The Green Factor in European Manufacturing: A case study of the Spanish ceramic tile industry

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ABSTRACT

This paper analyses how environmental issues have affected and are continuing to affect the evolution of European manufacturing industries based on the example of the Spanish Ceramic Tile Industry (SCTI)[1]. The Ceramic Tile Industry (CTI)[2] in Europe became very competitive and innovative in the early 1990s, with the Italian and the Spanish sectors, which are cluster-based, becoming world leaders. However, since 2008, this leadership position is being eroded. We provide an in depth analysis of the SCTI focusing on the influence of new European environmental regulations. The CTI has a major impact on the environment and has been the focus of environmental

[1] Spanish Ceramic Tile Industry (SCTI)
[2] Ceramic Tile Industry (CTI)

regulations. We also consider the innovation system and socioeconomic effects of the industry. In order to analyse the relationship between the environmental issues and innovation the empirical part of the paper builds on research on SCTI, including the industry value chain, and the innovation system and how it functions. We take account of the views of industry experts on the SCTI innovation system, its environmental impact and the constraints on the sector.

Current research at the local level suggests that the environmental impacts of the industry are outweighed by its huge contribution to socioeconomic wellbeing. The transition from national environmental legal frameworks towards EU-wide regulation has had a clear effect on both the strategic goals and the management of the industry and the new regulation combined with a more complex international economic scenario is jeopardizing European manufacturing industries. This applies especially to traditional industries. The case study demonstrates that the capacity of the SCTI to adapt to new scenarios will be vital for its future survival and success.

Keywords

Sustainability, distritual innovation systems, manufacturing industry, ceramic tile industry, environmental innovation, innovation system

1. INTRODUCTION

According to Eurostat[3] about one in ten (9.8%) of EU-27 non-financial business enterprises in 2009, a total of 2 million firms, were in manufacturing. In 2009, the European manufacturing sector employed 31 million people and generated EUR 1,400 billion in value added. Some 30% to 40% of all employment is in industry - mostly concentrated on districts or clusters. Manufacturing subsectors include activities with apparently relatively low labour productivity and average personnel costs, for example textiles and ceramic tiles; other activities, for example production of pharmaceutical

[3] Source: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Manufacturing_statistics_-_NACE_Rev._2# (downloaded 2012/10/03)

products, show considerably higher values for the same indicators. The manufacturing sub-sectors or traditional industries, are the most vulnerable to the new scenario. In this paper, we focus on the example of the Spanish Ceramic Tile Industry (SCTI).

This context is provoking debate over the sustainability of the so-called traditional industries in the EU due to the major transformations that are resulting from the process of globalisation and the current economic crisis. These transformations include the increasing demand for resources (especially energy and raw materials) from the world economies, and especially Brazil, Russia, India and China (the BRIC countries); increased public awareness of the diminishing capacity of the environment to assimilate the impacts of human activity; and increased demand for environmental sustainability.

The relationship between industry and the environment is receiving attention from academics, policy makers and companies (Zeng et al., 2010; Kivimaa and Mickwitz, 2011; López-Gamero et al. 2010; Weber and Rohracher 2012, Taddeo et al., 2012) and the analysis of environmental innovations is a growing research area in both the social and natural sciences (Markard et al., 2012). Environmental innovation can be understood as "all the changes in the product portfolio or in the production processes that tackle sustainability targets, like waste management, eco-efficiency, emissions reduction , recycling, eco-design or any other action implemented by firms to reduce their environmental footprint" (De Marchi, 2012: 615).

Angel et al. (2005) identify stricter end-market environmental regulation and increased concern among firms over reputation and operating legitimacy as the main drivers of adoption of firm-based environmental standards. De Marchi (2012) highlights environmental innovation is the way that companies integrate concern for the environment into their strategies while consolidating their competitive advantage. The SCTI in Spain is concentrated in certain municipalities in the province of Castellon (Molina-Morales et al. 2004) and overlaps with the Distritual Innovation System (DIS), which combines the perspectives of innovations system and the industrial district. The

DIS concept emphasizes the relevance of the territory for the industrial district form, but also other elements of the innovation system (Gabaldón-Estevan et al., 2012). The district approach provides the most suitable framework to study the SCTI in enabling a focus on the innovation system as well as the particularities of industrial agglomerations (Mota, 2004; Hassink, 2007). We analyse how they have affected and may continue to affect the evolution of Europe's traditional industries using the example of the SCTI. The paper is organised as follows: Section 2 discusses the methodology; Section 3 provides an analysis of the ceramic tile value chain and describes the SCTI innovation system and how it functions. Section 4 discusses the results of the analysis in the context of environmental issues.

2. METHODS

The paper builds and revisits evidence from research on the SCTI which is reviewed in Gabaldón-Estevan (2011) which focuses on the characteristics of the SCTI innovation system and analyse the CTI in the north of the autonomous region of Valencia and the Emilia Romagna region in the north of Italy. In these regions are located the most important ceramic tile clusters in Europe, which have similar problems to accomplish the EU environmental regulations (Minguillón et al, 2013).

Even though the study was mainly focused in SCTI, some data of the Italian ceramic tile cluster were included and analysed, to find out the common problems of the European CTI. To this end, the study involved 24 semi-structured interviews with representatives of the ceramic industrial districts in Italy and Spain. The interviewees included managers from the ceramic, electro-mechanical or glaze company representatives of employers' and workers' associations; representatives of public institutions specialized in technology or trade; representatives of research institutions conducting R&D for the CTI; and researchers interested in the area. The interviews provided information on the ceramic tile process, on the ceramic tile district, production and dissemination of innovation, the contributors and motivators of innovation, and factors related to global trends in production, the competition and trade.

Then the study focuses on the functioning of the SCTI innovation system. Function analysis, a recent development in the innovation system literature (Negro and Hekkert, 2008; Hekkert et al., 2007; Bergek et al., 2008), is grounded on the technological innovation systems and sectoral innovation systems approaches and based on functional analysis (Bergek et al., 2008; Jacobsson and Johnson, 2000; Edquist, 1997). Below is a brief summary of Gabaldón-Estevan and Hekkert (2013) which discusses functional analysis of the tile innovation system.

Data availability dictated the methodologies used and qualitative tools were substituted for some of the quantitative parts of Bergek et al.'s model. Section 3.3 is based partly on the methodology proposed by Bergek et al. (2008) to analyse the dynamics of the functioning of the system, which includes defining the innovation system in question and identifying its structural components (Sections 3.1 and 3.2) and mapping the innovation system pattern (Section 3.3).

The research included 15 semi-structured interviews with representatives of the SCTI innovation system, chosen on the basis of their expert knowledge on the SCTI. They included managers of ceramic, electro-mechanical glaze companies and spray-dried powder producers; representatives of employers' or technician's associations; directors of research institutions conducting R&D for the industry; academics and consultants. The interviews provided information on different aspects of the industry and the production process.

The interviews enquired about the six functions described by Johnson (2001), which are considered to be most relevant for an analysis of the innovation system (Knowledge development and diffusion, Influence on the direction of search, Entrepreneurial experimentation, Market evolution and competition, Legitimation / counteracting resistance to change, and Resource mobilization).

The main interest in the current paper is to establish the interactions between the innovation system and the new environmental requirements.

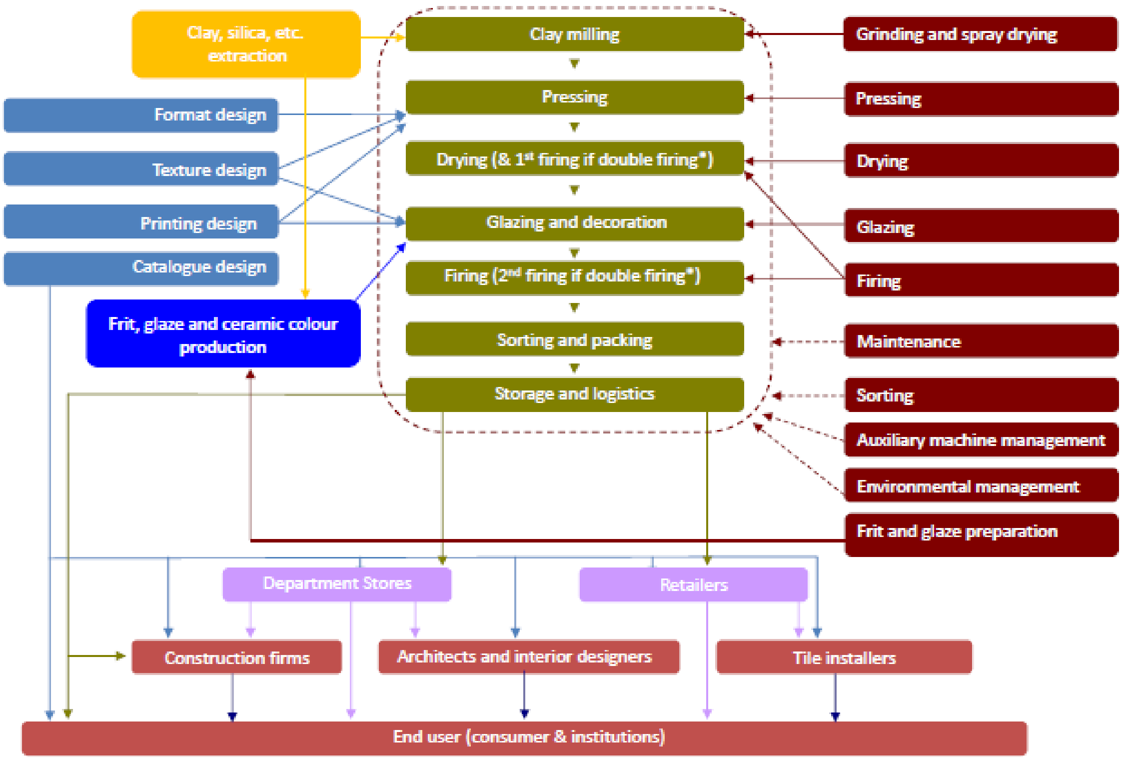
3. RESULTS

We summarize the evidence so far. This section is subdivided into three subsections which analyse the ceramic tile value chain (3.1), describe the SCTI innovation system (3.2), and discuss how it operates (3.3).

3.1. The value chain

Figure 1 depicts the six main elements of the ceramic tile production process. We provide a descriptive analysis of these elements and measure their contribution to the value chain.

Figure 1: Central elements in the ceramic tile production process



Source: Gabaldón-Estevan, 2011

The quality (i.e. organic composition) and characteristics (i.e. carbonates content) of the *raw materials* (clay) determine their suitability for ceramic tile production; their final cost is dependent mostly on the distance from their source (the mine) to the plant. There are two main types of clay, red and white, with different iron content. There is poor availability of white clays in both regions and they are imported (mainly from Eastern Europe - Turkey and Ukraine). In Spain, red clay is readily available and constitutes about two-thirds of the clay used in the industry.

Machinery and equipment are needed for all the activities of tile production - from raw materials grinding and storing, presses and kilns, and frits and glaze manufacture. Innovation in most ceramic tile companies is in the form of acquisition of new machinery (Gabaldón-Estevan, 2011). Russo (1996) highlights the importance of generic innovations that emerge from neighbouring districts, such as the spray-drier machine and the furnace tunnel, which were developed in other industries. The relationship between the ceramic tile and the machinery manufacturers is one of strong cooperation (Meyer-Stamer et al., 2004). The majority of machinery providers are Italian, although Spanish machinery providers are reasonably well specialized in machinery for preparation and application of frits and glaze and the Spanish machinery sector is a world leader for production of digital ink-jet printing machines (Sanz et al., 2011).

Ceramic frits, and ceramic colours and glazes are crucial for ceramic tile production. In mature markets, product differentiation relies more on aesthetics. The glaze is responsible for the final appearance and properties of the tile. Glaze producers innovate in designs and applications (Meyer-Stamer et al. 2004). The leading companies are Spanish and Italian (Tortajada-Esparza et al., 2008b) and Spanish companies have subsidiaries in Italy, Brazil, Indonesia, China and Mexico, and export over two thirds of their production (Tortajada-Esparza et al., 2008a, 2009).

Design is important for almost every consumer good and especially for decorative goods such as ceramic tiles. The design process involves collaboration between the designers and the ceramic tile, machinery and glaze producers.

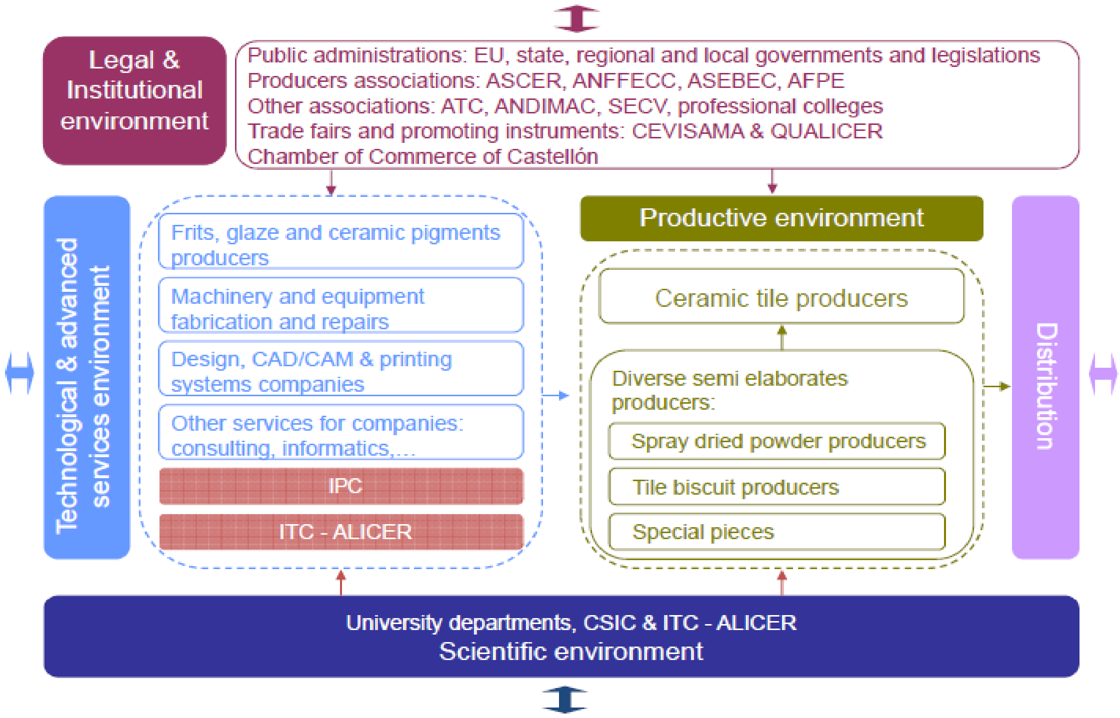
Partly because of being a heavy product, *production of ceramic floor and wall tiles* is a highly integrated process. Most tile production companies are medium or large sized (Meyer-Stamer et al., 2004).

Especially in Spain, *distribution* is most delegated to independent salesman and construction companies with only a few of the most important ceramic tile firms dealing directly with end users.

3.2. Mapping the innovation system

Figure 2 depicts the main components of the SCTI innovation system, which includes various actors, networks and institutions. It is adapted from Fernández de Lucio et al. (1996) and shows four environments (legal and institutional, production, scientific, and technological). The last three are governed by the legal and institutional framework in place.

Figure 2: components of the SCTI innovation system



Source: adapted from Fernández de Lucio et al. (1996)

The SCTI *production environment* includes end product producers and producers of intermediate or special pieces, such as unglazed ceramic tiles and spray-dried powder.

The SCTI *technological and advanced services environment* groups together all the institutions encompassing the technological knowledge required for innovation in the sector. This includes technologically new machinery, materials, consultancy and services. The productive environment and the potential capacity of the scientific environment are dependent on the features of this environment. Figure 2 shows that the actors involved in the technological and advanced services environment are the providers of novel or improved technological solutions and are responsible for their diffusion throughout the sector. They include frit, glaze and colour producers, and machinery and services providers. The firms and service providers in the sector which offer advice in the fields of design, computerization and new technologies, technology and marketing consultancy, etc. belong to the technological and advanced services environment. Some ceramics firms have in house design departments, but most buy technical designs or acquire them from their frit and glaze or special pieces providers.

The Instituto de Tecnología Cerámica (ITC) is a university institute whose mission is to promote and develop activities to improve the competitiveness of the Spanish ceramic tile industry, and to develop the frit and glaze subsector. The Spanish Instituto de Promoción Cerámica (IPC) in the Diputación de Castellón (a supra-local administrative entity) and is specialized in architectural ceramics applications.

The *scientific environment* is constituted of university and public and private research centres and research groups. It includes the University Jaume I (UJI) and the ITC. There are two UJI departments, Chemical Engineering (linked to ITC) and Inorganic and Organic Chemistry, that are mainly responsible for research in ceramic technology. Other public research institutions located outside the district have historical links with the SCTI actors through provision of R&D activity, such as Institute for Ceramic and Glass (ICG), which belongs to the Spanish Council for Scientific Research (CSIC), and Centre for Research on Graphic Design of the Universitat Politècnica de València (UPV).

The institutional environment, which is made up of the different public administrations, is very important. It is responsible for developing policy and heavily influences the industry. The activities of the various industry associations[4] contribute to the sector, and an annual trade fair (CEVISAMA) and a biennial congress (QUALICER) promote innovation and the industry products.

3.3. Highlighting the functions

[4] These include 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 interviewees were generally agreed that in relation to the SCTI innovation system, there is no possibility of an imminent technological leap and the present crisis is related mainly to the ending of a long period of growth where building construction, especially in Spain, played a major role. The other contributing factors are related to globalization (increasing competition from new producers, off shoring, environmental constraints, higher materials and energy prices) and generational changes that have resulted in mergers among firms. Technical innovations are generally incremental, and the technological challenges (reduction in the materials and energy consumption) are not being matched by alternative production processes. Technology improvements are likely to spread rapidly to other countries and any comparative advantage will not be enough to guarantee survival.

Spanish producers are highly skilled in the technological aspects of production and materials, and UJI and especially the ITC have historically contributed greatly to the generation and diffusion of knowledge, training of human resources, and improvements to ceramic tile firms' environmental efficiency (Picazo-Tadeo et al., 2007). There is a belief that the generation of knowledge for the industry, especially knowledge related to frits, glazes and colours, has reached a point in the asymptotic curve where the progress achieved in relation to effort expended, is decreasing. Spanish producers are able to produce high quality products and to optimize product characteristics, but generally lack the initiative to develop new breakthrough technologies (with the exception of injection technology), or to direct markets.

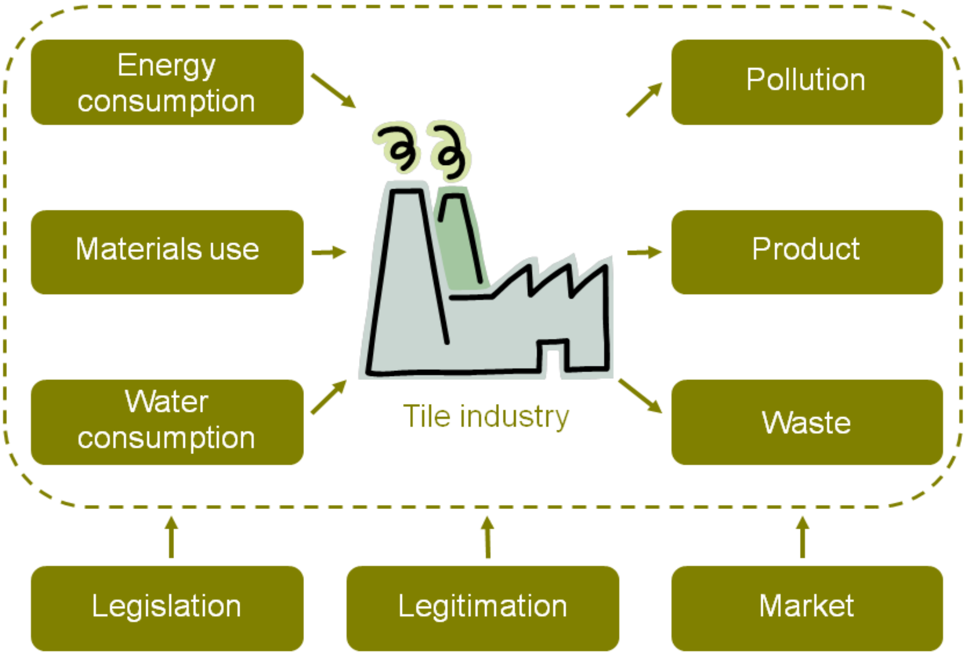
The analysis of the SCTI shows that a model change is required in the direction of search, following a period when the main competitor (Italy) was the leader in design and technology. The new competitors (Brazil, China, etc.) are imitating the strategies developed in the SCTI.

There is a need for another objective to enable a collective response that might allow the SCTI to escape from a pattern in which success was based on increased production, size, designs, uses, etc. Radical change will be required if the SCTI is to retain its technological and market leadership and compete on value added. Collaboration and a new innovation strategy is needed. This might be a focus on ‘ecological or green tiles’, as suggested by one interviewee, and might group together different agents and different sub-strategies, to form an umbrella organization able to produce ecological innovations, which would work to differentiate the sector from competitors. Such a strategy would involve revision of all parts of the value chain, from raw materials extraction to packaging and transportation, including water and energy consumption, etc. and marketing. It would require substantial resources devoted to R&D, but in the long run could establish the SCTI at the forefront of a new tile industry paradigm.

4. DISCUSSION

This study analysed the CTI value chain and innovation system. In this section the focus is on the role of environmental issues.

Figure 4: Environmental issues in the development of the SCTI



Source: own elaboration

Figure 4 shows that, in order to understand the role played by environmental issues we need to analyse nine areas. The first three (left-hand side of diagram) refer to the inputs needed for the industry activity with particular emphasis on energy consumption, materials use, and water consumption. The second three (right hand side of diagram) are related to outputs - pollution created, products, and waste generated. The last three (bottom of the diagram) are related to contextual aspects affecting the performance of the SCTI performance - the legal framework, industry legitimacy, and market evolution (introduced in Sections 3.2 and 3.3).

Energy consumption

The CTI consumes considerable amounts of energy along its value chain. The main energy consuming phases are: mining, transport of raw materials to the processing plants, the manufacturing process, and storage and delivery of the packaged ceramic tiles. Within the manufacturing process firing and drying are the environmental hot spots (Ibáñez-Forés, et al. 2013). The energy involved in the use and end of life phases is negligible (Benveniste et al., 2010)

At both ends of the value chain (raw materials and finished product), transport is by means of trucks (short and medium distances) and ships (longer distances).

The manufacturing process is an intensive user of energy, especially thermal energy (around 28 kwh/m^2) (Monfort et al., 2010b). Since the 1980s, when a pipeline was constructed, SCTI companies have been fuelled mainly by natural gas. The majority of the spray-dried powder producers have installed cogeneration units that produce heat and electrical energy, which has made them 85% or 90% energy efficient.

Electrical energy consumption in the ceramic tile process is around 3 kwh/m^2 (Monfort et al., 2010b), but thanks to the use of cogeneration systems, the net electricity balance in the overall SCTI is positive, meaning that more electricity is produced than is consumed. According to a recent study (Monfort et al., 2010) most SCTI companies are using the most energy efficient techniques. Although there are some additional savings measures that could be implemented, without a breakthrough development, further significant reductions in energy consumption are not envisaged. The trend in energy costs and increased concern in the EU over carbon dioxide emissions may constrain the short term development of the SCTI.

Materials use

The main problem related to the use of local raw materials (mainly red clays) is social acceptance of mining activity. The balance between environmental impacts (dust emissions, noise, soil degradation, etc.) and the benefits to the community is less evident as in the case of industrial activity (in relation to employment and taxes). Since the early 2000s, many municipalities have stopped issuing new mining permits and mining activity is being located in more remote areas, which is increasing the costs of raw materials transport. The increased demand for porcelain ceramic tiles, which are produced from imported raw material (white clays, feldspars, etc.) has eased the mining in the region problem. However, the use of imported raw materials involves more complex infrastructure and negotiations as well as even higher transport costs. There are also huge variations in the prices of some essential glaze raw materials such as zirconium silicate ($ZrSiO_4$) and zinc oxide (ZnO).To cope with this, some companies are implementing strategies to speed up the search for new formulations to reduce demand for these raw materials.

Water consumption

Water is an essential raw material and auxiliary input (Enrique et al. 2000). Most SCTI companies prefer the wet process to the dry process to prepare their raw materials. However, they have developed techniques that allow reuse of the wastewater in the manufacturing process, which is essential in periods of drought. Consumption of fresh water has been reduced by 50% and disposal of wastewater has reduced by 100% (Enrique, et al, 2000). Nevertheless, continuous efforts are being made (Gil et al., 2012; Melchiades et al., 2010; Shu et al., 2011, 2012a, 2012b) to improve the dry process for raw materials, which should make further major savings on water and thermal energy consumption and provide similar products.

Pollution

The industry has made progress in substituting most of the most hazardous elements (i.e., lead) that characterized production in the early years of the industry. However, there is room for more improvement (Picazo-Tadeo, et al., 2007). In wastewater disposal, there is still no solution to boron (B) removal. Current methods include ion exchange or membrane treatment, but these methods are costly and not feasible for treatment of industrial wastewater (Chong, et al., 2009). The problem has been resolved by reusing the wastewater.

Control of atmospheric pollution to meet the conditions in the IPPC Directive (now IED)[5] is difficult, since SCTI companies (ceramic tile producers, frit producers, etc.) have had to implement systems to remove mainly particulate matter and acid pollutants from emissions (Gabaldón et al., 2003; García-Ten et al., 2011; Monfort et al., 2008, 2010a, 2011). The interviewees highlighted that in the 2000s environmental firms have been set up to produce air filters (Gabaldón-Estevan and Hekkert, 2013).

There is new legislation on dust pollution, which requires spray-dried powder producers located less than 1 km from an urban area to carry out storage and handling of dusty raw materials in closed facilities. This is requiring heavy investment to comply with this requirement and/or introduce changes to the process.

Finally, although significant decreases have been achieved in carbon dioxide emissions (CO_2) through improved energy efficiency (from 12.2 kg in 1985 to 5.8 kg CO_2/m^2 in 2000 (Mezquita et al., 2009) further developments are needed given that dioxide emissions is one of the most important ecological indicator.

Product

From a sustainability perspective, ceramic tiles have some interesting properties: they are waterproof, ultra violet radiation and fire resistant, do not release volatile organic compounds at room temperature or toxic substances when exposed to high temperatures. These properties make them *durable*, that is, they require less frequent repair or renewal. They are *versatile* in terms of sizes, forms, colours and fixings, and can be used to provide thermal insulation or to increase or reduce light reflection. They are *low maintenance* compared to organic or textile materials, and the products required for their maintenance and cleaning have low environmental impacts. Ceramic is aseptic; it is inert and does not carry smells, bacteria or polluting agents.

However, the SCTI managers believe that there are opportunities for green developments related to new types of tiles, new ways of fixing and new applications.

[5]The original IPPC directive was adopted as Directive 96/61/EC which will be repealed with effect from 7 January 2014 by Directive 2010/75/EU on industrial emissions (so-called IED Directive).

The industry is working on the development of thinner ceramic tiles, which could reduce the raw materials inputs by up to 50% as well as the energy and water required for manufacture, transport and storage.

In recent years, several ‘green’ innovations have been reported (Garcia-Ten, 2010; Monfort, 2012), resulting from R&D related to new functions. For example, there are ceramic tiles that can remove NO_x from the air for use in cities, easy clean tiles which reduce the amounts of water and cleaning products needed for their maintenance, ceramic tiles that incorporate functional elements such as photovoltaic plates or smart systems, ceramic tiles used to form ventilated facades that improve thermal insulation of buildings in hot regions, radiant ceramic tiles, etc.

Waste

Most waste generated by ceramic tile production is reincorporated in the process (Monfort et al., 2004; Moreno et al., 1996). Some companies are producing tiles made of 80% recycled materials, that have the same technical and aesthetic properties as conventional tiles (Trilles-Lazaro et al., 2011). Waste from the manufacturing process is mainly reused as a raw material. This has been achieved through collaboration between the ceramic tile and spray-dried powder producers (Gabaldón et al., 2003). Current research is focusing on the development of ceramic compositions that include waste from other industries (ceramic and/or non-ceramic) to replace traditional raw materials or produce new products (Silva, et al., 2010; Baruzzo, et al., 2006; Youssef, 2002; Couto et al., 2001).

Environmental legislation and the legal framework

Current EU environmental legislation focuses on energy efficiency, greenhouse gas emissions and air quality control. The EPBD[6] promotes improvements to the energy performance of buildings in the EU, taking account of outdoor climatic and local conditions and indoor requirements and cost-effectiveness. The SCTI has used this

[6] Directive 2010/31/EU of the European Parliament and of the Council on the Energy Performance of Buildings.

opportunity to promote their recent developments for the building sector. The IPPC Directive (now the IED) was seen by most interviewees as beneficial because it promotes adoption of the best available technology in terms of energy use.

There was less agreement about the Kyoto protocol and carbon dioxide emissions because the SCTI is exposed to competition from countries with very lax legislation on greenhouse gas emissions. There is a hope, however, that Kyoto, as has been the case with the IED initiative, will force the use of the best available technologies.

The industry is also subject to European REACH[7] regulation, which has had a significant impact on frits and pigment producers due to the high costs of registering materials.

Legitimation

The SCTI has traditionally provided wealth and employment in the region, endowing it with good status and legitimation. However, public awareness of environmental and health issues increased in the 2000s. Production of ceramic tiles has increased from 225 million m^2 in 1990, to 609 million m^2 in 2005 (although in 2010 it decreased to 366 million m^2). This greatly increased production has had some major consequences given the high geographical concentration of this industry in the Castellon district. Also, EU, state and regional environmental regulation and control have increased the industry requirements related to protection of health and the environment. Finally the increase in other economic activities, such as tourism, especially second residences in coastal resorts in the province of Castellon, is competing over use of land and infrastructures. Several interviewees blamed recognised a lack of anticipation to adapt to the new environmental regulations. Both entrepreneurs associations and public administrations, were not forecasting environmental issues in spite of the environmental information available since early 1990s (Blasco, et al., 1992). There have been some efforts by

[7] REGULATION (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). As fired ceramic tiles are inert materials (the potential toxic compounds of glazes are immobilised after firing), this regulation has had a very low impact on ceramic tile producers.

producers' associations to forge agreements with administrations that have put in place environmental legislation, and some efforts from individuals to reduce pollution before this became compulsory. However the overall trend has been a slow adaptation to the new environmental legislation, and the lack of good channels of communication with the different social agents within the community. Some interviewees argued that the legislation is too harsh and renders a balance between technology and environmental protection impossible.

SCTI companies have had to make huge efforts over a relatively short period to adapt their plants to the new EU legislation, reducing their environmental footprint (Minguillon et al., 2007; Minguillón et al., 2009; Querol et al., 2007).

Some companies are making efforts to obtain certification, such as Environmental Management Systems, Ecolabels and Environmental Product Declarations (EPD) in order to improve their public image and secure markets in countries with high levels of environmental consciousness (Gabaldón et al., 2003).

Market

The industry is more concerned with branding and marketing strategies (market positioning, cost reductions) than R&D for several reasons. First, the returns from R&D investments take time. Is a defensive strategy towards avoiding imitation by competitors; it is also difficult to establish a joint strategy that could coordinate R&D from all the actors in the SCTI.

It is possible that production centres will relocate to areas where environmental restrictions are lower, labour is cheaper, and energy and primary materials more available. This process of delocalization has started among the main frits, glaze and pigment producers with the aim mainly of reducing transport costs. However, relocation can involve the problem of inserting technical teams to set up the new factories, which might explain why the CTI is generally reluctant to delocalize. As Spanish ceramic tiles are present in the EU, USA and Middle East markets, few efforts are being made to develop new markets, rather activity is aimed at better positioning in existing markets.

In the context of stronger competition and lower margins, providers (of frits, glazes and colour and machinery) are finding it difficult to pass on the costs of their R&D to users. This brings about a reduced effort on R&D, that causes the absence of large joint research projects. Large joint research projects could pick and adapt technologies from other industries that could be use for the ceramic tile industry (Physical vapour and chemical vapour deposition, microwaves, laser, plasma injection, hydrogen, electrical heating are all considered to be cleaner technologies). Besides, in the absence of large joint research projects most developments are directed at increasing capacity (heavier presses, larger kilns) rather than looking for more complex solutions (stronger materials that increase resistance, microwave kilns, dry route, lower temperature processes enabled by new material mixes, resistant organic colours[8] that require temperature of only 200Cº, new fixing mechanisms that facilitate repositioning). Although there are some local differences, Spanish and Italian ceramic tile producers experience the same problems as other European manufacturing industries: new environmental EU regulations, weak lobby at the European institutions, impacts of globalization, etc. Some interviewees were of the opinion that only a focus on technology and the ecology would make the European ceramic tile industry competitive in the long-term: water-free production process, toxic-free products, low carbon dioxide emission, etc. could result in EU produced ceramic tiles being identified as green and technologically superior.

Conclusions

Entrepreneurial activity in the SCTI is confined mostly to incumbents rather than new entrants. This corresponds to a Schumpeter Mark II scenario characterized by creative accumulation in which old, bigger companies dominate and new companies face entry barriers (Schumpeter, 1939). The established companies carry out improvements and experiment with new materials (white clays), new products (façade tiles) and new technologies (digital ceramic printing), which increases the resources required. The portfolio of products is increased, but the goal of reducing inputs and the environmental impacts of production activities gets more remote.

Energy saving and climate protection are items on the CTI's agenda (Criado, 2007). However, the threat to industry legitimation comes from environmental pressures on the region, due to the high concentration and rapid increase in production capacity since the 1990s, reduced only recently due to the economic crisis and especially in the Spanish building sector. The long tradition of this activity in the Castellón region increases the keenness to reach compromises between the industry and the local context. It is in the interests of the companies to invest in environmental protection measures. However, public awareness and environmental legislation are forcing the environment onto the agenda which means taking into account the environmental costs of this economic activity and forcing a convergence between economic and environmental sustainability.

It would seem that one solution would be to ignore production and focus on costs and technology, and move towards adjusting production capacity and increasing production flexibility, value added and stronger brand and distribution channel control, including design and aesthetics. A good strategy might be production and promotion of 'green' ceramic tiles made in UE (Spain and Italy), and emergence of synergies with the different actors involved.

Direct effects are reductions in waste generation and water consumption, and search for a reduction in the weight of tiles to diminish the energy needed for their fabrication and transport. But also the extension of those environmental requirements to other producers, or at least restrictions on imports, is seen as necessary for the local industry and the global environment. However, there is an extended believe that, in the long run, industrial activities with low value added and high environmental impacts, like the ceramic tile, will not be supported by European institutions. A strategy pursuing a more environmental friendly industry could act as a shared objective for both technical improvement and better positioning in mature markets.

Within a longer perspective, however, the industry's environmental footprint is of serious concern for its survival in the EU. In fact, some interviewees pointed to lack of interest among the EU authorities towards manufacturing processes as the origin of the major crisis of this industrial activity. In this complex new scenario a new strategy is needed that could concentrate R&D efforts on finding solutions to reduce dramatically the amounts of resources required and the environmental impacts, to assure the acceptance and the competitiveness of this type of industries in the EU.

Seems that the European traditional industries, as the one analysed in this paper, have to deal with this dilemma, either moving forward towards more efficient and sustainable production beyond the legal requirements or accomplish the minimum requirements at minimum cost, the authors believe the former alternative as the only one that will guarantee the survival at long-term. But this option can only succeed if it is adequately reinforced by the EU policies in order to avoid environmental dumping. Therefore, efforts demanded to the traditional industrial should be also directed towards implementing measures that guarantee a global reduction of the environmental impacts, which means that the imported products should fulfil similar environmental standards as those required to the EU manufacturers. Otherwise, the current policies will continue forcing the externalization of the environmental impacts thought the delocalization of manufacturing companies.

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