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Zooming into firms' location, capabilities and innovation performance: Does agglomeration foster incremental or radical innovation?

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ABSTRACT

This study answers the question on whether areas of agglomeration or high industry specialization constitute supportive prone-to-innovation environments for the generation of radical innovation. By drawing on the CIS distinction between incremental vs radical innovation, we disentangle the effect of industry specialization on the occurrence of radical innovations, a phenomenon mostly overlooked. By analysing a large dataset of 3,602 firms from CIS and other geographic datasets, results show that a firm's location in high industry specialization areas primarily trims incremental but not radical innovation. Firms' internal knowledge bases do matter more for radical innovation to occur, rather than location in agglomerations. External knowledge available in regions of high industry specialization is redundant for improving a firm's internal knowledge base for radical innovation and it is more likely to merely enable incremental innovation.

1. Introduction

Radical innovation accounts for substantial changes in a firm's knowledge, being usually new-to-the-market and offering new benefits to customers (Gatignon, Tushman, Smith & Anderson, 2002). While, the antecedents of radical innovation are researched from many management perspectives (e.g. Bouncken, Fredrich, Ritala & Kraus, 2018; Flor, Cooper & Oltra, 2018; Fores & Camisón, 2016; Roper & Hewitt-Dundas, 2017; Zhou & Li, 2012), their geographic dimension is not. This study focuses on this specific phenomenon, intersecting innovation management and economic geography strands, assuming the core importance of location as a strategic dimension of firms (e.g. Alcacer & Chung, 2014).

In this line of thought, this article investigates whether geographic concentration of companies, i.e. location in agglomerations, exerts incremental or radical innovations upon agglomerated firms, an under-researched topic. Despite abundant research on agglomeration and firm performance, management literature (e.g. Lee, 2018; Crescenzi & Gagliardi, 2018; Pinkse, Vernay & D'Ippolito, 2018; McCann and Folta, 2011; Bell, 2005) overlooks this phenomenon. Most studies measuring agglomeration and radical innovation are theoretical (e.g. Gilbert, 2012; Hervas-Oliver, 2016) and the ones addressing that relationship address one single industry (García-Villaverde, Elche, Martínez-Pérez & Ruiz-Hortega, 2017) or just a single cluster (e.g. Hervas-Oliver, Albors-Garrigos, Estelles-Miguel & Boronat-Moll, 2018; Ostergaard & Park, 2015, Isaksen, 2018). Overall, we lack generalizable studies using large-scale datasets to disentangle whether a firm's location in agglomerations promotes either incremental or radical innovation. This present study fills this gap by developing a capability-based theoretical framework aimed at deciphering and understanding the particular type of knowledge and innovation generated in agglomerations, using firm-level heterogeneity and capabilities as drivers of innovation in agglomerations (e.g. Hervas-Oliver & Albors-Garrigos, 2009) and then testing it over a large-scale dataset (3602 firms) that is made up of firms in multiple agglomerations (locations) of different industries.

This study is novel because literature for agglomerations and performance has analyzed innovation as a global construct that does not differentiate between radical innovation and incremental innovation. In this study, *industry specialization* is the type of agglomeration

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measure utilized, defined as areas that show a high concentration of a given industry in terms of relative (own) employment, occurring when a firm locates in a high own-employment region. In some studies those agglomerations are similar to clusters or industrial districts.[1] We address this gap at the firm level.

Our argument is as follows. Radical innovation is conceptualized as substantial changes in technology (e.g. Gatignon et al., 2002) and assumes important changes in a firm's knowledge, offering new benefits to existent or new markets and customers (Zhou, Yim & Tse, 2005). Radical innovations require new insight that is technology-distant to a firm's core technology and capabilities (e.g. Vanhaverbeke & Cloodt, 2014) and, therefore, it needs to access technology-distant knowledge (e.g. Flor et al., 2018; Green, Gavin & Aiman-Smith, 1995). Are agglomerations the right place to find that technology-distant knowledge for radical innovation occurs? We posit that in areas of high industry specialization, existing local networks and their lock-in knowledge might hinder the ability of located firms to spur radical innovation but encourage incremental innovation. High industry specialization areas present spatially-bounded knowledge primarily generated from recombining existing lock-in technologies. Agglomerated firms, also tend to over-search locally, avoiding boundary-spanning and technology-distant knowledge searching, constraining the development of radical innovation in clusters. The latter are claimed to be fundamentally supporting incremental innovation instead (García-Villaverde et al., 2017; Glasmeier, 1991; Rowley, Behrens & Krackhardt, 2000).

In addition, our argument sustains that, following Flor et al. (2018), the generation of radical innovation is primarily a function of a firm's internal capabilities and absorptive capacity (e.g. Barney, 1991; Cohen & Levinthal, 1990). We posit that radical innovation more likely originates from a firm's own absorptive capacity and internal knowledge, rather than from accessing to external boundary-spatial sources in agglomerations. The reason is based on the fact that the latter might present too technology-related and lock-in existing paradigms, becoming redundant for radical innovation to occur but promoting incremental innovation instead.

As regards utilizing CIS data, to the best of our knowledge, there is no study using a large-scale database focusing on understanding the relationship between a firm's location in areas of high industry specialization and the occurrence of radical innovation. This study utilizes data from the Spanish Community of Innovation Survey and information on industry specialization agglomeration in regions provided by the Spanish Statistical Office (INE). Thus, we test our model on 3602 Spanish firms from 2006, breaking down their locations and controlling for high industry specialization areas through location quotient coefficients in Spanish regions at 3 digit NACE codes. In doing so, we are responding to the following research question: are high industry specialization areas enabling incremental or radical innovation?

Our results indicate that, in general, high industry specialization does not enable radical innovation and that a prone-to-innovation environment proves very positive for new-to-the-firm incremental or imitative innovation to occur: in these settings, external knowledge negatively moderates a firm's internal knowledge base relationship to radical innovation. In other words, agglomerations (i.e. high industry specialization) exert innovation which is primarily incremental. These results contribute to extant literature on agglomerations (e.g. Acs, Braunerhjelm, Audretsch & Carlsson, 2009; Audretsch & Lehmann, 2005; Crescenzi & Gagliardi, 2018; García-Villaverde et al., 2017; Hervás-Oliver, Parrilli, Rodríguez-Pose & Sempere-Ripoll, 2021; Pinkse et al., 2018) and radical innovation (e.g. Bouncken et al., 2018; Flor et al., 2018).

This study contributes by adding a geographical dimension perspective on the antecedents of radical innovation, complementing extant studies (Flor et al., 2018; Fores & Camisón, 2016; Roper & Hewitt-Dundas, 2017) on the antecedents of absorptive capacity and open innovation strategies for radical innovation (e.g. Chesbrough, 2003). These insights open up new research avenues for understanding openness and capabilities (Alexy, West, Klapper & Reitzig, 2018) and specific types of innovation outcomes. Peripherally, insights are also added to introduce the geographical dimension in the coopetition model (e.g. Bouncken et al., 2018; Ritala, 2012) that also evidence the fact that coopetition and, specifically alliances with competitors, lead primarily to incremental rather than radical innovation.

The following section details the conceptual framework of our study and the stated hypothesis. Then, in the third section, we elaborate on our data and our empirical design. In the fourth section, the results are presented. Finally, conclusions are developed and some areas for future research are discussed.

2. Theoretical framework

2.1-Internal and external sources of knowledge for radical innovation

The resource-based view of firms (e.g. Barney, 1991) and also the dynamic capabilities perspective (Teece, Pisano & Shuen, 1997) posit that a firm's unique capabilities influence its performance. These capabilities are built up by developing internal sources of knowledge and sourcing external ones that are accessed and recombined (Kogut & Zander, 1992). Thus, innovation stems from unique and better (than competitors') capabilities that are effectively deployed into organizational routines (Nelson & Winter, 1982), activities and other processes. These unique internal capabilities are also related to and constitute, especially through the R&D function, the concept of *absorptive capacity* (Cohen & Levinthal, 1990) which is defined as "the ability of a firm to recognize the value of new external information, assimilate it and apply it to commercial ends" (pg. 128). Firms with a better internal knowledge base present greater absorptive capacity that facilitates benefiting more from the presence of external knowledge flows. This absorptive capacity is constituted and driven by a firms' internal knowledge base.

Radical innovations present substantial departures from existing practices, incorporating new knowledge about new markets and technologies. The comprehensive new knowledge that radical innovation requires is usually technology distant from firms' existing knowledge and presents the challenge to access larger technological distances not directly related to their core technology (e.g. Vanhaverbeke & Cloodt, 2014; Zhou et al., 2005). Evidence suggests that a firm's internal knowledge base stimulates a firm's radical innovation (e.g. Camisón & Fores, 2016; Chesbrough, 2003; Datta & Jessup, 2013; Flor et al., 2018; Gupta, Smith & Shalley, 2006; Laursen & Salter, 2006; Singh & Fleming, 2010; Zhou & Li, 2012; Chiang & Hung;, 2010). Radical innovations comprehend a substantial gap from existing knowledge and products (e.g. Abernathy & Clark, 1985; Gatignon et al., 2002), requiring technology-distant knowledge, the latter being a direct function of a firms' absorptive capacity. A positive relationship between absorptive capacity, search strategies and radical innovation is in evidence, a firm's internal capabilities being the fundamental asset to generate radical innovation (Flor et al., 2018). Similarly, as Bouncken et al. (2018) indicate, for radical innovation to occur, what is required is a strong firm's knowledge base that generates the necessary creativity and diversity, reducing also potential excessive uncertainties existing with radical innovations, especially from partnerships. These uncertainties might produce important tensions for new knowledge generation from cooperation agreements (e.g. Ritala, 2012) and appropriability (Bouncken et al., 2018; Laursen & Salter, 2014) that drive firms to internally generate knowledge, thus

[1] See Boix and Galleto (2009)

reducing partners' opportunism. In this line of thought, it is empirically evidenced that radical innovation is essentially based on a firm's internal knowledge base and depends less on external knowledge, albeit the latter must be technology-distant, as explained below.

Therefore, our first hypothesis is stated as follows:

H1: The greater the firm's internal knowledge base, the higher its radical innovation performance.

2.2. The geography of radical innovation

The crucial point is this: is technology-distant knowledge for radical innovation to occur present in those high industry specialization areas or clusters? The Marshallian view of agglomeration economies shows how location in agglomerations provides access to reduction of production costs, access to specialized inputs and suppliers and learning (e.g. Audretsch & Feldman, 1996; Feldman, 1994; Glaeser, Kallal, Scheinkman & Shleifer, 1992; Porter, 1990). Overall, high industry specialization constitutes a knowledge-rich environment that enables focal-industry located firms to innovate through interactive and systemic networks that produce external (to-the-firm) knowledge and improve performance (e.g. Belussi & Sedita, 2009; Glaeser et al., 1992; Saxenian, 1991). New knowledge is generated through a cumulative and network-based process. This externally (to the firm) generated knowledge, in no small part, comes from inter-firm and inter-personal interactions that are spatially-bounded and complement a located firm's internal knowledge base.

In agglomerations, located firms proactively seek to access opportunities by seeking external knowledge and thus benefiting from the positive combination of external and internal sources of knowledge. In high industry specialization areas, firms' search strategies to access external knowledge, however, are usually delimited to the existing lock-in and local available incumbent technologies and industries that do not promote nor facilitate the entrance of new ideas but potentially promote cognitive inertia, making local and existent technological paradigms permanent and difficult to change (Grabher, 1993; Martin & Sunley, 2006; Sull, 2001).

High industry specialization areas, therefore, are turned into spaces where creative destruction occurs with difficulty and they are fundamentally restricted to continuous or incremental innovation instead. The excessive focus on access to existing local focal-industry knowledge brings lock-in and prevents change from taking place (Glasmeier, 1991; Hervas-Oliver & Albors-Garrigos, 2014; Isaksen, Tödtling & Trippl, 2018; Martin & Sunley, 2006; Pouder & St. John, 1996; Sull, 2001). Since geographic proximity means repetitive and intense interactions among local firms, high industry specialization areas present ample opportunities for learning and imitating to other cluster firms (Bell & Zaheer, 2007). These learning, lock-in existing technologies and paradigms, may bias cluster firms' decisions and trigger inertia (Sull, 2001). As such, the latter is not easily generated but rather slowed or dodged because for radical innovation to occur, technology-distant to the local knowledge domain or knowledge from other industries is necessary (Gilbert, 2012:738; Rosenkopf & Nerkar, 2001). Therefore, we expect that a firm's location in high-own industry specialization areas enables the introduction of incremental innovation but does not facilitate the occurrence of radical innovation that demands technology-distinct and beyond local knowledge. Thus, the second hypothesis is stated as follows:

Hypothesis 2: A firm's location in a high industry specialization region is not related to radical innovation.

Accessing and using knowledge from external sources improves a firm's internal knowledge base by bringing new ideas and knowledge that positively impact new product development. A broad range of external sources of knowledge can enrich and expand a firm's internal knowledge base and thus stimulate a firm's innovation, although external sources *per se* do not drive radical innovation; for radical innovation to occur, those external sources are usually technology-distant and from new industries and are recombined with extant knowledge (e.g. Datta & Jessup, 2013; Flor et al., 2018; Green et al., 1995), otherwise they could be redundant. As such, we posit that when a firm locates in a high industry specialization region, then the locally available external knowledge accessed would not generate radical innovation. In other words, local and highly specialized networks become quite duplicative, hindering the ability to spur radical innovation. Thus, hypothesis 3a is stated as follows:

Hypothesis 3a: In high industry specialization regions external knowledge is not related to radical innovation.

Following the dynamic capabilities and the RBV (Teece, 2020; Teece et al., 1997), the combination of internal and external sources of knowledge form internal capabilities built upon synergistic and complex interrelationships difficult to imitate, contributing thus to improving a firm's innovation outcome (e.g. Stieglitz & Heine, 2007). This complex integration of internal and external sources of knowledge builds capabilities, producing an inimitable system whereby they improve one another (e.g. Rivkin, 2000) and positively influence innovation (Cassiman & Veugelers, 2006). That combination achieves new reconfigurations and integrations of distinct capabilities in a unique way that can increase the returns from innovation, creating the construction of a consistent system of interrelated activities and capabilities which mutually reinforce one another (Porter, 1996; Siggelkow, 2001; Teece et al., 1997) and that facilitate innovation (e.g. Cassiman & Veugelers, 2006; Hervas-Oliver, Luis, Garrigos & Gil-Pechuan, 2011), a fact proved in the geography of innovation strand (e.g. Pinkse et al., 2018), albeit not referring to radical changes.

As mentioned above, we posit that spatially-bounded lock-in existing technology is redundant for nurturing a firm's internal knowledge base for radical innovation: in high industry specialization areas firms' internal knowledge substitutes the external, as the latter is too embedded in the local context, does not generate sufficient novelty and therefore is not related to radical innovation.

This study, therefore, expects that a firm's location in a high industry specialization region enables a negative combination (substitution effect) of internal and external sources of knowledge on radical innovation. Interestingly, we are not claiming that radical innovation is not developed by agglomerated firms. On the contrary, we point out that agglomeration does not exert that effect but rather sustains incremental innovation. Agglomerated or cluster firms achieving radical innovation, therefore, would be based on a firm's own internal knowledge and boundary-spanning external unavailability in its focal agglomeration.

Thus, hypothesis 3b is stated as follows:

Hypothesis 3b: In high industry specialization regions a firm's internal knowledge base substitutes external knowledge for radical innovation to occur.

3. Empirical design

3.1. Data sources

This study utilizes firm-level and regional variables from two different databases. The firm-level data comes from the Spanish CIS 2006 that is based on the Community Innovation Survey, a standard core questionnaire developed by the European Commission (Eurostat) and Member States to ensure international comparability. CIS data offers a direct measure of success in commercializing innovations for a broad range of industries that other sources of information do not capture (Leiponen & Helfat, 2010). Firms are asked about the type of innovation introduced over the three-year period covered by the survey and the specific innovation activities carried out in the same period (innovation effects, expenditure, hampering factors, among many others), all of them associated with the innovation process. A key strength of CIS is that it collects data from a very large sample of firms, representative of all manufacturing and service industries across Europe, following the Oslo Manual (2018). There are many papers using CIS data (e.g. Laursen & Salter, 2006; Leiponen & Helfat, 2010) to measure firms' innovation processes.

As regards the agglomeration construct, the geographic data comes from the INE (Spanish Institute of Statistics, from the Ministry of Economics). The combination of both databases at the micro-level allows the testing of our hypothesis. The specific source is the *Census* of firms, which is presented using NACE-93 industry classification for each region (Spain comprises 17 regions). The location quotient (LQ variable, expressing whether there are agglomerations for a firm's location in a high-industry specialization region) is defined as LQ = (Lij/Li)/(Lj/L) where Lij is the number of jobs in the industry i in a region j, Li is the total number of jobs in the industry i in the country, Lj is the number of jobs in a region j, and L is the total number of jobs in the country. If the LQ is more than 1 the region is more specialized in an industry than the country's average and so we would conclude that such an industry benefits from Marshallian localization economies (Bergman & Feser, 1999; Porter, 2003). Then we cross both databases to match a firm's location and its LQs. More information available upon request.[2] Additionally, for the sake of regional control, we also include regional and industry dummies.

3.2. Samples and variables

3.2.1. Samples

Our empirical analysis covers the effects of introducing innovative activities by 3602 firms that indicated the introduction of product innovation, being new-to-the-firm and/or radical (new-to-the-market[3]). As stated by Roper and Hewitt-Dundas (2017), the use *new-to-the-market* innovative product works as a proxy for radical innovation, similar to what Kepataniou & Lee (2018) do using CIS data.

In the full sample 3602 firms introduced product innovations, that is, they are all innovators. From this figure, we observed three groups: (i) those firms solely introducing incremental innovations (1661); (ii) firms having introduced only radical innovations (819); (iii) and, firms having introduced both simultaneously (1122). Our focus is mainly devoted to understanding those introducing radical innovations (binary variable, through a logit); the baseline of the dependent variable constitutes those that solely introduce incremental innovations (incremental innovation, binary variable). From the original dataset of 3602 we develop 4 samples, explained below. See table 1.

The first sub-sample (Sample 1) consists of 2480 firms, presenting 819 (solely) radical innovators and 1661 incremental innovators (baseline). Then, zooming into high industry specialization areas, the second sub-sample (Sample 2) consists of 1663 firms located in regions where location quotient (LQ) is higher than 1, which is the assumption for existing high industry specialization effects. Regional literature has usually recommended setting the cut-off point at 1 value (e.g. Bergman & Feser, 1999), even though this is just a convention utilized in most studies, although we also use the variable itself.

Sample 2 presents 545 (solely) radical and 1122 incremental innovators in those high-industry specialization areas (variable LQ >1). The core sample is Sample 2, although we use Sample 1 as baseline. Samples 1 and 2 are treated econometrically by using radical innovators as phenomena of occurrence and incremental ones as a baseline in logit analysis (see below). Samples 3 and 4, in Appendix I for robustness checks, follow the same pattern (all those firms that innovate simultaneously in radical and incremental, Sample 3, and those that innovating simultaneously are located in agglomerations, that is, LQ>1, Sample 4).

Table 1
Description of the sample of Spanish firms in the CIS data.

Decision	All firms	LQ>1
Only new-to-the-market (radical)	819	545
Only new-to-the-firm (incremental)	1661	1122
Subtotal (first Sample and second sample)	**2480**	**1663**
New-to-the-market and new-to-the-firm simultaneously (in Appendix I)	1122	754
Total	**3602**	**2417**

Source: own; LQ>1 means high industry specialization regions;.
Appendix I: Sample 3 is amounting 2783 (1122+1661); Sample 4 is 1299 (754+545).

3.2.2. Variables

The variable *Knowledge* captures a firm's internal resources of knowledge. The latter is the knowledge base or innovation capability. In constructing this variable, following Hervas-Oliver et al. (2018), a factor analysis is used that includes R&D internal expenditure, and the percentage of human resources devoted to R&D in relation to total employees.[4] The resulting scores from a principal component analysis (PCA) represent the absorptive capacities, generating a single component (explaining 58.3%; KMO = 0.75, p<0.01). *Search* variables, ranging from 0-to-3 (none to high), as in Laursen & Salter, 2006, capture external sources of knowledge from the value-chain,[5] *suppliers, customers and competitors*. As usual in such analyses, we include control variables, such as Size, measured as the total number of employees, *Industry* classification, measured using 2-digit NACE-93 industry classification as dummies, and also the OECD's classification of low-, medium- and high technology intensive industries.

4. Results

Table 2 shows the descriptive statistics and correlation matrix. See table 2.

As our dependent variable (*radical innovation,* as phenomenon of occurrence) is binary, our econometric specifications follow a *logit* model. We use Sample 1 as a baseline and for controlling H2. This is done in Specification 1 where results from logit analysis testing the introduction of solely radical (819 firms) versus incremental (1661 firms) are presented. This first specification includes N = 2480.

Then, for the purpose of testing interaction from hypothesis H2 and H3ab it is also necessary to utilize Sample 2 (1663 firms), referring to those collocated in relatively high industry specialization regions (LQ>1; N = 1663; where 1122 introduce radical and 549 introduce incremental). Results are presented in Specification 2. As commented, we exclude in this analysis firms that introduce simultaneously both innovations, treating this subsample in Appendix I for robustness checks, Samples 3 and 4.

Clearly, in table 3 (Specification 1) a negative effect of LQs is shown on the dependent variable (radical), albeit significant at p<0.1 in Specification 1, clearly indicating the negative effect of industry specialization on incremental innovation (Sample 1, −0.0032, p<0.1). This result indicates that location (LQ) and its effects is not related to radical innovation, but diminishes it, showing a negative relationship and anticipating H2. As observed, H1 is supported, as it is clearly a strong positive relationship (0.491, p<0.01) with radical innovation from a firm's internal knowledge bases, even without controlling by location, as we do in Sample 2. Then, in Sample 2, it grows stronger (0.746, p<0.01), therefore, in agglomerations it also strongly leads to

[2] CIS data shows the region where a firm locates when it undertakes R&D expenditure. This offers location and its industry NACE, both combined, are assigned to a specific LQ value.

[3] The CIS (Community of Innovation Survey) defines it as a *significant impact on a market and on the economic activity of firms in that market* (OECD, 2005:58), as opposed to incremental innovation or new-to-the-firm innovation.

[4] Also, as Escribano et al., (2009) do.

[5] In a similar way to Laursen and Salter (2006), we create a composite indicator that ranges from 0-to-1 (low-to-high), by adding the external variables as 1 when the firm gets the higher value in the original dataset (3) and scoring 0, otherwise.

Table 2
Descriptive statistics and correlation matrix.

		Mean	SD	MIN	MAX	1	2	3	4	5	7	8
1	Size	3.664	0.014	3636	3692	1.0						
2	Med_tech	0.503	0.006	0.491	0.515	0.102*	1.0					
3	High_tech	0.111	0.004	0.103	0.118	−0.137*	−0.348*	1.0				
4	LQ	1869	0.024	1821	1916	0.129*	0.061*	−0.048*	1.0			
5	*Knowledge*	−0.004	0.012	−0.028	0.019	−0.363*	−0.085*	0.251*	−0.035*	1.0		
6	Search	0.629	0.010	0.608	0.649	0.055*	0.031*	−0.009	0.031*	−0.014	1.0	
7	Incremental innovation	0.539	0.006	0.525	0.549	0.199*	0.164*	0.013	0.050*	−0.018	0.152*	1.0
8	Radical innovation	0.289	0.005	0.278	0.300	0.130*	0.095*	0.039*	0.016	0.034*	0.131*	0.595*

* $P<0.01$.

radical innovation. These results indicate that firm heterogeneity matters for radical innovation to occur and a firm's internal knowledge base (*Knowledge* variable) is positively related to radical innovation. This partially supports H1. Similarly, the location effect (LQ −0.004, $p<0.1$) continues to be negative when a firm is located in a high industry specialization area, corroborating H2. See Table 3.

Then, at Sample 1, (Specification 1 in table 3), individual effects for *Search* variables are positive and significantly related to the introduction of radical innovation product (0.0977, at $p<0.05$, Specification 1). Then, in Specification 2 (Sample 2), we observe how the external sources variable is not significant (0.0881, $p>0.1$), indicating that external sources from agglomerations are not linked to radical innovation, validating H3a. Overall, these results strongly support H1, H2 and H3a and connect a firm's internal knowledge base to radical innovation and point out how location in agglomerations is not linked to radical innovation, nor its external knowledge sources.

In addition, at Specification 2, Sample 2, (table 3), we test the interaction effects signaled in hypothesis 3b for high regional industry specialization (LQ>1; 1663; Specification 2). Focusing on Specification 2, we observe a negative (substitution) effect between the internal capabilities and external knowledge (*Knowledge X Search*) combination and the introduction of new-to-the-market innovation (relatively high industry specialization, LQ>1; −0.299 at $p<0.01$), pointing out that a firm's location in a relatively high own-industry employment region does not enable the generation of new-to-the-market innovation. These results strengthen the above findings related to the fact that industry specialization does not positively relate to the occurrence of radical changes, totally in line with hypothesis 3b.

Specifically, the result from the interaction in Specification 2, Table 3, confirms hypothesis 3b about the fact that when a firm locates in a relatively high industry specialization region (LQ>1), then the combination of internal and external sources of knowledge negatively impact on a firm's radical innovation, vis-à-vis incremental innovation. In other words, firms located in high industry specialization regions that attempt to introduce new-to-the-market innovation tend to answer by increasing the development of internal capabilities and knowledge and reducing the access to external knowledge. Thus, the effect of internal capabilities on new-to-the-market innovation increases where the access to external knowledge decreases, suggesting a substitution between the two sources of knowledge. This is due to the fact that, in no small part, external, available knowledge is locked-in existing focal industry technology but does not incorporate pieces of technology-distant or different focal industry knowledge to be recombined in a sufficiently novel way to generate radical innovations.

As regards control variables, both Regions and Industry variables[6] present effects of variation, in relationship with discontinuous innovation, while Size shows a positive relationship with the dependent variable, indicating the influence of size and its related resources, which are necessary for the introduction of discontinuous innovation.

Overall, regressions show that agglomerations do not exert radical innovation (H2, Specification 1 from Sample 1 and Specification 2 from Sample 2). Rather, when controlling for location in high industry specialization regions (Sample 2, Specification 2), then only internal knowledge bases matter for radical innovation to occur but not for external knowledge to be available (H1 and H3a). In addition, location in high industry specialization regions (Sample 2, Specification 2) indicate that internal knowledge substitutes for external knowledge (substitution effect or negative interaction) for radical innovation to occur (H3b). Put differently, the external knowledge from agglomerations does not positively influence a firm's internal knowledge base for radical innovation.

These insights show that agglomerated firms might present spatially-bounded biased access to new ideas or flows of knowledge because of over-search within their respective agglomerations, obstructing the generation of sufficient novelty for radical innovation

Table 3
Logistic regression measuring the likelihood of introducing *radical* versus *incremental* innovation in relatively high-industry specialization. .

Solely radical (819) versus solely *incremental* innovation (baseline) (1661) (Yes=1; No=0); *N* = 2480 Sample 1 and Sample 2 (LQ>1, 1663)		
Samples	All firms, baseline (Sample 1)	High Industry Specialization Regions (agglomerations) Sample 2
Specifications	Specification 1	Specification 2
Intercept	−0.648**	−0.859**
	(0.278)	(0.340)
LQs	−0.00323*	−0.00425*
	(−0.00148)	(−0.00137)
Size	0.0177	0.0457
	(0.0448)	(0.0532)
Knowledge	0.491***	0.746***
	(0.0859)	(0.148)
Search	0.0977**	0.0881
	(0.0491)	(0.0600)
Knowledge X *Search*		−0.299***
		(0.104)
Regions	YES	YES
Industry	YES	YES
Lr Chi-Squared	81.01***	49.13***
Log-Likelihood	−1532.6	−494.9
N	2480	1663

Dependent variable from Sample 1 (0) incremental innovation (1661 firms), (1) radical innovation (819 firms); Dependent variable from Sample 2, 1663 firms.

*** $p<0.01$;.

** $p<0.05$;.

* $p<0.1$; Industry: including industry 2-digit NACE dummies. OECD's classification of low-, medium- and high technology intensive industries, show the same results (YES), using low-tech as baseline.

[6] Industry dummies and OECD classification into low-, medium-, and high-technology intensity. Both present similar results.

to occur. The rationale is based on the fact that agglomerated companies share the same expectations, routines, mental models and even knowledge bases that might restrict distinct responses to the environment to develop radical innovations (Berman, Down & Hill, 2002; García-Villaverde et al., 2017; Pouder & St. John, 1996; Walter, Lechner & Kellermanns, 2007). As a consequence, for radical innovation to occur, those external sources are usually technology-distant and from new industries and are recombined with extant knowledge (e.g. Datta & Jessup, 2013; Flor et al., 2018; Green et al., 1995), being unavailable in focal agglomerations (García-Villaverde et al., 2017). Therefore, for radical innovation to occur, what is required is a strong firm's knowledge base that generates the necessary creativity and diversity (Bouncken et al., 2018), which is not usually found among competitors (Ritala, 2012) and especially not local ones (García-Villaverde et al., 2017).

4.1. Robustness checks

Lastly, in Table A-1 (see Appendix I) we check the results this time by using Sample 3 (N = 2783), taking the dependent variable as the value of 1 when a firm *simultaneously* introduces both radical and incremental (1122 firms) innovations, versus taking value 0 when a firm is introducing only incremental innovation (1661 firms). In doing so, we test different ways of introducing radical innovation. Hypotheses are double checked and confirmed. For the sake of brevity and limited space in the article, additional figures of interactions plus explanations are available upon request. See Table A-1 in Appendix I for more details.

5. Conclusions

This article attempts to answer the following question: are high industry specialization areas (i.e. agglomerations) enabling incremental or radical innovation? Using CIS data for Spain (3602 firms) and other geographical datasets, our findings suggest a negative response to the research question.

Overall, we confirm the four stated hypotheses, producing the following insights. First, our results suggest that a (H1a) firm's internal capabilities do matter more for radical innovation to occur, vis-à-vis industry specialization effects, emphasizing the role of internal capabilities for radical changes (e.g. Datta & Jessup, 2013; Flor et al., 2018; Singh & Fleming, 2010), especially in high industry specialization areas (García-Villaverde et al., 2017). Therefore, high industry specialization areas primarily foster incremental and not radical innovation. Second, our results show that (H2) a firm's location in a relatively highly industrial specialized region negatively moderates and constrains the generation of radical innovation. Third, that available external knowledge generated in a high industry specialization region is lock-in existing technology and it turns out to be redundant for radical purposes (H3a). Fourth, (H3b) by introducing radical innovation in regions of high industry specialization, firms increase the development of internal capabilities and decrease the access to external knowledge, due to the fact that existing external knowledge is lock-in existing technology and paradigms (e.g. Gilbert, 2012). The negative (substitution) effect of the combination of internal and external sources of knowledge on introducing radical innovation suggest that in those specialization environments available external knowledge does not complement a firm's internal knowledge to generate radical innovation.

Overall, our study evidences that a firm's internal knowledge and capabilities exert an influence on radical innovation and that the agglomeration effects primarily drive incremental innovation. These conclusions are in line with the RBV and the dynamic capabilities perspective that point out that a firm's performance is based on its unique combination of internal capabilities. In contrast, for radical innovation to occur, non-local and technology-distant knowledge, unavailable in local lock-in repetitive interactions, is necessary (e.g. Bell & Zaheer, 2007; Flor et al., 2018; Gilbert, 2012; Green et al., 1995; Nieto & Santamaria, 2007; Ritala & Sainio, 2014). It should be noticed, however, that we do not rule out the generation of radical innovation by firms in regions of high industry specialization. Indeed, some firms introduce radical innovations. What we are pointing out is the fact that, in general, industry specialization is more likely to facilitate the generation of incremental and imitative knowledge that is based on existent lock-in technologies. In short, for radical innovation to occur, firms' internal capabilities matter, beyond regional effects from location.

In addition, these results reinforce extant literature on agglomerations and firm performance evidence about the fact that agglomeration supports innovation (e.g. Acs et al., 2009; Crescenzi & Gagliardi, 2018; Pinkse et al., 2018), albeit adding a new insight: internal knowledge bases matter more than spatially-bounded knowledge from agglomerations for radical innovation to occur, complementing the scarce literature on the phenomenon (e.g. García-Villaverde et al., 2017).

Our study presents implications for scholars, managers and policymakers. For scholars, our insight complements research on antecedents of radical innovation (Flor et al., 2018; Fores & Camisón, 2016; Roper & Hewitt-Dundas, 2017), adding a moderator to the existing model of internal and external sources of knowledge: a geographic dimension and its associated effects. Also, our results directly intersect the ongoing debate on the combination of internal and external sources of knowledge and open innovation (e.g. Cassiman & Veugelers, 2006; Laursen & Salter, 2014). In particular, our insight contributes to the antecedents of absorptive capacity and open innovation strategies (e.g. Flor et al., 2018) for radical innovation, by adding *geographical constraints* to a firm's search strategies. As firms build advantage by developing superior capabilities following the RBV (e.g., Barney & Arikan, 2001; Nelson & Winter, 1982; Rumelt, 1984), such capabilities, however, require the development of search strategies that are not constrained nor limited to agglomerations. In fact, what is necessary is access to technology-distant and boundary-spanning knowledge for radical innovation to occur. Capabilities, therefore, built from existing knowledge in agglomerations, will improve a firm's advantage, enticing incremental innovation but not radical innovation. In this chain of thought, search strategies and open innovation (e.g. Chesbrough, 2003) should be considered for the type of innovation to be accomplished and the specific capabilities enticing that innovation outcome. Scholars thus need to incorporate for competitive advantage building whether their search strategies and their associated geography (spatially-bounded or not) and technology-distance (to a firm's existing resources and technologies) are aimed at producing different types of innovation outcomes. This insight opens a new research avenue for understanding openness and capabilities (Alexy et al., 2018) and specific types of innovation.

Similarly, for scholars, it is important to consider geographic or spatially-bounded external knowledge for the alliances and cooperation with competitors, that is, coopetition (e.g. Bouncken et al., 2018; Ritala, 2012), introducing the geographic dimension in the coopetition model that also evidences the fact that coopetition leads to primarily incremental rather than radical innovation.

Following on from the above implications for scholars, managers need to understand i) the dimension of geography influencing their search strategies or open innovation, where they source knowledge from, and ii) how important location is, as a strategic dimension of firms (e.g. Alcacer & Chung, 2014). Both points might favor or constrain certain types of innovation in a firm's portfolio of innovation projects. In particular, managers should be aware of the fact that agglomerations and clusters may bias managers' mental models, due to the excessive focus and attention paid to the local competitors and the higher propensity that firms suffer in cluster by mimicking (local) competitors' strategies: location in regions of relatively high industry specialization does promote incremental or continuous innovation embedded into existent lock-in knowledge and paradigms, but it does not enable radicalness. Search strategies for external knowledge, therefore, should be organized accordingly: radical innovation requires technology-distant and non-local available knowledge, going beyond the focal agglomeration realm.

Lastly, policymakers need to implement this insight into their policy making process, paying attention to the type of cooperation promoted when launching inter-firm joint research collaboration incentives. In general, policy making should promote boundary-spanning openness or firms' search strategies to access to non-local/regional knowledge, fighting against potential inertia and lock-in problems due to excessive interactions, lock-in local clusters and agglomerations, promoting branching out (e.g. Tanner et al., 2014).

Specifically, the partner formation in alliances should be aimed at going beyond competitors (e.g. Ratila, 2012) and also especially those *spatially-bounded* ones within a firm's location.

Our study has some limitations. First of all, this study is based on cross-sectional data, due to CIS anonymity. Secondly, this study also is limited because of the dependent variables covering the construct of innovation, following CIS definitions. Third, the study is also limited to the Spanish context, the latter very rich in localization externalities and an industry composition biased toward low and low-medium technology intensive industries, especially traditional industries. Fourth, some special clusters, such as Silicon Valley, may not follow the rule posited in this study. For future studies, the same hypotheses need to be tested in other countries using CIS data and using different variables and data sources in order to triangulate results.

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Appendix I

Appendix I: Sample 3 amounts to 2783 (1122+1661); Sample 4 is 1299 (754+545).

In table A-1, we check results by changing the sample and the dependent variable, taking the value of 1 when a firm *simultaneously* introduces both radical and incremental (1122 firms) innovations, versus taking the value 0 when a firm introduces only incremental innovation (1661 firms); this is Sample 3. Then, Sample 4 is the same but only for firms located in LQ>1. Overall, (Table 3 and robustness checks in Table A-1), we are contrasting types of innovators and the influence from locating in high industry specialization regions. In general, according to table A-1, we can see that the results fully coincide with those from Table 3, that is, the LQ variable is negative and significant (at $p<0.05$ in Specification 3) and the interaction effects from LQ>1 (Specification 4) are negative and statistically significant (−0.333 at $p<0.01$).

Table A-1. Logistic regression measuring the likelihood of introducing radical and incremental innovation *simultaneously* (1122) vs solely incremental (1661), in relatively high- (LQ>1) industry specialization. N = 2783 (Sample 3); Sample 4 is 1299

Samples	All firms, Sample 3	High industry specialization regions (agglomerations), Sample 4
Specification	3	4
Intercept	−1.788***	−1.798***
	(0.259)	(0.315)
LQs	−3.10e-06**	−3.50e-06**
	(1.40e-06)	(1.67e-06)
Size	0.307***	0.252***
	(0.0399)	(0.0480)
Knowledge	0.650***	0.893***
	(0.0845)	(0.150)
Search	0.143***	0.147***
	(0.0444)	(0.0534)
Knowledge X Search		**−0.333***
		(0.101)
Regions	YES	YES
Industry	YES	YES
Lr Chi-Squared	135.54	85.15
Log-Likelihood	−1808.7	−569.8
N	2783	1299

Dependent variable: (0) solely incremental innovation (1661 firms), (1) radical innovation and incremental simultaneously (1122); ***$p<0.01$; **$p<0.05$; $p<0.1$; Industry baseline: including industry 2-digit NACE dummies; Appendix I: Sample 3 amounts to 2783 (1122 +1661); Sample 4 is 1299 (754+545)

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