Disruptive technology adoption, particularities for the clustered firms

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Abstract

This paper explores to what extent the internal attributes of a clustered firm influence its capacity to adopt a disruptive innovation. A multidimensional approach to the absorptive capacity (ACAP) model is used to distinguish between potential (acquisition and assimilation domains) and realized (transformation and exploitation domains) internal firm capabilities. Our evidence come from an empirical analysis of the firm population belonging to the Spanish ceramic tile cluster who have massively adopted a disruptive innovation. The econometric estimations suggest the relevance of the Exploitation dimension of ACAP for an early adoption of a new technology. On the contrary, the rest of dimensions doesn´t seem to be determinant when it comes to adopting a novelty earlier than others. In conclusion, and contrary to expected for non-clustered companies, the results bespoke of an uneven effect of potential and realized

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domains of ACAP of clustered firms regarding the adoption rate of distant technologies.

Keywords: disruptive technological innovation; industrial clusters; absorptive capacity; innovation; technology adoption; potential absorptive capacity; realized absorptive capacity.

Introduction

Over the last years, the territorial dimension of innovation has attracted attention of scholars and practitioners (MacKinnon et al. 2002; Moulaert and Sekia 2003; Doloreux and Parto 2005; Moulaert et al. 2005) particularly, as a path of regional development. In many of the cases, authors have used the concept of district or cluster (Becattini, 1979; Porter, 1990) as framework of analysis (Asheim and Coenen 2005; Giuliani 2005; Mattsson 2009; Huggins et al. 2012; Kesidou and Snijders 2012). Moreover, there are many contributions that attempt to describe how proximity facilitates frequency in contacts and closeness among actors in a cluster network (Piore 1990; Lorenz 1992; Inkpen and Tsang 2005). According to a part of the cluster literature, this characterization would generate tacit knowledge and high quality information exchanges and, consequently, would promote innovation for firms (Maskell and Malmberg 1999; Molina-Morales 2002; Bathelt et al. 2004).

Most of authors, more or less explicitly, assume that the relational characterization of the cluster becomes much more appropriate for step by step or minor improvements and incremental innovations of products and technologies than those considered radical or disruptive changes (Bianchi and Giordani 1993; Maskell 2001; Hassink 2005).

The existing literature on innovation in clusters, although claiming the value of real disruptive changes for cluster renewal and sustainability, often is exclusively focused on what is behind the incapability of these agglomerations to carry them out (Maskell and Malmberg 2007; Østergaard and Park 2015). Nevertheless, Saxenian (1991) found that in the rapidly changing environment of the computer industry, mostly in Silicon Valley, firms have moved away from arm-length supplier relations in order to build close relationships with only a selected number of them. More recently, some examples can be found describing how industrial clusters have renewed their possibilities of surviving through disruption (Molina-Morales et al. 2017; Hervás-Oliver et al. 2017).

Some authors, following the exploring and exploiting dimensions of organizational learning proposed by March (1991) but under a cluster perspective, tried to identify activities related to these two categories of innovation and suggested that, in some cases, clustered firms may benefit from both exploiting and exploring advantages (Rullani 2002; Fontes 2005; Giuliani 2007).

Our work aims to address above discussion by analysing which are the attributes of cluster´s companies related to the adoption of disruptive technologies. In fact, disruptive innovation processes have been rarely studied in the cluster context. Literature has been more focused on describing the cluster decline when facing disruption or the inertia as restricting factor of disruptive novelty (Suire and Vicente 2009; Staber and Sautter 2011; Crespo et al. 2013; Østergaard and Park 2013; Isaksen 2014). Often, these contributions are focused on cluster as unit of analysis and stress the identification of key cluster elements supporting or inhibiting adaptation to disruption. They rarely address, under a firm´s perspective, the internal attributes of the clustered firms as determinants of the adoption of disruptive innovations. In this vein, exceptionally, Hervás-Oliver et al. (2017) analyse how radical innovation occurs in Marshallian clusters and how they are able to overcome lock-in processes.

Explorative in nature, our work uses the firm as a unit of analysis and captures their internal attributes using the Absorptive Capacity model (hereinafter ACAP), firstly defined by Cohen and Levinthal (1994, 1990). Contributions on previous industrial cluster literature has used this internal firm attribute, to analyse how firms have different access to those knowledge which is provided by technological institutes

(Hervas-Oliver et al. 2012) or how the heterogeneity of knowledge of firms builds a cluster absorptive capacity (Giuliani 2005). Distinguishing among the four ACAP dimensions proposed by Zahra and George (2002) (acquisition, assimilation, transformation and exploitation) we aim to find which are the firm specific attributes that allow individual clustered firms to access and to exploit more rapidly a new disruptive technology. Literature has frequently analysed absorptive capacity as a one-dimensional concept (with some exceptions such as (Expósito-Langa et al. 2011)). A four-dimensional perspective becomes interesting since each dimension requires distinct organizational processes and is differentially developed in clustered. In short, this paper aims to focus on a particular inquiry: which dimensions of ACAP are influencing more significantly in the adoption of a disruptive innovation when this innovation is introduced on the cluster.

To develop these causal relations, the paper was drawn on the Spanish ceramic tile cluster and the recently introduced digital printing technology. We consider this case as a case of disruptive technological innovation according Markides differentiation between radical and disruptive innovations (Markides 2006).

The expected contribution is particularly relevant since the importance of the disruptive innovations have increased in the current context (Christensen 1997; Govindarajan and Kopalle 2006; Markides 2006; Tellis 2006). In contrast to incremental ones, these innovations represent major transformations of existing products or technologies. They make often the prevailing product designs and technologies obsolete (Chandy and Tellis, 2000).

In conclusion, we expect to contribute to the cluster debate open nowadays about how industrial clusters are able to restart their life cycles and face the important challenges, aiming to adapt their structures and strategies to the external global conditions The paper aims also to contribute to a broader literature inspired in the controversy regarding the differential benefits of incremental and radical or disruptive innovations as well as their specific differences according their specific contexts.

The remainder of this paper has been structured as follows: first we explain main concepts and propose the theoretical framework and the correspondent hypotheses, then we describe the empirical setting and later we test the hypothesised relations. Finally, implications and conclusions are discussed.

Theoretical framework and hypotheses

Proximity and innovation

A significant part of the literature has suggested that firms find a motivation to be located near the others as they may get a benefit from common external resources (e.g. Folta et al., 2006; McCann and Folta, 2008). These arguments have traditionally conceptualized as industrial cluster or district (Becattini, 1979; Porter, 1990).

In general, research on clusters assume that by being in the same place, organizations take advantage from external knowledge exchanges, since knowledge spillovers are geographically localized and locally bound (Krugman 1991; Jaffe et al. 1993; Alcacer and Chung 2007). The stocks of knowledge created through these exchanges are concentrated and, in some way available, exclusively for located actors (Bell et al. 2009). Innovation becomes, in consequence, a joint action among cluster members, where diverse relationships between firms and organizations foster not only trust and other shared norms and values but also transmission of tacit knowledge (Bell et al. 2009). In fact, many contributions have attempted to describe how firms spatially concentrated capture externalities derived from access to information and reciprocal exchanges of tacit knowledge (Maskell 2001; Gordon and McCann 2005; Waxell and

Malmberg 2007). To sum up, interactions among co-located actors have probably superior outcomes related to innovation compared to interactions among distant actors (Yli-Renko et al. 2001).

Since clustered firms operate within a boundaries of a close geographical scenario, they are idiosyncratic business networks (Sorenson 2003). Proximity fosters the frequency of personal contacts, the social relations between actors and reciprocity of benefits (Roxas and Chadee 2011). Interconnections and interactions between network members are a manifestation of the relational proximity. Close and mutual relationships (strong ties) are necessary to transfer and get access to particular information and knowledge from other firms (Hansen 1999). Particularly, in clusters as spatiality concentrated networks, the social capital can be highly exploited by networked firms (Ahlstrom and Bruton 2006; De Carolis et al. 2009).

Incremental and disruptive innovations. Technological change in industrial clusters

The specificities in clusters, as an aforementioned idiosyncratic case of network, have implications on the type of innovation that clustered firms develop. Clusters seem to be better adapted for incremental or contextual innovation. As it is well known, incremental innovations involve minor changes and modifications which are introduced in order to refine or reinforce existing products and technologies. In contrast, radical or disruptive consist of significant transformations that make the current products and technologies obsolete (Chandy and Tellis 2000)

Previous researches have extensively analysed the concept of disruptive innovation and other similar notions intending to capture the radical and discontinuous nature of some new technologies (Bower and Christensen 1996; Christensen 1997; Adner 2002; Charitou and Markides 2002; Christensen and Raynor 2003). We are aware that the emergence of several concepts capturing similar notions makes confusing its identification and clear delimitation (Abernathy and Utterback 1978; Gatignon et al. 2002). However, leaving aside the conceptual debate, we are interested in those technologies and innovations that go beyond incremental developments or little changes. This implies 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 as well as they may disrupt existing market linkages (Bower and Christensen 1996; Christensen 1997; Charitou and Markides 2002; Christensen and Raynor 2003; Gilbert 2003; Danneels 2004; Adner 2006; Govindarajan and Kopalle 2006). Thus, we adopt the proposal suggested by Markides (2006) who on the basis of the Christensen´s work (1997), distinguished between radical innovation for products and disruptive innovation for technologies. In the same vein and for the purpose of this research, we refer to 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, following the similar concepts suggested by different authors (Anderson and Tushman 1990; Danneels 2004; Markides 2006; Gilbert 2012).

In clusters, the lack of exploring capabilities to scan and respond to external and radical changes and was reported in seminal works by Harrison (1994) and, in similar terms, by Glasmeier (1991) who described how the Swiss watch firms presented a vulnerability in responding to disruptive external technological changes. Most of the further researches have been focused on the weakness of the strong ties in clusters (Grabher 1993), the reduced capacity to create breakthrough innovation (Chiarvesio et al. 2010) or how clusters are able to avoid decline through disruption (Østergaard and Park 2015). However, the above argumentation is somehow controversial, since, at least some counterexamples refute these arguments describing cases of industrial clusters accessing to new opportunities (Corò et al. 1998; Reig-Otero et al. 2014; Molina-Morales et al. 2017).

How clusters can overcome the limitations for generating these radical or disruptive advances has become a central research question. Previous studies have provided some suggestions. Belussi et al. (2008) claimed for opening the cluster up to external sources through the establishment of new links with external global networks. Sammarra (2005) and Biggiero (2006) proposed a selective relocation of activities outside the cluster. And others, like Giuliani (2011), have focused on the role played by technological gatekeepers to feed the cluster with new ideas, knowledge and technologies. Being aware of the aforementioned contributions, whose approach is focussed on considering the cluster as a homogeneous entity, we suggest to perform a different approach grounded on the individual company level, and to analyse which are the firm characteristics or attributes leading to the early adoption of a disruptive technology. The rate at which innovations are adopted by firms constitutes an important part of the process of technological change. In fact, investigation focussed on how both, firm and market specific characteristics, influence the decisions of adopting innovations has long been recognized as an important area of study. The diffusion theory provides different tools to assess the likely adoption and diffusion rate of a technology. Numerous factors have been identified as facilitators or hinders of the adoption and implementation of a technology. These factors include not only the characteristics of the technology, but also, and more relevant for us, the characteristics of the adopters and the means by which they learn and are persuaded to adopt the technology (Rogers 1983).

Clustered firm attributes through the Absorptive capacity perspective. Effects on innovation

Extended literature has already established a positive association between internal attributes (i.e. firm's capabilities) and firm performance (including innovation results). Stock et al. stressed the positive relationship between the capacity to assimilate and exploit knowledge and the company's capacity to innovate (Stock et al. 2001).Under a context of cluster, it is particularly relevant for firms to absorb and to exploit external knowledge resources from other co-located actors (McCann and Folta 2011; Ahlin et al. 2014). In clusters, individual firms benefit from accessing a series of capabilities which are not exclusive of an individual organization and belong to the community. Thus, the cluster creates its own mechanisms to identify changes of the external environment, and to facilitate access to new ideas or new opportunities.

Previous studies have demonstrated the existence of a common agreement in favour of a positive association between internal capacities, innovation and competitive advantage (Wernerfelt 1984; Barney 1991; Teece et al. 1997; Cassiman and Veugelers 2006; Vega-Jurado et al. 2008). In this sense, some specific findings can be found such as the argument defended by Belso-Martínez and Molina-Morales (2013) who suggest a curvilinear effect. They argued that, instead of investing continuously in internal resources, clustered firms should find an optimal balance since, at certain levels, costs would rise more than benefits. In the same vein, Molina-Morales and Expósito-Langa, (2011) suggested that the connectivity among the clustered firms amplifies the curvilinear effect of the R&D effort focussed on innovation.

Among firm internal capabilities as determinants of innovation, the absorptive capacity has received major attention by scholars since seminal work carried out by Cohen and Levinthal (1990). According to this authors, firms possessing a high absorptive capacity would develop higher organizational learning and better ability to apply external information and knowledge. ACAP can be considered as the ability of a firm to identify a valuable external knowledge, assimilate it, and apply it to commercial purposes (Escribano et al. 2009). ACAP has been seen as a way of new knowledge creation through the development of solving-problem skills (Kim 1998) or even as the ability of recognizing and understanding a potential new technology for further internally implementation (Mowery and Oxley 1995). Moreover, the additive systemic ACAP generated in clusters interacts with individual organization capacities and amplifies the potential access and exploitation to external resources (Giuliani and Bell 2005).

The notion of absorptive capacity as an ability to anticipate future technological advances was introduced by Cohen and Levinthal later on (1994). These authors suggested that investments in ACAP were associated with the ability of firms to predict technological avenues and consequently to obtain time advantages with respect to the competition (Lane and Lubatkin 1998; Van den Bosch et al. 1999). Following this argument, our work raises questions about the possible causal relationship between the ACAP of a company and its innovative capacity through the adoption rate of a new disruptive technology in the context of industrial clusters. In this sense, we follow other researches (Isaksen and Trippl 2016; Isaksen and Trippl 2017) considering novel technologies introduced on the market as the fundamental driving force behind new paths of development.

We follow Zahra and George (2002) that distinguish between the different dimensions of the ACAP, consequently we distinguish among set of different routines and processes by which external knowledge is acquired, assimilated, transformed and exploited. More precisely, we refer to: (a) acquisition dimension as the ability of the firm to identify and obtain knowledge from external sources; (b) assimilation dimension as to the ability to develop processes and useful routines by understanding, analysing and interpreting externally acquired knowledge (Szulanski 1996); (c) transformation dimension as developing and refining those routines that facilitate the combination of the existing knowledge with the acquired and assimilated one for future use (Zahra and George 2002); (d) exploitation dimension as the capacity of a firm to improve, expand, and use its existing routines, competencies, and technologies to create something new based on the transformed knowledge (del Carmen Haro-Domínguez et al. 2007).

In our case, we consider adequate to disaggregate the ACAP notion in those different dimensions following authors such as Zahra and George (2002), Jansen et al. (2005), Escribano et al. (2009) or Leal-Rodríguez et al. (2014a, 2014b). We agree that each dimension requires different paths of development into the organizations as well as they determine the development of differential innovative outputs (Leal-Rodríguez, Ariza-Montes, et al. 2014). Besides, in the context of the industrial cluster, specific conditions that clustered firms may present and strong interactions between firms makes this differentiation particularly interesting (Expósito-Langa et al. 2011).

In addition, the existence of systemic effects can affect differently to the different ACAP dimensions as we will try to justify in the following sections. Indeed, specific cluster peculiarities such as proximity, interactions or cooperation, among others, condition the behaviour of these dimensions (Zahra and George, 2002).

These authors also stablished a two-dimensional perspective of the ACAP. Under this consideration, knowledge acquisition and assimilation capacities are identified as *potential* ACAP while knowledge transformation and exploitation are considered as *realized* ACAP.

Potential ACAP has been defined as the ability to identify and evaluate new knowledge flows (Escribano et al. 2009). It leads the firm to renew its knowledge base and skills, favouring consequently its flexibility. This first dimension allows companies to reconfigure their bases of resources in order to be adapted for new emerging opportunities (Zahra & George, 2002).

Realized ACAP has been defined as the capability of firms to get profit from the external knowledge flows (Escribano et al. 2009). This second dimension comprises transformation capabilities (which enable firms to develop new processes or to add changes to existing ones) and exploitation capabilities (which enable firms to finally convert knowledge into new products and consequently to their performance and competitive advantage).

Hypotheses

Potential ACAP and technology adoption in clusters

The acquisition of external knowledge refers to the ability of a company to locate and acquire critical knowledge for its activity from external sources. This first dimension of identification corresponds to the notion of competitive scanning (McEvily and Zaheer 1999) that in the literature has been associated with the innovative capacity of the company. The development of this capacity implies a continuous control and analysis of the environment to detect opportunities and threats. The acquisition capacity is influenced by several factors such as the prior knowledge that the company has (Cohen and Levinthal 1990), recent scientific research, the effort devoted to generate routines for the acquisition of knowledge (Zahra and George, 2002) among others.

On the other hand, the belonging of companies to an industrial cluster conditions the way in which they identify external knowledge. In many cases these companies do not directly access external sources, but they do so from intermediaries. The existence of a series of local institutions, dedicated to support the cluster as a whole, and sometimes the leading companies themselves, serve as links between internal-to-the-district companies and the external environment (Malipiero et al. 2005). In this way, internal companies can benefit from a low-level cost and high quality exploration activities since they usually have systematic contacts with various external circles, other industries, other innovation systems, etc.

In short, the existence of intermediaries can affect both the quality and the focus of the searching activities of the clustered companies. Undoubtedly, the ability to identify knowledge from external sources carried out by the district requires a complementary capacity of absorption by the individual company. The larger and better the firm´s sources of information are, the greater the firm´s possibilities for exchanging and combining useful knowledge, and therefore, the greater the capacity to create and develop new products.

The assimilation of knowledge involves adapting the new one to the existing company knowledge base. External knowledge is found in specific contexts, which mostly make it difficult to understand and replicate outside the scope in which this knowledge has been generated. Therefore, it is crucial for the company to provide with internal processes that make all this knowledge useful and available to the organization (Teece 1981). However, in order to gain the *potential* added value of organizational knowledge it is not enough to adopt and exploit existing processes, the knowledge assimilation task should update the knowledge base continuously. For Nelson and Winter (1982) this process of assimilation is highly influenced by the tacit knowledge of the company, based on experience, know-how and other similar values distinguishing it from the explicit or codified knowledge. In the particular case of the industrial clusters, the dimension of assimilation of knowledge benefits from the access and exchanges of tacit knowledge within it.

The individual company has some instruments for these assimilation processes. For example, information technologies provide systematic processes of acquisition, storage and dissemination of organizational knowledge. Proximity, direct (formal and informal) relationships among people and organizations, high mobility of technicians and employees within the district, are elements that allow emulation, tacit knowledge acquisition which is difficult to be acquired in other circumstances (Tallman et al. 2004). However, despite these externalities, the routines and processes that manage knowledge, and allow the generation of new products or adoption of new technologies, occur, at the level of individual companies, interacting with the aggregate level. In this way we can consider that the greater the assimilation capacity of external knowledge of the company, the greater its capacity to develop new products and technologies. In short, the assimilation of external knowledge is a key element in the innovation processes, and more specifically in the industrial clusters innovation processes. Considering above theoretical development we can expect that the *Potential* ACAP will have a positive effect on the rapid adoption of a new technology for clustered firms. We are, therefore, expressing more formally the following hypothesis in relation to both dimensions of *Potential* ACAP:

H1.1: Clustered firms with higher acquisition capacity will adopt earlier disruptive technologies introduced in the cluster

H1.2: Clustered firms with higher assimilation capacity will adopt earlier disruptive technologies introduced in the cluster

Realized ACAP and technology adoption in clusters

Cohen and Levinthal (1990) emphasized in their works the importance of the application of assimilated knowledge. The exploitation dimensions refer to the routines that allow a company to perfect, expand and exploit existing skills, or create new ones, by incorporating the knowledge identified and analysed in their activity (Tiemessen et al. 1997). This supposes to internalize the previously created knowledge to develop and obtain, as a result, new products, processes, knowledge or new organizational forms (Spender 1996). During this phase, the exchange and combination of knowledge resources require some specific characteristics and capacities which will make a condition of the use of the new knowledge generated. At this point, high-quality information is required, and the ability of organizations and internal units to share and cooperate with other units and organizations acquires a prominent role.

In the context of industrial clusters, the literature has clearly proved how close contacts between organizations belonging to the same cluster generate a dense network of relationships. This density and recurrence in relationships provides organizations with a set of shared norms and values (for example, trust) that regulate exchanges of knowledge resources (Uzzi 1996; Uzzi 1997). In contrast to other characterizations, dense networks are more efficient in the processes of continuous improvement which are linked to the exploitation strategies of knowledge resources (Rowley et al. 2000). However, as the company networks of relationships are heterogeneous and distinctive, the companies of the district will present different capacities to exploit external sources of knowledge. Thus, the greater the capacity of exploitation generated by the network of relationships of the individual company, the greater its innovative capacity.

In clusters, the exploitation capacity of the individual firm may positively affect its capacity to innovate. Clustered firms receive a large amount of knowledge and other resources from the other members of the cluster. In consequence, innovation performance primarily depends on the exploitation capacity of the individual firm of these external resources of knowledge. Therefore, we would expect a positive relationship between internal resources and capacities and innovation. Accordingly, we can formulate the following hypothesis based on the different dimensions of realized ACAP:

H2.1: Clustered firms with higher transformation capacity will adopt earlier disruptive technologies introduced in the cluster

H2.2: Clustered firms with higher exploitation capacity will adopt earlier disruptive technologies introduced in the cluster

All four hypotheses are graphically summarized in Figure 1, which illustrates our analytical framework [Figure 1 near here]

Empirical setting

Context of the research

The empirical study is focused on the Spanish ceramic tile cluster. This cluster, which have been previously identified as a paradigm of a Marshallian-type industrial cluster (Boix 2009), is located in the Mediterranean Sea east coast of Spain, in Castellón province. Comprising an approximate area of 200 Km2, the cluster is defined by its main activity which is the wall and floor ceramic tile production.

This territorial entity, which is mainly composed by small-sized firms, is considered as the Spanish locus of the ceramic tile production. Around a hundred of ceramic tile manufacturing companies are located on this area and they produce over the 95 percent of the total Spanish production of the ceramic tile. This represented in 2016 a sales volume of 3.300 million of euros, and provided 15.000 direct jobs (ASCER 2016).

The cluster comprises not only the final firms, those firms which produce wall and floor ceramic tiles, but also other related firms devoted to other different activities of the ceramics value chain. Integrated firms and also Specialized firms are considered active and important members of the cluster. Among these group of firms, the glazing industries are considered the most important actors not only from a value creation point of view but also from a cluster knowledge supply point. In fact, this sub-sector achieved a sales volume of 1.200 million of euros in 2016 and provided 3.700 directs jobs (ANFFECC 2016).

Finally, together with these different kind of firms, cluster is made of a number of local, regional, or even national, institutions and organizations which support the cluster development, mainly, in terms of technological and business knowledge. Table1 provides a detailed information about the different actors comprising the cluster. [Table 1 near here]

The ceramic tile industry is an expanding industry which is mainly distributed around the world in cluster-type geographical concentrations (Boari et al. 2016). In this context, the European area is considered as the second manufacturing geographical area, in terms of squared meters, after Asia as shown in table 2. In terms of production, the Spanish ceramic tile cluster is the European manufacturing leader and is ranked as forth in the Top Manufacturing World Countries Rank (Baraldi 2017). [table 2 near here]

Regarding export performance, the Spanish tile sector is playing an important role not only at European level -where it is the export leader followed by Italy- but also at global level, being the second world exporter after China (Baraldi 2017). Drastic reduction of local market due to the building crisis suffered on 2009 and the leadership obtained thanks to the inkjet technological change produced in the cluster may be behind this strong exporting position (Molina-Morales et al. 2017).

The Spanish ceramic tile industry has been widely analysed by different authors under a cluster perspective (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; Russo, 1985). Academic literature identifies different factors such as highly skilled human resources, existence of a specific cluster technological knowledge, strong sectorial identity and cohesion, a common perception of markets, strong support of private and public institutions, high dynamism and competitiveness with frequent technological advances and an intensity in knowledge transmission (through different types of mechanisms such as constant creation of firms, human resources mobility, informal channels of communication) as key factors related to the cluster characterization.

In terms of network relationships, the Spanish ceramic tile cluster can be identified with the Arikan and Shilling archetype (2011) having a high coordination and low centralization due to technological complexity, low integration and high specialization in specific activities (Boari et al. 2016). Innovation in this context is mainly based in an exploitative model as a consequence of those strong ties created among the highly coordinated cluster members. In particular supplier ties with final ceramic tile producers have been identified as paramount in the cluster innovative processes (Hervas-Oliver 2004).

The Spanish cluster experienced a disruptive innovative phenomenon based on a radical change in the way of printing the ceramic tiles, the inkjet digital printing technology. As widely described by Molina-Morales et al. (2017) this innovation, which was introduced into the cluster by a visionary agent, changed the value chain of the ceramic tile business, first in the Spanish ceramic tile cluster and later on in the ceramic tile manufacturing industry worldwide.

Data collection for the analysis

This research is grounded on primary data collected at the firm level from the Spanish ceramic tile cluster. Due to the fact that this study is focussed on the adoption of an innovation, the digital printing disruptive technological innovation, data come exclusively from the so called final firms (those firms which perform the cluster´s defining activity). Final firms, as wall and floor ceramic tile manufacturers, are the companies which are able to adopt the aforementioned technology as impact of this innovation is produce over the ceramic tile manufacturing process. Other different cluster members such as, Specialized or Integrated firms are, in consequence, excluded of the present research.

Data collection was carried out through interviews based on a structured questionnaire. The selection of the respondent´s profiles was, at this point, relevant as they had to have the appropriate information regarding not only the adoption of a new technological innovation but also the innovative dynamics of their respective companies. Interviews were done to a great extent to firms´ and R&D managers as they had a first-hand knowledge about how the innovation under study was detected and why and how it was adopted or not. To a lesser extent, some interviews were carried out to other different staff such as marketing managers or technical managers if they were directly involved in the innovation adoption process.

The survey was conducted in two rounds between October 2016 and December 2017 and finally we were able to gather 75 complete questionnaires from a universe of 128 final firms present in the cluster in those dates. In order to extend the cluster´s firms characterization, business and performance information was also gathered from SABI database (Iberian Balances Analysis System).

Given the fact that this research work deals with a specific technology adoption and the relationship with a set of different firm´s characteristics, specifically, respondents were asked the following two questions:

- *Question 1: Is your company digital printing technology user?*
- *Question 2: If your company is a digital printing user, when did your company adopted?*

As this information is paramount to carry out our analysis, we ended up restricting our attention to the subset of companies for whom digital printing adoption was declared in the questionnaire. Figure 2 shows how digital printing technological disruptive innovation has been massively adopted among the companies interviewed.
[Figure 2 near here]

Measure of the absorptive capacity as a multidimensional concept

For the purpose of the present research, a multidimensional measure of ACAP is chosen. More in detail, we adopt the scale proposed by Flatten et al. (2011). These authors carry out the development and validation of a four-factor ACAP measure based on a relevant prior literature review and followed by a series of pre-tests two large survey-based studies which validate it. It assesses the degree to which a company engages in knowledge acquisition activities, assimilates acquired information into existing knowledge, transforms the newly adapted knowledge, and commercially exploits the transformed knowledge to its competitive advantage (Flatten et al. 2011). The four-factor ACAP measure is made of 14 items, each of them based on a 11-point Likert scale (0: strongly disagree to 10: totally agree) grouped as follows; (a) acquisition: 3 items, (b) assimilation: 4 items, (c) transformation: 4 items, (d) exploitation: 3 items.

Variable for the analysis

In the following section we will describe all of the variables included in the Logistic

Binomial Regression method that we used in this research.

Dependent variable

Early Adoption. This is a dichotomous variable. Its value is 1 when the company adopted the inkjet technology in 2010 or before. Conversely, the companies whose adoption was on 2011 or later are coded as a 0. Companies who did not adopted are coded as 0 as well. We established 2010 as the cut-off year because different technical and business events (produced mainly from 2008 and 2010) led to a general feeling at that time that the disruptive innovation had been successfully introduced, developed and adapted into the cluster. There was no doubt from that point that technological change would be a matter of time and diffusion of the new printing technique would be rather fast. In consequence, we consider early adopters to those firms which decided to adopt the novelty before every uncertainties and resistances were removed. As shown in Figure 3, the adoption frequency during time for the firms interviewed presents a peak in 2010 as response of the aforementioned consolidation of the new technology. [Figure 3 near here]

Descriptive indicators of the dependent variable are shown in **¡Error! No se encuentra el origen de la referencia.**. [Table 3 near here]

Control variables

Size of the company. This control variable is calculated through a factor analysis of three indicators: total assets, total revenues and number of employees (Cronbach’s alpha = 0,691; KMO=0,864).

Age of the company. This is a continuous variable that is calculated subtracting the year of company’s foundation from 2017. The final result gives us the amount of years of each firm's activity.

Orientation to technological innovations. This variable is the result of a factorial analysis concerning five items from our survey about product development and processes (Cronbach's alpha = 0,860; KMO=0,825). These five items are designed based on the product and process innovation questions of the Community Innovation Survey on Spanish manufacturing firms (PITEC), carried out by the INE (The National Statistics Institute), Spain's Science and Technology Foundation (FECYT), and Foundation for Technical Innovation (COTEC). PITEC is a panel survey, based on the Technological Innovation in Companies Survey (TICS), inscribed in the Spanish Sociological research centre (CIS), and designed to collect detailed information on innovation activities of Spanish firms in all sectors of the economy.

Orientation to organizational innovations. This variable is also the result of a factorial analysis. In this case we considered eight items about organizational and marketing activities (Cronbach's alpha = 0,929; KMO=0,868). As in previous variable, items used to build this one are based on questions of the Community Innovation Survey on Spanish manufacturing firms (PITEC) aforementioned.

Independent variables related to potential absorptive capacity

Absorptive capacity – Acquisition. This variable is the result of three items concerning the acquisition dimension of the absorptive capacity previously described (Cronbach's alpha = 0,819; KMO=0,695). The acquisition dimension is part of the potential absorptive capacity of a firm as expressed before.

Absorptive capacity – Assimilation. In this case, for the assimilation, we considered four items regarding this particular dimension (Cronbach's alpha = 0,925; KMO=0,839).

Together with the acquisition, this variable is also part of the potential absorptive capacity.

Independent variables related to realized absorptive capacity

Absorptive capacity – Transformation. This variable is computed also through a factorial analysis hat comprises four items about transformation activities (Cronbach's alpha = 0,957; KMO=0,869). Along with the exploitation dimension is one, this variable belongs to the realized absorptive capacity.

Absorptive capacity – Exploitation. This final dimension of the absorptive capacity is composed by three items about exploitation that are reduced to one dimension with a factorial analysis (Cronbach's alpha = 0,817; KMO=0,650).

Descriptive indicators for the control and the independent variables are reported on table4. [Table 4 near here]

Results

To test our hypothesis, we have computed a Binomial Logistic Regression (LOGIT) performed with the SPSS software package. The results show a general model that exhibits an 80% of correctness considering a cut value of 0,5. As we can see on Table 5, the model can predict correctly 60 cases over a total of 75 that completes our data. Additionally, we also report in this section other significance indicators of the model than can be observed in Table 6. [Table 5 near here]; [Table 6 near here].

Regarding the significance of the control variables (see Table 7), we observe how two control variables exert a positive and significant effect over the probability of being an early adopter of the technological innovation. On the one side, the age of the company has an EXP (B) coefficient of 1,082 indicating that companies with more general experience in the market can multiply by this coefficient their probability of early adoption. On the other side, companies with a high orientation on technological innovation can also multiply their probability of being early adopters by 4,737. The rest of the control variables that we have considered, size of the company and orientation towards organizational innovation, have both negative coefficients on the regression although not significant. [Table 7 near here]

In relation with the independent variables and regarding the different dimensions of the absorptive capacity, the results show how the exploitation dimension has a positive and significant effect on the dependent variable. Companies that perform exploitation related activities have more than 2 times chances of being early adopters as the EXP (B) coefficient suggests. However, this is the only dimension of the absorptive capacity that affects this such positive manner to the dependent variable. Acquisition, assimilation and transformation activities do not seem to be relevant when it comes to adopting the technology earlier for our sample of tile producer companies. This distribution of significances among the different dimensions has also some implications if we consider the separation between potential and realized absorptive capacity. In fact, our results indicate that tile manufacturers benefit from doing internal activities that aim to enhance their realized absorptive capacity rather than their potential one. Hence, our results do not confirm H1, concerning the positive effects of the potential absorptive capacity, and partially support H2 that refers to the realized ACAP.

Discussion of results and conclusions

The paper has attempted to contrast the effect of absorptive capacity on innovation through the adoption of a disruptive technological innovation in a context of industrial cluster. By doing so, we aimed to provide a better understanding of the determinants for firms of the earlier adoption of a disruptive technology under an industrial cluster context. ACAP model has been studied through the potential (exploring) and realized (exploiting) domains distinguishing, consequently, among the four dimensions proposed by Zahra and George (2002): acquisition, assimilation, transformation and exploitation.

Undoubtedly, the analysis of the association between individual attributes and exploration/exploitation activities of new technologies was not novel at all (McDermott and O'Connor 2002). However, the adaptation of the ACAP perspective to clustered firms is, as far as we know, is a relatively undeveloped avenue of research. Moreover, in our opinion, the study of the different factors comprising ACAP may contribute to clarify the innovative dynamics on clusters.

It must be mentioned that, whereas Hypotheses 1.1, 1.2 and 2.1 were not confirmed, Hypothesis 2.2 was statistically supported. This result suggests that the early adoption of a disruptive technology is not fostered by acquisition and assimilation capacities of firms when they belong to a cluster. In other words, potential absorptive capacity doesn´t seem to have a clear effect over the early adoption of a technological novelty for clustered firms. Even more, as the variable indicating the transformation capacity is not significant, it stresses its irrelevance for a clustered firm when early adopting of a far technological innovation. Conversely, the analysis shows how exploitation capabilities have a significant influence on this adoption.

What reveals our study and, in our opinion, what constitutes its main contribution refers to the uneven effect of the *potential* (exploring) and *realized* (exploiting) domains of the ACAP model on the early adoption of disruptive technologies for the clustered firms. Network peculiarities and proximity in these kind of territorial organizations may be underneath this result.

This research is relevant for many reasons; the importance of the industrial clusters as phenomenon of regional development, the dominant focus of previous research (mainly based on dynamics of adoption of incremental innovations), and the current challenges facing territorial agglomerations (aiming to adapt their structures and strategies to the external global conditions (Cooke et al. 2012)) may be some of these reasons. Disruptive technologies and innovation can be understood as possible survival alternatives and further clusters development (Østergaard and Park 2015). Moreover, the factors that once explained clusters' success can today become the main threat and restraint for them. In effect, clusters´ relational structure - which is much more appropriate for incremental technological improvements rather than radical or disruptive ones (Maskell 2001) - may avoid the introduction and development of breakthrough novelties into clusters, consequently avoiding in some extent their potential renewal.

In our understanding, and in contrast to what may happen in other different contexts, proximity between firms in clusters may affect the mechanisms to introduce (and exploit afterwards) the new technologies or external knowledge. Dense and recurrent relational structures in clusters lead individual organizations to share norms and values that regulate exchanges of knowledge resources (Uzzi 1996; Uzzi 1997). This peculiarity transforms clusters in efficient contexts for continuous improvement processes, linked to the exploitation strategies of knowledge resources (Rowley et al. 2000). In addition, individual companies are heterogeneous and distinctive, so they will vary their capacity to exploit external sources of knowledge coming from the other members of the cluster. The interactions between cluster and individual firm levels can be relevant in a close relational context. The finding that the dimensions of the ACAP differentially influence innovation in a clustered firm, contrasts with the way they have traditionally been regarded as a full benefit to organizations (Veugelers 1997; Stock et al. 2001; Tsai 2001). An established stream of research contains a number of examples which are worth mentioning (Expósito-Langa et al. 2011; Belso-Martinez et al. 2013).

In both studies, the ACAP was analysed as a factor to create innovative capacity in firms. Even though several researchers have suggested that some dimensions of ACAP could have a downside, our findings are particularly important to extend the existing literature. In fact, the different contribution of ACAP dimensions under a cluster context is, in our opinion, understudied and opens a new line of research to better understand the internal efforts performed on firms. Clustered firms may benefit from those cluster externalities which are focused on exploration of new technologies, focussing its efforts, consequently, on developing exploitation of the innovations.

The practical implication of our findings is for both cluster and individual firm levels. In order to foster adaptation and renewal, clusters should establish systematic mechanisms to detect and introduce new and exclusive ideas through cluster networks. On the other hand, clustered firms should develop first, their own portfolio of abilities to enhance their interaction with clusters´ actors and take profit of the exchanged knowledge. Second, they should specially develop exploiting capabilities since, as our results suggest, they will play an important role to benefit from a novelty. As a matter for further discussion, we suggest that, in order to access external sources of new and exclusive knowledge, firms in districts can use indirect ties by means of intermediary agents (Molina-Morales and Martínez-Fernández 2004). In particular, local institutions and supporting organizations are relevant actors in territorial networks that provide external scanning abilities for the cluster (Molina-Morales et al. 2017).

We are aware that our research has some limitations. They are related with the specific conditions which are developed into the cluster which were probably acting as a moderator of these causal relationships. On the other hand, only one industry has been analysed. Clustered firms are so particular and specific conditions are so difficult to replicate that general conclusions can be biased. We acknowledge the need to apply this approach to other contexts and industrial clusters in order to strengthen the results of the research and to gain broader validation.

The following points can be viewed as well as possible future avenues of research for the development of this study. The fine-grained process through which network structure is created or modified is an interesting and important area for future research. It is critical to know to what extent firms are externally conditioned or, on the contrary, they have a degree of freedom to decide the pattern of cluster internal interactions. Another fruitful area of inquiry is the dynamics of how firms' networks evolve and change in response to external challenges and new opportunities such as a disruptive technological innovation.

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Tables

Table 1: Actor´s profile comprising the Spanish ceramic tile cluster. Source: elaborated by authors

Cluster members	Member description	Specific cluster activity
Final firms	Firms carrying out the cluster´s defining activity	Wall and floor ceramic tile manufacturers
Specialized firms, (supporting firms)	Firms involved in supply activities for final firms	Glazing industries, chemical additives manufacturers, ceramic machinery and ceramic equipment suppliers, atomized clays producers, etc.
Integrated firms	Firms performing activities belonging to other industries but integrated in the cluster	Industrial services, project services, shipping and road transport services, design and marketing services, packaging services, etc.
Institutions and organizations	Entities which support the cluster	Educational centres, research institutes, trade associations, etc.

Table 2: Ceramic tile production grouped by geographical manufacturing areas. Source: elaborated by authors from (Baraldi 2017).

Position	**Geographical areas**	**% on world production**	**Total production in 2016 (in millions of sq. m)**
#1	Asia	71,5	9.331
#2	European Union (28 countries)	10,0	1.304
#3	Central South America	8,3	1.086
	Rest of world areas	10,2	1.335
TOTAL PRODUCTION		100	13.056

Table 3: Descriptive statistics of the dependent variable. Source: elaborated by authors.

	Code	**Frequency**	**Percentage**	**Cumulative percentage**
Adopters after 2011/non-adopters	*0*	*24*	*32,0*	*32,0*
Adopters before 2010 (included)	*1*	*51*	*68,0*	*68,0*
Total		*75*	*100,0*	

Table 4: Descriptive statistics of the control and independent variables. Source: elaborated by authors.

	N	Mean	Median	Mode	S. Deviation	Variance	Range	Minimum	Maximum
Size of the company	*75*	*0,00*	*-0,28*	*-,49*	*1,00*	*1,00*	*7,62*	*-0,48*	*7,14*
Age of the company	*75*	*35,53*	*31,00*	*17,00*	*21,13*	*446,33*	*101,00*	*3,00*	*104,00*
Technological innovation orientation	*75*	*0,00*	*0,32*	*0,78*	*1,01*	*1,01*	*2,79*	*-2,02*	*0,78*
Organizational innovation orientation	*75*	*0,00*	*0,58*	*0,83*	*1,01*	*1,01*	*2,59*	*-1,76*	*0,83*
Acquisition	*75*	*0,00*	*0,03*	*1,16*	*1,01*	*1,01*	*4,63*	*-2,89*	*1,74*
Assimilation	*75*	*-0,01*	*0,14*	*0,14*	*1,00*	*1,00*	*4,96*	*-3,33*	*1,63*
Transformation	*75*	*-0,01*	*-0,05*	*,11*	*1,00*	*1,01*	*6,09*	*-3,83*	*2,26*
Exploitation	*75*	*-0,01*	*0,22*	*1,09*	*1,00*	*1,01*	*4,38*	*-2,64*	*1,75*

Table 5: Contrast between predicted and observed values of the model. Source: elaborated by authors.

Observed		Predicted: Early Adoption 0	Predicted: Early Adoption 1	Correct (%)
Early Adoption	**0**	*17*	*7*	*70,8*
	1	*8*	*43*	*84,3*
Global Percentage				***80,0***

Table 6: General significance of the Binomial Logistic Regression (LOGIT). Source: elaborated by authors.

	Chi-squared	gl	Sig.	R^2 (Cox y Snell)	R^2 (Nagelkerke)
Model	*30,173*	*8*	*0,000*	*0,331*	*0,464*

Table 7: Binomial Logistic Regression results (LOGIT). Source: elaborated by authors.

	B	**Std. Error**	**Wald**	**gl**	**Sig.**	**Exp(B)**
Intercept	*-1,443*	*0,780*	*3,423*	*1*	*0,064*	*0,236*
Size of the company	*-0,166*	*0,421*	*0,155*	*1*	*0,693*	*0,847*
Age of the company	*0,079*	*0,026*	*9,285*	*1*	*0,002*	*1,082*
Technological innovation orientation	*1,555*	*0,612*	*6,451*	*1*	*0,011*	*4,737*
Organizational innovation orientation	*-0,421*	*0,664*	*0,402*	*1*	*0,526*	*0,656*
Acquisition	*-0,290*	*0,462*	*0,394*	*1*	*0,530*	*0,748*
Assimilation	*0,129*	*0,412*	*0,099*	*1*	*0,754*	*1,138*
Transformation	*-0,278*	*0,400*	*0,480*	*1*	*0,488*	*0,758*
Exploitation	*0,795*	*0,435*	*3,337*	*1*	*0,068*	*2,215*

Figures

Figure 1: Analytical framework. Source: elaborated by authors.

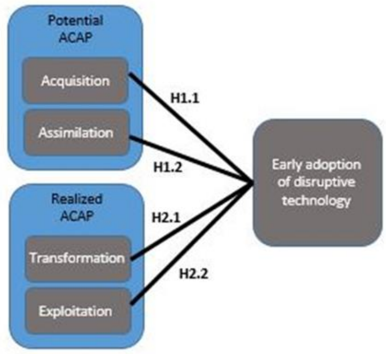


Figure 2: Percentage of adopters and non-adopters, among the companies interviewed in 2017 belonging to the Spanish ceramic tile cluster, of the digital printing technological disruptive innovation. Source: elaborated by authors.

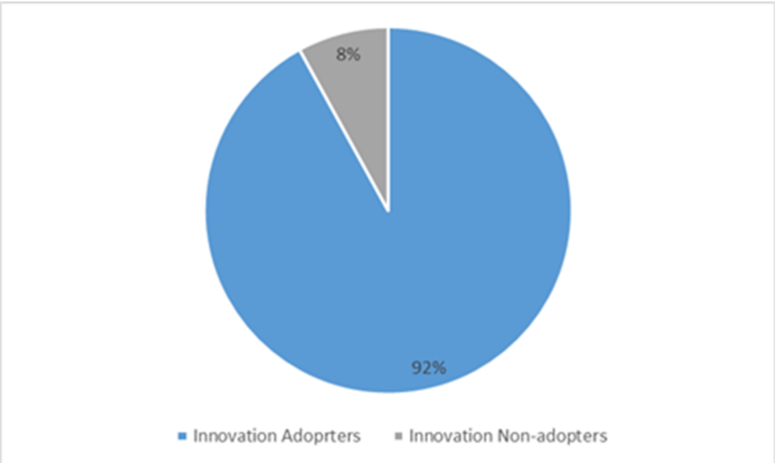
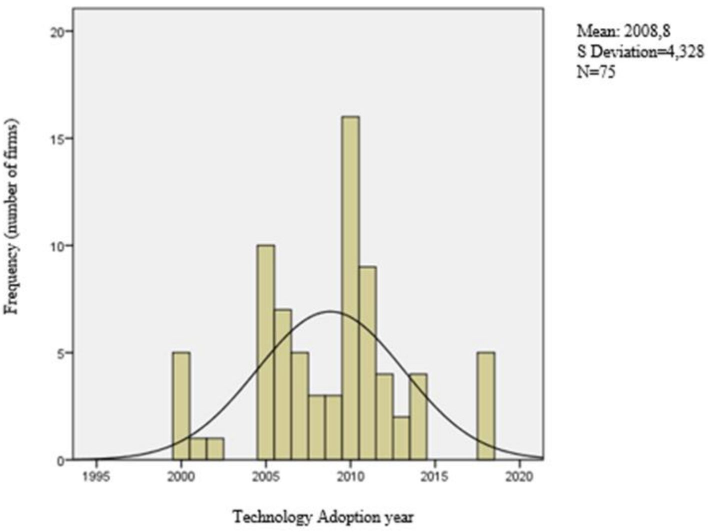


Figure 3: Distribution in time (years) of interview firms adopting the digital printing innovation. Source: elaborated by authors.



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