International breadth in coopetition and innovation performance: Evidence from the Spanish biotechnology industry

Vanesa Barrales-Molina [a 1], Leopoldo Gutiérrez- Gutiérrez [a] & Marta Riquelme-Medina [a]

[a] *Department of Business Organization I, University of Granada, Spain*

This article has been officially published in the journal *Industry and Innovation* by Taylor & Francis Group, and it is available at the following URL: https://doi.org/10.1080/13662716.2022.2156850

To cite this article: Vanesa Barrales-Molina, Leopoldo Gutierrez-Gutierrez & Marta Riquelme- Medina (2022): International breadth in coopetition and innovation performance: evidence from the Spanish biotechnology industry, Industry and Innovation, DOI: 10.1080/13662716.2022.2156850

FUNDING

The work was supported by the Government of Spain [PID2021.124725NB.I00].

[1] Corresponding author. Vanesa Barrales-Molina. Email address: vanesabm@ugr.es. Department of Business Organisation I, University of Granada, Spain.

International breadth in coopetition and innovation performance: Evidence from the Spanish biotechnology industry

Vanesa Barrales-Molina [a], Leopoldo Gutiérrez- Gutiérrez [a] and Marta Riquelme-Medina [a]

[a] *Department of Business Organization I, University of Granada, Spain*

ABSTRACT

Collaboration with competitors –coopetition– enables access to valuable knowledge and resources for innovation and is seen as common practice in some knowledge-intensive sectors. Using longitudinal data from the Spanish biotechnology sector (a total of 1605 observations), this study examines the relationship between international breadth of coopetition – the sum of the different international areas in which a firm's coopetitors are located - and innovation performance. The results show that a firm must collaborate with competitors in more than a single geographical area to begin to experience the positive effect of international breadth on innovation performance. Further, the results vary significantly in the presence of two different contingencies. Under conditions of lack of technological information, international breadth increases in value. When perceived market uncertainty is high, however, optimal results are achieved when international breadth is limited to a single area.

KEYWORDS

Coopetition, international breadth, biotechnology, technology information, market uncertainty.

1. Introduction

The term ‘coopetition’ was introduced in the 1980s to indicate collaboration that occurs among actors who are simultaneously competitors (Bengtsson and Kock, 2000; Bengtsson and Raza-Ullah, 2016; Luo, 2007). Over the past decade, the study of coopetition has gained a leading role in scholarly journals on strategy, innovation, and operations management. Since the introduction of the term, over 500 research studies that include the word ‘coopetition’ in the title, abstract, or keywords have been published in Business, Management, and Accounting. We also see a significant spike in conceptual studies and literature reviews (e.g., Bengtsson and Kock, 2014; Bengtsson and Raza-Ullah, 2016; Corbo, et al., 2022; Dorn et al., 2016; Hoffmann, Lavie, Reuer and Shipilov, 2018), case studies that explore the phenomenon in depth (Blanka and Traunmüller, 2020; Cassiman et al., 2009; Chiambaretto et al., 2019; Nemeh and Yami, 2019), and quantitative studies that test the relationship of coopetition to other variables, such as innovation (Bouncken et al., 2018; Markovic et al., 2020; Quintana-Garcia and Benavides-Velasco, 2004; Ritala, 2012), value creation (e.g., Lan et al., 2019; Lehtonen et al., 2020), efficiency (Li et al., 2011), and business performance (Estrada and Dong, 2020; Le Roy and Czakon, 2016). Paralleling this academic interest, the business landscape shows increasing evidence of the use of coopetition. For example, in the smartphone sector, collaboration agreements have been signed between Nokia, Sony Ericsson, and Samsung; in the electronics sector, the collaboration between Sony and Samsung is common knowledge; more recently, Amazon and Netflix have begun to collaborate for joint exploitation of an iCloud platform even though they compete in the business of streaming leisure content.

In these studies analyzing coopetition, the connection most studied has been coopetition's impact on innovation (Bengtsson and Raza-Ullah, 2016; Dorn et al., 2016; Corbo et al., 2022). In some knowledge-intensive sectors such as information technologies, aeronautics, and biotechnology, innovating requires technological and market knowledge with a high level of complexity. Such knowledge is difficult to find in collaboration agents that are not one's competitors (Bouncken et al., 2018; Miotti and Sachwald, 2003). In other sectors as well (e.g., the automotive industry), collaboration with competitors can pursue joint exploitation of resources available and share the cost of innovation and manufacturing (Segrestin, 2005). However, studies of coopetition warn that coopetition is not universally valid (Crick and Crick, 2021; Czakon et al., 2020; Le Roy and Czakon, 2016) and requires study to identify what contexts and contingent variables make it the most advisable practice (Dorn et al., 2016; Ritala, 2012; Shu et al., 2017; Wu, 2014).

To deepen the value of coopetition for innovation, previous studies have analyzed the ideal characteristics of competitor partners to ensure the best innovation performance (Dorn et al., 2016; Kraus et al., 2018). The literature in this area suggests that collaboration with competitors that are similar in culture, knowledge, and goals can ensure the most effective knowledge transfer without slowing the pace of innovation projects (Bouncken et al., 2018; Gnyawali and Park, 2009; Ritala and Hurmelinna-Laukkanen, 2009; Yan et al., 2020). This argument could suggest that coopetition concentrated in only one or a few international areas ensures easier flow of knowledge and reduces the difficulty of translating collaboration effort into innovation. Further—and especially in knowledge-intensive sectors, due to their geographical concentration through key

clusters in specific regions and countries (Gertler and Levitte, 2005)—the most valuable coopetitors for collaboration could be located in a few international areas. Therefore, due to either the preference for similar partners or the spatial concentration of knowledge, coopetition concentrated in just one or very few international areas may be desirable to increase innovation performance.

However, innovation is the fruit of recombining knowledge and different ideas (Kogut and Zander, 1992), and recombining similar knowledge limits the possibilities for innovation (Kafouros et al., 2014; Nieto and Santamaría, 2007). Then, collaborating with competitors that are geographically dispersed—for example, with those located in different international areas—can provide the opportunity to access a greater variety of complementary knowledge and resources for innovation (Dorn et al., 2016). Within research on coopetition, we thus find tension between suitability of collaborating with partner competitors concentrated in few international areas and the value that can be provided by collaboration with competitors located in a wide variety of international areas. To research this tension, we analyze the variable international breadth of coopetition, defined as the sum of the different international areas in which a firm's coopetitors are located. The research question we wish to tackle is therefore whether or not collaboration with a greater international breadth of competitors increases a firm's innovation. To answer this question empirically, we develop two study goals: (i) to analyze how international breadth in collaboration with competitors influences innovation performance, and (ii) to study what innovation context affects this relationship, which is defined by the difficulties the firm encounters in attempting to innovate.

To tackle these questions, this study focuses on the biotechnology sector, where some initial empirical papers were framed to analyze the relevance of coopetition (see e.g.: Powell et al., 1996; Miotti and Sachwald, 2003; Quintana-Garcia and Benavides-Velasco, 2004) and frequent real cases reveal how coopetition has contributed to improve innovation through the combination of competitors' resources, competencies, and knowledge (Vlaisavljevic et al., 2022). An illustrative example of international coopetition in biotechnology industry is the five-year strategic alliance signed by the North American biotech Paradigm Genetics and the German biotech Lion Bioscience AG, whose collaboration was aimed to develop and co-sell a new plant and a new biotech software.[2]

We use secondary Spanish Technological Innovation Panel (PITEC) data for 2012-2016, which contain information on innovation in a sample of 321 Spanish biotechnology firms, a total of 1605 observations. The results obtained confirm that the relationship between international breadth of coopetition and innovation performance follows a U-shape. That is, the relationship begins as negative but quickly reaches a threshold beyond which the relationship becomes positive. Further, our analysis confirms that the context of innovation, defined by lack of technological information and market uncertainty, moderates this relationship significantly, although in different ways. Whereas lack of technological information makes international breadth of coopetition even more valuable,

[2] It should be noted that coopetition in the biotech sector and in other sectors is currently occurring in more complex contexts such as innovation ecosystems and technology platforms, although this new business reality is not the subject of our research. The recent advances in vaccines against COVID-19 are a clear example of a technology platform where many collaborators (including biotech competitors) share knowledge and resources to develop new products around a common based (Messenger RNA technology) (Grimpe et al., 2022). This technology platform is similar to 'product platforms' conceptualized by Boudreau and Lakhani (2009) where collaborative communities work upon the base of mRNA technology, achieving simultaneusly the advance of such technology.

market uncertainty makes collaboration with partner competitors from few international areas sufficient to achieve maximum innovation performance.

Our study produces two major valuable contributions to existing research on coopetition. First, it provides evidence to justify the value of collaboration with competitors from diverse international areas, which have different cultures and provide the opportunity to obtain complementary knowledge. Second, our study agrees with other prior research on the need to analyze the contingencies that affect the value of coopetition (Bengtsson and Raza-Ullah, 2016; Dorn et al., 2016; Ritala, 2012). Although lack of technological information and market uncertainty are two crucial factors motivating collaboration with competitors, the effects are not the same in each case. The empirical evidence from our study shows that decisions to collaborate with international competitors from different international areas should be based on the circumstances that hinder innovation in the firm.

The rest of the article is structured as follows: Section 2 describes the theoretical framework within which the hypotheses are developed. Section 3 details the data used in the study, the variables analyzed, and the statistical analysis performed. Section 4 presents the results of the research, and Section 5 discusses the main findings, as well as the study's primary limitations and conclusions.

2. Theoretical framework and hypotheses

Coopetition is the situation in which a firm both collaborates and competes with the same agent (Nalebuff and Brandenburger, 1996). This form of collaboration has been studied at different levels: among firms in the same sector (Bouncken et al., 2018); among different areas, teams, or branches of the same firm (Chiambaretto et al., 2019; Luo, 2005); and within a collaboration network or business ecosystem (Gnyawali et al., 2006).

When the goal is innovation, collaborating with competitors enables access to complementary resources and knowledge (Bouncken et al., 2018; Bengtson and Raza-Ullah, 2016), uniting forces to create or access new markets (Ritala, 2012) and sharing the risk and cost of more ambitious innovation projects (Dorn et al., 2016). Traditionally, firms in knowledge-intensive industries have used coopetition more frequently than other types of firms (Bouncken and Kraus, 2013; Hoffman et al., 2018) because the knowledge and resources required to innovate are often found in competitors and because it is necessary to advance quickly on risky, costly innovation projects (Gnyawali and Park, 2009). The value of coopetition for innovation has been demonstrated, for example, in the biotechnology sector (Quintana-García and Benavides-Velasco, 2004), the automotive industry (Segrestin, 2005), and the aerospace industry (Salvetat and Geraudel, 2012), as well as in the cell phone sector (Rice and Galvin, 2006). But undertaking collaboration with competitor firms involves tension and risk and may even translate into worse profitability (Estrada and Dong, 2020). The high probability of opportunism and knowledge spillover (Le Roy and Czakon, 2016) presents greater challenges in defining how to appropriate the value of the collaboration results. The most recent studies seek to identify the circumstances

in which coopetition is most advisable, and their results show, for example, that firms must develop solid absorption capacity to ensure real learning from partner competitors (Fredrich et al., 2019; Wu, 2014). The field also recognizes the importance of determining which characteristics are desirable in the partner competitor (Bengtsson and Raza-Ullah, 2016; Dorn et al., 2016; Kraus et al., 2018).

2.1. International breadth in collaboration with competitors

It has been argued that having cultural traits, administrative processes, and goals similar to those of the competitor is ideal for achieving the best results from coopetition (Czakon et al., 2020; Dorn et al., 2016). Similarity increases the ease and fluidity of acquiring and assimilating knowledge from the other party (Gnyawali and Park, 2009; Yan et al., 2020), although it also increases the risk of opportunism and knowledge spillovers (Bouncken et al., 2018). Despite this risk of coopetition, prior studies obtain empirical evidence that cultural and organizational similarity create an environment of trust crucial to supporting work with a competitor partner (see, for example, Bierly and Gallaguer, 2007; Lascaux, 2020; Rice and Galvin, 2006; Rosenkopf and Almeida, 2003; Segrestin, 2005; Zeng, 2003). Consistent with these findings, the decision to develop collaboration with coopetitors in a single geographical area could help to translate collaboration effort into higher innovation performance.

In the fashion industry, for example, Italian and French companies have traditionally developed dense stable networks with regular partners within regional and national boundaries. Such networks build solid trusting relationships and take advantage of similar cultural backgrounds without incurring higher costs

and risks due to the international collaboration (Djelic and Ainamo, 1999). Similarly, in the biotechnology industry, geographical concentration of knowledge in particular clusters and regions is appreciable and becoming stronger over time (Gertler and Levitte, 2005) and consequently, biotech companies could feel the necessity to collaborate with competitors located in specific and limited countries and clusters to access to knowledge and complementary resources concentrated there. For instance, among the top cities for biotech companies, Boston, San Francisco, and San Diego rank the first positions (Fierce Biotech, 2022) suggesting that any biotech company could access to needed and enough complementary resources collaborating only with coopetitors located in USA. Consequently, and based on previous research on coopetition and according to these specific features of biotechnology industry, coopetition concentrated in one or a few international areas could ensure higher impact on innovation performance due to learning-by-interacting that enables geographical concentration of coopetitors. In a context of knowledge complexity, effective learning essentially requires close interaction that leads to understanding and assimilation of the knowledge stock available in partners. And such learning requires increased quality and frequency of interaction to ensure that shared knowledge is ultimately integrated into innovation projects (Tubiana et al., 2022).

On the other hand, because innovation requires combining different ideas and forms of knowledge (Kogut and Zander, 1992), collaborating with competitors in more than one international area could give firms access to valuable resources that are distributed unequally. Being able to manage collaboration with competitors in multiple international areas at the same time also increases opportunities to recombine knowledge (Rosenkopf and Almeida, 2003). Some

empirical articles, in the biotech context in particular, highlight the value of international alliances in increasing firms' repository of capabilities and technological knowledge (see, for example, Al-Laham and Souitaris, 2008). In fact, because countries vary considerably in the nature of the innovation they perform and the innovation systems they develop (Kafouros et al., 2014; Miotti and Sachwald, 2003), each country could accumulate unique knowledge and resources in specific scientific and technological areas (Phene and Almeida, 2008). Since collaboration with competitors from various international areas can make innovation less dependent on the same national innovation system (Arranz and Fernández de Arroyabe, 2008), such collaboration could ultimately provide access to and exploitation of unequally distributed knowledge for greater innovation performance.

These arguments identify two opposing forces that generate tension concerning where to seek a partner competitor. On the one hand, they recommend focusing on coopetition concentrated geographically in one or a few international areas; on the other, they recommend seeking partner competitors in different international areas to access valuable and sophisticated knowledge incrusted in multiple international innovation systems (Al-Laham and Souitaris, 2008; Arranz and Fernández de Arroyabe, 2008; Kafouros et al., 2014). International breadth in collaboration with competitors may therefore have a complex influence on innovation performance.

One issue that explains the complexity of this relationship is the cost of accessing and collaborating effectively with competitors located in many different international areas. According to Orr and Scott (2008), in addition to cultural differences and geographical distance, the cost of international collaboration

increases due to the need to understand a foreign institutional system, with different regulations and rules that govern behavior in each country. Essentially, this international complexity is translated into more time spent in meetings, delay communication and travel expenses, making difficult that international collaboration generates better innovation performance. Consistently, high international breadth of coopetition will provide fewer opportunities for learning-by-interaction with coopetitors due to geographical dispersion of partners and higher coordination costs due to their international diversity. Attempts to increase such international breadth could thus affect innovation performance negatively due to greater diversity of international alliances and the need to manage the conditions of many international areas simultaneously. Prior research has analyzed the negative role of international diversification on performance (see, for example, Capar and Kotabe, 2003 and Orr and Scott, 2008). Language barriers, different institutional systems and physical distance multiplied by the number of international areas with which the firm collaborates consume time and effort that could be devoted to sharing knowledge effectively and advancing innovation projects. International collaboration also negatively affects difficulties inherent in managing collaboration with competitors. These difficulties include time required to create relationships of trust, which will be even more complex due to cross-national differences (Lascaux, 2020; Kraus et al., 2018), prior negotiations to avoid opportunism (Raza-Ullah et al., 2014), and tensions that arise between collaboration and competition (Dorn et al., 2016). Such negative effects could be offset by increasing international breadth in collaboration with competitors, however, enabling access to and exploitation of a growing repository of knowledge and resources from a broad variety of different innovation systems.

For example, international breadth would mean greater probability of finding a partner competitor that can help to solve the problems encountered in each innovation project and increase the pace at which projects can advance. This positive effect could also be explained by a learning effect due to prior collaboration with competitors in other areas (Fang et al., 2011; Hewitt-Dundas et al., 2019).

We thus hypothesize a U-shaped relationship between international breadth of coopetition and innovation performance. On the left side of the curve (decreasing slope), the firm is likely to face declining innovation performance explained by initial attempts at collaborating with competitors in different international areas. Complexity, coordination costs, and geographical, institutional, and cultural distance compound the inherent difficulties of collaborating with competitors. Once a certain level of international breadth has been reached, however, this relationship will become positive due to the learning effect that occurs when a firm has achieved expertise by collaborating with the first coopetitors located in different international areas. This learning effect, as well as the access to highly diverse complementary knowledge, could offset the initial costs and declining innovation performance.

Hypothesis 1: *There is a U-shaped relationship between international breadth in coopetition and innovation performance.*

2.2. Lack of technological information

Various contingencies could also moderate this U-shaped relationship, changing the shape of the U-curve. Specifically, the literature on coopetition indicates that need for technological information and market uncertainty are factors motivating

coopetition (Bouncken et al., 2018; Ritala, 2012; Wu, 2014), potentially affecting the value of international breadth. Shu et al. (2017) found solid evidence to argue that the value of coopetition increases with technological turbulence and when industrial technologies are changing constantly.

Lack of technological information is one of the factors most analyzed in the literature, as a driver of both formation of strategic alliances in general (Zidorn and Wagner, 2012) and the search for alliances with competitors (Bouncken et al., 2018; Rice and Galvin, 2006). Competitors may in fact accumulate valuable technological experience by developing their own technologies to solve the same problems a firm faces in its innovation projects (Wu, 2014). When searching for technological information, however, firms tend to explore the closest geographic contexts, as shown in the citation of patents and scholarly articles on firms that are close to each other or the search for alliances within regional clusters (Rosenkopf and Almeida, 2003). Other studies demonstrate, however, that exploring international domains of technological information can help to develop innovation with greater impact (Arranz and Fernández de Arroyabe, 2008; Rosenkopf and Nerkar, 2001). Going beyond the possibilities offered by a single international area enables access to diverse technological knowledge incrusted in diverse international innovation systems (Kafouros et al., 2014).

Lack of technological information may thus condition the relationship between international breadth in collaboration with competitors and innovation performance. Lack of technological information assumes weakness or difficulty innovating, which adds to the difficulty of managing alliances with competitors located in different international areas. Managing these situations at the same time could worsen the negative effect of innovation performance, especially when

international breadth is still limited and few opportunities exist to access valuable technological information. When international breadth increases, however, we expect these effects to be offset by the possibility of finding specialized technological information in the diversity of international partner competitors. Even, these opportunities to access to many international partners and their repositories of technological knowledge and capabilities could compensate the difficulty to manage different international alliances in dissimilar contexts. Thus, lack of technological information causes a more pronounced curve, and negative and positive effects of international breadth may be even stronger when the firm experiences great lack of technological information. Following this reasoning, we propose:

Hypothesis 2: *Lack of technological information moderates the U-shaped relationship between international breadth in coopetition and innovative performance such that the U-shaped relationship is steeper in firms affected by high lack of technological information.*

2.3. Market uncertainty

Another contingency potentially moderating the U-shaped relationship between international breadth in collaboration with competitors and innovation performance is market uncertainty. When a firm perceives high market uncertainty, it is unable to predict consumers' response to innovative products. This lack of knowledge impedes determination of the specific characteristics of the products consumers value and thus knowledge of their buying patterns (Beckmann et al., 2004). Prior research demonstrates that such uncertainty is a common incentive triggering collaboration with competitors (Bicen et al., 2021;

Bouncken et al., 2018; Bouncken et al., 2019; Burgers et al., 1993; Ritala, 2012). Analyzing the history of strategic alliances between Nokia and Ericsson, for example, Rice and Galvin (2006) show that collaboration intensified when the firms developed innovation for the markets least known to and farthest from both firms. Another competitor firm feels the same need to collaborate by reducing market uncertainty, possibly even to become the sole common competitive force defining the technological and market standards against the other competitors (Burgers et al., 1993; Ritala, 2012).

Among the frequent examples of coopetition in biotechnology industry, Bio-Rad and NuProbe have recently signed a product development agreement to combine their sophisticated knowledge to design digital PCRs for diagnosis, at the same time that NuProbe offers the possibility to access to the Asian market to this North American partner. According to this evidence, collaborating with competitors from different international areas around the world opens more opportunities to reducing the market uncertainty associated with each international market. In the face of high market uncertainty, we can thus expect that it will be beneficial to increase international breadth in collaboration with competitors.

Initially, however, market uncertainty can be yet another aggravant in the prior negative relationship between international breadth of partner competitors and innovative performance. Low international breadth may not be sufficient to counteract market uncertainty, and interaction between difficulty managing alliances with diverse international competitors and lack of information on the market can produce an even more pronounced negative effect at the start of the curve. Once the firm passes the turning point in international breadth, however, the combined effect of market uncertainty and international breadth can cause an

even more positive effect on innovation performance. We thus propose that market uncertainty causes a more pronounced U-curve, accentuating the negative and positive effects of international breadth even more strongly.

Hypothesis 3: *Market uncertainty moderates the U-shaped relationship between international breadth in coopetition and innovative performance, such that the U-shape is steeper in firms with high market uncertainty*.

3. Empirical setting and methods

3.1. Data and sample

The data used in this study come from PITEC, “a panel database that enables monitoring of technological innovation activities by Spanish firms and is produced jointly by the Spanish National Statistics Institute (INE) and the Spanish Science and Technology Foundation (FECYT), with advice from a group of academic experts” (PITEC, 2019). The questions included in the PITEC questionnaire are based on the Community Innovation Survey (CIS) and form part of the general Plan for statistics on science and technology advanced by the statistical office of the European Union (Eurostat), following the directives of the Oslo Manual (OECD, 2005). The questionnaires are sent to CEOs of the firms participating in the panel. The response rate is usually around 90% due to conditions agreed upon by the INE and the firms participating in the survey. PITEC thus provides data that are highly representative of Spanish firms (Chapman, Lucena and Afcha, 2018). The CIS questionnaire is also very widely used in research on innovation (Laursen and Salter, 2006; Leoncini, 2016; Roper et al., 2017) because it facilitates comparison with prior studies that use similar data sets. It is

also increasingly standard practice to use PITEC in scholarly research (e.g., Chapman et al., 2018; Coad et al., 2016; Trigo and Vence, 2012).

PITEC analyzes business innovation strategies using nearly 500 variables of over 12,000 company cases. Since it uses a fixed panel, it performs a yearly observation of the firms composing the panel, facilitating matching and building time series of great scientific utility to enable establishment of causal relationships. The data included in PITEC are anonymous to make it easier for firms to respond frankly, increasing credibility and strengthening the reliability of the results (Fernández-Olmo and Ramírez-Alesón, 2017; López, 2011). The main advantages of using PITEC for studies like ours include: (i), its focus primarily on business innovation strategies, making the data perfect for the orientation of our study. (ii), its use of a CIS-type data base, ensuring widespread use and acceptance among economists and researchers; (iii), its design based on a panel data survey, which solves problems of other prior studies that use CIS data, such as “the simultaneity between input and outputs, by lagging explanatory variables” (Barge-Gil and López, 2014, p.1637).

We conduct our study on the Spanish biotechnology sector, where *coopetition* has traditionally been analyzed (see, e.g., Quintana-Garcia and Benavides-Velasco, 2004). Various conditions in the sector make coopetition a common phenomenon: (i) as a knowledge-intensive sector, it requires advance of scientific and technological knowledge to develop its innovation projects (Broekel et al., 2015; Kehoe and Tzabbar, 2015; Shan and Song, 1997; Zidorn and Wagner, 2012), and competitors are the partners that often demonstrate the sophisticated complementary knowledge needed (Powell et al., 1996; Miotti and Sachwald, 2003; Quintana-García and Benavides-Velasco, 2004); (ii) since the sector

develops costly, high-risk projects, it is common to attempt to establish strategic alliances with competitors to share the costs of innovation infrastructure and risk (Broekel, Fornahl and Morrison, 2015; Quintana-Garcia and Benavides-Velasco, 2004). The Spanish biotechnology sector fulfills these conditions. According to a recent ASEBIO 2018[3] report, certain figures attest to the strength of Spain's biotechnology sector as the subject for study of innovation and strategic alliances: (i) Spain is the ninth world power in knowledge production in the biotechnology sector based on number of scholarly publications; (ii) in 2018, 537 applications for patents were registered in this sector and 299 granted; (iii) collaboration with other agents is an essential part of the innovation process, as shown in 2018 by nearly 200 international strategic alliances in the European environment (27%) and with the United States (8%), Latin American countries (3%), and Asian countries (3%); (iv) of all strategic alliances created in 2018, 27% were with other biotechnology firms; (v) in 2018, Spanish biotech firms launched a total of 86 new products and services in areas such as personalized medicine, food safety, and medical devices and diagnostic tests.

From the total sample of firms surveyed in PITEC—over 12,000 in each year studied here—we select the firms identified as biotechnology firms. The PITEC survey defines these firms as those that perform activities based on science and technology applied to living organisms or composites obtained from them to generate knowledge or products of value, including bioinformatics and nanobiotechnology. To perform the analysis, we take a five-year time frame, 2012-2016 including both start and end years. Next, we purify the sample to

[3] The ASEBIO report is an annual report prepared by the Spanish Bioindustry Association. Published since 1999, the report is the authoritative document on the Spanish biotechnology sector that reviews the main economic, market, and financial aspects of the sector.

preserve only data from firms that responded annually to the survey throughout the period 2012-2016, thus avoiding problems caused by unbalanced panel data (Wooldridge, 2010). This procedure yields 321 biotechnology firms that responded to the survey in all five years studied, a total of 1605 observations. To rule out problems of bias in the sample, we use ANOVA tests to compare the 321 firms retained to those that did not answer in all five years with respect to sales volume, number of employees, and significant product and service innovations. The results show no significant differences between the two groups. Table 1 presents the descriptive information for 2016 for the sample analyzed.

Table 1. Sample description

Total sales	Sample
Less than 1 million euros	14.64%
From 1 to 10 million euros	36.44%
From 10 to 100 million euros	34.26%
More than 100 million euros	14.64%
Number of employees	**Sample**
Fewer than 25 employees	29.90%
From 25 to 100 employees	31.15%
From 100 to 500 employees	27.41%
More than 500 employees	11.52%
Type of firm	**Sample**
Private firms without foreign participation in capital	67.60%
Private firms with over 50% foreign participation	15.57%
Research associations and other institutions	7.16%
Private firms with less than 50% foreign participation	6.23%
Public firms	3.42%

3.2. Variables

3.2.1. Dependent variable: measuring innovation performance

Our study analyzes the effects of international breadth of coopetition on innovation performance, measured by *number of patent applications.* PITEC includes an initial filter question designed to distinguish firms that applied for patents during the survey year and the two preceding years (n and n-2). Firms that answer positively must then indicate, in a new question, the absolute number of patent applications submitted between n-2 and n. Number of patent applications is a dependent variable commonly used to measure innovation outputs in the biotechnology sector (see, e.g., Bertoni and Tykvová, 2015; Shkolnykova and Kudic, 2021; Subramanian et al., 2013), as it provides valuable information for comparing firms that work in the same industry (Basberg, 1984; Zidorn and Wagner, 2012). Unlike the period in which the patent is granted or the total number of patents in a firm, the patent application represents the end of a research project (Quintana-Garcia and Benavides-Velasco, 2008) and is thus a more precise measure of the period when innovation occurred. This measure is even more important when we seek to analyze innovation resulting from collaboration in periods prior to the moment of patent application. In addition, in a context in which strategic alliances are common for developing innovation, especially with competitors, patent application become a crucial mechanism for appropriating the value generated through innovation (Phene and Tallman, 2014; Zidorn and Wagner, 2012).

3.2.2. Independent and moderating variables

The main explanatory variable in our research is *international breadth in coopetition*, measured as the sum of the different international areas in which a firm's coopetitors are located. PITEC includes one binary variable to indicate whether or not the firm surveyed collaborated with competitors in the period from n-2 to n. If the firm answers yes, PITEC asks additional questions to determine the location of the competitors with which the firm collaborated, including the following response options: the same country, another European country, the United States, China and India, and other countries. To measure *international breadth in coopetition*, we thus build a variable that includes the total number of international areas to which the partner competitors in the period analyzed belong. Values for this variable range from 0 (does not collaborate with any competitor) to 5 (collaborates with competitors from all five international areas proposed). Table 2 describes the combinations of international areas selected in the responses, showing that the most common choice is simultaneous collaboration with competitors in the same country (national coopetition) and in European countries. Additionally, the variable international breadth includes the value 0 to reflect no coopetition, enabling us to compare the effect of the option of no international breadth rather than limiting our analysis to the value of adding/not adding more international areas. A value of 1 for the variable international breadth does not necessarily mean that the company collaborates with national competitors; the 1 may refer to any international area selected as single area. (Table 2 shows that some respondents selected 'Another European country' as the only international area.) At the same time, the addition of international areas to measure international breadth aligns with the approach

used in other international business studies (Kafouros et al., 2014) and in the open innovation literature (Faems et al., 2005; Laursen and Salter, 2006) when researchers seek to capture the diversity and dispersion of alliances.

Table 2. Distribution of international areas selected in answers.

International areas of coopetitors	Sample percentage
Same country, European country	41.38%
Same country	27.59%
European country	9.66%
Same country, European country, US	7.59%
Same country, European country, China and India, other	3.45%
Same country, European country, US, other	2.76%
European country, other	2.76%
Same country, European country, other	2.76%
European country, US, other	0.69%
Same country, European country, US, China and India, other	0.69%
Same country, US	0.69%

As to the variables introduced to analyze moderating effects, the PITEC database includes a set of factors that can hinder or damage innovation performance in a firm. We therefore include two factors that may hinder innovation but that have also been identified in the literature on coopetition as drivers of collaboration with competitors (Bouncken et al., 2018; Ritala, 2012). Our empirical study specifically

evaluates the moderating role of lack of technological information and market uncertainty. Concerning these variables, the respondents evaluate the level of importance of each factor that hinders innovation in their firm. Each factor is measured on a four-point Likert-scale (high difficulty, medium, low, and not applicable) for the period n-2 to n.

3.2.3. Control variables

To establish the control variables, we first consider the possibility that *size* of the organizations analyzed is somehow related to development of patents. To test this, we include the logarithm of number of employees, composed of average number of employees in the organization surveyed. Second, we include *age* of the organization to detect a possible experience effect of its age. Finally, to control for the firm's effort in innovation, we include the variable *R&D intensity*, measured as the quotient of R&D expenditure and total business volume of the firm (Laursen and Salter, 2006).

3.3. Research model

To estimate the model proposed, we performed a panel data firm-level analysis with fixed effects, using Stata 14 software. To determine whether the estimation should be performed with fixed or random effects, we performed the Hausman test (Hausman, 1978). Although the test was significant (Chi^2=93.72; p=0.00), recommending estimation using fixed effects, we also included an estimation using random effects to increase robustness of the results. The proposed model for estimating the relationship between international breadth in coopetition and number of patents is:

$$\textit{Number of patents}_{it} = \beta_0 + \beta_1\ \textit{international breadth}_{it} + \beta_3\ \textit{international breadth}^2_{it} + \beta_4\ \textit{international breadth}^2 * \textit{lack of technological information}_{it} + \beta_5\ \textit{international breadth}^2 * \textit{market uncertainty}_{it} + \textit{control variables}_{it} + \eta_i + \psi_t + \varepsilon_{it}$$

The subindexes i and t identify firm and period, respectively. To control for problems of unobservable firm heterogeneity, we include a firm-specific component of the error term (η_i). We also include dummy variables (ψ_t) for the years included in the study's time frame. Finally, we examined the possible effect of outliers in the sample by repeating the estimation using winsorized variables. The results obtained show no differences from the original model, strengthening that model's consistency.

4. Results

4.1. Main results

Table 3 summarizes the descriptive statistics and correlation matrix of the variables. The correlation values observed indicate no problems of multicollinearity among the variables.

Table 4 reports the results obtained for estimation of fixed effects of the number of patent applications. Model 1, which includes only the control variables, shows that only size influences the dependent variable positively and significantly. Model 2 adds the main effects of international breadth in coopetition. We followed the procedure in Haans et al. (2016) to test H1 by including both international breadth and its squared term in the specification. Model 3 enables us to contrast the influence of the moderating variables (lack of technological breadth and market uncertainty) by including the simple interaction term and the squared term in specifying the model (Haans et al., 2016). Proceeding to Model 3, we see that

explanatory power and significance increase progressively, while maintaining consistency of the results.

If we take Model 3 as our reference, the results show that the influence of international breadth in coopetition follows a U shape relative to the number of patent applications. The results also fulfil the three conditions sufficient for a U-shaped relationship: (1) the coefficient of international breadth^2 is positive and significant (β=2.554***, $p<0.001$), (2) the slope is sufficiently steep at both ends of the data range (-1.863*** and 11.329*** respectively), and (3) the turning point (1.022) is located well within the data range (Haans et al., 2016; Lind and Mehlum, 2010). Figure 1 shows the curve estimated for the relationship between international breadth in coopetition and number of patent applications for the range of data on international breadth. These results support H1. The results confirm that a firm must collaborate with competitors in more than a single international area to begin to experience the positive effect of international breadth on innovation performance. Thus, collaborating with competitors in a single international area would produce the worst results for innovation performance, and innovation performance would begin to improve if the firm collaborates with competitors in at least two international areas. According to our results, this single international area is not necessarily a single area on which all the respondents concur; each respondent may have selected a different international area (Table 2 shows that respondents selected ‘same country’ and ‘European countries’ as single areas).

Table 3. Descriptive statistics and correlation matrix

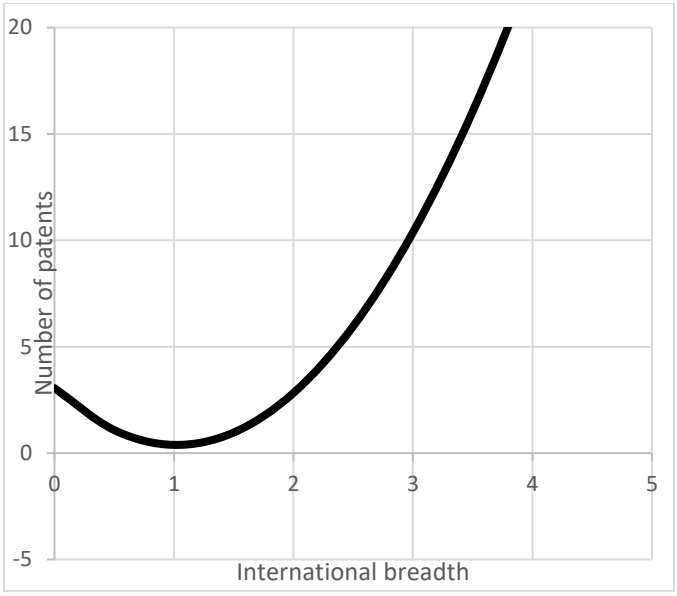
	Mean	SD	Min	Max	1	2	3	4	6	7	8
1. Number of patent applications	1.703	8.424	0	150	1.00						
2. International breadth	2.300	0.706	0	5	0.35	1.00					
3. Lack of technological information	2.841	0.802	1	4	0.01	-0.02	1.00				
4. Market uncertainty	2.275	1.000	1	4	-0.06	-0.10	0.39	1.00			
5. Size	253.55	738.82	1	9,036	0.24	0.26	0.04	0.02	1.00		
6. Age	29.551	20.210	6	116	0.07	-0.00	0.02	0.04	0.18	1.00	
7. R&D intensity	4.151	91.415	0	3,379	0.00	-0.01	0.03	-0.03	-0.01	-0.04	1.00

Table 4. Panel data firm-level analyses

	Panel data fixed effects estimation								
	Model 1			Model 2			Model 3		
	B	S.E.	t-value	B	S.E.	t-value	B	S.E.	t-value
Geographical breadth				-1.046**	0.448	-2.33	-5.222***	1.720	-3.04
Geographical breadth^2				0.974***	0.183	5.32	2.554***	0.713	3.58
Lack of technological information							0.127	0.206	0.62
Geographical breadth X Lack of technological information							-1.142**	0.553	-2.07
Geographical breadth^2 X Lack of technological information							0.835***	0.223	3.74
Market uncertainty							-0.162	0.165	-0.98
Geographical breadth X Market uncertainty							3.556***	0.512	6.94
Geographical breadth^2 X Market uncertainty							-1.896***	0.212	-8.92
Size	3.119**	1.311	2.38	2.762**	1.293	2.14	2.981**	1.253	2.38
Age	-0.283	0.276	-1.02	-0.277	0.271	-1.02	-0.231	0.262	-0.88
R&D intensity	-0.001	0.001	-1.04	-0.001	0.001	-1.06	-0.001	0.001	-1.16
Constant	4.704	8.726	0.54	4.922	8.577	0.57	3.055	8.322	0.37
Observations	1,605			1,605			1,605		
R^2	0.009			0.044			0.114		
F	1.90*			7.28***			11.66***		
Number of id	321			321			321		

*p<0.10; **p<0.05; ***p<0.01

Figure 1. Relationship between international breadth in coopetition and number of patents



To test the moderating effects formulated in H2 and H3, we also examine Model 3. The influence of lack of technological information is positive and significant (β=0.835***, p<0.001). According to Haans et al. (2016), positive moderation of a U-shape steepens both sides of the curve. As seen in Figure 2, the slope of the relationship between international breadth and number of patent applications is higher in situations with great lack of technological information. In our results, the steeper slope is especially visible on the ascending side of the U-curve. These results support H2.

The estimations show the moderating effect of market uncertainty to be significant and negative (β=-1.896***, p<0.001). These results indicate that market uncertainty moderates the relationship significantly, but in the direction opposite to that argued in H3—meaning in visual terms that the U-curve flattens when market uncertainty is high. The influence of this moderating factor merits in-depth analysis beyond the value estimated for the coefficient, however. Figure 3 shows that the U-curve increases as market uncertainty increases gradually. The

moderating influence of market uncertainty thus causes a radical change in the U-curve, which takes an inverted U-shape. This effect, known as ‘shape-flip’ (Haans et al., 2016; Haans, 2019), has been found in other strategic management studies (see, e.g., Uotila et al., 2009). The phenomenon occurs when the influence of the moderating variable is so strong that it begins to soften the slope of the U-curve. As this value continues to increase, it causes the curve to flip and invert. Inversion is usually explained by two contrary latent forces caused at the same time by the moderating variable (Haans et al., 2016). This result prevents us from affirming H3 and confirms instead a much more complex relationship than that formulated in the hypothesis.

Figure 2. Moderating effect of lack of technological information

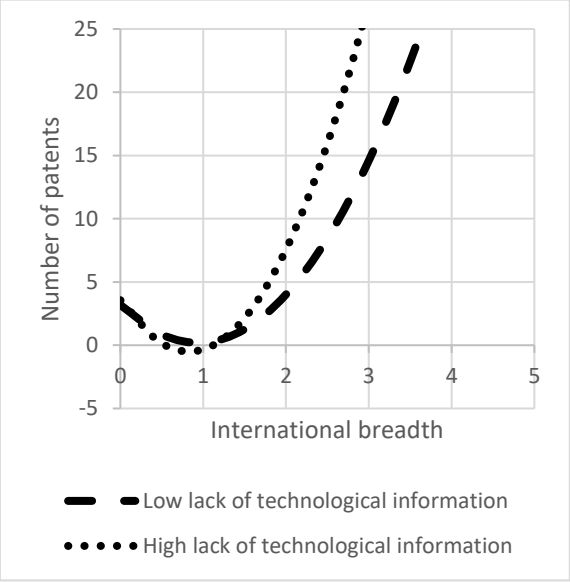
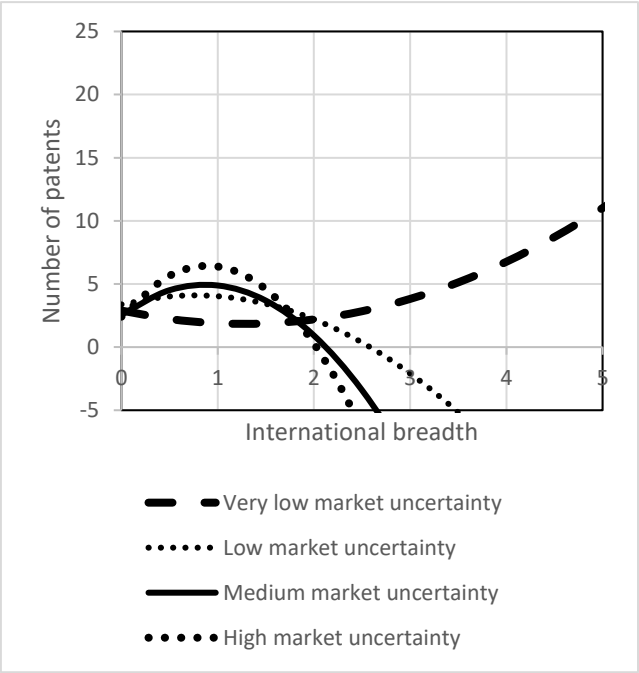


Figure 3. Moderating effect of market uncertainty



4.2. Robustness check

To analyze the robustness of our estimations, we estimated the empirical models using random effects. The results obtained are consistent with those presented in Table 3. We also performed the estimation using winsorized estimators and found no significant change in the results obtained.

We used two procedures to test for problems of endogeneity, which would indicate that a greater number of patents could drive cooperation with competitors in different locations. First, we conducted the Granger causality test, which showed no problems of reverse causality and a causal direction from cooperation with competitors to number of patent applications. Second, the problem of spurious correlation with unobservable characteristics of the firm is solved by estimation of fixed effects. This estimation eliminates the component (η i) from the error term (the source of problems involving spurious correlation).

5. Discussion

Our empirical study was designed to illuminate the debate over whether or not it is worthwhile to increase international breadth when collaborating with competitors. The study also analyzed how difficulties encountered in the innovation process affect the relationship between international breadth in coopetition and innovation performance.

First, we analyzed the influence of a set of control variables that may affect innovation performance but found only size to be positively related to innovation performance; the other control variables (age and R&D intensity) were not. This finding shows that these control variables have little relevance when considering key issues for innovation, such as characteristics related to collaboration and difficulties encountered in innovating. Still, the significant influence of size on innovation performance has been demonstrated generally in studies of strategic alliances and innovation performance, indicating that larger firms can perform better in terms of innovation quantity, probably because they can embark on larger-scale innovation projects (Elia et al., 2019).

Second, our results confirm that the relationship between international breadth in coopetition and innovation performance only begins to be positive when international breadth is greater than one. According to these results, choosing no coopetition ensures better results than collaborating with competitors from a single area (whether national or international). The relationship between international breadth and innovation performance become positive, however, when international breadth is higher than one area. Accordingly, although concentration of knowledge in specific clusters and countries could suggest that

a company would prefer to focus on coopetition with very specific areas, our results show that opening coopetition to globally dispersed partners increases innovation performance. In addition, our findings could suggest that it is not easy to begin managing coopetition itself and that this early effort translates into lower innovation performance if a company collaborates with competitors located in a single international area only. Once collaboration with coopetitors in a first area is mastered, innovation performance increases as the firm extends collaboration to competitors in additional international areas. This finding suggests that the problems of learning to manage coopetition and the international coordination required can easily be offset by the possibility of exploiting the knowledge and resources of partners located in very diverse international innovation systems (Phene and Almeida, 2008; Rosenkopf and Almeida, 2003), as well as by the learning effect experienced when increasing the international diversity of coopetitors. To date, the literature on coopetition has stressed the value of finding an ideal partner (see, e.g., Markovic et al., 2020; Kraus et al., 2018), while arguing that such a partner is probably more similar in work processes and organizational culture, due to for example to geographical overlap (Czakon et al., 2020; Dorn et al., 2016; Gnyawali and Park, 2009). This approach would suggest that national competitors or competitors in few different international areas are preferable (Segrestin, 2005) because it will be easier to ensure an environment of trust for knowledge transfer and innovation with less cross-national differences (Lascaux, 2020). Our results show, however, that it is even more beneficial to collaborate with competitors from different international areas. This result advances scientific research evidence on international coopetition and international diversity of coopetitors, as well as research on the biotechnology sector.

This finding also adds nuance to the research on breadth as it relates to openness of innovation. Laursen and Salter (2006),[4] for example, measured breadth by the number of different knowledge sources used for innovation and found that there is a point of over-search beyond which increasing the number of knowledge sources negatively affects innovation performance. If we focus on the biotechnology sector and coopetitors, however, innovation performance grows with international breadth, indicating that each international area adds value without reaching a point of over search.

Third, this study analyzes how lack of technological information to innovate influences the relationship between international breadth in collaboration with competitors and innovation performance. The results obtained enabled us to contrast the hypothesis proposed, which suggests that lack of technological information causes a more pronounced U-curve. This result agrees with the results of other empirical studies in the field of coopetition indicating that technological issues are crucial to explaining the value of coopetition (Rice and Galvin, 2006; Shu et al., 2017; Wu, 2014). But our research contributes further to the literature on coopetition by providing an additional explanation, showing that collaboration with a considerable international breadth of competitors can be very favorable when lack of technological information hinders innovation. This lack of information also enables exploitation of even greater international breadth of partners, translating into greater innovation performance. More precisely, establishing strategic alliances with competitors from diverse international areas

[4] Other noteworthy differences between the two studies to keep in mind when comparing their findings include their comparisons of Spanish biotech firms vs. U.S. firms from all economic sectors, longitudinal vs. transversal data, and different measures of innovation as dependent variable.

provides the opportunity to access technological information distributed unevenly in international innovation systems.

Fourth, our study proposes that difficulty in innovation derived from high market uncertainty could also positively moderate the relationship between international breadth in coopetition and innovation performance, leading to a more pronounced U-curve. Our results show, however, that the influence of market uncertainty on this relationship is even more complex, leading to an inverted U-curve. From this striking result, we conclude that is it inadvisable to increase international breadth when market uncertainty is high, as collaborating with competitors in a single international area already maximizes innovation performance. This finding may be explained by the fact that market uncertainty can be offset by collaborating more closely with competitors from the same international area, that is, with those who define a series of standards and agreements that limit the conditions in an uncertain market. Further, problems of coordination derived from collaboration in different international areas may not be offset by the benefits of international breadth for reduction in market uncertainty.

Our analysis and comparison of these two moderating factors also contributes to the literature on coopetition. According to our results, the value of international breadth in coopetition differs greatly depending on whether the difficulties come from technological or market issues. When facing lack of technological information to innovate, it is very positive to increase international breadth of the competitors with which the firm collaborates. This conclusion suggests that technological information is distributed at international level and that it will always be worthwhile to add more international areas in collaboration with competitors. If market uncertainty is what hinders innovation, however, limiting coopetition to

a single international area already generates maximum benefit, and it is not worthwhile to incur the cost of coordination with other international areas. This diversity of results enables us to confirm the need to adopt a contingent approach to studying the value of coopetition in innovation, a conclusion also suggested by various studies in the field (see, e.g., Dorn et al., 2016; Le Roy and Czakon, 2016; Neme and Yami, 2018; Ritala, 2012).

As with all studies, this research has some limitations, which provide new opportunities for future research. First, the study was performed on the Spanish biotechnology sector, which fulfils a series of conditions well-suited studying the value of coopetition to innovation (Quintana-Garcia and Benavides-Velasco, 2004). This focus prevents us, however, from generalizing widely from the results and advises contrasting the hypotheses formulated in other knowledge-intensive sectors in which coopetition is also a common phenomenon. The influence of international breadth in innovation performance should be also analyzed in other industries where the most well-known examples of coopetition have taken place (e. g. digital industry). Likewise, we should not ignore that coopetition currently occurs in more complex entities such as platforms and innovation ecosystems (Riquelme-Medina et al., 2022), the nature of which should be incorporated into this analysis.

Second, we used the dependent variable number of patent applications in a two-year period to approximate the firm's innovation performance. Although it is common in the biotechnology sector to patent innovation, especially when establishing strategic alliances, patents are not a perfect measure of innovation performance (Zidorn and Wagern, 2012), since innovation results are not always

patented and the firm may innovate in services that do not become protected by patents. Future studies should consider other, more comprehensive variables of innovation performance, such as patents applied, citations received, or profits obtained from innovation. Third, our study is based on secondary data, and the main independent variable (international breadth of coopetition) is constructed from the categories in the PITEC questionnaire. A more detailed breakdown of international areas in the answers available might have benefitted our study, as it would provide a more precise record of the international diversity of the competitors with whom the firm collaborates. Better disaggregation of the categories reflecting the international location of coopetitors would be valuable to enable research on individual differences in each international area and its role in increasing innovation performance.

As to managerial implications, we find that managers in the biotechnology sector should place more emphasis on extending collaboration with competitors located in different international areas, despite difficulties derived from geographic distance. To do so, managers should ensure access to enough different international areas to make their diversity valuable for innovation. This recommendation is especially important when the biotechnology firm finds that it lacks technological information to advance the innovation projects, Further, for firms facing market uncertainty concerning innovation, international breadth lacks the value it acquires in the case of lack of technological information.

References

Al-Laham, A., & Souitaris, V. (2008). Network embeddedness and new-venture internationalization: Analyzing international linkages in the German biotech industry. *Journal of Business Venturing*, *23*(5), 567-586.

Arranz, N., & de Arroyabe, J. C. F. (2008). The choice of partners in R&D cooperation: An empirical analysis of Spanish firms. *Technovation*, *28*(1-2), 88-100.

ASEBIO, (2018). Informe Asebio: Situación y tendencias del sector de la biotecnología en España. Asebio, Madrid.

Barge-Gil, A., & López, A. (2014). R&D determinants: Accounting for the differences between research and development. *Research Policy*, *43*(9), 1634-1648.

Basberg, B. L. (1984). Patent statistics and the measurement of technological change: An assessment of the Norwegian patent data, 1840–1980. *World Patent Information*, *6*(4), 158-164.

Beckman, C. M., Haunschild, P. R., & Phillips, D. J. (2004). Friends or strangers? Firm-specific uncertainty, market uncertainty, and network partner selection. *Organization Science*, *15*(3), 259-275.

Bengtsson, M., & Kock, S. (2014). Coopetition—Quo vadis? Past accomplishments and future challenges. *Industrial Marketing Management*, *43*(2), 180-188.

Bengtsson, M., & Raza-Ullah, T. (2016). A systematic review of research on coopetition: Toward a multilevel understanding. *Industrial Marketing Management*, *57*, 23-39.

Bertoni, F., & Tykvová, T. (2015). Does governmental venture capital spur invention and innovation? Evidence from young European biotech companies. *Research Policy*, *44*(4), 925-935.

Bierly III, P. E., & Gallagher, S. (2007). Explaining alliance partner selection: Fit, trust and strategic expediency. *Long Range Planning*, *40*(2), 134-153.

Bicen, P., Hunt, S. D., & Madhavaram, S. (2021). Coopetitive innovation alliance performance: Alliance competence, alliance's market orientation, and relational governance. *Journal of Business Research*, *123*, 23-31.

Blanka, C., & Traunmüller, V. (2020). Blind date? Intermediaries as matchmakers on the way to start-up—industry coopetition. *Industrial Marketing Management*, *90*, 1-13.

Boudreau, K. J., & Lakhani, K. R. (2011). How to manage outside innovation. MIT Sloan Management Review Sloanselect Collection, 50-57.

Bouncken, R. B., Fredrich, V., & Kraus, S. (2019). Configurations of firm-level value capture in coopetition. *Long Range Planning*.

Bouncken, R. B., Fredrich, V., Ritala, P., & Kraus, S. (2018). Coopetition in new product development alliances: Advantages and tensions for incremental and radical innovation. *British Journal of Management*, *29*(3), 391-410.

Bouncken, R. B., & Kraus, S. (2013). Innovation in knowledge-intensive industries: The double-edged sword of coopetition. *Journal of Business Research*, *66*(10), 2060-2070.

Broekel, T., Fornahl, D., & Morrison, A. (2015). Another cluster premium: Innovation subsidies and R&D collaboration networks. *Research Policy*, *44*(8), 1431-1444.

Burgers, W. P., Hill, C. W., & Kim, W. C. (1993). A theory of global strategic alliances: The case of the global auto industry. *Strategic Management Journal*, *14*(6), 419-432.

Capar, N., & Kotabe, M. (2003). The relationship between international diversification and performance in service firms. Journal of international business studies, 34(4), 345-355.

Cassiman, B., Di Guardo, M. C., & Valentini, G. (2009). Organising R&D projects to profit from innovation: Insights from co-opetition. *Long Range Planning*, *42*(2), 216-233.

Chapman, G., Lucena, A., & Afcha, S. (2018). R&D subsidies & external collaborative breadth: Differential gains and the role of collaboration experience. *Research Policy*, *47*(3), 623-636.

Chiambaretto, P., Massé, D., & Mirc, N. (2019). “All for One and One for All?”: Knowledge broker roles in managing tensions of internal coopetition: The Ubisoft case. *Research Policy*, *48*(3), 584-600.

Coad, A., Segarra, A., & Teruel, M. (2016). Innovation and firm growth: Does firm age play a role?. *Research Policy*, *45*(2), 387-400.

Corbo, L., Kraus, S., Vlačić, B., Dabić, M., Caputo, A., & Pellegrini, M. M. (2022). Coopetition and innovation: A review and research agenda. Technovation.

Crick, J. M., & Crick, D. The dark-side of coopetition: Influences on the paradoxical forces of cooperativeness and competitiveness across product-market strategies. *Journal of Business Research*, *122*, 226-240.

Czakon, W., Klimas, P., & Mariani, M. (2020). Behavioral antecedents of coopetition: A synthesis and measurement scale. *Long Range Planning*, *53*(1), 101875.

Djelic, M. L., & Ainamo, A. (1999). The coevolution of new organizational forms in the fashion industry: A historical and comparative study of France, Italy, and the United States. *Organization Science, 10*(5), 622-637.

Dorn, S., Schweiger, B., & Albers, S. (2016). Levels, phases and themes of coopetition: A systematic literature review and research agenda. *European Management Journal*, *34*(5), 484-500.

Elia, S., Petruzzelli, A. M., & Piscitello, L. (2019). The impact of cultural diversity on innovation performance of MNC subsidiaries in strategic alliances. *Journal of Business Research*, *98*, 204-213.

Estrada, I., & Dong, J. Q. (2020). Learning from experience? Technological investments and the impact of coopetition experience on firm profitability. *Long Range Planning*, *53*(1), 101866.

Faems, D., Van Looy, B., & Debackere, K. (2005). Interorganizational collaboration and innovation: Toward a portfolio approach. *Journal of Product Innovation Management*, *22*(3), 238-250.

Fang, S. R., Fang, S. C., Chou, C. H., Yang, S. M., & Tsai, F. S. (2011). Relationship learning and innovation: The role of relationship-specific memory. *Industrial Marketing Management*, *40*(5), 743-753.

Fierce Biotech (2022). The top biotech hubs in 2022. https://www.fiercebiotech.com/special-reports/top-biotech-hubs

Fredrich, V., Bouncken, R. B., & Kraus, S. (2019). The race is on: Configurations of absorptive capacity, interdependence and slack resources for interorganizational learning in coopetition alliances. *Journal of Business Research*, *101*, 862-868.16-27.

Gertler, M. S., & Levitte, Y. M. (2005). Local nodes in global networks: the geography of knowledge flows in biotechnology innovation. Industry and Innovation, 12(4), 487-507.

Gnyawali, D. R., & Park, B. J. (2009). Co-opetition and technological innovation in small and medium-sized enterprises: A multilevel conceptual model. *Journal of Small Business Management*, *47*(3), 308-330.

Gnyawali, D. R., He, J., & Madhavan, R. (2006). Impact of co-opetition on firm competitive behavior: An empirical examination. *Journal of Management*, *32*(4), 507-530.

Grimpe, C., Minssen, T., Price II, W. N., & Stern, A. D. (2022). Will mRNA Technology Companies Spawn Innovation Ecosystems?. Harvard Business Review Digital Articles.

Haans, R. F., Pieters, C., & He, Z. L. (2016). Thinking about U: Theorizing and testing U-and inverted U-shaped relationships in strategy research. *Strategic Management Journal*, *37*(7), 1177-1195.

Haans, R. F. (2019). What's the value of being different when everyone is? The effects of distinctiveness on performance in homogeneous versus heterogeneous categories. *Strategic Management Journal*, *40*(1), 3-27.

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica: Journal of the Econometric Society*, 1251-1271.

Hewitt-Dundas, N., Gkypali, A., & Roper, S. (2019). Does learning from prior collaboration help firms to overcome the 'two-worlds' paradox in university-business collaboration?. *Research Policy*, *48*(5), 1310-1322.

Hoffmann, W., Lavie, D., Reuer, J. J., & Shipilov, A. (2018). The interplay of competition and cooperation. *Strategic Management Journal*, *39*(12), 3033-3052.

Kafouros, M. I., Buckley, P. J., & Clegg, J. (2014). The effects of global knowledge reservoirs on the productivity of multinational enterprise: The role of international depth and breadth. In *The Multinational Enterprise and the Emergence of the Global Factory* (pp. 220-254). Palgrave Macmillan, London.

Kehoe, R. R., & Tzabbar, D. (2015). Lighting the way or stealing the shine? An examination of the duality in star scientists' effects on firm innovative performance. *Strategic Management Journal*, *36*(5), 709-727.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science*, *3*(3), 383-397.

Kraus, S., Meier, F., Niemand, T., Bouncken, R. B., & Ritala, P. (2018). In search for the ideal coopetition partner: An experimental study. *Review of Managerial Science*, *12*(4), 1025-1053.

Lan, S., Liu, K., & Dong, Y. (2019). Dancing with wolves: how value creation and value capture dynamics affect complementor participation in industry platforms. *Industry and Innovation*, *26*(8), 943-963.

Lascaux, A. (2020). Coopetition and trust: What we know, where to go next. *Industrial Marketing Management*, *84*, 2-18.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal*, *27*(2), 131-150.

Lehtonen, M. J., Ainamo, A., & Harviainen, J. (2020). The four faces of creative industries: visualising the game industry ecosystem in Helsinki and Tokyo. *Industry and innovation*, *27*(9), 1062-1087.

Le Roy, F., & Czakon, W. (2016). Managing coopetition: The missing link between strategy and performance. *Industrial Marketing Management, 53*, 3-6.

Leoncini, R. (2016). Learning-by-failing: An empirical exercise on CIS data. *Research Policy*, *45*(2), 376-386.

Li, Y., Liu, Y., & Liu, H. (2011). Co-opetition, distributor's entrepreneurial orientation and manufacturer's knowledge acquisition: Evidence from China. *Journal of Operations Management*, *29*(1-2), 128-142.

Lind, J. T., & Mehlum, H. (2010). With or without U? The appropriate test for a U-shaped relationship. *Oxford Bulletin of Economics and Statistics*, *72*(1), 109-118.

López, A. (2011). The effect of microaggregation on regression results: An application to Spanish innovation data.

Luo, Y. (2005). Toward coopetition within a multinational enterprise: A perspective from foreign subsidiaries. *Journal of World Business*, *40*(1), 71-90.

Markovic, S., Jovanovic, M., Bagherzadeh, M., Sancha, C., Sarafinovska, M., & Qiu, Y. (2020). Priorities when selecting business partners for service innovation: The contingency role of product innovation. *Industrial Marketing Management*, *88*, 378-388.

Miotti, L., & Sachwald, F. (2003). Co-operative R&D: why and with whom?: An integrated framework of analysis. *Research Policy*, *32*(8), 1481-1499.

Nalebuff, B., & Brandenburger, A. (1996). *Co-opetition: A Revolution Mindset that Combines Competition and Co-operation: The Game Theory Strategy That's Changing the Game of Business*.

Nemeh, A., & Yami, S. (2019). Orchestrating resources for FMA in coopetitive NPD. *R&D Management*, *49*(1), 64-85. s. New York.

Nieto, M. J., & Santamaría, L. (2007). The importance of diverse collaborative networks for the novelty of product innovation. *Technovation*, *27*(6-7), 367-377.

OECD, 2005. *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*. OECD Editions Paris.

Orr, R. J., & Scott, W. R. (2008). Institutional exceptions on global projects: A process model. Journal of International Business Studies, 39(4), 562-588.

Phene, A., & Almeida, P. (2008). Innovation in multinational subsidiaries: The role of knowledge assimilation and subsidiary capabilities. *Journal of International Business Studies*, *39*(5), 901-919.

Phene, A., & Tallman, S. (2014). Knowledge spillovers and alliance formation. *Journal of Management Studies*, *51*(7), 1058-1090.

PITEC (2019). Spanish Technological Innovation Panel. Ministry of Economy and Competitiveness. Spanish Government. Available at: http://icono.fecyt.es/pitec (accessed 16 January 2019).

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, 116-145.

Quintana-Garcia, C., & Benavides-Velasco, C. A. (2004). Cooperation, competition, and innovative capability: A panel data of European dedicated biotechnology firms. *Technovation*, *24*(12), 927-938.

Quintana-Garcia, C., & Benavides-Velasco, C. A. (2008). Innovative competence, exploration and exploitation: The influence of technological diversification. Research policy, 37(3), 492-507.

Rice, J., & Galvin, P. (2006). Alliance patterns during industry life cycle emergence: The case of Ericsson and Nokia. *Technovation*, *26*(3), 384-395.

Ritala, P. (2012). Coopetition strategy–when is it successful?: Empirical evidence on innovation and market performance. *British Journal of Management*, *23*(3), 307-324.

Ritala, P., & Hurmelinna-Laukkanen, P. (2009). What's in it for me? Creating and appropriating value in innovation-related coopetition. *Technovation*, *29*(12), 819-828.

Riquelme-Medina, M., Stevenson, M., Barrales-Molina, V., & Llorens-Montes, F. J. (2022). Coopetition in business Ecosystems: The key role of absorptive capacity and supply chain agility. Journal of Business Research, 146, 464-476.

Roper, S., Love, J. H., & Bonner, K. (2017). Firms' knowledge search and local knowledge externalities in innovation performance. *Research Policy*, *46*(1), 43-56.

Rosenkopf, L., & Almeida, P. (2003). Overcoming local search through alliances and mobility. *Management Science*, *49*(6), 751-766.

Rosenkopf, L., & Nerkar, A. (2001). Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. *Strategic Management Journal*, *22*(4), 287-306.

Salvetat, D., & Géraudel, M. (2012). The tertius roles in a coopetitive context: The case of the European aeronautical and aerospace engineering sector. *European Management Journal*, *30*(6), 603-614.

Segrestin, B. (2005). Partnering to explore: The Renault–Nissan Alliance as a forerunner of new cooperative patterns. *Research Policy*, *34*(5), 657-672.

Shan, W., & Song, J. (1997). Foreign direct investment and the sourcing of technological advantage: Evidence from the biotechnology industry. *Journal of International Business Studies*, *28*(2), 267-284.

Shkolnykova, M., & Kudic, M. (2021). Who benefits from SMEs' radical innovations?—empirical evidence from German biotechnology. Small Business Economics, 1-29.

Shu, C., Jin, J. L., & Zhou, K. Z. (2017). A contingent view of partner coopetition in international joint ventures. Journal of International Marketing, 25(3), 42-60.

Statistical Office of the European Communities. (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data* (No. 4). Publications of the OECD.

Subramanian, A. M., Lim, K., & Soh, P. H. (2013). When birds of a feather don't flock together: Different scientists and the roles they play in biotech R&D alliances. *Research Policy*, *42*(3), 595-612.

Trigo, A., & Vence, X. (2012). Scope and patterns of innovation cooperation in Spanish service enterprises. *Research Policy*, *41*(3), 602-613.

Tubiana, M., Miguelez, E., & Moreno, R. (2022). In knowledge we trust: Learning-by-interacting and the productivity of inventors. Research Policy, 51(1), 104388.

Uotila, J., Maula, M., Keil, T., & Zahra, S. A. (2009). Exploration, exploitation, and financial performance: Analysis of S&P 500 corporations. *Strategic Management Journal*, *30*(2), 221-231.

Vlaisavljevic, V., Gopalakrishnan, S., Zhang, H., Cabello-Medina, C., & Guilbault, M. (2022). Dancing with wolves: how R&D human capital can benefit from coopetition. R&D Management, 52(3), 449-464.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT press.

Wu, J. (2014). Cooperation with competitors and product innovation: Moderating effects of technological capability and alliances with universities. *Industrial Marketing Management*, *43*(2), 199-209.

Yan, Y., Dong, J. Q., & Faems, D. (2020). Not every coopetitor is the same: The impact of technological, market and geographical overlap with coopetitors on firms' breakthrough inventions. *Long Range Planning*, *53*(1), 101873.

Zeng, M. (2003). Managing the cooperative dilemma of joint ventures: The role of structural factors. *Journal of International Management*, *9*(2), 95-113.

Zidorn, W., & Wagner, M. (2012). The effect of alliances on innovation patterns: An analysis of the biotechnology industry. *Industrial and Corporate Change*, *22*(6), 1497-1524.