationship diversity	1.169	38.299	0.000	3.219	1.169	38.299	0.000	3.219								
Interorganizational relationship diversity, squared					-0.582	0.355	0.551	0.559								
Customer-Supplier diversity									0.993	1.64	0.20	2.699	-5.68	0.48	0.48	0.003
Same group company-competitor diversity									-0.535	0.50	0.47	0.586	-8.64	2.87	0.09	0.000
Other partner types diversity									0.648	1.39	0.23	1.912	-0.21	0.01	0.91	0.807
Customer-Supplier diversity, squared													13.69	0.64	0.42	88301
Same group company-competitor diversity, squared													19.40	2.91	0.08	3E+08
Other partner types diversity, squared													1.754	0.27	0.60	5.777
-2 Log Verisimilitude	1862.306				1862.306				399.641				393.998			
R^2 Cox-Snell	0.069				0.069				0.016				0.034			
R^2 Nagelkerke	0.092				0.092				0.022				0.047			
X^2	100.687				100.687				5.038				10.681			
Significance	0.000				0.000				0.025				0.030			
N	1416				1416				1416				1416			
% Global Classification Table	61.2				61.2				68.6				67.6			

Table 3. Regressions for goods innovation

Goods Innovation	Model 1				Model 2				Model 3				Model 4			
	B	Wald	Sig	Exp (B)	B	Wald	Sig	Exp (B)	B	Wald	Sig	Exp (B)	B	Wald	Sig	Exp (B)
Constant	-1.946	88.23	0.000	0.143	-1.946	88.23	0.00	0.143	-0.464	1.68	0.19	0.628	-0.468	1.712	0.19	0.626
Company size	0.085	6.524	0.011	1.089	0.085	6.524	0.01	1.089	0.111	2.70	0.10	1.118	0.113	2.792	0.09	1.119
Company age	-0.002	0.726	0.394	0.998	-0.002	0.759	0.38	0.998	0.002	0.12	0.72	1.002	0.002	0.115	0.73	1.002
Sector	0.926	83.71	0.000	2.524	0.926	83.71	0.00	2.524	0.516	6.07	0.01	1.675	0.511	5.948	0.01	1.666
Internal R&D expenses	0.009	38.94	0.000	1.009	0.009	38.94	0.00	1.009	0.002	0.39	0.52	1.002	0.003	0.500	0.47	1.003
External R&D expenses	0.002	0.981	0.322	1.002	0.002	0.963	0.32	1.002	-0.003	0.34	0.55	0.997	-0.003	0.316	0.57	0.997
Interorganizational relationships diversity	1.167	47.28	0.000	3.214	1.167	47.28	0.00	3.214								
Interorganizational relationships diversity, squared					-0.619	0.525	0.46	0.538								
Customer-Supplier diversity									1.308	4.77	0.02	3.700	0.077	0.000	0.99	1.080
Same group company-competitor diversity									-0.278	0.17	0.67	0.757	-4.208	0.865	0.35	0.015
Other partner types diversity									0.554	1.35	0.24	1.740	0.537	0.107	0.74	1.710
Customer-Supplier diversity, squared													2.782	4.800	0.02	16.154
Same group company-competitor diversity, square													8.877	0.763	0.38	7167
Other partner types diversity, squared													0.102	0.001	0.97	1.107
-2 Log Verisimilitude	2388.900				2388.900				533.882				533.825			
R^2 Cox-Snell	0.101				0.101				0.041				0.041			
R^2 Nagelkerke	0.134				0.134				0.056				0.056			
X^2	197.926				197.926				17.550				17.607			
Significance	0.000				0.000				0.001				0.001			
N	1866				1866				1866				1866			
% Global Classification Table	62.5				62.5				60.8				60.300			

Table 4. Regressions for service innovation

Services Innovation	Model 1				Model 2				Model 3				Model 4			
	B	Wald	Sig	Exp (B)	B	Wald	Sig	Exp (B)	B	Wald	Sig	Exp (B)	B	Wald	Sig	Exp (B)
Constant	-1.04	20.214	0.00	0.353	-0,994	18,539	0,00	0,370	-0,650	2,371	0,12	0,522	-0,556	1,783	0,18	0,573
Company size	0.195	25.863	0.00	1.215	0,190	24,457	0,00	1,209	0,266	11,372	0,00	1,305	0,266	11,24	0,00	1,304
Company age	0.000	0.033	0.85	1.000	0,000	0,019	0,88	1,000	0,001	0,027	0,87	1,001	0,001	0,011	0,91	1,001
Sector	-1.20	107.98	0.00	0.299	-1,194	105,39	0,00	0,303	-1,125	21,150	0,00	0,325	-1,116	20,70	0,00	0,327
Internal R&D expenses	0.006	12.847	0.00	1.006	0,006	13,364	0,00	1,006	0,005	1,240	0,26	1,005	0,006	1,465	0,22	1,006
External R&D expenses	-0.00	0.622	0.43	0.998	-0,002	0,639	0,42	0,998	0,000	0,000	0,99	1,000	0,001	0,007	0,93	1,001
Interorganizational relationships diversity	1.050	27.856	.000	2.858	-0,029	0,002	0,96	0,971								
Interorganizational relationships diversity, squared					1,526	30,409	0,00	4,600								
Customer-Supplier diversity									0,206	0,091	0,76	1,228	-4,048	0,461	0,49	0,017
Same group company-competitor diversity									-1,065	2,183	0,14	0,345	-1,184	2,985	0,08	0,306
Other partner types diversity									0,957	3,6690	0,05	2,604	0,145	0,007	0,93	1,156
Customer-Supplier diversity, squared													8,974	0,510	0,47	7894,31
Same group company-competitor diversity, squared													7,584	0,479	0,48	1966,12
Other partner types diversity, squared													1,912	4,804	0,02	6,770
-2 Log Verisimilitude	1788.757				1785.982				437.595				434.949			
R2 Cox-Snell	0.124				0.125				0.107				0.114			
R2 Nagelkerke	0.165				0.167				0.145				0.154			
X2	188.099				190.874				40.431				43.077			
Significance	0.000				0.000				0.000				0.000			
N	1426				1426				1426				1426			
% Global Classification Table	65.4				64.9				65.4				65.7			

Despite the expected collinearity between the variables and their quadratic values for analyzing the inverted U effect, the adjustment parameters of Models 1 and 2 of Tables 2 and 3 for the case of the IR diversity variable have not changed. Models 3 and 4 of Tables 2, 3 and 4 offer a better fit, and are more consistent in relating the study variables (-2 Log Verisimilitude, R2 Cox-Snell, R2 Nagelkerke, X^2).

With regard to Hypothesis 1 (the positive influence of IR diversity on innovation), the model results for PI, GI and SI (Model 1) allow us to conclude that this hypothesis is confirmed positively, and with a 99% confidence level. These results show that the diversity of the partner types in IRs makes PI 3,219 times more likely, GI 3,214 times more likely, and SI 2,858 times more likely. These results are consistent with the work of Leeuw *et al.* (2014) who found a positive and significant relationship between IR diversity and innovation.

For Hypotheses 1a, 1b and 1c (partner diversity effect of IRs on innovation for each of the three partner type groups with which the company interacts), the results of regression Model 3 in Table 3 allows us to partially confirm Hypothesis 1a (customer and supplier diversity favors GI) positively, and with a 97% confidence level, indicating that GI is 3,700 times more likely. This result is consistent with Ozer and Zhang (2015) who confirm that having a network of relationships with providers and customers boosts PI.

Hypothesis 1c in Table 4 (the diversity of consultants, universities, public research organizations and technology centers favors service innovation) is positively confirmed with a 95% confidence level, making SI 2.604 times more likely. This type of relationship diversity enables companies to access various resources and the knowledge necessary for innovating goods and services (Wassmer, Li, & Madhok, 2017). Unlike the results of previous literature, however, our results do not show any significant effect for Hypothesis 1b, nor do companies obtain a positive effect on PI resulting from IR diversity with companies in the same group and/or with competitors.

The results do not confirm Hypothesis 2 (inverted U-shaped relationship between the type of partner diversity and innovation). They show that the relationship between partner diversity in IRs and innovation is linear, unlike the work by Hagedoorn *et al.* (2018) and Hottenrott y Lopes-Bento (2016), who demonstrated that there is an inverted U-shaped relationship between these variables. One possible explanation for this result is that company network links increase trust and strengthen interpersonal relationships between partners, which helps maintain the positive effect of partner diversity on innovation. In addition, the more deeply-rooted these links are, the greater the trust and reciprocity between the partners. (Burt, 2004; Mariotti & Delbridge, 2012; Ozer & Zhang, 2015; Uzzi, 1997; Uzzi & Lancaster, 2003). This result requires further in-depth analysis in future research on this topic.

Finally, with regard to Hypotheses 2a, 2b and 2c that proposed the inverted U-shaped effect on the relationship between IR diversity and innovation in each of the three strategic partner groups, the results of Model 4 do not allow us to confirm these hypotheses for the innovation of goods or services. With regard to Hypothesis 2a (the effect of IR diversity with customers and suppliers on PI results in an inverted U-shaped relationship), in Model 4 of Table 3 the regression coefficient is positive and significant, indicating that the relationship between customer diversity and supplier relationships and the innovation of goods is linear. For Hypothesis 2c (the effect of IR diversity with consultants, universities and research entities on PI results in an inverted U-shaped relationship), in Model 4 of Table 4 the regression coefficient is positive and significant, indicating that the relationship between the diversity of the relationships with consultants, universities and research entities and service innovation is linear (without an inflection point), making innovation 6,770 times more likely. These results do not confirm that companies may become highly sensitive and mistrust each other when IR diversity increases, as claimed by Kobarg *et al.* (2019).

Regarding the control variables, company size is a factor that significantly affects innovation activities, since it positively influences absorption capacity, which promotes and boosts innovation activities (Beck & Schender-

Wicki, 2014). In relation to the sector, this aspect has a positive and significant influence on the innovation of goods (Østergaard, Timmermans, & Kristinsson, 2011). The results show that expenditure on internal R&D is important for product innovation, whether of goods or services. The models indicate that the age and external R&D innovation expenditure do not have a significant impact.

CONCLUSIONS

Taking into account the importance of IRs in PI (Mayskens & Carssrud, 2013), this study provides new evidence in the study of the influence of IR diversity on PI, whether of goods or services. We also analyzed whether the effect of the partner-type diversity of IRs on PI varies according to the type of strategic partner with which the company decides to maintain a relationship.

With data from the Spanish Technological Innovation Panel, 12 binomial logistic regression models were developed that allowed us to show the positive and significant effect of partner diversity in IRs on PI, both for goods and services (Beck & Schenker-Wicki, 2014). The more diverse the types of strategic partners with which the company decides to engage, the greater the probability of obtaining relevant heterogeneous and complementary knowledge for promoting (and boosting) product innovation (Amara & Landry, 2005; Leeuw *et al.*, 2014; Meyskens & Carssrud, 2013; Nieto & Santamaría, 2007). This study shows that the diversity of the relationships a company maintains with its commercial partners (customers and suppliers) favors more innovation of goods. This is because the company is able to access knowledge related to the market and its tendencies, which is necessary for developing innovations in goods and successfully introducing them into the market (Arranz & Arroyabe, 2008). IRs with customers and suppliers play a crucial role in R&D activities because they contribute complementary knowledge of customers' needs (Arranz & Arroyabe, 2008). Likewise, the diversity of the relationships that a company maintains with non-industrial partners (consultants, universities and research entities) favors the benefits of diversity in service innovation. This type of relationship allows access to technological knowledge that can be used for developing innovative services in accordance with new technological tendencies. This result coincides with previous studies that argue that relationships with universities open up new market segments favoring PI, by accessing the new knowledge that is necessary for developing high-quality and novel service innovations (Laursen & Salter, 2006; Tether, 2002) favoring their commercialization (Oerlemans, Knoben, & Pretorius, 2013). In short, this study enabled us to demonstrate that IR diversity is beneficial to PI, whether of goods or services (Wassmer *et al.*, 2017). The diversity of the relationships with customers and suppliers enhances the diversity benefits in the innovation of goods, while relationships with consultants, universities and research entities does the same for service innovation. Finally, the results do not allow us to affirm that too much diversity leads to declining returns in innovation. Diversity (global and by partner type) provides the company with moderately related and complementary knowledge. In our sample, greater IR diversity is valuable and has no detrimental effect on PI (Noseleit & Faria, 2013).

The results of this study have practical implications, both at the government and business levels. At the governmental level, it is important that the Spanish government makes use of incentives to promote PI that derives from taking advantage of the external knowledge acquired from IRs. This is especially important, since many companies do not have the internal knowledge or sufficient resources to innovate and remain competitive (Beers & Zand, 2014). Therefore, we can certainly say that they need relationships with other companies in order

to increase sales, improve competitiveness and, therefore, stay in the market for much longer through product innovation.

The results of this study have practical implications, both at the government and business levels. The results show the importance of developing policies that foster interorganizational relationships, and the need to promote such policies. At the business level, it is important for the company to define those knowledge-management policies that facilitate the appropriation of external knowledge from these interorganizational relationships, and that, at the same time, reduce the risk of leaking key important knowledge in order to maintain a competitive edge.

In any case, the results are limited by the source of information that is used. Future research, therefore, should use other empirical contexts, and study the influence of government policies, cultural aspects, other forms of innovation (incremental and radical), or analyze whether there are any differences that depend on company characteristics, and deepen the inverted U relationship, which this study was unable to confirm.

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AUTHORS' CONTRIBUTIONS

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