PAPER

Title: Technological innovation performance in clustered firms. The role of adoption of disruptive technological innovations

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Abstract:

This study aims to provide deep understanding about the factors behind the technological innovation performance of the firms belonging to industrial clusters. Based on data obtain from a survey carried out in the Spanish Ceramic tile cluster, this paper uses a configurational comparative method, namely fuzzy-set qualitative comparative analysis (FsQCA), to investigate to what extent the adoption of a disruptive innovation in connection with other firm's resources affects to the innovative results of clustered firms. Results show that, to be an early adopter of a disruptive technology or to have a strong absorptive capacity is a necessary condition for firm´s high innovation performance. Likewise, these two characteristics are key determinants for those firms being strong technological innovators.

Keywords: disruptive technological innovation; industrial clusters; technological innovation; technology adoption; clustered firms; fsQCA analysis.

JEL codes: O31, O32, O33

1. Introduction

Over the last decades, a lot of research has been devoted to innovation in territorial contexts like clusters and regions (Giuliani and Bell, 2005; Pouder and St. John, 1996; Sammarra, 2005). This fertile literature has contributed significantly to different topics, for instance, innovation was related recently to the territorial resilience (Bristow and Healy, 2018).

However, there are still some relevant unresolved or controversial issues, suggesting new directions of the research. Particularly in clusters, a mainstream in the previous literature suggested that they are better adapted for incremental changes and innovations than discontinuous ones (Becattini, 2001; Bellandi, 1996; Elche-Hortelano et al., 2015; Molina-Morales, 2002). In fact, disruptive innovations have rarely studied in these territorial contexts (to see some exceptions, (Hervás-Oliver et al., 2017; Molina-Morales et al., 2017; Reig-Otero et al., 2014). Against this background, in this paper, we are aiming to contribute to latter direction research by deepening in the implications of the disruptive technologies adoption by clustered firms. Thus, to contribute to the discussion, we address two specific questions, that is, what are the main effects of earlier adoption of disruptive technologies in terms of new products, services or processes and how the internal firm attributes can moderate these effects.

To develop this objective, we use a complex causality (Meyer et al., 1993) approach using the Qualitative Comparative Analysis (QCA) technique (Ragin and Davey, 2016; Ragin, 2008; Woodside, 2016). We applied it to a sample of 88 ceramic tile companies representing the 75% of the total population of independent tile manufacturing companies of the Spanish ceramic tile cluster. In this cluster a disruptive technology was introduced last decade affecting significantly the structure of the whole cluster and the individual companies' strategies and performances. The contribution of this paper is twofold. First, we advance in the understanding of the adoption of disruptive technologies in specific contexts, like the territorial clusters, and second, we contribute the cluster specific literature investigating the role of interactions between internal attributes and the speed of technology adoption.

2. Theoretical framework and propositions

Previous work on innovation literature has extensively analysed the disruptive innovation and other similar notions that were intended to capture the radical and discontinuous nature of some new technologies and innovations (Adner, 2002; Ansari et al., 2016; Bergek et al., 2013; Bower and Christensen, 1995; Charitou and Markides, 2002; C. Christensen, 1997; O'Reilly III and Tushman, 2016). We are aware that the emergence of several concepts addressing at similar notions makes confusing its correct identification and clear delimitation (Abernathy and Utterback, 1978; Bergek et al., 2013; Christensen and Raynor, 2003; Danneels, 2004; Gatignon et al., 2002; Hüsig et al., 2005). However, leaving aside the conceptual debate, in the context of our research, we are focused on technologies and innovations beyond incremental developments or little changes, implying the replacement of products and technologies by new ones that can be created or (in our case) adopted by companies. In this sense, disruptive changes can broaden and develop new markets and may disrupt existing market linkages (Adner and Zemsky, 2006; Christensen and Bower, 1996; Govindarajan and Kopalle, 2006; Slater and Narver, 1998). At that point, we adopted the suggestion made by Markides (2006) about the work by Christensen (1997) of distinguishing between radical innovation to refer to products and disruptive innovation for technologies. In conclusion for the cluster context and for the purpose if this paper, we define disruptive innovation as a technological change that incorporates new knowledge, resources or skills that makes obsolete the value of incumbent systems and technologies in the cluster.

Reviewing previous work on the innovation in clusters we found a dominant claim to consider that local characteristics in clusters, such as of intense relationships, trust, and other relational features, make clusters as a particularly appropriate space for circulation, absorption and modification of already existing knowledge and technologies (Nadvi and Halder, 2005). In the same vein, the notion of contextual knowledge that Becattini (2001) defined to be tacit and based on experience, benefits from the social and spatial context where it is generated. Consequently, it is difficult to be reproduced outside the original context and describes the bases of the learning process in clusters.

As a result of the aforementioned argument, apparently, due to this relational structure, clusters rarely alter the stock of knowledge in more than an incremental way (Humphrey and Schmitz, 2000). In fact, only internal mechanisms without looking beyond the boundaries of the cluster are critically viewed by some previous literature

(Lagendijk, 2002). For example, in a seminal work Glasmeier (1991) analysed the difficulties of Swiss watchmaking companies to face external technological radical changes, which involved the digital technology. In the same vein some other Italian failure cases have been reported in Lazerson and Lorenzoni (1999).

However, previous research is not conclusive since, against the above arguments, there are some counterexamples of cases showing both successful exploration and exploitation of disruptive technologies introduction in clusters (Saxenian, 1991). Moreover, although still in a marginal way, the ability of generating or adapting disruptive innovations in clusters has been addressed by several authors recently (Albors-Garrigos and Hervas-Oliver, 2014; Hervás-Oliver et al., 2017; Molina-Morales et al., 2017; Reig-Otero et al., 2014).

Since existing businesses show distinctive attributes, they vary in the way they respond to disruptive technologies. Indeed, some of them succeed improving their competitive position and others fail suffering negative consequences. The latter are, probably, better adapted to the previous technological regime (Bergek et al., 2013; Sull et al., 1997). An explanatory line of how companies differ in reacting to changes comes from their absorption capacity level (Cohen and Levinthal, 1990). In fact, these internal attributes of the firm have been found to be a determinants of firms' innovation performance (Cassiman and Veugelers, 2006; Leal-Rodríguez et al., 2014; Vega-Jurado et al., 2008).

To sum up, in spite of the limited attention paid by authors, disruptive innovation creation and adoption is possible in the cluster context. Moreover, the distinct internal attributes of clustered firms can affect significantly the implication of the new technologies.

2.1.Effects of the early adoption of disruptive technologies in clusters

Once the new disruptive technology is introduced, most of the previous work has focused on the determinants of success or failure of firms in an industry. It is said that incumbent firms vary in responding to changes. According to Tripsas (1997) factors such as the investment in developing the new technology; the technical capabilities; and the ability to appropriate the benefits of technological innovation through specialized complementary assets, are factors associated to success in the adoption of the new technology. Regarding failure, firm leaders in the previous technology may have difficulty retaining his position. Among other reasons, because of established organizational routines (Leonard-Barton, 1995), or the focus on current demand and the fear of losing the benefits offered by existing products (Adner and Zemsky, 2006; Burgelman, 1996; Christensen and Bower, 1996; Reinganum, 1983).

Disruptive technologies produce changes in technological trajectories that usually have windows of opportunity for all types of companies (including new or small ones) because in these moments of change previous advantages disappear (Markman and Waldron, 2014; Park and Lee, 2006). New technology frequently allows improve innovation in all dimensions. Regarding products, it is important to emphasize that, as described above, the new technology enhances properties of the manufactured products, as well as the product portfolios offered by the companies. Both the design performance and the development of new products have benefited enormously from this technological change. Similarly, a new technology could improve processes and offered services by reducing cost or time, enhancing quality, flexibility, etc. It can be expected that an early adoption of the disruptive technology enables new and important opportunities for clustered firms to improve their innovation performance.

In the context of cluster is particularly important for the clustered firms to be first in the adoption of a new technology due to the easy flow of knowledge and ideas inside the cluster network. Factors like intense exchange, emulation mechanisms and others among companies (Molina-Morales, 2002) make an earlier adoption of the new technology more valuable. We are aware of the difficulties involved in assessing innovation performance in such specific contexts. In cluster, there are several reasons why many companies do not use patents to protect their knowledge (Grant, 1996), so instead we followed the recommendation of authors such as Tushman and Nadler (1986) or Kim and Min (2015), who related innovation to new product, service or process creation in terms of business units.

Considering above arguments we expect that clustered firms that adopt first the new disruptive technology introduced in the cluster develop a higher innovation performance in all its dimensions. In the context of the fsQCA analysis, we can express that being early adopter may be considered a sufficient condition related with the outcome (to have a high innovation performance). Consequently, this condition will be present in the logical combinations of factors leading to the outcome. We have expressed in a more formal way this proposition.

Proposition 1: Configurations including the condition of being an early adopter of the disruptive technology are path to strong technological innovation.

2.2. Effects of internal attributes on innovation performance of the clustered firms

In cluster literature, authors argued that clustered firms benefit accessing a series of resources and capacities at cluster level which are not exclusive of an individual organization, and what have been identified as higher-order resources and capabilities (Foss, 1996).

Moreover, clusters have specific mechanisms to identify changes of the external environment, and to facilitate access to new ideas or new opportunities. On the other hand, apart from latter systemic level, the internal attributes influence on individual firm outcomes. In particular, absorptive capacity (Cohen and Levinthal, 1990) exerts a positive effect on innovation performance of the firms (Cassiman and Veugelers, 2006; Vega-Jurado et al., 2008).

Moreover, the cluster capacities interact with individual organization level capacities and amplifies the potential access and exploitation to external resources (Giuliani and Bell, 2005). In consequence, is particularly relevant for firms to absorb and exploit external knowledge resources from other co-located actors (McCann and Folta, 2011).

Previous research is almost entirely coincident in finding a positive relationship between absorptive capacity and innovation for the clustered firms. However, there was a great variety even discrepancy in the way that this relationship can be represented. Some authors found a curvilinear effect between both variables (Belso-Martinez et al., 2013). That is, clustered firms should find an optimal balance, since at certain levels costs of investing in internal resources would rise more than benefits. Similarly, it was suggested that connectivity among the clustered firms amplifies the curvilinear effect of the R&D effort focussed on innovation (Expósito-Langa et al., 2011). Clustered firms receive a large amount of knowledge and other resources from the other members of the cluster. In consequence, firms' innovation performance primarily depends on their capacity to profit from these external resources of knowledge.

In the context of the fsQCA analysis, we can express as follows; all combinations of factors including high values of internal attributes related to absorptive capacity can be considered as sufficient conditions leading to the outcome (to have a high innovation performance). Thus, we state the following proposition:

Proposition 2: Configurations including conditions that involve possessing internal attributes related to absorptive capacity are path to strong technological innovation.

3. Empirical setting

3.1. Context of the research: The Spanish ceramic tile cluster

This paper is based in the Spanish ceramic tile cluster located in the province of Castelló. This cluster has already been studied by many authors that recognize its interest as a representative of these type of industrial agglomerations (Albors-Garrigos and Hervás-Oliver, 2013; Expósito-Langa et al., 2011; Molina-Morales, 2002; Molina-Morales and Martínez-Fernández, 2009; Reig-Otero et al., 2014). In particular, the ceramic tile cluster of Castelló accounts with several aspects that make it very relevant for the worldwide ceramic industry. Among its main attributes we can find: technological knowledge, highly skilled labour, strong identity, cultural embeddedness, the institutional ecosystem, knowledge transmission activities, internal business and technological networks, etc.

In the current economic scenario, the ceramic tile industry of Castellón produces the 94% of the total Spanish production of wall and floor tiles according to ASCER[1], the sales volume of the sector in 2017 was 3.510 million of Euros from where 2.686 correspond to exports (76.5%). The sector accounts with an associated direct employment of approximately 15.000 people. The main industrial activities involved in the production of wall and floor tiles are represented in the Castelló cluster. Among these activities we can find: final wall and floor tiles producers, frits and glazes manufacturers, machinery and equipment manufacturers, atomizers, chemical additives providers, complementary

[1] Spanish Association of Wall and Floor tiles manufacturers. Data in this section come from ASCER website http://www.ascer.es checked on September, 2018

tiles manufacturers or digital design providers, among others. As a representative of the cluster agglomeration model, the ceramic tile industry in Castellón also accounts with a rich institutional ecosystem that provides support to the cluster firms. Among these supporting organizations, either with a national or regional span, we can name: research centers (ITC), the local university (Universitat Jaume I), important trade associations (ASCER, ASEBEC[2] and ANFFECC[3]), chambers of commerce and many more. The range of activities and its positive effect on the cluster has been analyzed previously in the literature where the research show their implication either in the business or the technological networks (Molina-Morales and Martínez-Cháfer, 2016).

3.2.Methodology: Qualitative Comparative Analysis

The Qualitative Comparative Analysis (QCA) consists of a combination of qualitative and quantitative methodological approaches that was originally developed for sociological and political sciences (Ordanini et al., 2014; Ragin, 2014; Sager and Andereggen, 2012). However, other fields of science are devoting interest in QCA. This is the case of studies that focus on configurations of constructs characterized by a certain degree of complexity in fields like strategic management, innovation or marketing, among others (Fan et al., 2017; Fiss, 2007; Greckhamer et al., 2008; Ordanini et al., 2014; Ordanini and Maglio, 2009; Roig-Tierno et al., 2017). QCA methodology focuses its analysis on causal recipes leading to an output (Ragin, 2008). More precisely, this configurational comparative method identifies one or some alternative combination (recipes) of antecedent conditions (ingredients) that lead to a specific outcome or to the outcome's negation. In this sense, it unravels causal complexity of conditions rather than to analyse its net effects (Woodside and Baxter, 2013). Consequently, QCA is characterised by its equifinality, meaning that the same outcome might be a result of different combination of causal conditions (Ragin, 2008; Woodside and Baxter, 2013).

In this section, we will carry out the analysis in two steps. The first step consists in assessing the presence of necessary conditions for the outcome (strong technological innovator); that is, to evaluate whether the presence or absence of any of the conditions

[2] Spanish Association of machinery manufacturers.

[3] Spanish Association of frit, glaze and ceramic colour manufacturers.

under study (or a logical combination of them) is necessary for the final manufacturing companies to introduce be a strong technological innovator. The second step consists in analysing which conditions or patterns (paths) are sufficient for final companies to intensively perform technological innovations (product and/or process innovations).

The idea behind QCA is complex causality. Under this notion: "*social phenomena have multiple and conjectural causes. The way in which a certain condition X affects a specific outcome Y depends on the presence or absence of other conditions. Similarly, a specific outcome can be caused by different combinations of conditions*" (Befani et al., 2007, p. 173). This implies the presence (or absence) and interaction of various forces and diverse configurations of elements having into account that an outcome (or result) in one case may not be the same in other occurrences. Thus, conjunction, equifinality and asymmetry are characteristics considered in the solution portfolio that emanates from QCA analysis (Meyer et al., 1993). This allows the results to be a better proxy of reality they represent. In this sense, QCA provides an interesting approach and some advantages for managerial and innovation studies (Ordanini et al., 2014; Woodside, 2016). In any case, the general perception for the authors that compare the QCA results with other traditional methods and conventional techniques is that QCA a very good complement. In fact, some of these studies point to the fact that relying solely on regression analysis, for example, can be misleading in certain occasions (Woodside, 2016).

In this research paper que have used fuzzy-sets QCA (FsQCA) which is the latest version of QCA (Crilly et al., 2012; Fiss, 2011, 2007; Ragin, 2008). By doing this we perform a cross-case systematic analysis to find out about the relationships among variables in terms of set membership. To do so, QCA is based on Boolean algebra in order to uncover combinations and configurations of variables that yield to necessary and sufficient conditions to obtain a certain outcome. The outcome, in our case, is belonging to the set of firms that are strong technological innovators.

The sequence of steps to perform the analysis, according to Fiss (2011), involves the following tasks: defining the property space, developing the membership measures to the different sets, evaluation of consistency among set relationships and the final logical reduction. In the first phase, we must identify all the possible conditions that cause the outcome (property space). This means that we need to define the possible configurations of drivers or attributes that enable the result under study. This is an important step due to the fact that choosing the correct drivers is key to a successful analysis. This selection, consequently, has to be done according to existing theoretical knowledge (Ordanini et al., 2014). See Table 1 to identify the property space in our analysis.

Table 1: Outcome and conditions: description and codifications.

Type	Name and Code	Description
Outcome	Strong Technological Innovators (Technological Innovation (INN_TEC))	Innovations of products, processes introduced by the companies.
Condition	Early Adopters (EARLY)	Consideration of being early adopter before the massive adoption of the technology
	Strong Absorptive capacity of the company (ACAP)	General Absorptive capacity of the company
	Experienced R&D Firm (ARD)	Experience of the R&D Department.
	Big firm (SIZE)	Size in terms of factor from employees, assets y revenues. (Average values from 2007-2013)
	High amount of R&D resources (PID)	Intensity of R&D research in terms of employees in R&D Department (% over total employees of the company)

Once we have the sets defined we need to assign a value of memberships. In other words, and applying to our research, we need to know the extent to which the cluster firms are a member of the different sets defined in the first phase. This step is also known in the QCA literature as the calibration process which can be either direct or indirect (Ragin, 2008). In our case we used the direct calibration method, following the recommendations of Ragin (2008) for medium to large samples. Direct calibration is performed by indicating whether a certain condition is fully in or fully out of a particular set at the point of maximum ambiguity. In our case we used the fsQCA package in R to do our calibration (Duşa and Thiem, 2014) whose results are shown in Table 2.

Table 2: Descriptive statistics and calibration points.

	Descriptive statistics			Calibration Anchors		
	Max	**Min**	**Mean (S.D)**	**Fully-in**	**Crossover**	**Fully-out**
INN_TEC	5	0	3.52 (1.76)	5	4	1
EARLY	17	0	8.05 (3.88)	9	6	4
ACAP	2.0	-3.4	0.00 (0.99)	1.3	-0.6	-1.5
ARD	100	0	11.97 (12.34)	20	13	5
SIZE	7.7	-0.50	0.00 (0.99)	0.3	0	-0.4
PID	40	0	6.23 (7.88)	10	5	0

NOTE: As in Crilly et al. (2012), values of 1.99 and 2.99 have been computed as 2 and 3 in the fsQCA software.

After calibrating our variables, the next step was building the truth table to organize all the possible configurations of conditions and their correspondence to the outcome presence. In order to do so we used the software package fsQCA 3.0 (Ragin and Davey, 2016). This software package, by means of logical reduction, is able to provide the solutions that are relevant. Finally, we conclude the analysis focusing on the necessary and sufficient conditions. By doing we can identify whether a particular condition or a combination of them yields to the outcome or are always present in every combination that cause the outcome. To evaluate the importance and suitability of every solution in the portfolio we use the measures of consistency and coverage provided by the software, also for the overall coverage.

3.3.Sample and Data

A survey, based on a structured questionnaire, provided the primary data needed for this research. The aim of these survey was to gather detailed information about the adoption process of the technological innovation, the digital printing technology, developed to improve the tile manufacturing process. Consequently, among all firm categories which comprise the cluster, interviews were only addressed to the final tile producer category: the wall and floor ceramic tile manufacturers. They are those members of the cluster who, potentially and exclusively, are able to adopt the digital printing technology. Other different cluster´s company categories such as, specialized or integrated firms were, in consequence, out of the purpose of present research.

The survey was carried out -in two rounds- to firms pertaining to the Spanish ceramic tile cluster from October 2016 to February 2018. It yielded a sample of 88 firms from a universe of 118 independent tile manufacturing firms present in the cluster at that moment according ASCER[4].

The majority of the respondents were R&D or firm managers. These respondent profiles were considered the most suitable for the purpose of this study as, taking into account the specific structure of the ceramic tile companies in the cluster, they are normally who have a general information about how new technologies are introduced and how innovative dynamics are developed in their own companies. Nevertheless, and to a lesser extent, some interviewees had a different profile such as marketing manager or technical manager if they were directly involved in the innovation adoption process.

Moreover, secondary information was gathered from SABI database (Iberian Balances Analysis System) in order to obtain different features of the companies as well as their business and performance information.

4. Results and discussion

4.1.Analysis of the necessary conditions

As proposed by Schneider and Wagemann (2010) and Rihoux and Ragin (2009), Table 3 presents the results of the FsQCA test of necessary conditions for the outcome *Strong Technological Innovator* as well as its absence (indicated by (~)). In our study, test of necessary conditions is checking whether the presence or absence of any of the conditions under study is necessary for the final tile companies to be strong technological innovators in terms of product and process development. A condition, or a combination of conditions, is considered as "necessary" if the consistency score exceeds the threshold of 0.90 while the coverage score exceeds the threshold of 0.50 (Schneider and Wagemann, 2010). In case of the outcome *Strong Technological Innovator*, the logical combination "OR" of conditions: "early adopter" and "Strong Absorptive capacity of the company" exceeds the threshold of 0.9 and therefore may be considered as a necessary condition

[4] Data in this section come from ASCER website http://www.ascer.es checked on September, 2018

(Ragin, 2008; Schneider and Wagemann, 2010). Consequently, we can suggest that for a final tile producer, in most of the cases, to be a strong innovator is not possible without either “to be an early adopter of the disruptive technology” or “to have a strong absorptive capacity” (Legewie, 2013).

4.2.Analysis of sufficient conditions

In order to analyse the sufficient conditions related with the outcome (and its absence), the construction and examination of the truth table is required (Mas-Verdú et al., 2015; Ragin, 2008). The truth table contains all possible logical combinations (Fiss, 2011; Ragin, 2008). Specifically, in our study, there are 32 possible configurations (2^5), where 5 is the number of suggested conditions in this study. Categorization of the conditions were followed (Schneider et al., 2010).

Depending on the approach used to simplify assumptions a fsQCA analysis yields three different solutions: complex, intermediate and parsimonious (Ragin, 2008). The causal recipes proposed by these three different solutions may differ more or less from each other, nevertheless they are always equal in terms of logical truth and never will contain contradictory information (Legewie, 2013). Firstly, the complex solution does not allow for any simplifying assumptions to be included in the analysis; therefore, this solution term is often hardly reduced in complexity and barely helps with the data analysis, especially when operating with more than a few causal conditions. Secondly, the parsimonious solution reduces the causal recipes to the smallest number of conditions possible. The conditions included in it are "prime implicants," i.e., they cannot be left out of any solution to the truth table. The decisions on logical remainders are made automatically, without regard to theoretical or substantive arguments on whether a simplifying assumption makes sense, so some authors strongly argues against it (Ragin, 2008; Schneider and Wagemann, 2007).

Table 3: Analysis of necessary conditions.

Conditions	Consistency	Coverage
Outcome: Strong technological innovator		
Conditions	**Consistency**	**Coverage**
Early Adopter (EARLY)	0.762	0.635
~ Early Adopter (EARLY)	0.331	0.597
High amount of R&D resources (PID)	0.581	0.729
~ High amount of R&D resources (PID)	0.580	0.606
Experienced R&D Firm (ARD)	0.512	0.750
~ Experienced R&D Firm (ARD)	0.623	0.580
Strong Absorptive capacity of the company (ACAP)	0.814	0.698
~ Strong Absorptive capacity of the company (ACAP)	0.335	0.569
Big firm (SIZE)	0.442	0.826
~ Big firm (SIZE)	0.684	0.560
EARLY and ACAP	0.663	0.727
EARLY or ACAP	0.913	0.627
Outcome: ~ Strong technological innovator		
Conditions	**Consistency**	**Coverage**
Early Adopter (EARLY)	0.704	0.4431
~ Early Adopter (EARLY)	0.419	0.571
High amount of R&D resources (PID)	0.500	0.474
~ High amount of R&D resources (PID)	0.714	0.563
Experienced R&D Firm (ARD)	0.403	0.447
~ Experienced R&D Firm (ARD)	0.775	0.545
Strong Absorptive capacity of the company (ACAP)	0.664	0.430
~ Strong Absorptive capacity of the company (ACAP)	0.534	0.685
Big firm (SIZE)	0.291	0.410
~ Big firm (SIZE)	0.877	0.543
EARLY and ACAP	0.516	0.428
EARLY or ACAP	0.851	0.442

Note: All condition listed above has been calibrated

Finally, the intermediate solution includes selected simplifying assumptions to reduce complexity, but on the other hand does not include assumptions that might be inconsistent with theoretical and/or empirical knowledge introduced by the researchers (Legewie, 2013). In summary, it could be understood as a complex solution simplified in some extent through fundamental theoretical or substantive knowledge (Schneider and Wagemann, 2012). At this point, the knowledge and experience of researchers is paramount to drive the "qualitative side" of the logical methodology. The intermediate solution is widely used in literature as can be considered as a good compromise between the other two solutions for unravelling causal complexity of conditions in fsQCA analysis (Crilly et al., 2012; Eng and Woodside, 2012; Fiss, 2011; Henriques et al., 2017; Mas-Verdú et al., 2015; Santos et al., 2018; Schneider et al., 2010). In this study the assumptions carried out are the presence of the conditions “early adoption of the disruptive technology” and “strong absorptive capacity” for the outcome as in our opinion, they are the most driving conditions for the ceramic tile companies to be really strong innovators in terms of product and processes taking into account the innovative history of the ceramic tile cluster in the last decade. These proposed assumptions allow our analysis to match up to our theoretical expectations as proposed by Schneider and Wagemann (2010).

Table 4 presents the results of the analysis of the sufficient conditions according the intermediate solution for the outcome (*strong technological innovator*). The results are validated according the insights from (Fiss, 2011; Ragin, 2008, 2006a; Ragin et al., 2006; Rihoux, 2003). Table 4 shows the different combinations of conditions that comprise alternative sufficient paths or recipes to the outcome. We used the notation proposed by Ragin (2009) and Fiss (2011) according to which black circles indicate the presence of a condition, white circles indicate the absence of the condition and blank spaces “don’t care”. Furthermore, big circles indicate core conditions and small circles indicate peripheral conditions. While core conditions are considered as essential for the outcome, peripheral ones are less important or in some cases, expendable or exchangeable (Fiss, 2011). The author defines: “*core elements as those causal conditions for which the evidence indicates a strong causal relationship with the outcome of interest and peripheral elements as those for which the evidence for a causal relationship with the outcome is weaker*” (Fiss, 2011:394). In our case, all recipes shown in the table contain a combination of core and peripheral conditions.

Each of these paths are characterised by three different scores: raw and unique coverages and consistency. The raw coverage score reflects the extent to which this recipe can explain the outcome. The lower a coverage score, the less empirically relevant a causal recipe; it is able to explain fewer cases in which the outcome occurred (Legewie, 2013). On the other hand, the unique coverage score shows the proportion of cases that can be explained exclusively by that recipe. It is meaningful because it indicates how many cases a given recipe can explain without any other recipe offering explanation. Often there is considerable overlap between recipes, so it is not unusual for the unique coverage scores to be rather low (< 0.15) (Legewie, 2013). Recipes with higher unique coverage thus gain relevance because without them more cases would be beyond the explanatory reach of the model. Finally, the recipe´s consistency score reflects the amount of cases that are not fitting with this specific path. The lower a consistency score of a path, the more cases do not fit the patterns identified by it or, in other words, the more substantial are the contradictions that certain cases pose to this recipe. Ragin (2009) recommends a consistency threshold of 0.80; in our case, all recipes´ scores comply with this threshold.

Moreover, Table 4 shows the overall coverage and consistency for the solution which indicates the robustness of our solution. The solution´s coverage score reflects the empirical importance of a given solution. It should be as high as possible, usually above a score of 0.25. The solutions' consistency score confirms that the specific configuration of antecedents is sufficient for explaining the outcome condition (Ragin, 2008). Different authors consider a robust solution those whose consistency threshold are at least 0.75, but preferably 0.85 or higher (Ragin, 2006a, 2006b; Rihoux and Ragin, 2009; Woodside and Baxter, 2013). Regarding the overall consistency and coverage values obtained from the intermediate solution of our research, we stress the fact that they surpass the minimum values which are considered suitable; the consistency score is 0.84 (indicating that the combined recipes account for about 84% of the membership to the outcome) while coverage score is 0.56.

Finally, Table 4 shows the overlapping coverage score. The extent of overlap indicates two things. On the level of the data set, it shows how strongly the cases cluster along certain dimensions on the causal conditions. On the level of the single cases, it shows in how many cases with the occurrence of the outcome can be explained in more than one way (Legewie, 2013). In our case, overlapping coverage score is 0.33.

Our sufficiency analysis shows five different paths to the outcome. In effect, as stated before, all of them comply with the threshold of 0.8 recommended by Ragin (2008). The analysis suggests two differentiated tendencies for achieving the outcome (*to be a strong technological innovator*). By the one hand, configurations 1, 2, 3 and 4 refer to those companies which are early adopters of the disruptive technology, have a strong absorptive capacity or both together; this cluster of configurations presents a higher raw coverage scores and consequently represents a higher amount of cases. On the other hand, configuration 5 refers to those companies that do not present the previous conditions but are large, experienced in R&D tasks and invest important amount of resources in R&D. In four out of the five paths proposed by the fsQCA analysis, early adoption, strong absorptive capacity (or both) are present as antecedent conditions to be a strong technological innovator, in terms of product or process developments. While in three of them early adoption is present, in other three recipes strong absorptive capacity is an ingredient to reach an intense activity from a technological innovation point of view. These findings show that early adoption and strong absorptive capacity may be important conditions which match up to our theoretical expectations and is in line with the innovation and knowledge management literature.

Table 4: Results of the intermediate solution.

Outcome: Strong Technological Innovator

Consistency cut-off: 0.82
Frequency threshold = 1

Path number	Antecedent Conditions: Early Adopter	Strong ACAP	High amount of R&D resources	Experienced R&D Firm	Big firm	Coverage: Raw	Coverage: Unique	Consistency
1	●	●	⬤	⬤		0.356	0.157	0.845
2	●	●			⬤	0.347	0.042	0.867
3		●		○	⬤	0.241	0.013	0.893
4	●			○	⬤	0.237	0.009	0.870
5			⬤	○	⬤	0.157	0.011	0.887

Solution coverage: 0.56
Solution consistency: 0.84
Overlapping coverage score: 0.33

Note: black circles "●" indicate the presence of antecedent conditions. White circles "○" indicate the absence or negation of antecedent conditions. The blank cells represent ambiguous conditions. Furthermore, large circles indicate core conditions, and small circles refer to peripheral conditions.

Path 1 is especially interesting because its raw coverage is 0.356. This means that around 36% of the cases can be explained through this configuration of antecedent conditions. On the other hand, this configuration as presenting a unique coverage of 0.157 which means that it is able to exclusively explain almost 16% of all cases. Moreover, it shows two core conditions, high amount of R&D resources and to be an experienced R&D firm. This configuration leads to the conjecture that companies may be strong technological innovators (regardless of their size) if they adopt early a new technology and they combine a strong absorptive capacity, a high amount of R&D resources and an extensive experience in R&D tasks. Concurrently path 2, having a similar raw coverage score but a lower unique coverage one, substitute the big size of the firm for high amount of R&D resources and an extensive experience in R&D tasks in relation to path 1. This result points out that companies may be strong technological innovators (regardless of their size and experience of the R&D department) if they adopt early a new technology and they are big enough. This path present only a core condition, large size of the firm.

On the other side, path 5 corresponds to strong technological innovative companies that are characterised by big size, high investment in R&D (both conditions are core) even with the absence of Experienced R&D department. This path is the less representative as the raw coverage score is 0.157 meaning that just the 16% of the cases can be explained through it. This finding is in line with the researchers´ expectations as, not only in the Spanish ceramic tile cluster but also generally in the ceramic tile industry, big tile companies have easy access to knowledge and innovation capabilities through the specialized companies. In this sense, the Spanish ceramic tile cluster is considered as a supplier dominated cluster (Pavitt, 1984) where technological innovation is developed and provided by the specialized suppliers, mainly the frit, glazes and digital ink suppliers, to their customers, the final tile manufacturing companies.

5. Conclusions and implications

In this paper we attempted to uncover the combinations of factors and properties present in the cluster firms that exhibit strong technological innovation behaviour. To do so we have performed a fsQCA analysis. This technique provides a very interesting approach that enables to obtain causal recipes leading to an output (Ragin, 2008). Our results show an interesting equifinality as we can see how the same outcome, being a strong technological innovator, can be obtained combining the presence and/or the absence of different conditions.

Our results highlight the importance of early adoption of new and disruptive technologies jointly with the absorptive capacity in becoming a firm characterized as a strong technological innovator. Indeed, these two factors are present in the majority of the paths which lead to high technological innovation performance. Furthermore, the analysis also shows how the early adoption of disruptive technologies in combination with the absorptive capacity is a strong determinant of innovation. This is quite clear in the necessity and sufficient analysis where both conditions have a prominent role in the several path that lead to being strong as a technological innovator.

These insights have important implications either for policy and practitioners. Innovation, as highlighted recently in the literature, is a very important element of the territorial resilience (Bristow and Healy, 2018). In this sense industrial clusters can benefit from uncovering the ingredients that shape firms as strong technological innovators. This knowledge can be profitable either for managers that look to increase the innovative performance of their companies, or the policymakers looking to enhance the resilience of the territories under their influence.

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