

An analysis of the Spanish Ceramic Tile Industry Research Contracts and Patents

Daniel Gabaldón-Estevan^{1,2}, Liney Manjarrés Henríquez^{2,3}, F. Xavier Molina-Morales⁴

1-Department de Sociologia i Antropologia Social. Universitat de València – Valencia, Spain. Daniel.Gabaldon@uv.es

2-INGENIO - Instituto de Gestión de la Innovación y del Conocimiento (CSIC – UPV). Universidad Politécnica de Valencia – Valencia, Spain.

3-Universidad Autónoma del Caribe - Barranquilla, Colombia

4-Departamento de Administración de Empresas y Marketing. Universitat Jaume I – Castellón de la Plana. Spain

An analysis of the Spanish Ceramic Tile Industry Research Contracts and Patents

In this work we apply a systemic approach to the analysis of a particular geographic territory, the industrial district. We are particularly interested in analysing the interaction between the productive-technological environment and the scientific environment by an examination of research contracts and patents. Our analysis shows that R&D activity in the Spanish ceramic tile District Innovation System was mainly conducted by suppliers. Final producers' innovation efforts were related to non-technological aspects and differentiation.

Keywords: innovation system, ceramic tile, industrial district, patent, research contracts

1. Introduction

Innovation is a central issue for companies and firms are re-evaluating their products and services, and their corporate cultures with a view to improving them (Bartlett and Ghoshal

1990). Sources of innovation can be internal or external to the firm; but increasingly firms are dependent on the external environment for knowledge and innovation. A theoretical tradition in the literature, systems of innovation, stresses the relevance of external sources of knowledge for development and innovation (Dosi, Pavitt and Soete 1990; Lundvall 1992 or Edquist 1997). This tradition emphasizes the importance of economic, social, political, organizational and institutional factors that influence the development, diffusion and use of innovations. Systems of innovation allows a systematic examination of the structure of and interactions between different levels and elements that intervene in the innovation process. Most studies refer to the national or regional level. There are other levels, like sectoral or local, that are relevant and the concept has been applied in several fields (Oinas and Malecki 2002). Systems of innovation literature is vast and provides an essential tool for the analysis of the innovation process in territorial contexts (see Gabaldón-Estevan, 2016 for a review).

Industrial districts (ID) consist of groups of mainly small and medium sized enterprises (SMEs) located in a specific territory, with high levels of specialization and interdependence and the presence of various agents and institutions (Becattini 1990; Brusco 1990). In this paper we want to analyse the interactions between the productive-technological environment and the scientific environment through an examination of research contracts and patents. We aim to integrate two different concepts and perspectives, such as industrial district and innovation system. In fact, we have applied the systemic approach to the ceramic tile industrial district. The aim of the paper is to analyze the interactions between the components of the district innovation system. As the main notion of the system refers to the interactions in this paper we analyze in detail interactions through the analysis of research contracts and patents. In particular, we study the role of different activities in the productive and technological environments of the

system based on research contracts between individual firms and research institutes, as well as firms' patenting activity.

In this paper we use the concept of District Innovation System (Gabaldón-Estevan, Molina-Morales and Fernández-de-Lucio 2012) to emphasize the relevance of territory when an industry adopts the ID form but is also dependent on other elements in the innovation system. The District Innovation System (or DIS) is formed by a set of institutions, firms and promotion mechanisms that offer continuous support to district firms. The DIS involves interconnections and cooperation among elements within the same environment for the purposes of innovation.

The paper is structured as follows. Section ii presents the theoretical background to the research. Section iii presents the methods and data for the empirical analysis. Section iv deals with the description and main features of the Spanish ceramic tile DIS, and section v focus on the results of the analysis of research contracts and patents of firms in the DIS. We discuss the results in section vi and conclude in vii where implications of this study are also highlighted.

2-Theoretical Framework

Previous research (Acs and Audretsch 1991; Cohen 1995; Geroski 1995) stresses the importance of considering both internal and external factors as determinants of firm innovation (Sternberg and Arndt 2001). In general, inter-organizational relationships create opportunities for knowledge acquisition and exploitation (Dyer and Singh 1998; Lane and Lubatkin 1998; Larsson et al., 1998). Some authors propose specific externalities. For instance, public research, a geographically localized externality, is considered critical for the process of technological change (Autant-Bernard, 2001).

Moulaert and Seika (2003) reviewed a number of territorial innovation models, including innovation system and cluster, concluding that despite their apparent semantic

unity these models are conceptually quite diverse. Moreover, none is a consequence of several factors such as the immediate of them defines the purpose of innovation explicitly, suffering from conceptual ambiguity. Similarly, Simmie (2005) traced the historical development of innovation theory to provide explanations about why the firms, organizations and institutions located in some regions generate so much more innovation than others.

In addition, several subnetworks within the district were identified and analyzed, among them the information network, the technological knowledge network and others, so that each of these flows affects a specific group of actors and also unequally (Breschi et al. Lissoni 2001, Lissoni 2001, Boschma and Frenken 2006, among others). Similarly, Morrison and Rabelotti (2005) discuss the notions of core and periphery networks in the cluster (in Spain, Molina-Morales et al., 2012), to differentiate between subnetworks with high intensity of relations and the periphery most connected with external networks

Consequently, a systemic perspective seems appropriate since it considers different elements and levels involved in the innovation process, their interdependencies, and the way they act. The concept of National (Regional) Systems of Innovation in particular focuses on the environment and the institutions at national (see Dosi, Pavitt and Soete 1990; Lundvall 1992; Edquist 1997) or regional level (Cooke and Morgan 1993; Cooke 1996). Further, the study of innovations and innovation systems has been enriched using other approaches such as technological systems (Carlsson and Stankiewicz 1995; Hughes 1984; Callon 1992), the sectoral perspective proposed by Breschi and Malerba (1997; Malerba 2002) and more recently the socio-technical transitions from a Multi-Level Perspective (MLP) (Geels, 2002). These studies offer a complex and interactive framework to understand the dynamics of innovation in a particular environment. The systemic view suggests a number of conditions that should be considered. For any

innovation system agents and institutions are considered only in relation to their contribution to innovation. In order to improve innovation performance a systematic consideration and redesign of the interfaces between different parts of the system is required.

The districts are geographically defined production systems, characterized by a large number of companies that deal with various phases and shapes in the production of a homogeneous product. *A socioeconomic entity which is characterized by the active presence of both a community of people and a population of firms in one naturally and historically bounded area* (Becattini 1990: 39). Industrial district refers explicitly to the community of people and the context in which knowledge flows and numerous diverse categories of relationships occur. Social issues are seen to be the result of the economic success of private firms, while the success of economic issues for Becattini is the result of the social cohesion within a community of people. People are at the center of the analysis, and economic activities are the mean. Becattini tries to generalize his conclusions to other countries. In the context of this work, we understand the notion of a district system of innovation as a system of relationships where companies are generated that facilitate processes of innovation and that are produced within an industrial district, a social entity that is related to a specific territory, but generally does not conform to specific political and administrative boundaries.

From this perspective DIS concept requires that the unit of analysis be extended to include not only the companies and institutions but includes those elements of its innovation system conceived as both a technological system and a product, with which it interacts, within the same regional innovation system or outside it. It also assumes a network of public and private institutions that offer what Brusco (1990) calls 'real services'.

In the context of the present study, we understand the notion of ID, in the broad sense of the term, as referring to a physical and relational space where externalities are generated for firms.

Specifically, a DIS is defined as:

a system of relationships within an industrial district where externalities facilitate firms' innovation processes [...] An industrial district is understood as a social entity, which, while linked to a territory, usually does not conform to the limits of a specific administration. District innovation system emphasizes the relevance of territory, that is, when an industry adopts the district form, but is also dependent on other elements in the innovation system. Consequently, the district innovation system is made up of a set of institutions, firms and promotion mechanisms that offer continuous support to district firms. The district innovation system involves interconnections and cooperation among elements within the same environment for the purposes of innovation. (Gabaldón-Estevan, 2016: 83).

The advantage of the DIS approach is that it overcomes the potential limitations of the district concept to capture and explain the innovative processes occurring within it but, at the same time, does not ignore the unique specificities that characterize and differentiate an ID from other levels of analysis.

3-Methods

For the description of the District Innovation System of the Ceramic Tile in Castellón (see figure 1 for the location of the industry within the Valencia region) our analysis follows the model developed in the studies of the Valencian Innovation System by Fernández-de-Lucio (Fernández-de-Lucio and Conesa, 1996; Fernández-de-Lucio et al., 1999, Fernández-de-Lucio, Gabaldón-Estevan and Gómez, 2005).

Figure 1. Location of the ceramic tile DIS within other industrial agglomerations in the Comunitat Valenciana region (Spain)

Source: El mapa dels districtes industrials d'Espanya Conference by Joan Trullén,
Castellón 28/06/2005

The research builds on previous research on the abovementioned district and its counterpart in the north of Italy and information from 36 semi-structured interviews with representatives of the ceramics ID in Castellón (Spain) and in Sassuolo (Italy) in the years 2004 and 2008 (see table 1).

Table 1. Description of the informants' interviews

* Representatives.

Source: own elaboration.

Some of the interviewees were managers from ceramic (Cooperativa Cerámica d'Imola; Keraben; Zirconio; TAU), electro-mechanical (L.B.; System; Cimes) and glaze companies (Vernis; Ferro); others were representatives of employers' and workers' associations (Assopriatrelle; Ascer; ANFFECC; ACIMAC; ASEBEC; ATC) some were representatives of public institutions specialized in technology or trade (Cámara Oficial de Comercio, Industria y Navegación-COCIN Castellón) specialized journalists (Ceramic World Review-CWR, Tile Edizioni); and some were in charge of research institutions directly responsible for research and development for the industry (Instituto de Tecnología Cerámica-ITC; Instituto de Cerámica y Vidrio-ICV; Centro Ceramico di Bologna-CCB), or academics working on these issues (Università degli studi di Modena e Reggio Emilia-UMRE; Universitat Jaume I-UJI). The analysis is centred on the 1999 to 2004 period (figure 2).

Figure 2. Evolution of the Spanish ceramic tile production 1969-2012.

Source: ASCER.

The interviews addressed the ceramic tile production process and value chain, the relevant elements and the roles of the elements of ceramic tile districts, how innovations are produced and disseminated through agents in the market, how different agents participate in the innovation process, and how innovation is stimulated in the sector. They also enquired into more general aspects of sector evolution such as global production trends, competition and trade.

The 2004 interviews followed a flexible and ad-hoc interview guide that allowed a discussion reflective of the nature of organisation each of the interviewees represented. For the 2008, a more structured interview guide was used in order to apply a functional analysis to the ceramic tile innovation system (a full description can be seen at Gabaldón-Estevan and Hekkert, 2013).

For the analysis of the interactions among the Productive, Technological and Scientific Environments in the DIS a quantitative approach is found more suitable. For this data from the companies belonging to the three most representative producers' associations are exploited. Regarding the dataset of enterprises: the initial list was constructed from the enterprises in the sectors' three main producers' associations (ASCER, ANFFECC and ASEBEC) which provided a total of 281 companies. Of these, 57 were excluded either because their head offices were located outside of the Castellón province or because their status was "not active" when the analysis was conducted. Distinguishing atomizer companies from ceramic tile producers (all of which belong to ASCER) was done on the basis of the Clasificación Nacional de Actividades Económicas (the Spanish Classification of Economic Activities) 4-digit classification. The selection of companies includes firms located in Castellón associated with ASCER (the Association of Ceramic Tile Manufacturers of Spain, which includes ceramic tile producers, producers of special pieces and clay atomizers), ANFFECC (the Association of the

Spanish Ceramic Frits, Glazes and Colour producers), and ASEBEC (the Spanish Manufacturers of Machinery and Equipment for the Tile Industry). Thus, our companies' dataset is not a sample but includes all active companies located in the Castellón province.

As shown in table 2, the degree of concentration of sector companies in Castellón province is always higher than 75%. The largest group is the ceramic tile producers. The number of its employees is more variable than in other groups because this group includes some smaller companies which focus on the production of special pieces. This group's revenues and employee benefits are higher than for the machinery companies, but lower than frits, glaze and colours production firms, which, on average, have lower results.

Table 2. Description of the type of companies included in the dataset

* ASCER includes both ceramic tile producers (final) and atomizer companies.

Source: own elaboration.

Apart from the list of memberships of the different employers' associations mentioned above, the data for this paper comes from four different sources. The first, patent data, is the Spanish Office for Patents and Marks (OPEM) dataset. All patents (Spanish, European, and international) registered by the companies in the above described dataset of companies for the years 1999 to 2004, were collected.

The second data source is contracts with Valencian public universities. We collected information on contracts between companies in our data base and any of the public universities in the Valencia region, in the years 1999 to 2004. This produced a total of 218 records of contracts, agreements and other R&D, between Valencian universities and the companies in our dataset.

The third data source is contracts with the Spanish National Research Council (CSIC). The list provided by CSIC for contracts between the dataset of firms and any of

the following centres belonging to CSIC: the Ceramics and Glass Institute (ICV), the Materials Sciences Institute of Aragón (ICMA), and the Materials Structure Institute (IEM). The time frame was again 1999-2004. This provided a total of 33 records of contracts, agreements and other R&D collaborations between CSIC centres and the companies in our dataset.

We collected data on financial and economic indicators from SABI; they refer the last available year, being the date of the query February 2007. SABI is the directory of Spanish and Portuguese companies and provides general and financial information on 95% of all Spanish companies. SABI data are provided by the Trade Register in the form of an official trade register.

4-The District Innovation System of the Ceramic Tile in Castellón

The ceramic tile industry includes the production of floor and wall ceramic tiles, decorative pieces, frits, glaze and colours, machinery and equipment and other activities related to the ceramic process. At the Castellón ceramic tile DIS several institutions, firms and promotion instruments offer continuous support to the Spanish ceramic tile industry. See figure 3 for a schematic description of the elements of the District Innovation System of the Ceramic Tile in Castellón.

Figure 3. Elements of the District Innovation System of the Ceramic Tile in Castellón

Source: own elaboration.

The productive environment of the DIS includes ceramic floor and wall tile producers, and producers of special pieces, and producers of diverse semi-elaborate products such as unglazed tiles and atomized clay.

The technological and advanced services environment of the DIS includes any institution able to offer and deliver technological knowledge that can be transformed into

innovations. This includes technologically new machinery, materials, counselling and services. Note that the elements of this environment are the nexus between the requirements of the productive environment and the potential capacities of the scientific environment. The agents from the technological and advanced services environment are any provider that brings novel or improved technological solutions, such as frit, glaze and colour providers, machinery providers and varied services providers (design, CAD/CAM, serigraphy, etc.), and diffuses them in the sector. Those firms or service providers from the sector that offer advice in the fields of design, computerization and new technologies, technological and market consultancy, etc. also belong to the technological and advanced services environment. Some ceramics firms (18% according to Fundación BANCAIXA, 1999) had their own internal design department, but most of buy designs for technical studies or obtain them from their providers of frits, glaze and colours or special pieces.

The scientific environment consists basically of the research groups from the universities and the public and private research centres. The specific organizations are Jaume I University (UJI) and the Institute of Ceramic Technology (ITC) which is linked to the Department of Chemical Engineering of UJI. Two departments in UJI, Chemical Engineering and Inorganic and Organic Chemistry, are responsible for most of the research developed for the sector in the areas of ceramic technology, chemistry, environmental pollution and ceramic design. The Centre for Research on Graphic Design, belonging to the Polytechnic University of Valencia (UPV), conducts research on systematization and control of glazing lines in order to reduce the amount of glaze used, increase the quality of the final product, and reduce the emergence undesirable shading. The Institute for Ceramic and Glass (ICV), part of CSIC, conducts basic and applied research in various fields related to ceramics and glass for the frits, glaze and colours subsector.

The institutional environment is comprised of various public administrations whose policies influence the industry activity in the district. ASCER, ANFFECC, ASEBEC, ATC, ANDIMAC and AFPE are all active in the sector; fairs and congresses (the International Exhibition for Architectural Ceramic and Bathroom Furnishings, CEVISAMA; the World Congress on Ceramic Tile Quality, QUALICER) help to promote products are important sources of information for technological innovation; the Trade, Industry and Navigation Chamber of Castellón, the Industrial Engineers Professional Association and the Entrepreneurship Confederation of Castellón are support and services providers to encourage entrepreneurship within the industry. Due to the relevance of the tile sector in the local economy, the role of these actors is very important in this sector.

The efforts of all these actors contribute to the technological advancement of the sector (Gabaldón-Estevan and Hekkert 2013; Gabaldón-Estevan, Criado and Monfort 2014). They interact and collaborate in the innovation process enabled by a series of interface structures. These include chambers of trade, professionals' associations, marketing associations, etc. The innovation system is open and international due to the frit, glaze and colour industry (Tortajada-Esparza, Gabaldón-Estevan and Fernández-de-Lucio 2008; Tortajada-Esparza, Fernández-de-Lucio, and Gabaldón-Estevan 2008; 2009), which exports more than half of its production, the exports from the tile industry, the dependence on Italy for technology and capital goods and the close relationship between the ITC and foreign R&D institutes such as the Italian Ceramic Centre at Bologna and the collaborations between producers in Castellón and Emilia Romagna such as ASCER and Assopiastrelle.

5-Results

In this section, we analyse the interactions between the productive, technological and scientific environments in the ceramic tile DIS in Castellón by examining research contracts and patents (see figure 4).

Figure 4. Interactions between the productive, technological and scientific environments in the ceramic tile DIS in Castellón

Source: own elaboration.

We carry out two types of analysis. First, we take the aggregate of the groups in order to analyse their roles in the system. Second, for each group we select the most innovative companies and compare them with the remaining firms.

Table 3 shows a total of 54 companies out of the 224, that is a 24% of the companies had contracts with one or more public universities in the Valencian Community or with CSIC.

We identified 251 activities that represent a total of € 5,142,487.

Table 3. The distribution of the research contracts and patents at the DIS

Source: own elaboration.

In relation to the types of contracts with Valencian universities, R&D dominates, accounting for more than 90% of the total value. Technological support and consultancy is less relevant, accounting for just over 5%. Services constitute a large number of actions but their value is small (less than 3%). The departments involved number 27 from the four universities: the top three departments (Chemical Engineering, Inorganic and Organic Chemistry, and the Technology Department) from UIJ account for almost 80% of the total contracts in the period analysed. Among the contracts with CSIC, all but one are for R&D and are mostly with the Institute for Ceramic and Glass.

The most notable finding for the distribution of research contracts and patents among the different firms within the district is the relative high weight of frits, glaze and colours producers, the small representation of final product producers, and the marginal role of the other two groups of companies, machinery and equipment and atomized clay.

Table 3 also shows the number of patents applied for by the different groups of companies belonging to the DIS. During the period under study a total of 49 patents were granted. Since most applications are from single companies this suggests that most innovations are developed in-house. With reference to the number of patents granted to the different activity groups in the district, frits, glaze and colours companies rank highest followed by the machinery producers group. No patents were applied for by the atomized clay producers group.

The aim of the next analysis is to improve understanding of innovative companies. We define an innovative company as any company that, in the period under analysis, signed a research contract or applied for a patent. We analyse the differential characteristics of the two groups of companies: innovative and the non-innovative. First we consider all the companies including both innovative and non-innovative firms (N=224). Table 4 presents the Pearson correlations for a series of financial variables and economic indicators; the dummy variable is innovation.

Table 4. Correlations between innovation, size and business volume

Source: SABI 2007 and own elaboration.

When considering all companies, innovative companies are positively and significantly correlated with size, measured as number of employees and total revenues. This allows us to characterize these companies as large. The other indicators for return on assets and measures of productivity are not significant which means that inside the district innovating is not associated with an improvement on productivity.

In the next step of the analysis we complete the characterization of the innovative companies using variables based on SABI data. Those variables being firm age, number of employees, total revenue, return on assets, profit per employee, ratio of employee costs to total revenue, and number of shareholders.

Table 5. Results of variance analysis (ANOVA) of mean comparison

* $p < 0,10$; ** $p < 0,05$; *** $p < 0,01$; (a) Mean (b) Standard Deviation.

Source: INE 2000, 2004 and own elaboration.

The fourth block of the table supports the findings from the correlation analysis that innovative companies are larger. Although there are small differences between groups, innovative companies are older, have lower returns on assets and slightly more shareholders; however, these differences are not significant and the means are not statistically different.

With respect to the ceramic tile companies, the findings confirm that there is a positive association between company size and number of innovations. However, when we test the financial data (Return on Assets and Profit per Employee) for those companies identified as innovative, they show lower performance. However, it should be noted that this wide deviation in values from the mean may affect the significance of the results. For the frits, glaze and colours companies, the data confirm the positive associations between the size and innovation, and return on assets and innovation. The small number of companies in this group and the large deviation in the values from the mean may explain the lack of significance. For the machinery and equipment companies, the significance of both size and age is confirmed. Differences between the values for Return on Assets between the two groups of companies, although higher for non-innovative companies, are not significant, due again to the reduced number of companies in this group. Finally, the

group of atomizer companies shows different behaviour, but again the small number of companies makes it impossible to draw robust conclusions.

In order to control for the results of our analysis we collected aggregate data for the behaviour of groups of companies from the Spanish Statistical Agency, INE, which publishes data on innovation. The INE survey identifies innovative companies that, during the previous three years to being surveyed, have introduced technologically new or improved products into the market or have introduced technologically new or improved processes into their production methods for of goods or provision of services.

Table 6. Innovation data from INE survey

Source: INE 2000, 2004 and self-elaboration.

Table 6 shows that the number of innovative companies is larger in the case of the frits, glaze and colours subsector; however, the percentage of companies engaged in innovation is similar for both groups, and the final producer group scores higher for non-technological innovations. We see also that there are higher levels of specialization in product innovation in the ceramic tile producers group rather than in process innovations. These data complement the data already presented because final companies generally do not use technological innovation as a differentiation strategy; they tend instead to focus on non-technological innovations and product innovation.

6-Discussion

The finding from this research can be explained by the particular conditions existing in the DIS. Below, we highlight some conclusions.

(1) The role of frits, glaze and colours firms in the innovation system. We find that this subsector is the main driver of innovation in the district and this imply some relevant consequences, in particular for ceramic tile producers. In terms of competitive

advantage, ceramic tile producers find it difficult to differentiate their products using technological innovations. The technological innovations in the district are available to all district firms. The lack exclusivity means that other means for differentiation must be found. Some firms differentiate through organizational innovations, generally related to product distribution and marketing. We checked our results against data from INE's 2004 and 2006 reports on innovation, which confirmed that ceramic tile producers use non-technological innovation more than other district activities to differentiate their products.

Ceramic tile producers tend not to patent to protect their innovations. Therefore, the number of patents applied for by ceramic tile producers is small. Most patenting in the ID is aimed at maintaining competition, although there are internal mechanisms that allow innovations to be spread to other district firms. The latter implies that innovations in districts are not exclusively exploited by a single final firm but they are available to other firms as well. Consequently, the potential competitive advantage of firms cannot rely on patenting and must be searched for in other domains of the firm's strategy.

In our view, the actions of ceramic tile producers are based on the principles of the ID. Intense internal relationships encourage the diffusion of innovation within the district. The high rate of mobility of technicians and managers between district companies and informal relations (social, family and professional association) foster the exchange of information and knowledge and the diffusion of innovation.

(2) The implications for ceramic tile producers are a degree of homogeneity, and a need to access external suppliers to enable differentiation with respect to the competition. Many studies assume a high level of internal homogeneity among firms in ID. The existence of shared resources that are not exclusive to individual firms, but which, at the same time, are not available to firms outside the district, seems to justify this homogeneity in terms of firm behaviour and performance (see Becattini 1979, 1990; and

the analyses comparing firms inside and outside districts and work on the so-called district effect by Signorini 1994; Molina 2001; Paniccia 1998, 1999; Hernández and Soler 2003; Soler and Hernández 2001). However, this homogeneity is not confirmed by our analyses. Observation of some districts shows that they are not comprised of homogeneous communities of entrepreneurs or technicians sharing know-how and information. On the contrary, although some resources flow more or less freely within the district, flows of knowledge generally are limited to certain subgroups or district 'clubs'.

Districts are no longer self-contained in relation to all the activities. They need to access external resources. This openness promotes increased diversity or asymmetry among firms and organizations. Not all firms and organizations have the same capacity to access external networks and size is a relevant factor in this context. Small firms are likely to encounter barriers to access to external networks due to the lack of R&D departments or a high productive specialization. Morrison and Rabelotti (2005) identify two types of networks within districts. They describe the Core Network as a dense network based on tacit knowledge comprised mostly of SMEs with a low innovation capacity. They define the Periphery Network as a dispersed network with numerous connections with external actors, composed mostly of large sized companies with good innovation capacity. In other words, the shift to a new model of district open to external networks challenges the idea of internal homogeneity.

(3) The characterization of the other two subgroups of activities in the district. With respect to the atomizer companies, their low innovative activity can be explained by their productive process. These firms use raw materials (directly from the clay mines) and convert them to the required level of granulation for the ceramic process. They use the technology provided by the district machinery and equipment firms. They focus on

organizational and logistical aspects to achieve competitive advantage. This explains the lack of patenting activity.

Firms in the machinery and equipment subsector are dependent on Italian districts whose firms are the innovators. However, there is a high level of patenting activity because Italian patents have to be registered in the Spanish territory. This explains the lower cost of patenting in this sector compared to other sectors in the district.

The operation of the machinery and equipment sector is explained by the interaction with the Italian ceramic tile district. The Italian district is located in the Emilia Romagna (Sassuolo) region, particularly in the provinces of Modena and Reggio Emilia. In 2004, these two provinces accounted for more than 80% of total Italian production. This rises to 90% of total Italian production when including all Emilia Romagna provinces.

(4) How do innovative firms compare non-innovative firms in each group of activities in production? Our findings support the significant association between innovation and the two main indicators of size: number of employees and total revenue. Innovative firms are larger. This association is particularly evident in the case of final producers and frits, glaze and colours producers, the activities where innovation is most relevant.

Innovative firms are also generally older firms with the exception of atomizer companies where younger firms are more innovative than older ones. However, company age seems not to be a significant factor since company founders may have had previous experience in other companies within the district and since the companies in most cases are the result of a spin-off process. This previous experience acts as a moderator on the possible impact of the age on cumulative knowledge and innovation.

7-Conclusions and policy discussion

In this paper we proposed the concept of District innovation system to overcome limitations of ID and (regional/sectoral) innovation system, in order to analyse certain territorial entities. In this research we analysed the case of the ceramic tile district innovation system. In particular, we studied the role of different activities in the productive and technological environments of the system based on research contracts between individual firms and research institutions, and firms' patenting activity.

The main findings are as follows. Technological innovation within the district is mostly achieved by frits, glaze and colours companies. The data indicate an intense relationship between firms, particularly from the frits, glaze and colours subsector, with university departments and with ICV of the CSIC. This type of cooperation is focused mostly on R&D projects. The ceramic tile producers focus their innovation on non-technological developments. Other activities do not play a role in the innovation process. This is consistent with Nelson's (1993) primary typology of enterprises where he distinguishes types of industries based on a characterization of their technical change process: *bulk commodities producers* (i.e. atomizers, final producers, special pieces producers), based on minimal product and process innovation, which exploit equipment and input suppliers as the sources of their innovation, and *providers of technology and advanced services* (i.e. mechanics and electronics, and frits, glaze and colours) which are responsible for most innovation in the ceramic tile districts.

Patenting to protect innovation is generally not used by companies in the ceramic tile industry where innovation diffuses to other firms. Many companies prefer alternative non-contractual means of protection. However, data on patenting for the period considered shows there is a lack of cooperation between frits, glaze and colours producers and limited cooperation between firms and other elements in the DIS.

Our analysis shows that R&D in the Spanish ceramic tile DIS is mainly carried out by providers of frits, glaze and colours, and that ceramic tile producers focus on non-technological innovations. It shows weak use of patenting to protect innovations, low levels of cooperation between the frits, glaze and colours providers, and very limited cooperation with other elements of the DIS. We can conclude that technological innovations diffuse easily within the DIS which is the reason why ceramic tile producers focus on non-technological innovations as their differentiation strategy. The lack of homogeneity within the DIS is particularly relevant considering that external networks with enterprises and agents are a strategic asset.

The main conclusion from our research is that the specific characteristics of the inter-organizational environment in ID need to be considered for systemic analysis of the innovation process. The internal regime of accessing, transmission and exploiting knowledge and innovation determines this particular system. On the other hand, from a global perspective the existence of other districts allows interactions and a certain international division of labour among districts, which may influence the development of a particular district.

The most important finding is the lack of a significant association between innovative activities (as we have defined them) and performance indicators. We think that specific conditions within the district induce the existence of alternative competitive factors.

This research has some limitations as well. First, heterogeneity and lack of data on innovation in companies limits the analysis. We hope to extend this research with the addition of data on firms' access to external innovation sources. This would allow an examination of whether more innovative firms are also those that access external sources or whether there is asymmetric use of external and internal sources. We acknowledge the

limitations of this type of individual analysis. In order to complement this, further research could compare different districts in order to obtain more rigorous conclusions. One more limitation of the study is that the data used refers to the years comprised between 1999 to 2004. We believe that extending the temporal scope would shed more light on the connections between the productive and technological environments of the system.

Regarding policy, our study rises doubts on whether the classical instruments for the characterisation of innovation activity and innovative firms (Oslo manual) is an accurate tool for assessing innovative activities in DIS as the one presented here. We believe that the abovementioned characteristics of an ID force companies to consider other strategies to protect innovations for competitors.

Funding

This work was supported by the *Ministerio de Economía y Competitividad* (Ministry of Economy and Competiveness) of Spain, under project ECO2015-67122.

References

Acs, Z.J. and Audrestsch, D.B. 1991. *Innovation and Small Firms*. Cambridge, MA: The MIT Press.

Autant-Bernard, C. 2001. "Science and knowledge flows: evidence from French case." *Research Policy*, vol. 30, 1069-1078.

Bartlett, C.A. and Ghoshal S. 1990. "Matrix Management: Not a Structure, a Frame of Mind." *Harvard Business Review* Jul-Aug; vol. 68, nº 4, 138-45.

- Becattini 2001. *'The Caterpillar and the Butterfly. An Exemplary Case of Development in the Italy of the Industrial District'*. Firenze, Italy: Felice Le Monnier.
- Becattini, G. 1979. "Dale Settore Industriale al Distretto Industriale. Alcune considerazioni sull'unit  di indagine in economia industriale." *Revista di Economia e Politica Industriale*, n  1, 7-14.
- Becattini, G. 1990. "The Marshallian industrial district as a socio-economic notion" in *Industrial districts and inter-firm cooperation in Italy* (Pyke, F., Becattini, G. and Sengerberger, W. eds.). Geneva: International Institute for Labour Studies, 37-51.
- Bellandi, M. 1996. "Innovation and Change in the Marshallian Industrial Districts," *European Planning Studies* 4(3), 357-368.
- Breschi, S. and Malerba, F. 1997. "Sectoral Systems of Innovation: technological regimes, Schumpeterian dynamics and spatial boundaries" in *Systems of Innovation* (Edquist, C. ed.). London: Frances Pinter, 130-156.
- Brusco, S. 1990. "The idea of the industrial district: its genesis" in *Industrial districts and inter-firm co-operation in Italy*" (Pyke, F., Becattini, G. and Sengerberger, W. eds.). Geneva: International Institute for Labour Studies.
- Callon, M. 1992. The dynamics of techno-economic networks. In Coombs, R. & Walsh, V. (Eds.) *Technical change & company strategies: Economic & sociological perspectives* (72-102). San Diego: Harcourt Brace Jovanovich Publishers.
- Carlsson, B. and Stankiewicz, R. 1991. On the nature, function & composition of technological systems', *Journal of evolutionary economics* 1(2), 93-118.
- Cohen, W.M. 1995. "Empirical Studies of Innovative Activity." in *Handbook of the Economics of Innovation and Technological Change* (Stoneman, P. ed.). Oxford: Blackwell, 182-264.

- Cooke, P. 1996. "Regional innovation system: concepts, analysis, and typology." At *RESTPOR 96: global comparison of regional RTD and innovation strategies for development and cohesion*. Working paper. Brussels: European commission.
- Cooke, P. and Morgan, K. 1993. The Network Paradigm: New Departures in Corporate and Regional Development. *Environment and Planning D: Society and Space* 11(5): 543-564.
- Dosi, G., Pavitt, K. and Soete, L. 1990. *The Economic of Technical Change and International Trade*. London: Harvester/wheatsheaf.
- Dyer, J. and Singh, H. 1998. "The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Strategy." *Academy of Management Review*, 23: 660-679.
- Edquist, C. 1997. *Systems of innovation; Technologies, Institutions, and Organizations*. London and Washington: Printer Publishers.
- Elche-Hortelano, D., Á. Martínez-Pérez, and P. M. García-Villaverde 2015. 'Bonding capital, knowledge exploitation and incremental innovation in clusters of cultural tourism: the World Heritage Cities in Spain' *Investigaciones Europeas de Dirección y Economía de la Empresa* 21(3): 120-128.
- Fernández-de-Lucio, I., Conesa, F., Garea, M., Castro, E., Gutiérrez, A. and Bodegas, M. A. 1996. *Estructuras de interfaz en el sistema español de innovación. Su papel en la difusión de tecnología*, Valencia: Universidad de Politécnica de Valencia.
- Fernández-de-Lucio, I., Gabaldón-Estevan, D. and Gómez-de-Barreda, C. 2005. *La innovación en el sector de pavimentos y revestimientos cerámicos de la Comunidad Valenciana*. Valencia: Alto Consejo Consultivo en I+D de la Presidencia de la Generalitat Valenciana.

Fernández-de-Lucio, I., Gutiérrez, A., Jiménez, F. and Azagra J.M. 1999. “Las debilidades y fortalezas del Sistema Valenciano de Innovación” in *Sistemas Regionales de Innovación* (Olazarán M. and Gómez M. eds.). Bilbao: Universidad del País Vasco, 251-278.

Fundación Bancaja 1999. *El Cluster cerámico en Castellón. Iniciativa de refuerzo de la competitividad*. Valencia: Bancaja.

Gabaldón-Estevan, D. 2016. Innovation Diffusion in the European Ceramic Tile Industry Supply Chain. In *Supply Chain Strategies and the Engineer-to-Order Approach* (76-97). Hersey: IGI Global.

Gabaldón-Estevan, D. and Hekkert M.P. 2013. “How Does the Innovation System in the Spanish Tile Sector Function?” *Boletín de la Sociedad Española de Cerámica y Vidrio* 52 (3): 151-158.

Gabaldón-Estevan, D., Criado, E. and Monfort, E. 2014. “The Green Factor in European Manufacturing: A case study of the Spanish ceramic tile industry.” *Journal of Cleaner Production* 70: 242-250.

Gabaldón-Estevan, D., Molina-Morales, F. X. and Fernández-de-Lucio, I. 2012. “Sistemas Distrituales de Innovación.” *Arbor* 188 (753) 63-73.

Geels, F. W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*. 31(8-9), 1257-1274

Geroski, P. A. 1995. “What do we know about entry?” *International Journal of Industrial Organization* 13(4): 421-440.

Hernández, F. and Soler, V. 2003. “Cuantificación del efecto distrito a través de medidas no radiales de eficiencia”, *Investigaciones Regionales*, 3: 25-39.

- Hughes, T. (1984). The evolution of large technological systems. In Bijker, W., Hughes, T. & Pinch, T. (eds.) *The social construction of technological systems: New directions in the sociology and history of technology*, Cambridge: MIT Press, pp. 51-82.
- Instituto Nacional de Estadística. 2002. *Encuesta sobre innovación tecnológica en las empresas 2000*. Madrid: Instituto Nacional de Estadística.
- Instituto Nacional de Estadística. 2006. *Encuesta sobre innovación tecnológica en las empresas 2004*. Madrid: Instituto Nacional de Estadística.
- Lane, P. J. and Lubatkin, M. 1998. "Relative absorptive capacity and interorganizational learning." *Strategic Management Journal*, vol. 19: 461-477.
- Larsson, R., Bentsson, L., Henriksson, K. and Sparks, J. 1998. "The inter-organizational learning dilemma: collective knowledge development in strategic alliances." *Organization Science* 9(3): 285-305.
- Lundvall, B. A. 1992. *National systems of innovation*. London: Printer.
- Malerba, F. 2002. "Sectoral systems of innovation and production." *Research Policy* 31(2): 247-264.
- Maskell, P. 2001. "Knowledge Creation and Diffusion in Geographic Clusters" *International Journal of Innovation Management* 5(2), 213-225.
- Molina-Morales, F. X. 2001. "European Industrial Districts: Influence of Geographical Concentration on Performance of the Firm." *Journal of International Management* 7(3): 1-15.
- Molina-Morales, F. X. 2002 'Industrial districts and innovation: the case of the Spanish ceramic tiles industry' *Entrepreneurship & Regional Development*, 14(4): 317-335.

- Morrison, A. and Rabellotti, R. 2005. *Knowledge and Information Networks: Evidence from an Italian Wine Local System*, CESPRI Working Papers n° 174, Centre for Research on Innovation and Internationalisation. Milano: Università Bocconi.
- Moulaert F. and Sekia F. 2003. Territorial innovation models: a critical survey, *Regional Studies* 37, 289–302.
- Nelson, R. 1993 *National Innovation Systems*. New York: Oxford University Press.
- Oinas, P. and Malecki, E. J. 2002. “The Evolution of Technologies in Time and Space: from National and Regional to Spatial Innovation Systems.” *International Regional Science Review* 25(1): 102-131.
- Paniccia, I. 1998. “One, a Hundred, Thousands of Industrial Districts.” Organizational Variety of Local Networks of Small and Medium-Sized Enterprises, *Organization Studies* 4(19): 667-699.
- Paniccia, I. 1999 “The Performance of IDs. Some Insights from the Italian Case.” *Human Systems Management* 18: 141-159.
- Parra-Requena, G., Molina-Morales, F.X. and P. García-Villaverde 2010. ‘The Mediating Effect of Cognitive Social Capital on Knowledge Acquisition in Clustered Firms, *Growth and change* 41(1), 59-84.
- Signorini, L. F. 1994. “The price of Prato, or measuring the industrial district effect.” *Papers in Regional Science* 73(4): 369-392.
- Simmie, J. 2005. "Innovation and Space: A Critical Review of the Literature." *Regional Studies* 39(6): 789-804
- Soler, V. and Hernández, F. 2001. “La misurazione delle economie esterne marshalliane attraverso i modelli DEA.” *Sviluppo locale* VIII(16): 86-105.

- Sternberg, R. and Arndt, O. 2001. "The firm or the region: what determines the innovation behaviour of European firms?" *Economic Geography* 77(4) 364-382.
- Tortajada-Esparza E., Gabaldón-Estevan, D. and Fernández-de-Lucio, I. 2008 La evolución tecnológica del distrito cerámico de Castellón: la contribución de la industria de fritas, colores y esmaltes. *Boletín de la Sociedad Española de Cerámica y Vidrio* 47(1): 57-80.
- Tortajada-Esparza, E., Fernández-de-Lucio, I. and Gabaldón-Estevan, D. 2008 Competitiveness and Profitability. New Challenges in the Ceramic Frit, Glaze and Colour Industry, Part 1 *Interceram* 57(6): 436-439.
- Tortajada-Esparza, E., Fernández-de-Lucio, I. and Gabaldón-Estevan, D. 2009 Competitiveness and Profitability. New Challenges in the Ceramic Frit, Glaze and Colour Industry, Part 2 *Interceram* 58(1): 36-39.