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Working Paper Nº 2009/01

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Research Contracts And Patents In The Spanish Ceramic Tile District Innovation System

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Abstract

This work applies the systemic approach to analyze the innovation process in an industrial district through the notion of the *District Innovation System*. We are particularly interested in the analysis of the interactions between the productive-technological and the scientific environments through the analysis of research contracts and patents. The empirical section of the paper develops a quantitative analysis of the interactions between different actors of the system included in the district.

This analysis was used to indicate the special features of the innovation system in a territorially bounded industrial district. Findings suggest relevant conclusions about specific characteristics of the inter-organizational environments in the industrial district which have to be considered.

Author Keywords: innovation systems, industrial districts, tile industry, agglomeration, research contracts, patents.

KeyWords Plus: innovation systems, industrial districts, tile industry, agglomeration.

1 Introduction

Innovation has become a central issue for companies. In fact, companies have started to re-evaluate their products and services, as well as their corporate culture, in order to improve them (Barlett and Ghoshal, 1990). And, even though the sources of innovation can come both from inside or outside the organisation, firms are increasingly dependent on the external environment as a source for knowledge and innovation (Patrucco, 2003). One theoretical tradition that has stressed the relevance of the external sources for knowledge development and innovation is systems of innovation (Dosi et al., 1990; Lundvall, 1992 or Edquist, 1997), where the relevance of factors such as economic, social, political, organizational, or institutional ones that influences the development, diffusion and use of innovations has been stressed out.

This concept brings a systematic look at the structure and interactions between the different levels and elements that intervene in the innovation process. Most of the previous research has been referred to national or regional level. However, innovation contexts can be represented for other territorial entities. Indeed, recently this concept had been applied to a variety of fields (Oinas and Malecki, 2002) and has motivated a vast literature, becoming an essential instrument on the analysis of the innovation process in territorial contexts.

Authors have paid a lot of attention on intraregional linkages between innovative actors, and particular between innovative firms and research institutions (Sternberg, 1999). In this work we apply the systemic approach to the analysis of a particular territory (Kaufmann and Todtling, 2000).

Industrial districts are made up of a group of SMEs in a specific territory, where specialization and interdependence are high between them and with different agents and institutions (Becattini, 1990, Brusco, 1990). We are particularly interested in the analysis of the interaction between the productive-technological environment and the scientific environment through the analysis of research contracts and patents. This analysis was used for a double purpose: first, to indicate the special features of the innovation system in the territorially bounded industrial district; and second, to better understand the particular case of the innovation system of the Spanish tile district.

This work starts with a review of the conceptual development of both the innovation systems approach and the industrial districts literature. We propose the notion of

"District Innovation System" (DIS) as a concept that emphasizes the relevance of the territory, when an industry adopts the ID form but is also highly dependent on other elements of the innovation system. After the description of the main features of the Spanish tile DIS, the focus of the empirical work is on the analysis of the research contracts and patents (years 1999-2004) of the enterprises that belong to the industrial district (we account for 224 companies out of a total of 281 registered). Our analysis shows that R&D activities in the Spanish tile DIS are mainly carried out by providers of frits, glaze, and colours, whereas ceramic tile producers are focussed on non-technological innovations. It also shows weak use to patenting as a way to protect innovations, scarce cooperation between the frits, glaze and colours providers, and very limited cooperation with other elements of the DIS. Altogether we conclude that technological innovations spread with few restraints inside a DIS, and this causes ceramic tile producers to focus on non-technological innovations as their differentiation strategy. Moreover, the lack of homogeneity within the DIS is particularly relevant considering the external networks that the different enterprises and agents have, becoming a strategic asset for them.

2 Theoretical Framework

2.1 The innovation system

A number of authors have argued that innovation is a major factor in creating value for firms (Barlett and Ghoshal, 1990; Hitt et al., 1996; Andersson et al., 2002). Innovation is understood as knowledge converted in new product, service or process (or significant changes in already existing ones) which is put into the marketplace. More specifically, Moran and Ghoshal (1996) argue that new sources of value are generated through new exploitations of knowledge resources and particularly thought exchanges and combinations of knowledge resources. In this way, innovation can be associated to the firm's ability to exchange and combine resources. Moreover, firms can access knowledge and consequently innovation through both internal sources (like internal

R&D departments) and external sources which can be found in the environment in which they operate.

Previous research (Acs and Audretshc, 1991; Cohen, 1995 or Geroski, 1995) has stressed the importance of considering both internal and external-firm factors as determinants of innovation (Sternberg and Arndt, 2001). This individualistic view fails since variables such as cooperation between firms and organizations are ignored. In general, inter-organizational relationships create opportunities for knowledge acquisition and exploitation (Dyer and Singh, 1998; Lane and Lubatkin, 1998; Larsson et al., 1998; Pekkarinen and Harmaakorpi, 2006). In particular, authors have proposed some specific externalities. For instance, public research, a geographically localized externality, is considered critical for the technological change process (Autant-Bernard, 2001).

Consequently, a systemic perspective seems to be appropriate since it considers different elements and levels involved in the innovation process, their interdependencies, and the way they act. Particularly the concept of the National (Regional) System of Innovation (see: Dosi et al., 1990; Lundvall, 1992; Edquist, 1997) has focused on the environment and their institutions at the national or regional level. These studies offer a complex and interactive framework to understand the dynamics of innovation in a particular environment. The systemic view presents a number of conditions to be considered. For any innovation system agents and institutions are considered only for 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.

This view assumes the existence of failures in the innovations' market, what justifies some political interventions. Capacities and abilities are not uniformly distributed among firms, the best practices on innovation are not rapidly spread among firms, and the markets failures can include those of the institutions in coordinating, connecting and satisfying the needs of the system, etc. On the other hand, it is assumed that the institutional setting differs from one territory to another and thus it is more appropriate for some phases of the process to be located in a specific territory. In conclusion, the innovation system should serve to ensure information and knowledge flows through all actors, such as: the interfaces between firms, research centers, entrepreneurs, investors, consultancies, patent agencies, local institutions, and other intermediate agents (Lundvall and Borrás, 1998).

2.2 The industrial district

The concept of the industrial district has traditionally been defined as a *socioeconomic entity which is characterised 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). An industrial district supposes the existence of a population of firms that are specialised in one or more phases of the production process. The district is characterised by being a group of firms that work together, where the division of labour takes place on an interfirm rather than intrafirm basis. Furthermore, there is also a network of public and private institutions that offer what Brusco (1990) calls *real services*.

Within the context of our work we understand the notion of a district, in a broad sense of the term, as referring to a *physical and relational space* where externalities are generated for firms Harrison (1992). Despite the different visions that can be found, a review of the literature provides us with a set of common ideas and postures that are useful for our research and which we have set out in the following points:

(1) Face-to-face contact and physical proximity between firms facilitates interaction and the transfer of resources and knowledge, which would be difficult to achieve with long-distance relations;

(2) The critical value of districts has more to do with social or relational resources than with tangible externalities or physical infrastructures;

(3) Of those who participate in districts, the leading players are not only final producers but also suppliers of intermediate products and services, as well as a wide range of institutions, such as universities, trade associations, industrial policy agents and other local or regional institutions.

Integrating the concept of industrial district with the conceptual development of the national and regional system of innovation we propose the notion of District Innovation System (DIS) which emphasizes the role of the territory under the above-mentioned premises.

3 The district innovation system of tile in Castellón

The ceramic tile industry includes the production of floor and wall ceramic tiles, decorative pieces, frit and glaze, machinery and equipment as well as other activities related to the ceramic process. This is an industry mainly distributed in geographically concentrated industrial districts all over the world such as: China, Spain, Italy, Brazil, Portugal and others.

The Spanish district is located in Castellon province and, more particularly, at *la Plana Alta; la Plana Baixa* and *L'Alcalaten* counties (*comarcas*). More than 90% of the Spanish ceramic tile production is concentrated there within no more than a 20 kilometre radius. Spain is the European leading producer and the second worldwide after China in terms of square metres produced. With respect to the international market share (21.2%) Spain ranks in second place after Italy (ASCER, 2005).

At the Castellón tile DIS several institutions, firms and promotion instruments offer their permanent support to the Spanish floor and wall ceramic tiles industry (MOLINA-MORALES, 2002). In figure 1 the participants of the sector are represented, inside their own environment, following the model developed in the studies of the Valencian Innovation System (FernÁndez and CONESA, 1996). Like in any system, the interrelation and cooperation between and within the different elements of the different environments is considered of critical relevance for innovation processes. Therefore, the Castellón tile DSI will be defined for the grouping of the elements in their environments and, in particular, for the relationships of the elements of a same environment and with elements of different ones.

The *productive environment* of the DIS includes not only the floor and wall ceramic tiles producers, but also the producers of special pieces, as well as diverse semi-elaborated products manufacturers like unglazed tiles producers and atomized clay providers.

The *technological and advanced services environment* of the DIS groups any institution able to offer and deliver technological knowledge that can be transformed into innovations. This includes technologically new machinery, materials, counselling and services. It is important to highlight that the elements of this environment are the nexus between the requirements of the productive environment and the potential capacities of the scientific environment.

As is shown in figure 1, the agents from the technological and advanced services environment are any provider that brings novel or improved technological solutions and spreads them on the sector like frit, glaze and colour providers, machinery providers and varied services providers (design, CAD/CAM, serigraphy, etc.)

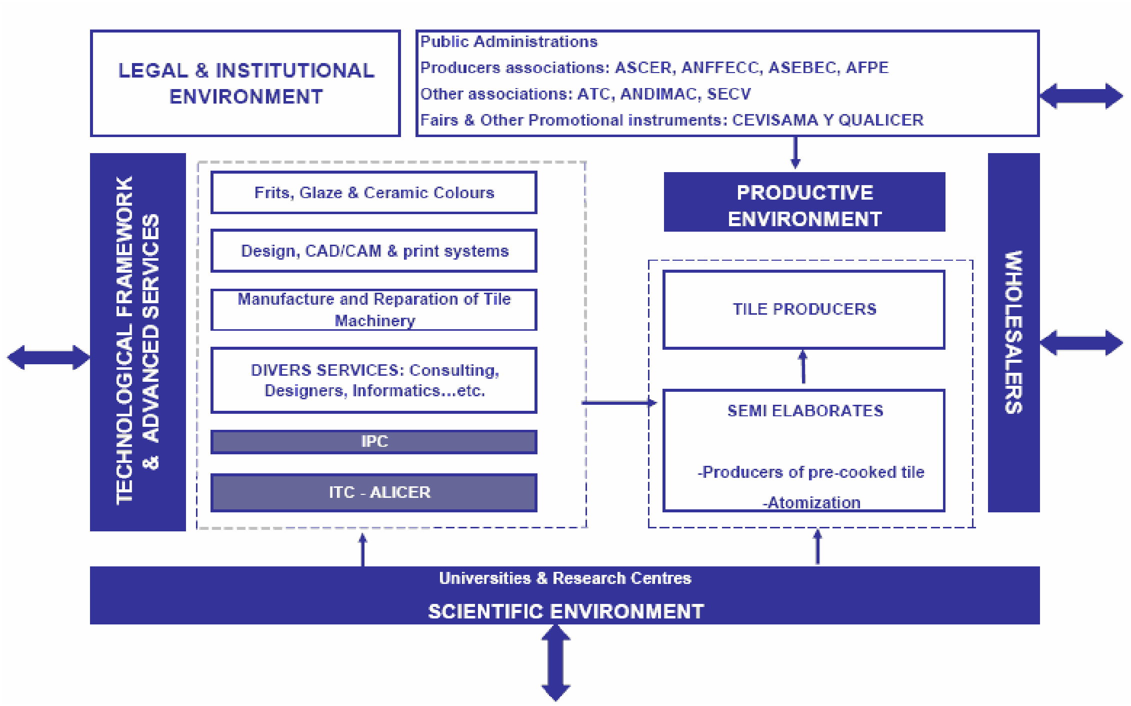

Figure 1: The District Innovation System (DIS) of tile in Castellón. Source: Adapted from Fernández and Conesa, 1996

Those firms or service providers from the sector that offer aid in the fields of design, computerization and new technologies, technological and market consultancy, etc. also belong to the technological and advanced services environment. Some ceramic firms (18% following a study from the Fundación BANCAIXA (1999)) have their own internal design department, but most of them buy the designs to technical studies or get them from their providers of frit and glaze or special pieces.

The Instituto de Tecnología Cerámica (ITC, Institute of Ceramic Technology) is a mixed university institute, formed both by the Jaume I University and the Asociación de Investigación de las Industrias Cerámicas (AICE – Ceramic Industries Research Association), that belongs to the Valencian Community Technological Institutes network supported by the regional government (Consellería de Industria y Comercio de la Generalitat Valenciana) through the IMPIVA (the Institute for the Valencian Medium and Small Industry). The purpose of the ITC is to promote and develop activities addressed to improve the competitiveness of the tile industry, and it has particularly contributed to the development of the frit and glaze subsector. Recently the ITC has merged with the Asociación para la Promoción del Diseño Cerámico (ALICER- Association for the Promotion of Ceramic Design), a technological institute created to endorse the incorporation of a global design policy in the firms' strategy, to promote research on industrial design, to train designers for the sector, and to jointly promote the Spanish ceramic design. The Instituto de Promoción Cerámica (IPC-Ceramic Promotion Institute) is an entity dependent on the Diputación de Castellón (a supra-local administrative entity) and is specialized in architecture application ceramics in diverse fields. One of their most relevant works has been the Proyecto Colocación (To-Place Project) that tried to unify the criterion for selecting the materials and to carry out the ceramic coverings.

The *scientific environment* is basically made up by the research groups from the universities and the public and private research centres. More specifically in the scientific environment of the DIS there are the Jaume I University (UJI) and the Institute of Ceramic Technology (ITC) which is linked to the Department of Chemical Engineering of that university. Two departments, Chemical Engineering and Inorganic and Organic Chemistry from the UJI, are the main ones responsible for the research being developed for the sector in the areas of ceramic technology, chemistry, environmental pollution and ceramic design. At the Universidad Politécnica de Valencia (UPV) the Centro de Investigación en Tecnologías Graficas (Centre for Research on Graphic Design) focuses its 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 production of non-desired tones. The Instituto de Cerámica y Vidrio (Institute for Ceramic and Glass), that belongs to the CSIC (the Spanish Council for Scientific Research), carries out basic and applied research in different fields that are related with ceramics and glass and that have been of value for the frit and glaze subsector.

Closing this analysis is the institutional environment, made up by the different public administrations that, by means of developing different policies, can influence, in a more or less intense way, the industrial activity. The different support associations (the Association of Ceramic Tile Manufacturers of Spain, ASCER; the Association of the Spanish ceramic frits, glazes and colours producers, ANFFECC; the Spanish manufacturers of machinery and equipment for the tile industry, ASEBEC; the Spanish Association of Tile Technicians, ATC; the Spanish Association of Tile and Construction Materials Distributors, ANDIMAC; the Spanish Association of Special Pieces Producers, AFPE) constitute highly relevant agents for the sector; the fairs and congresses (the International Exhibition for Architectural Ceramic and Bathroom Furnishings, CEVISAMA; the World Congress on Ceramic Tile Quality, QUALICER) function as instruments for promotion and are important sources of information for technological innovation; finally, the Trade, Industry and Navigation Chamber of Castellón, the Industrial Engineers Professional Association and the Entrepreneurship Confederation of Castellón work as support and services providers for the entrepreneurship within the industry. Due to the relevance of the tile sector for the local economy, these actors play a more significant role in this sector than in others.

Of special note is the Spanish Association of Tile Technicians (ATC), founded in 1976. The idea of grouping technicians of the tile industry in the same association, regardless of their professional level, came as a result of the interest of a group of technicians that understood the opportunity for creating a platform from which to spread scientific and technical knowledge. Nowadays the ATC has around 650 professionals and about 140 associated companies that belong to tile, frit and glaze or capital goods producers as well as to any of the auxiliary industries. Altogether, the social mass of the ATC represents about 80% of the professionals that work in the tile industry. The contribution of this association is noticeable as a facilitator of the communication between the professionals that belong to the different parts of the innovation system, improving its articulation. In fact, no similar association can be found in any of the other traditional sectors at the Valencia region.

The efforts done by the different elements of the described environments are relevant for the technological advancement of the sector. But even more relevant are the interrelations established between them, which facilitate joint innovative process. For that, a series of interface structures favour the interaction between the different agents involved and spread the innovations within the sector. Within those structures are the trade chambers, the sector professionals associations, the promotion entities, etc. In addition it has to be noted the openness or internationalisation of the innovation system, especially due to the frit, glaze and colour industry that exports more than half of its production, the export directed production of the Spanish tile industry, the high dependency of Italy on technology for capital goods, as well as a tight relationship between the ITC with foreign institutions of R&D such as the Italian Ceramic Centre at Bologna or those found between producers associations at Castellon and Emilia Romagna like the one between ASCER and Assopriastrelle.

4 The interactions between the productive, the technological, and the scientific environments in the DIS

Figure 2 shows the objective of our empirical analysis. We have analyzed the interactions between the productive, the technological, and the scientific environments in the District Innovation System of tile in Castellón.

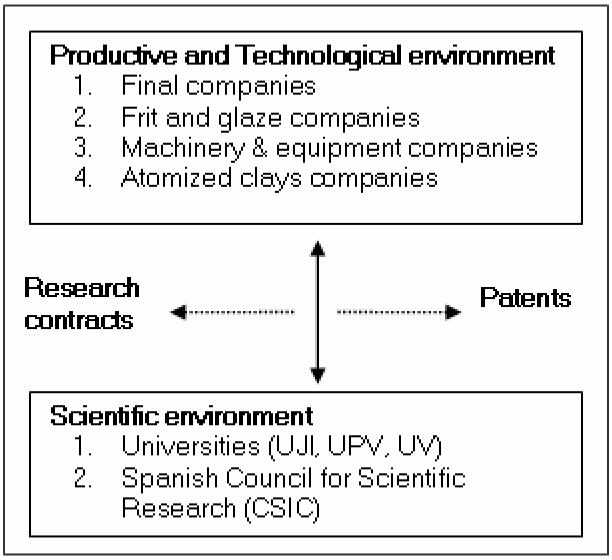

Figure 2: *The interactions between the productive, the technological and the scientific environments in the DIS.*

4.1 The sampling[1]

For this research data from the companies belonging to the three most representative producers associations has been used. Therefore, the selection includes the companies located in Castellón that are associated with the ASCER (the Association of Ceramic Tile Manufacturers of Spain, which includes, together with ceramic tile producers, those of special pieces and clay atomizers), ANFFECC (the Association of the Spanish ceramic frits, glazes and colours producers), and ASEBEC (the Spanish manufacturers of machinery and equipment for the tile industry) in order to obtain a characterisation of the companies. Hence, the sample is not a representative one but a collection of information referred to the complete population of companies associated to the mentioned three employers association.

As is shown in table 1, the level of association of the sector companies at Castellón province is always higher than 75%.

Table 1: *Description of the sample*

Activity	Association	Total associates	Sample	Activity over total sample	Mean (SD) employees	Mean (SD) revenues
Final	ASCER	175	141	80.6%	145 (174.6)	22076.7 (27233.6)
Frit and glaze	ANFFECC	26	20	76.9%	174.9 (167.8)	48538.7 (51663.7)
Machinery and equipment	ASEBEC	70	53	75.7%	25.0 (19.9)	3843.5 (3614.5)
Atomizers	ASCER*	10	10	100%	103.3 (59.7)	22539.2 (9812.1)
Total		281	224	100%	117.8	20146.2

* ASCER includes both ceramic tile producers and atomizer companies; therefore, the 10 atomizer companies are also accounted for in the 175.

In brief, the characterisation of the companies responsible for the main activities shows that the most populated group is the ceramic tile producers, whose number of employees has more variability than the other groups. This is because this group includes, together with the big ceramic tile producers of tiles, other smaller companies, some of which are focused on special pieces. This group has revenues and benefits per employee above those belonging to the machinery companies but much lower than those devoted to frit and glaze production, which causes them to have, on average, lower results.

We have carried out two types of analysis. Firstly, we have taken the aggregate of the groups in order to analyze their role in the system. Secondly, for each group we have characterized those companies that participate in innovative actions to compare it with the rest of the group companies.

4.2 Contracting with Valencian Universities[2] and with the Spanish Council for Scientific Research (CSIC)[3]

As can be seen in table 2 a total of 54 companies out of the 224 included in our sample, or 24% of the sample, contracted with one or more of the public universities of the

Valencian Community or with the CSIC. Altogether we found 251 actions with a total amount of € 5,142,487.

Table 2. *The distribution of the research contracts and patents at the DSI*

	Ceramic tile producers	Frit and glaze producers	Machinery and equipment producers	Atomized clay producers	Total
Total number of companies	141	20	53	10	224
Number of companies that do contract	25	17	10	2	54
Percentage	17,7	85	18,9	20	24,1
Total contracted in thousand €	1352.736	3569.079	92.295	128.377	5142.487
Percentage over total contracted in the district	26.3	69.4	1.8	2.5	100
Total subsector annual business volume in thousand €	3112817	970773	203705	225392	4512687
Percentage of total contracted over a business volume	0.04	0.37	0.05	0.06	0.11
Number of patents	12	28	9	0	49
% over total patents	24.5	57.1	18.4	0	100
€ contracted by patent	112728	127467	10255	-	104948
Efficiency indicator	0.39	2.88	4.42	0	0.95

Concerning the types of contracts done with Valencian universities there is a predominance of R&D contracts, which account for more than 90% of the total value. The technological support and consultancy has much less relevance, which accounts for little more than 5%. Another contract type is the rendering of services that are significant in number of actions but marginal regarding value (under 3%). With reference to the departments involved, 27 departments belonging to the four universities are identified, though the first three departments, all belonging to Jaume I University of Castellón, account for almost four fifths of the total contracted by the companies of the sample and for the period under analysis. Those three departments are the Chemical Engineering, Inorganic and Organic Chemistry, and the Technology Department. In relation to the contracting with the CSIC, all but one contracts are R&D type and are mainly with the Institute for Ceramic and Glass.

The most noticeable finding of the distribution of research contracts and patents between the different activity groups inside the district is the relative high weight of the frit and glaze producers, the minor prominence of the final product producers, and the marginal role of the other two groups of companies, the machinery and equipment and the atomized clay companies.

Table 2 also shows patent data[4] that were requested by the different groups of companies belonging to the DIS. During the period under study a total of 49 patents were requested. Since most of the patents have been requested just for a sole company, it may be suggested that innovations are basically developed in-house. With reference to the number of patents obtained by the different activity groups in the district, the frit and glaze companies are also the ones who score best; there are a relatively high number of patents in the machinery producers group, but no protective activity in the group of atomized clay producers.

With the second analysis we try to improve our understanding of the innovative companies. In order to proceed we define an innovative company as any company that, for the period under analysis, has had a research contract or has obtained a patent. What we have analyzed here are the differential characteristics of those two groups of companies, the innovative and the non-innovative.

In the first part of this analysis we have considered the total of the sample including both the innovative and the non-innovative (N=224). Table 3 shows Pearson correlations of a series of variables of financial and economic indicators[5], the dummy variable being innovation.

Table 3: *Correlations between innovation, size and business volume*

	Innovation
Number of employees	**0.402*** (0.000)**
Total revenues	**0.408*** (0.000)**
Return on Assets (ROA)	**-0.026 (0.703)**
Profit per employee	**0.045 (0.508)**
Ratio of employee cost and total revenues	**-0.029 (0.668)**

N=224, *p<0.10; **p<0.05; ***p<0.01;

For the sample as a whole the innovative companies show a positive and significant correlation with size, both measured as employees and total revenues. This allows us to make a first basic characterization of those companies as being larger. The other indicators, those measuring both return on assets and different measures of productivity, show not significant correlations. The latter means that inside the district innovating is not associated with an improvement on results.

In a further step in our analysis we have completed the characterisation of the innovative companies inside the district completing the available variables of the SABI dataset, those variables being age, number of employees, total revenues, return on assets, profit per employee, ratio of employee cost and total revenues, and number of shareholders.

Table 4: *Results of variance analysis (ANOVA) of mean comparison.*

	Innovative (1)	Not innovative (2)	F
Ceramic tile producers (N=141)			
Company age	27.8 (a) (12.8)(b)	24.0 (14.4)	1.458
Number of employees	334.8 (296.2)	105.1 (96.9)	47.390***
Total revenues	46459.8 (45704.3)	16821.7 (17602.9)	29.280***
Return on assets (ROA)	1.67 (9.7)	4.2 (7.4)	2.175*
Profits per employee	4.125 (19.048)	8.081 (17.930)	0.940
Ratio of employee cost and total revenues	25.012 (8.225)	23.035 (8.938)	1.033
Number of shareholders (owners)	3.8 (3.8)	3,4 (3.3)	0.290
Frit and glaze producers (N=20)			
Company age	25.3 (13.5)	22.7 (12.9)	0.102
Number of employees	197.2 (172.5)	48.0 (33.0)	2.138*
Total revenues	55212.2 (53346.2)	10722.0 (8158.2)	1.990*
Return on assets (ROA)	7.35 (8.2)	4.5 (2.7)	0.334
Profits per employee	21.250 (27.160)	9.333 (10.116)	0.541
Ratio of employee cost and total revenues	15.361 (3.864)	19.897 (8.364)	2.506*
Number of shareholders (owners)	3.1 (2.6)	3,0 (2.0)	0.005
Machinery and equipment producers (N=53)			
Company age	24.0 (10.3)	15.9 (10.1)	5.219**
Number of employees	47.9 (22.0)	19.5 (15.2)	23.623***
Total revenues	5395.1 (2149.8)	3482.6 (3805.1)	2.329*
Return on assets (ROA)	3.1 (5.6)	5.3 (11.4)	0.324
Profits per employee	4.000 (6.200)	8.175 (16.086)	0.641
Ratio of employee cost and total revenues	32.359 (13.649)	26.905 (21.918)	0.562
Number of shareholders (owners)	1.5 (1.8)	1.4 (1.7)	0.031
Atomized clay producers (N=10)			
Company age	13.0 (8.5))	19.1 (15.8)	0.265
Number of employees	108.0 (19.8)	102.2 (67.3)	0.014
Total revenues	31883.5 (5555.7)	202.0.2 (9391.0)	2.694
Return on assets (ROA)	5.9 (4.6)	2.1 (1.5)	4.895*
Profits per employee	25.000 (11.314)	10.625 (10.197)	3.090*
Ratio of employee cost and total revenues	8.930 (3.168)	15.941 (11.178)	0.711
Number of shareholders (owners)	3.5 (0.7)	5.6 (2.9)	0.990
Total sample (N= 224)			
Company age	25.8 (12.5)	21.7 (13.8)	3.703*
Number of employees	230.0 (247.2)	82.6 (89.8)	42.718***
Total revenues	41070.7 (46125.5)	13499.22 (15945.6)	44.411***
Return on assets (ROA)	3.9 (8.7)	4.4 (8.4)	0.145
Profits per employee	10.170 (21.487)	8.250 (16.983)	0.440
Ratio of employee cost and total revenues	22.739 (10.559)	23.606 (13.563)	0.185
Number of shareholders (owners)	3.1(3.1)	3 (3.1)	0.117

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

The lower part of the table supports the conclusions of the correlation analysis in that innovative companies are larger. Although small differences between the groups are found, the innovative companies are older, with lower return on assets and with a slightly higher number of shareholders; however, those differences are not significant and the means are not statistically different.

With respect to the ceramic tile companies, findings confirm that there is a positive association between size of the companies and their number of innovations. However, when we test the financial data (Return on Assets and Profit per Employee) these companies, identified as innovative, demonstrate lower performance than the rest of companies. Nevertheless, it must be noted that such high deviation among values from the mean may affect the significance of the results. Regarding the frit and glaze companies, data confirms the positive association between both the size and innovation and between return on assets and innovation. The small size of the sample and the big deviation of the values from the mean can be the reason for the lack of significance. Concerning the machinery and equipment companies, significance of both size and age is confirmed. Differences between the value of Return on Assets between the two groups of companies, although higher for innovative companies, are not significant, again due to the small size off the sample. Finally, the sample of atomizer companies shows a differentiated behaviour, but the scarce number of companies included makes it impossible to extract rigorous conclusions.

4.3 Control of findings

In order to control for the results obtained in our analysis we have proceeded to collect aggregate data of the behaviour of the groups of companies from the INE[6] official data on innovation. In this section some general features that allow us to identify the innovation strategy developed by the tile producers in the technological field are analyzed. Following the recommendations of the Oslo–manual (OECD/Eurostat, 1997) this survey identifies innovative companies who, during the last three years, have introduced technologically new or improved products to the market or have introduced technologically new or improved processes in their production methods of goods or provision of services.

Table 5. *Innovation data from INE survey*

	Ceramic tile producers	Frit and glaze producers
Percentage of companies with research contracts	**17%**	**85%**
Patents per company	**0.085**	**1.40**
Percentage of technological innovative companies according to INE	**44%**	**69%**
Percentage of companies with innovative effort	**57%**	**62%**
Percentage of companies with non-technological innovations	**63%**	**54%**
Percentage of product innovative companies	**92%**	**69%**
Percentage of process innovative companies	**44%**	**46%**

Source: INE 2000, 2004 Self-elaboration.

Table 5 shows that the number of innovative companies is larger in the case of the frit and glaze subsector; however, the percentage of companies with innovative effort is very similar for both groups, and the final producer group scores higher regarding non-technological innovations. A higher specialization on product innovation in the ceramic tile producers group rather than in process innovations is also shown. This data complements the data already presented because, in general terms, final companies do not use technological innovations as a strategy for differentiation but they rather focus on non-technological innovations and in product innovation.

5 Conclusions

This research has analyzed the case of the innovation system in the ceramic tile district. In particular, we have studied the role played by different activities included in the productive and technological environments of the system. We have used for the analysis the research contracts between individual firms and research institutions and the patenting activities of firms.

The main findings are as follows. Technological innovation within the district is primary assumed by glaze and frit companies. The collected data indicates an intense relationship between firms, particularly from frit and glaze subsector, with departments in the university and with ICV of the CSIC. This type of cooperation is mostly focused on R&D projects. The ceramic tile producers focus their innovation on non-technological developments. Other activities play no relevant role in the innovation process.

Regarding patenting activities as an innovation protection mechanism, generally speaking, they were not used by companies in the ceramic tile industry. The reasons can be found in the difficulties to avoid copies or to be emulated for neighbor. In fact in many cases, companies prefer the alternative non-contractual mechanism of protection. On the other hand, data from patenting activities for the period considered evidenced a lack of cooperation between glaze and frit producers and a limited cooperation between firms and other elements of the Distritual Innovation System (DIS).

Apart from the own interest which the case study provides, the findings of the research can be explained through the particular conditions existing in the DIS. We would like to underline some conclusions from the research.

(1) The role of the frit and glaze firms in the innovation system. Taking the whole system into consideration, our findings confirming this subsector as the real driver of the innovation process in the district imply some relevant consequences, in particular for ceramic tile producers.

From a competitive advantage perspective, ceramic tile producers have difficulties to differentiate their products using technological opportunities. There is an internal-district market of technological innovations available all for member of the district. The lack of an anticipatory or exclusive use of technological innovations encourages searching for differentiation in alternative non-technological innovations. We refer to organizational innovation, generally, related to product distribution and marketing. We have controlled these results with data from an external source (IVE's report on innovation) that confirmed this conclusion showing how ceramic tile producers used the non-technological innovation much more than other activities of the district.

On the other hand, ceramic tile producers rarely use patents to protect innovation, since innovations are externally acquired. In fact, findings pointed to the number of patents obtained by ceramic tile producers being very low. Patents in the district are used to protect suppliers from competitors; but they are internal market mechanisms which disseminate innovation among district customers. In consequence, innovations in districts are not exclusively exploited by a single final firm but they are available for a number of them, so the potential competitive advantage of firms must be searched for in other domains of the firm's strategy.

In our opinion, reasons of the ceramic tile producers' behavior come from the principles of the industrial districts notion. Intense internal relationships cause the diffusion of the innovations within the district. The high rate of mobility of technicians and executives (their movement from one company to another inside the district), or the relevancy of the informal non-business relationships (including friendship, familiar relationships, or membership to professional associations) are all mechanisms for fostering exchanges of information and knowledge. All these conditions result in innovations being easily spread, therefore making the exclusive use of innovation more difficult.

(2) Theoretical implications. The implications for the ceramic tile producers can be, on the one hand, a certain degree of homogeneity, and on the other, the need to access district external suppliers to permit a certain degree of differentiation with respect to the rest of the local competitors.

Generally speaking, authors have assumed that there is a high degree of internal homogeneity among the firms in these conglomerations. The existence of shared resources that are not exclusive to any individual enterprise but which, at the same time, are not available to outside firms seems to justify this homogeneity both in terms of behaviour and performance. This homogeneity was at the base of the seminal works by Becattini (1979, 1990) and also the analyses conducted to compare firms inside and outside the district or between districts, that is, the so-called district effect (Signorini, 1994; Molina-Morales, 2001; Paniccia, 1998, 1999; Hernández and Soler, 2003; Soler and Hernández, 2001). However, the idea of homogeneity is far from being confirmed by real cases (Morrison, 2008). The simple observation of some cases of districts shows that they are not formed by homogeneous communities of entrepreneurs or technicians sharing their know-how and information. On the contrary, although there are resources flowing more or less freely within the district, in general, the flows of knowledge are limited to certain subgroups or clubs of the district.

Nowadays, districts are no longer self-contained for all activities. On the contrary, they need to be open in order to access external resources. This openness provokes an increasing diversity or asymmetry among the firms and organizations. Not all firms and organizations show similar capacity to access external networks. For instance, size can be a relevant factor in this context. In fact, small firms encounter barriers that complicate access to external networks. That is a consequence either of the lack of relevant R&D departments or of a high productive specialization. Morrison and Rabellotti (2005) have identified two types of networks within districts. They term Core Network as a dense network with a great amount of tacit knowledge, mostly SMEs, with a low innovation capacity. On the other hand, they define Periphery Network as a disperse network with a lot of connections with external actors outside the district, composed mostly of larger sized companies showing a higher 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 transform raw materials (directly from the clay mines) to convert them to an adequate level of granulation for the ceramic process. These companies use the technology provided by the machinery and equipment firms in the district. In consequence these firms are focused on organizational and logistical aspects to obtain the competitive advantage. This fact can explain the lack of patenting activities.

Regarding the machinery and equipment subsector, they showed a great dependence on the Italian district. This fact explains that innovations are obtained by Italian companies and in consequence they are not significant in the Spanish district context. In this case patenting activities have a relative greater weight as a result of the extension of the Italian patents to be registered in the Spanish territory. This can be support for the lower cost associated to the patent in comparison with the other sectors in the district.

The behavior of the machinery and equipment sector can be understood through the existence of strong activity in the Italian ceramic tile district and the numerous interactions between both districts. The Italian district is located in the Emilia Romagna (Sassuolo) region, particularly in the provinces of Modena and Reggio Emilia. In 2004, both provinces accounted for more than 80% of the total Italian production, and including all regions this reaches 90%.

Although in both districts the main activity was production of floor and wall ceramic tile, there are other relevant productive activities. In Sassuolo, the sector of machinery and equipment is a very relevant activity for the ceramic industry. According to the ACIMAC (Italian trade association), in 2005 the Italian sector was formed by about 175 companies with a business value of €1,777 million, exporting activities account for 74 of the totsal revenues. On the contrary, the sector in Spain was formed by 70 companies who are members of ASEBEC (Spanish trade association) with a business value of €235 million and exporting activities accounting for 18% of revenues. A significant percentage of these firms are subsidiaries and joint ventures with Italian firms. In order to explain the causes of the Italian industry advantage it is important to underline the particular relevancy of the economies of scale in this activity. Moreover, since many customers buy complete plants, it is very difficult for new entrants from other countries (as with the case of Spain) to compete. It must be mentioned that the area around the Italian district (Emilia Romagna and particularly Bologna) enjoyed a brilliant mechanical tradition, adequate to foster production in this particular industry.

(4) *How are the innovative firms in comparison with non-innovative firms in each group of activities from the productive environment*? Findings supported the significant association between innovation and the two main indicators of size, which are number of employees and total revenue. Therefore, we can say that the innovative firms are the larger firms. This association was much more evidence for the final products and glaze and frits producers, just the activities where innovation is the most relevant. Consequently the previous conclusion is reinforced.

Regarding the age of the companies, innovative ones have been operating longer than non-innovative ones. Exceptionally, in the case of the atomizer firms, younger firms are more innovative than older ones. Company age doesn't seem to be a significant factor since the company founders may have had previous experience in other companies within the district and since these companies are in most of the cases the result of spin-off processes. This previous experience acts as a moderator on the possible impact of the age on the cumulative knowledge and innovation.

We dare say that the most important finding refers to 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

Final remarks. The main conclusion from our research is that specific characteristics of the inter-organizational environments in the industrial district have to be considered for a correct systemic analysis of the innovation process. The internal regime of accessing, transmission and exploiting knowledge and innovation determine 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 between districts, in a way that can condition the development of one particular district.

Finally, some limitations in this research must be mentioned. First, the heterogeneity and poor data sources on innovation of the companies have restricted the possibilities of the analysis. We expect to expand this research by adding data on firms' access to external innovation sources. That will allow us to verify if more innovative firms are also those which access these external sources or if, on the contrary, there is an asymmetric use of both external and internal sources. We acknowledge the limitations that this type of individual analysis could have. In order to compliment this, further research could be oriented to compare different districts in order to obtain more rigorous conclusions.

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[1] Regarding the sample of enterprises: The initial list was built up with the names of those enterprises belonging to the sectors' three main producers associations (ASCER, ANFFECC and ASEBEC) accounting for a total of 281 companies. Of those, 57 were deleted either because their head office was located out of the Castellón province or because their status was "not active" when the analysis was conducted. Finally, the splitting of the atomizer companies from the ceramic tile producers list (all of them belong to ASCER) was done following the CNAE classification number of four digits. All data refers to the last available year, being the query done in February 2007.

[2] Regarding the contracts with Universities sample: The query from the original dataset consisted in compiling data about all the contracts done by the companies belonging to our company sample with public universities of the Valencian Community. The time span was from 1999 to 2004. Therefore, the university contracts sample accounts for a total of 218 contracts, agreements, or other R&D activities.

[3] Regarding the contracts with CSIC sample: The list was made up from a dataset facilitated from the Spanish Council for Scientific Research. The complete file had 387 contracts, agreements, or other R&D activities signed between 1991 to 2005 with the following institutes: 040301 (the Institute for Ceramic and Glass), 020164 (the Materials Science Institute of Aragón), and 010103 (the Institute of Structure of the Matter). The contracts of the companies of our sample with any of those institutes, and for the period 1999 to 2004, accounted a total of 33.

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[4] This data has been obtained from the Spanish Office for Patents and Marks (OPEM) dataset. All patents (Spanish, European, and international) registered by the companies of the sample during the years 1999 to 2004, had been collected.

[5] All this data has been collected from SABI and are referred to the last available year, being the date of the query February 2007. SABI is a directory of Spanish and Portuguese companies that provides general and financial information representing 95% of all Spanish companies. SABI data are provided from *Registro Mercantil* as official trade register.

[6] The information source used is the Encuesta sobre Innovación Tecnológica de las Empresas (the Companies Technological Innovation Survey) for the years 2000 and 2004 from the Spanish Statistical Agency [INE (2002) Encuesta sobre innovación tecnológica en las empresas 2000; and INE (2006) Encuesta sobre innovación tecnológica en las empresas 2004. Instituto Nacional de Estadística, Madrid]. This data refers to the sector companies which headquarters are located in the Valencian Community and have more than 9 employees. It has only been possible to obtain data from the final and from the frit and glaze companies.