THE CERAMIC SECTOR DIGITALIZATION

THE SPANISH ISSUE

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ABSTRACT

The ceramic industry is the most important economic sector in the province of Castellón, and the third sector in Spain. The economic crisis, which began in 2007, had a major impact and repercussions on this sector than in others.

Its high geographical concentration and the support of important and official institutions, led the Spanish ceramic sector to the top of the industrial innovation. As a result of the investments in new technologies, a Spanish company managed to patent a revolutionary method of digital printing.

This dissertation studies 20 Spanish companies by means of an econometric model, how the digitization of ceramic printing, allowed to regenerate the Spanish ceramic sector between the years 2007 and 2015.

JEL Classification: C30, F14, L61

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INTRODUCTION

The ceramic sector is one of the most important in the Spanish industry. That is what the 'Asoción Española de Fabricantes de Azulejos y Pavimentos Cerámicos', ASCER in acronyms, puts forward as a big argument when they affirm that this third industry sector is the one that contributes the most to the Spanish trade balance.

The Spanish tile industry is characterized by being an industrial cluster. Michael Porter (1999), collaborator at Harvard University, points that "clusters are geographic concentrations of interconnected companies and institutions that operating in a particular sphere". This sector is considered as an industrial cluster because in a small geographical area, is concentrated the 94% of the production and the 81% of the companies in the Spanish ceramic sector; as well as a multitude of support and public institutions, this is what is known as the ceramic district of Castellón's province.

According to the lastest sectoral inform from the IVACE, named "*Productos cerámicos de la Comunidad Valencia*", in April 2016 Castellón was the first Spanish region in terms of ceramic export, ant the 76% of total exportation in 2015. The cluster's impact in this small province is enormous, both economically and occupationally, as well as a socially.

In recent years, as it has arrived with other economy sectors in our country, the ceramic one has been really affected by the economic crisis. Thousands of jobs form this sector were destroyed, and dozens of companies had to close in a few years. Despite this, the Spanish tile industry bet on its world leadership in R+D+i, and thanks to this strategy, we are no living what is known as the third revolution of the ceramic industry: the digitization.

In 2000 a Spanish company introduced the first digital printer for ceramic tiles. Thenceforth, Spanish manufacturers have invested in this revolutionary machinery to be more competitive worldwide. All this has allowed, according to ASCER, that Spain in 2015 became, once again, the main producer and exporter of the European Union, and the second exporter worldwide.

These data are encouraging and indicate that after a few years of uncertainty the Spanish tile industry can, once again, be positioned as one of the most competitive all over the world.

OBJECTIVES

After evaluating the above data, we have considered interesting to study the impact of ceramic digitization in the sector. Concretely, we have tried to analyze whether the investments made by the different manufacturers of ceramic tiles in this type of digital printers during the last years, have had a great impact in the regeneration of the tile sector.

It is why the objectives of this work are:

To understand the importance of the ceramic sector in Spain through a global vision of the current global industry position and national sector situation.

To know why we can identify as an industrial cluster the ceramic industry in Castellón and its repercussion in the province.

To obtain a database of the main tile factories, where these investments in digital machinery, made in recent years, are reflected.

To propose a valid econometric model valid for analysis of the main companies in the ceramic sector by utilizing the proposed database.

To analyze the impact of ceramic digitization in the sector, by using the econometric model that we will propose.

To reach a solid conclusion, on whether these investments in new machinery have achieved their aim objective: to gain competitiveness and to revive the sector in the midst of a period of crisis.

METHODOLOGY

In the first place, it is necessary to compile databases for later analysis, in that sense, the first step was to seek information from different secondary information sources, such as reports, magazines or books that are specialized in the tile sector. From these sources, it was possible to extract an overview of the tile sector, both at a global and at a national level.

Some of the key words that have been used for the search of the necessary bibliography from which we have elaborated this work are: 'Tile sector', 'ceramic cluster', 'ceramic digitization' or 'R+D+i in the ceramic industry'.

Second, we contacted different companies in Castellón dedicated to the manufacture of tile, which have provided us with interesting information about their investments in digitalization. In some cases we visited the factories, we met with their financing and purchasing department and we could see how the digital injection printers work.

Besides these sources, the SABI database has been used to gather all the economic and financial data of the companies that we have analyzed. For the purpose of use SABI, a search filter has been established, specifically definite by an activity code, the CNAE 2331: Manufacture of ceramic tiles.

Once the database was constructed, the next step of study was the economic analysis. For this purpose, we used different statistical and econometric instruments, among which the main software tool was R Software. With regard to the econometric methods used, different econometrics books have been consulted: '*Introduction to econometrics: a modern approach*', writed by Jeffrey M. Wooldridge (2000) or '*Applied econometrics*' writed by A.Muñoz Cavanes (2007).

THE CERAMIC SECTOR

As in the whole of the Spanish economy, the consequences of deep global crisis affected the ceramic sector in a significantly way, because of that economic growth was stagnated in 2008. As J.Mestre Castelló affirmed in Levante's newspaper, in a 2009's publication: 'The financial crisis and the housing crash have ended a decade of growth and have plunged the main sector of the province of Castellón in an unprecedented recession'. The manufacture of ceramic tiles decreased drastically between 2008 and 2009 all over the world. In large part, this decline was led by the two major producers, Spain and Italy, who were forced to reduce its production in this period in an approximately a 30 percent. In the midst of the financial crisis, the president of the Cámara de Comercio de Castelló, Salvador Martí Huguet, stated that: 'Ceramics is seriously injured'.

However and in spite of the recession suffered by the whole economy, the tile industry experienced a small global growth in 2010. In 2011 the 10 billion square meters produced were first exceeded for the first time, according to the KMPG report *'The tile sector in Spain through 21 large companies 2011-2007*', and since then this production has not stopped growing.

In the following sections we will analyze how the sector has behaved worldwide in recent years. We will see how the sector has been regenerated, mentioning aspects such as production, exports and consumption. Once analyzed this items from a global perspective, we will proceed to analyze in detail the case of Spain.

THE CERAMIC TILE INDUSTRY WORLDWIDE

PRODUCTION

The production of tiles worldwide has not stopped growing in recent years, but as we can see in *Table 1*, and according to the report '*World production and consumption of ceramic tile*' published by ACIMAC in 2016, growth stalled between 2007 and 2009, as it was previously growing at a rate of over 500 million square meters a year, and during this period, the production only managed to grow 3'49 percent, that is, 300 million square meters in two years.

In 2010 and 2011 production began to grow at an accelerated pace, as in only two years, the world production of tiles increased by 2,000 million square meters, surpassing the barrier of 10 billion in 2011. Since then, production has increased at constant rates until 2015, because as we can see in *Table 1*, the production of tiles managed to surpass 12,355 million square meters.

TABLE 1.

WORLD PRODUCTION AREAS (SQ.MT MILL.)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	%World
EU	1.589	1.441	1.088	1.139	1.188	1.179	1.185	1.192	1.218	9.9%
OTHER EUROPE	445	434	387	447	480	524	606	570	572	4.6%
NAFTA	268	284	259	272	290	302	306	308	327	2.6%
SOUTH AMERICA	853	938	932	1.001	1.098	1.138	1.158	1.194	1.193	9.7%
ASIA	4.853	5.198	5.583	6.407	7.234	7.720	8.330	8.703	8.627	69.8%
AFRICA	286	308	348	372	331	356	368	401	413	3.3%
OCEANIA	8	8	7	6	5	5	5	5	5	0.0%
TOTAL	8.252	8.548	8.533	9.546	10.512	11.224	11.958	12.373	12.355	100%

Source: Preparated by the autor from reporting data Acimac Survey dept."World production and consumption of ceramic tiles", 4th edition 2016

Asia remains to be the leader of the sector, with a share of 69'8 % of the world production; this means that more than two thirds of the tiles are made in this continent. The Asian manufacturers produced in 2007 a total of 4,440 million square meters and in 2015 almost doubled that amount reaching 8,627 million m2. This growth was mainly influenced by the activity of countries such as China, India or Vietnam, as 5 of the 10 largest tile manufacturers, as we can see in *Table 1*, are Asian countries.

The European Union is the second manufacturer in the world. In 2007, 1,589 million square meters were manufactured, and during the crisis production this amount fell to 1,088 million in 2009, largely due to the reduction of m2 manufactured in Spain and Italy, the leaders of European producers. But the European tile sector managed to refloat and since 2009 has increased its production to reach 1,218 million square meters in 2015, with a share of 9.9 percent of world's production.

Europe is closely followed by South America, with a share of 9.7 percent and a total production of 1,193 million square meters in 2015. Like Asia, but to a lesser extent, these countries have not stopped growing and their production is increasing year after year. In large part, thanks to Brazil, the second manufacturer in the world.

In *Table 2*, we can see the main tile manufacturer's countries. The table includes a total of ten countries, all them together produced 82'8 per cent of world production in 2015. We see how 5 of the 10 countries are Asian, 3 are European and 2 are American.

TABLE 2.

WORLD PRODUCTION BY COUNTRIES (SQ.MT MILL.)

COUNTRY	2007	2008	2009	2010	2011	2012	2013	2014	2015	%World
1. CHINA	3.200	3.400	3.600	4.200	4.800	5.200	5.700	6.000	5.970	48.3%
2. BRAZIL	637	713	715	753	844	866	871	903	899	7.3%
3. INDIA	385	390	490	550	617	691	750	825	850	6.9%
4. SPAIN	585	495	324	366	392	404	420	425	440	3.6%
5. VIETNAM	254	270	295	375	380	290	300	360	440	3.6%
6. ITALY	559	513	368	387	400	367	363	382	395	3.2%
7. INDONESIA	235	275	278	287	320	360	390	420	370	3.0%
8. TURKEY	260	225	205	245	260	280	340	315	320	2.6%
9. IRAN	250	320	350	400	475	500	500	410	300	2.4%
10. MEXICO	215	223	204	210	221	231	230	230	242	2.0%
TOTAL	6.580	6.824	6.829	7.773	8.709	9.189	9.864	10.270	10.226	82.8%
TOTAL WORLD	**8.252**	**8.548**	**8.533**	**9.546**	**10.512**	**11.224**	**11.958**	**12.373**	**12.355**	**100%**

Source: Preparated by the autor from reporting data Acimac Survey dept."World production and consumption of ceramic tiles", 4th edition 2016

The leadership of China is indisputable, since with a quota of 48.3 percent, in 2015 made almost half of the tiles manufactured worldwide, 5,970 million square meters in total. Undoubtedly, China has succeeded in boosting global production growth in recent years, and everything indicates that they will continue to be so for the next few years.

Followed by Brazil with a market share of 7.3 percent and a total of 899 million, India with a 6.9 percent and 850 million square meters, and in fourth place is Spain, with a share of 3'6 per cent and 440 million square meters manufactured. In 2011 both Italy and Iran displaced Spain to the sixth place in the ranking of manufacturers; but, as we can see in the Table 2, Spain has managed to climb 2 positions in just 5 years.

Once exposed this data we can verify that, despite the severe crisis in Spain and Europe, with business' losses of 30% in the Spanish's companies, the ceramic sector has not stopped growing, thanks to the tiles demand from Asia and Latin America.

CONSUMPTION

As well as the production, tiles consumption is increasing, since in the last years this material has acquired different uses non-existent until now, some examples can be kitchen countertops or facade cladding.

TABLE 3.

WORLD CONSUMPTION AREAS (SQ.MT MILL.)

	2015	%World	%var 15/14
EU	910	7.5%	+5.0%
OTHER EUROPE	532	4.4%	-2.0%
NORTH AMERICA	505	4.1%	+9.3%
CENTRAL-SOUTH AMERICA	1.279	10.5%	-0.5%
ASIA	8.166	67.1%	+0.6%
AFRICA	731	6.0%	-2.7%
OCEANIA	52	0.4%	+8.3%
TOTAL	12.175	100%	+0.8%

Source: Preparated by the autor from reporting data Acimac Survey dept."World production and consumption of ceramic tiles", 4th edition 2016

World tiles consumption reached in 2015 the total amount of 12.175 millions square meters produced, the highest figure to date. Asia, apart from being the world's largest producer, is also the main tiles consumer, the 61.7% of total consumption in 2015. Either by size, population or by being in constant development, the Asian continent has been for years the largest consumer.

The European Union registered a recovery that increased to 910 million square meters global demand (+5%), including strong growth in Poland, the United Kingdom, Spain, Romania and Belgium, and a small Italian recovery. Conversely, demand in markets outside European Union decreased from 543 million to 532 million square meters (-2%), this is due to the downturn in Russian and Ukraine, which was not adequately offset by the recovery in Tukey, as Luca Baraldu (2016) has concluded.

In Central America and South America, consumption was 1,279 million square meters, 0.5 percent less than in 2014. Despite being the second consumer worldwide, its share of consumption is 10.5% and has stagnated in recent years. Demand in Africa rose from 751 to 713 million square meters, a decline of 2.7%, partly due to the drop in consumption in Niger and Libya. The consumption of tiles in Africa is around 6% of the world consumption.

TABLE 4.

WORLD CONSUMPTION BY COUNTRIES (SQ.MT MILL.)

COUNTRY	2007	2008	2009	2010	2011	2012	2013	2014	2015	%World
1. CHINA	2.700	2.830	3.030	3.500	4.000	4.250	4.556	4.894	4.885	40.1%
2. BRAZIL	535	605	645	700	775	803	837	853	816	6.7%
3. INDIA	397	403	494	557	625	681	718	756	763	6.3%
4. VIETNAM	210	220	240	330	360	254	251	310	400	3.3%
5. INDONESIA	178	626	297	277	312	340	360	407	357	2.9%
6. SAUDI ARABIA	110	136	166	182	203	230	235	244	263	2.2%
7. USA	249	211	173	186	189	204	230	231	254	2.1%
8. TURKEY	161	129	138	155	169	184	226	215	234	1.9%
9. MEXICO	174	177	163	168	177	187	187	197	216	1.8%
10. RUSSIA	176	191	139	158	181	213	231	219	192	1.6%
TOTAL	4.890	5.528	5.485	6.213	6.996	7.346	7.831	8.326	8.380	68,8%
TOTAL WORLD	**8.060**	**8.350**	**8.500**	**9.410**	**10.472**	**10.964**	**11.582**	**12.077**	**12.175**	**100%**

Source: Preparated by the autor from reporting data Acimac Survey dept."World production and consumption of ceramic tiles", 4th edition 2016

The main tile producers, China, Brazil and India, are the largest consumers, as we can see in Table 4. This is a fact that does not surprise us, since they are developing countries and the building sector is booming in these countries. Saudi Arabia and the United States, both two consume more than twice as much tile as they produce; in fact, they are the main importers of tiles of the world, since more than 60 percent of its consumption comes from the tiles import. Russia, despite being in 13th place in terms of tile production and consuming 192 million square meters in 2015, is able to cover its demand with its own production.

Spain's role in global tiles production is surprising, since it is the fourth largest producer in the world, but it is not into the 10 largest consumers. As we will see below, Spain is one of the leading countries in terms of tile exports.

EXPORTS

We have already seen that the world's tile industry is booming and continues to grow year after year thanks, in large part, to exports from producing countries. In 2015, as we can see in Table 5, 2,735 million square meters of tiles were exported around the world, of which 85.1 per cent correspond to the ten main world exporters. Growth over the last few years has been constant and in 2015, 22.1 percent of world production went directly to exports.

TABLE 5.

TOP EXPORTING COUNTRIES (SQ.MT MILL.)

COUNTRY	2012	2013	2014	2015	%National production	%World	%Var 15/14	Value (Mill €)	Export Price (€/sq.mt)
1. CHINA	1.086	1.148	1.110	1.089	18.2%	39.8%	-1.9%	n.a.	n.a.
2. SPAIN	296	318	339	378	85.9%	13.8%	11.5%	2.425	6.5
3. ITALY	298	303	314	317	80.2%	11.6%	0.9%	4.318	13.7
4. INDIA	33	51	92	122	14.4%	4.5%	32.6%	498	4.1
5. IRAN	93	114	109	112	37.3%	4.1%	2.8%	380	3.4
6. TURKEY	92	88	85	77	24.1%	2.8%	-8.9%	451	5.9
7. BRAZIL	59	63	69	77	8.6%	2.8%	11.0%	265	3.4
8. MEXICO	63	61	62	61	25.2%	2.2%	-1.6%	320	5.2
9. EAU	54	58	55	54	71.1%	2.0%	-1.8%	297	5.5
10. POLAND	42	48	42	42	30.4%	1.5%	0.0%	222	5.3
TOTAL	2.107	2.255	2.277	2.329	24.2%	85.1%	2.2%		
TOTAL WORLD	**2.524**	**2.666**	**2.695**	**2.735**	**22.1%**	**100.0%**	**1.5%**		

Source: Preparated by the autor from reporting data Acimac Survey dept."World production and consumption of ceramic tiles", 4th edition 2016

Regarding the information par countries, we are no longer surprised by the role of China, the world's leading exporter. After growing at a significantly slower pace since 2012, China´s export experienced the first real downturn in 2014 (-3,3%) and fell again un 2015 from 1.110 to 1.089 million square meters (-1.9%) equivalent to an 39,8% of world exports. Saudi Arabia became the largest tiles buyer after China, 64 million square meters; followed by South Korea and the Philippines, inform Luca Baraldi (2016).

Spain managed to grow 11.5 percent in 2015, consolidating as the second largest exporter in the world, with 378 million square meters of tiles exported, accounting 13.8 percent of total world exports. After 7 years in decline the national consumption in Spain took off in 2015, but it is surprising the percentage of Spanish's exports, with a shocking 85,1% percent of the national production. Saudi Arabia confirmed its position as the leading export market by volume: 34.1 million square meters (+19.7%); followed by France with 33 million square meters (+17.8%), Algeria with 25 million square meters (+8.9%) and United Kingdom with 19 million square meters (+24.3%). In recent years Spain has established as a great producer of quality tile, like Italy, but it has managed to adjust its prices to be more competitive, we mean: in 2015 the average price per square meter was around 6.5€ and the average Italian price did not fall from 13€. In Spain, exports represented a value of 2.452 billion Euros in 2015.

Italy, like Spain, is a big exporting country in terms of tiles, since it exported in 2015 the 80.2 percent of its national production, that is 317 million square meters of tiles, with a quota of 11.6% of total world exports. As in our country, the main buyers are developed countries looking for better quality, such as Germany, France and United Kingdom. Exports from Italy were valued at 4,318 million Euros, surpassing Spain, because its average price doubles Spanish's one.

These countries are followed by India, Iran, Turkey, Brazil, Mexico, United Arab Emirates and Poland, but with quotas of less than 5% of world exports. These countries, with the exception of United Arab Emirates, export less than 40% of their national production, and their average price is 5€ per square meter.

The exports of tiles worldwide exceeded the value of 10 billion Euros in total by 2015.

IMPORTS

Regarding imports, as we have mentioned here above, we should note that the main importers are the USA, Saudi Arabia, Iraq, Germany and France. They are large importers, since imports account for between 60 and 90 percent of their consumption. They are considered the largest importers because their imports' account are between 60 and 90 percent of their total consumption.

TABLE 6.

TOP IMPORTING COUNTRIES (SQ.MT MILL)

COUNTRY	2012	2013	2014	2015	%National consumption	%World	%Var 15/14
1. USA	139	160	159	175	68.9%	6.4%	9.9%
2. SAUDI ARABIA	155	155	149	174	66.2%	6.4%	16.8%
3. IRAQ	105	121	102	106	99.1%	3.9%	3.9%
4. GERMANY	89	89	95	100	83.3%	3.7%	5.3%
5. FRANCE	107	95	99	99	87.6%	3.6%	0.0%
6. SOUTH KOREA	61	65	76	85	63.9%	3.1%	11.8%
7. NIGERIA	61	84	90	70	86.4%	2.6%	-22.2%
8. UAE	52	53	54	64	74.4%	2.3%	18.5%
9. PHILIPPINES	38	46	53	60	61.9%	2.2%	13.2%
10. THAILAND	52	68	49	56	29.2%	2.0%	14.3%
TOTAL	859	937	926	989	68.4%	36.2%	6.8%
TOTAL WORLD	**2524**	**2666**	**2695**	**2735**	**22.5%**	**100.0%**	**1.5%**

Source: Preparated by the autor from reporting data Acimac Survey dept."World production and consumption of ceramic tiles", 4th edition 2016

If we look at Table 6, as expected, imports are not as concentrated as in previous tables, since the largest importer, the United Stated, only imported 175 million square meters of tiles in 2015, which accounts for 6.4% of world imports; followed by Saudi Arabia with a very similar data. In all, the top ten importers only have reached a share of 36.2 percent of total imports, that is 989 million square meters of the 2,735 millions square meters from the total tiles imported worldwide, so the 22.5 percent of global consumption comes from the import.

THE NATIONAL SECTOR

Once we have observed the ceramic sector worldwide, we will examine our national's tile sector.

TABLE 7.

THE CERAMIC SECTOR IN SPAIN.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PRODUCTION	585	495	324	366	392	404	420	425	440	492
EXPORTS	2.295	2.211	1.673	1.747	1.897	2.082	2.240	2.328	2.452	2.570
NATIONAL	1.871	1.460	918	801	700	575	557	574	643	746
TOTAL	4.166	3.671	2.591	2.548	2.597	2.656	2.793	2.902	3.095	3.316

Sales in millions of euros and production in millions of square meters.

Source: Preparated by the autor from ASCER data.

The Spanish ceramic sector reached its maximum production in 2007, with a total of 585 million square meters, and after the onset of the economic crisis, it fell to 324 in 2009. In large part this decline was prompted by the decline of domestic sales, as in only two years the national sales revenue descended by 50 percent, from 1,871 million Euros in 2007 to 918 million Euros in 2009. Exports also declined but in a smaller proportion.

Production started to increase in 2010; thanks to slightly increase in exports, but the decrease in domestic sales did not improve the results from the previous year. However in 2011 the increase in exports allowed to improve the production results and the Spanish ceramic sector started to ascend. Since 2011 the production started a progressive ascent and reached the 492 million square meters in 2016. Largely encouraged by the rise in exports, as in 2014 the barrier of 2.3 billion Euros was exceeded, improving the results they had before the global crisis. Domestic sales

started to grow in 2014, but due to the strong decline, they made only 557 million Euros in 2013, quantities still so far from the pre-economic crisis.

This growth is mainly due to the fact that the Spanish ceramic sector is the one that invests most in R + D + i, it has bet to gain competitiveness thanks to the increase of quality. In addition, in recent years Spanish manufacturers have invested many millions of euros to modernize installations, improve production processes and increase the quality of their products.

The ceramic sector, in recent years, and due to the introduction of digital printing, has evolved to what we could call ‘the third industrial revolution’. In the year 2000, Kerajet, a Spanish company, launched a printing system that 'for the first time allows printing by the method of inkjet on ceramic supports, merging and integrating technologies until defining a unique and consistent system for the world of ceramics" explained the company. According to the company, "it immediately received the prestigious ‘Alfa de Oro’, recognition awarded by the Spanish Society of Ceramics and Glass, which rewards every year the most important innovations in the sector”.

According to Jesús Fernández, director of Digital Solutions of the Esmalglass-Itaca Group, "three-quarters of the machines that exist now in Spain were sold between 2008 and 2010. Digitization has made this sector more competitive in costs, benefits and design, compared to other sectors of Coating of surfaces ".

Isidro Zarzoso, president of Ascer, explained that productive investments have two lines: the capacity of expansion, to respond to growing demand; and improvement in systems, technologies and production processes, to increase efficiency and competitiveness, and to expand supply, with innovative products that are distinguished in quality, design and performance. From the point of view of production systems, two key movements are pointed out: the transformation produced by the industry 4.0, with technologies and digitization systems of the processes and working methods; and the arrival of large formats, thanks to the technology which enable the continuous production.

One of the companies that has grown the most in recent years has been Pamesa Cerámica. One of the keys to its growth was to improve their productivity, which measured in square meters sold per employee went from 31,096 in 2007 to 45,627 in 2012. They achieved this improvement, according to Roig, through investments in ovens and, above all, because "we have bet heavily on the new inkjet technology, digital printing, which is revolutionizing the industry and who is the future of this industry". Pamesa has incorporated 21 digital printing machines, a technology that

allows to cover the ceramic pieces in a much more agile way, cheaper and more flexible than traditional baking (Alfonso, J. 2012).

Grespania is the second company who has made other of the major investments in the ceramic sector, it has invested 25 million of Euros in technology and in a large 'porcelain laminate' plant. There are other companies like Baldocer, which has an expansion project to introduce the necessary technology to manufacture monumental piece; and Halcón Cerámica, who incorporated, in December 2015, a new plant with 70,000 square meters, equipped with digital technology systems and six ovens, to which it designated an investment of 11 million of Euros, that allowed it to double its productive capacity, up to 110,000 square meters per day. Meanwhile, Colorker expanded its facilities in 2016 and now is engaged in a 4.0 industry-based digitization process; Ceramicas Fanal has announced that it will increase its production center too (Fontanillo, O. 2017).

THE IDENTIFICATION OF THE NATIONAL CERAMIC INDUSTRY AS A CLUSTER

In Spain, the ceramic sector is considered as an industrial cluster. Michael Porter (1999), investigator in Harvard's University, noted that "clusters are geographic concentrations of interconnected companies and institutions with which they operate in a determinated sector". The tile industry in Spain is characterized by its high geographical concentration in the province of Castellón, especially in the south-east area of the province, comprising little more than 20 localities, including Castellón, Onda, Villareal and Almazora. According to ASCER data, 94% of the tile companies in Spain are located in the province of Castellón, beause the 81% of the companies in this sector are located there.

FIGURE 1.

INDUSTRIAL DISTRICT OF THE CERAMICS OF CASTELLÓN.

Fuente: Budí, 2008

This geographical concentration of companies who work in the ceramic sector, contributes a clear example of organization of the productive activity in the form of cluster or industrial district. It encloses the totality of elements that define a cluster both in its quantitative aspects, related to the geographic concentration of the activity, and in those of a qualitative purpose, which make reference to the relationships that are established among its members. This gives this cluster a unique character and this unique quality is one of the keys to its strong competitiveness worldwide.

At this moment, the ceramic's industrial district in Castellón is composed by more than 150 companies dedicated to the manufacture of tiles, and employ more than 15,000 people. But it should be noted that this is a smaller number than before the arrival of the crisis, because in 2006 the sector employed more than 27,000 people. The average number of workers in these companies is 150 employees.

This industrial district is composed by all types of companies that cover the entire manufacturing process, from the raw material to the final product. There are companies that are specialized in a certain phase of the production process, especially in those that choose to bring more value to the product, processes in which is required more specialized knowledge or technologies. Other companies or business groups integrate the different stages of production within the same factories.

This is a good indicator of cluster's member some typical behaviors. For example, the ability of big firms to take advantage of scale's economies, by incorporating all phases

of the production process in his factory. In addition, many companies behave cooperatively at some specific stages of the manufacturing process, even among competitors, in order to be more competitively, all together, in foreign markets.

In one hand, in Castellón's ceramic cluster, we find the following companies: Companies of extraction and atomization of raw materials, companies of manufacture of pavements and ceramic coverings that integrate the whole productive process, companies who produce only special pieces, companies of frits, enamels and ceramic colors, etc. In addition, there are different auxiliary companies linked to this sector, such as companies who provides machinery, who made maintenance's works, transport and services companies, all them fundamental to gain in external competitiveness.

On the other hand, other typical characteristic in Castellón's cluster is the close relationship between the companies and the organizations and institutions that support this sector. Among which the most important is the Jaume I University's Institute of Ceramic Technology (ITC). This innovational and technologic center, created to support and promote this tiles' sector, carries out I + D + i activities, support technological information Companies, conducts laboratory tests, it makes quality controls and certifications, as well as gives students a modern technical training.

Other organizations that support the industry are: The National Association of Ceramic Tile Manufacturers, the National Association of Frits, Enamels and Ceramic Dyes' Manufacturers, the Association for the Promotion of Ceramic Design, the Jaume I University, etc.

All the companies who belong to this cluster and all the supporting organizations generated a flow of information, economic relations between companies of the same sector and even informal relations between entrepreneurs and workers that sometimes derive in the participation in associations, fairs or others alliances outside work. This makes the ceramic cluster of Castellón unique and very competitive.

DATABASE

Once established the concrete subject in which we are going to focus our analysis, we must create a database where all Spanish ceramic sector economics data are reflected. For this reason we have contacted different companies in Castellón who are dedicated to the manufacture of tiles, all them have provided us useful information about their investments.

Another tool that we have used has been the SABI database, which has provided us with all the economic and financial data of the companies analyzed. For this reason, we established a search filter by activity code, CNAE 2331: Manufacture of ceramic tiles. From all companies that this tool showed us, we took a random sample of 20 companies, all of them operate in Castellón's province, which is not surprising, since according to the report of 2016 Ceramic Products of the Comunidad Valenciana published by IVACE, approximately 94% of the national production came from this province, where 81% of all Spanish tiles companies are located.

The aim of this analysis is to test whether the installation of digital printing has regenerated the ceramic sector. Being as the first printers were installed in 2008, we will analyze the previous year 2007, and the last available year 2015. We must take into account that, as we have seen previously, 2007 until today, has been the best year for the ceramic sector in Spain; in addition, we shouldn't forget that 2007 was the best year before the economic crisis and 2015 was the best year after the economic crisis.

From the twenty companies that we have selected, we extracted all the 2007 and 2015's data who were necessary for our subsequent analysis (see appendices 1 and 2). At the beginning we preselected 15 variables, but we concluded that there were too many data, all of them were relevant a priori but we decided to make groupings, so that in the end we had 6 essential variables object of study, which we express in millions of euros:

- **res_exc**. This variable corresponds to the result of the year that the companies obtained in 2007 and 2015.

- **var_im.** This is a key variable in the study, since it has the information about the investments in property, plant and equipment is made by companies. Specifically, this variable studies the total investments of the eight years prior to

the year under study, that is, this variable includes the investments made between 2000 and 2007 who help us to study the 2007 year; and we have study the investments concentrated between 2008 and 2015 for the analysis of the year 2015.

- **fix_lia.** This variable corresponds to the fixed liability of the companies, that is, all the long-term debts that the companies maintain with suppliers or financial entities in 2007 and 2015.

- **cur_lia**. Represents the current liabilities that the companies present in their balance sheets. It is the result of grouping the variables, fin_deb, tra_cre and o.cur_lia, namely: it contains the financial debts, commercial creditors and other net liabilities.

- **ass_fix.** This is the fixed asset variable. In our dissertation we do not include all the variables of fixed assets, but the items of intangible assets (im_inm) and other fixed assets (o.ass_fix), we leave out the tangible fixed asset because it is already present in the variable var_im.

- **cur_ass.** On this occasion we re-group variables again, specifically the stocks' variables, deb and o.curr_ass. They all represent the current assets held by companies in their 2007 and 2015 balance sheets.

These will be our variables in the study we will carry out in the next section.

ANALYSIS

Once our database has been built, we can reflect the investments from the main manufacturers of ceramic tiles in digital machinery that they have done in recent years, after that we propose a valid econometric model for the analysis of said databases. Our main objective is to analyze the impact of ceramic digitization in the sector, to reach this goal we will use different statistical and econometric tools, and definitely the main work tool, software R.

First of all, we propose the model from which we will analyze the year 2007, then we will analyze the year 2015, and finally we will analyze the most significant differences between these years.

MODEL OF STUDY IN 2007

In order to analyze Castellón's ceramic sector in 2007 we use the following regression model

$$Res\_exc = \beta 0 + \beta 1\ var\_im + \beta 2\ fix\_lia + \beta 3\ cur\_lia + \beta 4\ ass\_fix + \beta 5\ cur\_ass + u$$

We estimate the parameters of this model through software R (See Annex 3) and we obtain the following results:

To work more clearly we have presented the results in their usual way.

$$Res\_exc = -1{,}3882 + 0{,}1803\ var\_im - 0{,}3269\ fix\_lia - 0{,}0156\ cur\_lia + 0{,}3114\ ass\_fix + 0{,}1170\ cur\_ass$$

(0.9327) (0.0633) (0.0818) (0.0594) (0.0527) (0.0477)

Once this model has been estimated, we could see that the coefficient of determination R2 is equal to 0.9584, that is to say, the explanatory variables included in the model explain the 95.84% from the total variation of the dependent variable res_exc.

Next we must analyse the coefficients that are next to the variables, and which variables are significant in the model and which are not. We found that there are four variables that are significant at 10%.

The results show that the result of the accounting year, if all other explanatory variables remain constant, in 2007 would have had a value of -1.3882, the companies would lose approximately one million euros, since these data are in millions of euros. Starting from

this base, we will see the impact that each of the model's explanatory variables have on the result of the fiscal year.

The var_im variable, which shows the increase in tangible fixed assets in recent years, has a coefficient with the expected sign, +0.1803. In fact, the more they invest in machinery made the greater the tangible fixed assets, and better profits companies get. Specifically through this variable we have been able to explain, among other things, that the companies that invested in machinery between the years 2000 and 2007, obtained in 2007 greater profits.

Another significant variable is fix-lia with a coefficient of -0.3269, this does indicate that in 2007 the companies with the fixed passive obtained minor benefits, which was to be expected, since in the liabilities are the debts in the long term generated by such investments, specifically in suppliers of fixed assets and the debts with credit institutions. And it is logical that bigger investments have bigger debts and smaller results in the short term.

Cur_lia is an important variable too, with a coefficient of -0.0156. As it arrives with the fixed liability, if companies have higher short-term debt the results will be lower, which is to be expected. Payments to suppliers, repayment of loans with financial institutions and other short-term payments resulted in the companies obtaining lower results in 2007. In this case, software R indicates that the variable is not significant. This is why R has used the following contrast:

- **T- Student Contrast**

  The contrast of the significance of a parameter is made by t-Student's test. To do so, it is based on two hypotheses:

  Ho: $\beta = 0$ The coefficient that accompanies the variable is not significant.

  H1: $\beta \neq 0$ The coefficient that accompanies the variable is significant.

  Then the t-Student is calculated and the critical value is identified, and since, in this case the critical value is greater than t, the null hypothesis cannot be rejected. Therefore, the cur-lia variable is not significant in the 5% significance model.

With the variables ass_fix and cur_ass it happens just the opposite, in addition to being significant both them have positive coefficients, 0.3114 and 0.11170 respectively. This indicates that if they had a greater active, the result of the exercise that the companies obtained in 2007 was greater. As expected, the more rights a company has, the better

results are obtained, either because it has greater production capacity or because it have greater power of self-financing.

Once we have analysed individually the significance of the variables and once we have seen that the values are the expected ones, it is necessary to test whether all the variables included in the model are jointly significant. This is why we realized the following test:

- **F- Snedecor Contrast.**

The following hypotheses are considered:

Ho: $\beta 1 = \beta 2 = \beta 3 = \beta 4 = \beta 5 = \beta 6 = 0$. Jointly non-significant.
H1: NO Ho. Jointly significant.

Once the statistical F is calculated and the critical value is identified, a statistical evidence is obtained: all the variables included in the model are jointly significant, at a significance level of 5%.

Another of the contrasts that are carried out, to see if it is a valid model, is to see if there is an inadequate relationship between the dependent variable and the explanatory variables. In this case the contrast that we are going to carry out, is the contrast of the bad specification of Reset.

- **RESET contrast.**

If the function is correctly specified any nonlinear function of it is added to this equation, it should be significant (Wooldridge, 2010).

The procedure we have to follow in this case is: First, estimate the regression model by ordinary least squares (OLS) and reserve the adjusted values, secondly estimate an auxiliary regression by adding polynomials of the adjusted values and finally contrast the jointly significance of these polynomials by comparing the unrestricted and the restricted model. To calcul that, we will use the software R.

The hypotheses we raise are:

Ho: $\beta 7 = \beta 8 = 0$. Good specification of the original model.

H1: No H0. Poor functional specification of the original model.

The R2 of the restricted or original model was 0.9584 and the R2 of the unrestricted model in which we added the polynomials of the adjusted values is equal to 0.9717 (See Annex 4).

After obtaining the value of F and after have compared it with the critical value, we can not reject the null hypothesis and therefore we obtain statistical evidence that the original or restricted model is well specified and there is no specification error due to an inadequate functional form, with a Level of significance of 5%.

To see if we are before unbiased and efficient estimators, we must see if the assumptions of Gauss-Markov are fulfilled. The first of the assumptions is the linearity in the parameters, which is fulfilled since the population regression function is linear in the population parameters.

The second assumption is the random sampling that is also fulfilled since the sample of 20 observations is random. The third assumption is the average of null conditioned, in this case the error term does not depend on the value taken by the explanatory variables.

The fourth assumption is that of no perfect collinearity, in our model none of the variables is constant and there are no exact linear relationships between them, so it is also fulfilled. Finally, the fifth assumption is homoscedasticity, which tells us that the conditional variance of the error term must not depend on the values taken by the explanatory variables (Wooldridge, 2010).

- **Breusch-Pagan.**

  To contrast the presence of heteroscedasticity we will use the Breusch-Pagan contrast. We propose the following hypotheses:

  H_O: $var(u_i) = \sigma^2$ Homoskedasticity

  H_1: $var(u_i) \neq \sigma^2$ Heteroscedasticity

  To test these hypotheses we must calculate the squared residuals and re-estimate the regression using the squared residuals as the dependent variable. In this occasion we will use software R (see Annex 5).

  In this case, since the F is less than the critical value and we can not reject the null hypothesis, therefore, the Homoscedasticity assumption is fulfilled.

Having into account the five Gauss-Markov assumptions, the estimators β_0 ,β_1 ,β_2 ,β_3 ,β_4 ,β_5 and β_6 are the linear ones, unbiased and optimal or minimum variance (ELIO) estimators. There is no need to search for alternative estimators, any other is better than this we have evalued. Our model presents efficient estimates.

MODEL OF STUDY IN 2015

After analyzing the ceramic sector of the region of Castellón in 2007, we will carry out the same analysis for the year 2015. For this we use the same regression model:

$$Res\_exc = \beta 0 + \beta 1\ var\_im + \beta 2\ fix\_lia + \beta 3\ cur\_lia + \beta 4\ ass\_fix + \beta 5\ cur\_ass + u$$

We estimate the parameters of the model in software R and we obtain the following results (see Annex 6).

In order for us to work more easily, we will rewrite the results as follows:

$$Res\_exc = \underset{(0.7905)}{-0,2968} + \underset{(0.0245)}{0,0639\ var\_im} \underset{(0.0172)}{-0,1403\ fix\_lia} \underset{(0.0415)}{-0,0082\ cur\_lia} + \underset{(0.0086)}{0,1689\ ass\_fix} + \underset{(0.0251)}{0,1151\ cur\_ass}$$

One of the values that it returns to us is the coefficient of determination R2 with a value of 0.9743, this value indicates that the explanatory variables explicate 97.43% of the variability of the dependent variable. Through the variables of immobilized material, liabilities and assets, we were able to explain almost 100% the result of the fiscal year.

One of the first steps in determining whether the model is valid is to analyze which variables are significant in the model and which are not. We found that there are four variables that are significant at 10%, var_im, fix_lia5, ass_fix5 and cur_ass5.

As for the coefficients that accompany the variables, we see that as in the previous model, the result of the exercise would also be negative if all other variables remained constant. In this case, the intercept is -0.2968 which means that if the rest of variables were constant, the result of the exercise obtained by the companies in the year 2015 would have been -296,800 euros. After having this datum, we will see the impact that the other variables have on the result for the fiscal year 2015.

The first variable we find is the var_im, as we have explained above, is the reason why the tangible assets have increased in the last seven years. The coefficient that accompanies var_im is +0.0639, and it is positive as we expected. Investments in property, plant and equipment, such as new printers, have had a major impact on the

results obtained by companies in 2015. Therefore, if the companies make big investments in new machinery, they obtain greater profits.

The second variable included in the model is fix_lia5, with a coefficient of -0.1403. As in the 2007 model, the fixed liability of a company causes lower profits to be obtained, which is logical since in the fixed liability are the debts. In the ceramic sector the renovation of machinery is constant and those debts contracted with fixed and long-term fixed assets suppliers will always have a negative impact on the result of the year.

The third variable is cur_lia5, with a coefficient of -0.0082. As with the rest of the liability, if the debts were higher, the results in 2015 were lower, which was to be expected. But in this case the R software tells us that the variable is not significant. Contrasting the t-Student's test we obtain a t-value of -0,198 that is much lower than the critical value and therefore we can not reject the null hypothesis, where $\beta_4 = 0$.

Another variable is ass_fix5, which includes all items of fixed asset less tangible asset. R estimates that the coefficient is +0.1689, as expected because as they made larger long-term investments or higher intangible assets, the result of the year that the companies obtained in 2015 was higher. Specifically for each million euros that a company owned in fixed asset items, the result increased by 168,900 euros.

The last variable included in the regression model is cur_ass5, with a positive coefficient of +0,1151. This means that the greater current assets, the better results are obtained by the companies. It is a very significant variable since both the stock and the debtors provide large earnings within the year.

Once we have observed that most of the variables are significant in our model and we have seen that the values are the expected, we will test if all variables included in the model are jointly significant.

Using the F-Snedecor contrast, we obtained a statistical evidence: all the variables included in the regression model are jointly significant, with a significance level of 5%.

The next step is to see if there is any inappropriate relationship between the dependent variable and the explanatory variables. To investigate this poinnt we use the contrast of bad specification of Reset again.

The R^2 of the restricted or original model was 0.9743 and the R^2 of the unrestricted model in which we added the polynomials of the adjusted values is equal to 0.9815 (see Annex 7). This time, with a significance level of 5%, we can not reject the null hypothesis and therefore we obtain statistical evidence that the original or restricted

model is well specified and there is no specification error due to inadequate functional form.

As in the previous model, the assumptions of Gauss-Markov are fulfilled. There is linearity in the parameters, the sampling is random, the error term does not depend on the value of the explanatory variables, there is no perfect colinearity between the variables and the homoscedasticity assumption is fulfilled (see Annex 8). Therefore, the estimators are linear, unbiased and optimal. This model also presents efficient estimates.

VARIATIONS BETWEEN 2007 AND 2015

Once the data are analyzed in 2007 and 2015, it is necessary to estimate a new model, in which we can see the differences between this two years. To realize that we use the following regression model:

$$Res\_exc(2007) - res\_exc(2015) = \beta 0 + \beta 1\ var\_im(2007) - var\_im(2015) + \beta 2\ fix\_lia(2007) - fix\_lia(2015) + \beta 3\ cur\_lia(2007) - cur\_lia(2015) + \beta 4\ ass\_fix(2007) - ass\_fix(2015) + \beta 5\ cur\_ass(2007) - cur\_ass(2015) + u$$

We estimate the parameters of the model in software R and we obtain the following results (see Annex 9).

$$Res\_exc = -1{,}6739 + 0{,}0818\ var\_im - 0{,}0798\ fix\_lia - 0{,}0378\ cur\_lia + 0{,}0662\ ass\_fix + 0{,}1179\ cur\_ass$$

(0.6626) (0.0243) (0.0249) (0.0467) (0.0515) (0.0477)

Once the model is estimated, we see that the coefficient of determination R^2 equals 0.7436, that is, the explanatory variables included in the model explain 74.36% of the total variation of the dependent variable.

We see that three of the variables included in the model are significant at 10%. The fact that these variables are significant in the model, gives value to our study; it indicates that the tile sector has undergone great changes between the years 2007 and 2015. Now we are going to analyze if these changes are due in large measure to the investments in immobilized material.

This is whys it is necessary to see what happens with the var_im variable. As we can see, it is one of the most significant variables of the model, this indicates that the tangible assets played a very important role between 2007 and 2015. Specifically, the

sum of tangible fixed assets of the 20 companies we have analyzed increased by 130 million euros between 2007 and 2015. A very high value if we take into account that the company with the highest fixed assets in 2015 had a tangible fixed assets of 114 million Euros.

The variable var_im, in this case, is accompanied by the +0.0818 coefficient, since it is a positive coefficient, it is indicating that the increase in investments in tangible assets (property, plant and equipment) in recent years, affected positively the result obtained by the Companies in 2015. To clarify, a tile manufacturer in the years of crisis invested more in tangible assets than in the years before the crisis, so its results in 2015 were much higher than in 2007.

If we compile all the information provided by the analysis of the three models, regarding the variations in tangible fixed assets, we see that in all three models the coefficient that accompanies the var_im variable is positive, namely +0.1803 in 2007, +0.0639 in 2015 and +0.0818 in the model of variation. Therefore, in 2007 and 2015, the companies that made the most investments in tangible assets obtained better results.

In addition, the intercept from the models is -1.3882 for 2007 and -0.2968 for 2015, which indicates that the companies, keeping everything else constant, obtained greater profits in 2015 since that intercept is greater. Specifically the difference is 1.0914, so keeping everything else constant, in 2015 the tile manufacturers obtained 1,091,400 euros more than in 2007.

CONCLUSIONS

After analyzing the Spanish ceramic sector between 2007 and 2015 by 20 companies, we can draw a series of conclusions.

After interviewing several factories around Castellón, we concluded that the main tile manufacturers in Spain, in less than 10 years, have modernized all their installations, installing new production lines that have allowed them to increase production and reduce costs. Among this new machinery, according to companies, the most revolutionary machine have been digital printers in which several million euros have been invested.

The database shows that investments in tangible assets have increased significantly in recent years. In 2007 the companies had a much lower fixed asset values than in 2015. Specifically, the sum of the tangible fixed assets of the 20 companies, increased by 130 million euros in that period of time. A very high value if we take into account that the company with the highest fixed assets in 2015 had a tangible fixed assets of 114 million euros.

The results of our analysis indicate that the investments made by Spanish tiles producers in the fixed assets between 2000 and 2007 were very significant and had a certain impact on the results obtained in 2007. Between 2007 and 2015, as a result of the economic crisis, corporate profits began to decline, but acquisitions of new production machines were not affected and most companies doubled their tangible assets, largely due to the purchase of digital printers. 2015's results of the analysis (last year with available data), reveal that these investments also have had a great impact on the annual results obtained by companies.

According to our model, in 2007, if we keep everything else constant, the companies started with losses of 1,338,000 euros and in 2015 they were reduced to 296,800 euros, a significant fact to highlight.

In addition, one of the most significant variables in our model is the variation in tangible fixed assets, which supports the idea that the growth of the results was possible thanks to the investments made in new machinery. For all these reasons, we can point out that in the Spanish tile industry, if there is an important investment, the companies reach better results. This could be the reason why Spanish ceramics continues to invest in R + D + i and is the world leader in this area.

If we contrast the results of this study with the data presented by ceramic tile manufacturers in some reports and media, there is sufficient evidence that investments in digital printing played a very important role in the regeneration of the ceramic sector, allowing to improve the results of the companies, to gain competitiveness and to become the second exporter worldwide.

This work should not be taken as a perfect model to explain the regeneration of the ceramic sector, as we encounter certain limitations to make a perfect study. The lack of accurate and specific data from the most representative companies in the sector about their investments in digital printers has limited our study, but with SABI data the objective of this study has been achieved. We have proved that digital printing has had a great impact on the regeneration of the Spanish ceramic sector.

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ANNEXES

ANNEX 1. DATA TABLE YEAR 2007

EMPRESA	emp	ope_inc	res_exc	inm_inm	inm_mat	o.ass_fix	stocks	deb	o.cur_ass	fix_lia	fin_deb	tra_cre	o.cur_lia	fp	var_im
PAMESA CERAMICA, SL	480	160,386	5,982	0,286	46,103	12,465	27,477	103,847	2,688	20,576	99,334	21,227	9,21	42,52	-26,808
PORCELANOSA, SA	1041	211,472241	31,417209	1,599645	139,038342	185,172639	32,504428	67,529275	0,922242	121,180376	0,101531	20,834282	16,934997	267,715384	12,471754
ARGENTA CERAMICA, SL	187	48,860156	1,402691	7,066624	17,525869	3,528693	9,287335	19,155258	1,397717	14,990656	18,373401	12,627153	4,178137	7,792149	17,135211
COMPACGLASS, SL	146	14,301	2,966	1,158	5,406	0,01	0,156	7,279	0,558	0	0	0	4,605	8,804	5,214
VENIS, SA	804	174,325798	21,817807	1,182145	62,1643	149,125301	28,959194	56,907425	0,237431	106,045462	0,011465	33,970159	7,018772	151,439938	11,578381
BALDOCER, SA	205	55,204145	5,071159	0,001701	16,877638	2,140208	9,937459	16,653374	7,350157	0	0	8,109199	1,064	43,787338	10,655677
CERAMICA SALONI, SA	556	108,77918	2,940038	3,07802	48,385838	30,308568	45,428161	45,073081	1,360238	43,010467	35,608538	20,898786	7,302353	66,813762	-4,279142
GRESPANIA, SA	519	98,160322	9,09446	2,213457	45,828139	6,359364	40,354964	22,024936	4,702769	13,455431	5,603595	16,626393	8,419162	77,379049	23,791869
MARAZZI IBERIA, SL	267	103,855889	5,005739	0,291656	16,885245	6,923286	15,92641	32,188422	3,013609	5	5,304322	13,271928	28,586218	23,066162	0,446317
HALCON CERAMICAS, SA	293	57,172521	-2,401531	0,340186	9,409937	10,599236	17,287208	23,609387	2,376231	11,064966	17,953364	10,137579	2,916811	21,559465	-1,52526
CERAMICAS BELCAIRE, SA	243	42,924	-0,129	0,164	24,691	0,001	11,503	10,039	0,536	7,506	2,545	12,094	5,275	19,513	1,57
CICOGRES, SA	159	18,160436	0,218634	0,956099	6,45197	0,002203	2,048423	7,869361	1,646333	3,757754	4,286816	4,69314	0,579557	5,657123	2,590064
CERAMICAS MIMAS, SL	89	18,743411	0,194886	0,097498	5,717739	0,328893	3,908739	6,013235	1,306248	8,450271	2,253233	3,716255	2,478493	0,474098	5,716798
BESTILE, SL	112	24,643768	-1,572349	3,343731	8,37358	3,481103	10,725042	17,232009	1,880107	12,2865	6,917788	15,273768	7,552098	3,005416	3,93931
AZULEV, SA	295	57,207876	4,487273	0,199006	18,242808	10,513755	16,247299	16,043991	0,175182	5,276899	8,258431	12,099491	5,140511	30,646709	-0,604642
EMIGRES, SL	67	12,663962	0,365913	0,038845	5,024002	1,034215	3,15812	4,558086	1,405414	0,684609	7,141856	3,399246	0,39533	3,597643	1,336169
ROIG CERAMICA, SA	389	65,411714	1,293241	2,930882	46,738011	2,514742	25,861348	32,869643	15,086747	39,871129	32,54829	27,377291	3,900658	22,304005	27,916392
CRISTAL CERAMICA, SA	140	27,662349	0,082143	2,752579	15,549184	0,025068	5,149291	9,088431	6,457486	7,343653	10,229395	8,12637	3,279346	10,043275	9,241814
IBERO ALCORENSE, SL	133	29,481329	1,237547	0,102103	24,101334	0,006866	7,275455	8,998262	2,839676	5,517229	10,183105	8,417175	0,733462	18,472725	12,397087
AZULEJOS PLAZA, SA	94	40,819723	0,37442	1,180191	18,470358	1,207625	11,045787	22,311273	5,697527	13,030657	13,329854	15,522062	1,046641	16,983549	14,165073

Source: Elaboration of the author

ANNEX 2. DATA TABLE YEAR 2015

EMPRESA 2015	emp	ope_inc	res_exc	inm_inm	inm_mat	o.ass_fix	stocks	deb	o.cur_ass	fix_lia	fin_deb	tra_cre	o.cur_lia	fp	inve	var_im
PAMESA CERAMICA, SL	481,000	295,738	13,500	0,548	69,125	3,693	75,447	41,931	26,982	41,444	46,631	35,684	13,574	80,393	61,823	23,022
PORCELANOSA, SA	765,000	174,014	35,057	1,770	106,221	189,531	30,561	37,570	1,315	24,854	0,056	7,422	24,990	309,648	53,919	-32,817
ARGENTA CERAMICA, SL	303,000	150,057	6,882	0,631	38,859	0,861	28,751	54,098	5,304	19,141	31,744	19,719	24,822	33,080	46,419	21,334
COMPACGLASS, SL	374,000	131,683	8,320	9,493	79,223	41,067	1,884	1,540	0,076	29,312	2,610	21,962	18,196	61,203	29,401	73,817
VENIS, SA	512,000	114,109	24,423	1,063	114,631	198,034	23,504	24,273	0,141	119,622	0,019	4,414	13,237	224,353	103,974	52,466
BALDOCER, SA	294,000	99,845	14,989	0,132	32,998	32,401	19,641	33,176	10,631	0,090	29,988	14,129	4,565	80,206	31,808	16,120
CERAMICA SALONI, SA	357,000	89,122	1,941	0,633	28,548	15,264	26,136	32,933	13,844	36,333	2,586	29,604	5,350	43,487	56,352	-19,837
GRESPANIA, SA	375,000	78,114	6,955	0,477	27,161	15,846	44,569	21,056	19,611	13,629	1,660	8,508	12,632	92,290	31,932	-18,667
MARAZZI IBERIA, SL	348,000	77,037	7,083	0,310	21,214	1,333	16,446	20,432	9,051	0,301	0,000	7,822	7,553	53,110	17,189	4,329
HALCON CERAMICAS, SA	251,000	87,048	5,312	1,446	21,448	2,673	18,198	27,625	32,990	30,303	26,055	9,317	12,634	26,071	19,850	12,038
CERAMICAS BELCAIRE, SA	195,000	47,475	-0,670	0,119	13,913	3,397	0,753	6,963	1,047	1,815	0,174	12,918	2,279	9,006	14,362	-10,778
CICOGRES, SA	121,000	43,083	0,440	0,175	13,108	1,107	9,200	11,855	1,593	6,081	11,878	11,511	1,637	5,932	12,276	6,656
CERAMICAS MIMAS, SL	138,000	38,852	0,790	0,001	11,526	2,464	11,867	10,472	1,910	9,306	9,694	7,371	5,800	6,069	15,596	5,808
BESTILE, SL	137,000	35,490	0,011	0,514	10,802	2,394	3,732	20,288	0,772	23,863	1,398	3,007	20,862	-11,307	8,451	2,429
AZULEV, SA	237,000	34,967	2,611	1,892	31,058	5,631	28,398	9,554	0,131	15,318	11,524	8,375	1,722	39,725	15,589	12,815
EMIGRES, SL	99,000	32,226	5,867	0,096	12,152	0,314	8,326	14,380	2,909	6,000	1,665	6,432	6,552	17,526	13,343	7,128
ROIG CERAMICA, SA	139,000	31,966	-6,347	0,309	40,166	25,158	10,993	7,582	0,651	99,474	0,977	4,659	4,565	-24,817	28,005	-6,572
CRISTAL CERAMICA, SA	148,000	31,906	1,078	0,179	12,269	0,248	7,408	11,133	1,545	4,196	6,520	2,876	6,056	13,134	7,390	-3,280
IBERO ALCORENSE, SL	122,000	29,869	1,705	0,187	15,252	1,315	9,221	10,580	0,858	3,196	6,451	4,822	3,514	19,431	4,399	-8,849
AZULEJOS PLAZA, SA	95,000	27,203	-0,324	0,188	11,325	3,170	13,220	9,616	2,633	16,883	3,791	7,337	3,304	8,837	5,062	-7,145

Source: Elaboration of the author

ANNEX 3. MODEL 2007

```
> mod07<-lm(res_exc~var_im+fix_lia+cur_lia+ass_fix+cur_ass,data=CS2007)
> summary(mod07)

Call:
lm(formula = res_exc ~ var_im + fix_lia + cur_lia + ass_fix +
    cur_ass, data = CS2007)

Residuals:
    Min      1Q  Median      3Q     Max
-5.1069 -0.8056  0.4808  1.0062  2.1870

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -1.38822    0.93277  -1.488  0.15885
var_im       0.18032    0.06327   2.850  0.01285 *
fix_lia     -0.32686    0.08185  -3.994  0.00133 **
cur_lia     -0.01562    0.05942  -0.263  0.79649
ass_fix      0.31139    0.05270   5.909 3.81e-05 ***
cur_ass      0.11701    0.04770   2.453  0.02788 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.949 on 14 degrees of freedom
Multiple R-squared:  0.9584,    Adjusted R-squared:  0.9436
F-statistic: 64.59 on 5 and 14 DF,  p-value: 3.601e-09
```

ANNEX 4. RESET.MODEL 2007

```
> mod07res<-lm(u2~var_im+fix_lia+cur_lia+ass_fix+cur_ass,data=CS2007)
> summary(mod07res)

Call:
lm(formula = u2 ~ var_im + fix_lia + cur_lia + ass_fix + cur_ass,
    data = CS2007)

Residuals:
   Min     1Q Median     3Q    Max
-3.928 -2.526 -1.219  0.470 22.055

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.71957    3.06907   1.538    0.146
var_im      -0.17843    0.20817  -0.857    0.406
fix_lia      0.10989    0.26930   0.408    0.689
cur_lia     -0.10304    0.19551  -0.527    0.606
ass_fix     -0.08637    0.17340  -0.498    0.626
cur_ass      0.04525    0.15695   0.288    0.777

Residual standard error: 6.413 on 14 degrees of freedom
Multiple R-squared:  0.06602,   Adjusted R-squared:  -0.2675
F-statistic: 0.1979 on 5 and 14 DF,  p-value: 0.9581
```

ANNEX 5. BREUSCH-PAGAN.MODEL 2007

```
> res07<--1.38822+0.18032*var_im-0.32686*fix_lia-0.01562*cur_lia+0.31139*ass_fix+0.11701*cur_ass
> res07_cuad<-res07^2
> res07_cubo<-res07^3
> mod07nr<-lm(res_exc~var_im+fix_lia+cur_lia+ass_fix+cur_ass+res07_cuad+res07_cubo,data=CS2007)
> summary(mod07nr)

Call:
lm(formula = res_exc ~ var_im + fix_lia + cur_lia + ass_fix +
    cur_ass + res07_cuad + res07_cubo, data = CS2007)

Residuals:
    Min      1Q  Median      3Q     Max
-4.2467 -0.2970  0.1479  0.5251  2.3732

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.4002758  0.9326999  -0.429   0.6754
var_im       0.0656444  0.0751208   0.874   0.3993
fix_lia     -0.1520256  0.1046247  -1.453   0.1719
cur_lia     -0.0060931  0.0533311  -0.114   0.9109
ass_fix      0.0479128  0.1219015   0.393   0.7012
cur_ass      0.0714589  0.0476447   1.500   0.1595
res07_cuad   0.0864980  0.0411909   2.100   0.0576
res07_cubo  -0.0016600  0.0009061  -1.832   0.0919
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.738 on 12 degrees of freedom
Multiple R-squared:  0.9717,    Adjusted R-squared:  0.9552
F-statistic: 58.83 on 7 and 12 DF,  p-value: 2.416e-08
```

ANNEX 6. MODEL 2007

```
> mod15<-lm(res_exc~var_im+fix_lia5+cur_lia5+ass_fix5+cur_ass5,data=CS2015)
> summary(mod15)

Call:
lm(formula = res_exc ~ var_im + fix_lia5 + cur_lia5 + ass_fix5 +
    cur_ass5, data = CS2015)

Residuals:
    Min      1Q  Median      3Q     Max
-2.1691 -1.0586 -0.4327  1.0622  3.6528

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.296762   0.790521  -0.375 0.712989
var_im       0.063890   0.024484   2.609 0.020595 *
fix_lia5    -0.140267   0.017173  -8.168 1.07e-06 ***
cur_lia5    -0.008238   0.041509  -0.198 0.845538
ass_fix5     0.168968   0.008657  19.518 1.50e-11 ***
cur_ass5     0.115124   0.025158   4.576 0.000432 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.782 on 14 degrees of freedom
Multiple R-squared:  0.9743,    Adjusted R-squared:  0.9651
F-statistic:   106 on 5 and 14 DF,  p-value: 1.288e-10
```

ANNEX 7. RESET.MODEL 2007

```
> mod15res<-lm(u2.15~var_im+fix_lia5+cur_lia5+ass_fix5+cur_ass5,data=CS2015)
> summary(mod15res)

Call:
lm(formula = u2.15 ~ var_im + fix_lia5 + cur_lia5 + ass_fix5 +
    cur_ass5, data = CS2015)

Residuals:
    Min      1Q  Median      3Q     Max
-2.8035 -1.5363 -0.6470  0.3837 10.3665

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.750287   1.451996   1.894   0.0791 .
var_im       0.021869   0.044971   0.486   0.6343
fix_lia5    -0.004964   0.031542  -0.157   0.8772
cur_lia5    -0.084608   0.076241  -1.110   0.2858
ass_fix5    -0.013238   0.015901  -0.833   0.4191
cur_ass5     0.052493   0.046209   1.136   0.2750
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.272 on 14 degrees of freedom
Multiple R-squared:  0.1221,    Adjusted R-squared:  -0.1914
F-statistic: 0.3895 on 5 and 14 DF,  p-value: 0.8479
```

ANNEX 8. BREUSCH-PAGAN.MODEL 2007

```
> res15<--0.2968+0.06389*var_im-0.1403*fix_lia5-0.0082*cur_lia5+0.1689*ass_fix5+0.1151*cur_ass5
> res15_cuad<-res15^2
> res15_cubo<-res15^3
> mod15nr<-lm(res_exc~var_im+fix_lia5+cur_lia5+ass_fix5+cur_ass5+res15_cuad+res15_cubo,data=CS2015)
> summary(mod15nr)

Call:
lm(formula = res_exc ~ var_im + fix_lia5 + cur_lia5 + ass_fix5 +
    cur_ass5 + res15_cuad + res15_cubo, data = CS2015)

Residuals:
    Min      1Q  Median      3Q     Max
-2.4586 -0.8237  0.1053  0.5262  3.0829

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.3422118  0.7823385   0.437 0.669574
var_im       0.1287617  0.0393252   3.274 0.006650 **
fix_lia5    -0.1085034  0.0215693  -5.030 0.000294 ***
cur_lia5    -0.0540768  0.0482031  -1.122 0.283872
ass_fix5     0.0741959  0.0457160   1.623 0.130555
cur_ass5     0.1106946  0.0306377   3.613 0.003560 **
res15_cuad   0.0306121  0.0218860   1.399 0.187211
res15_cubo  -0.0004027  0.0004521  -0.891 0.390557
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.632 on 12 degrees of freedom
Multiple R-squared:  0.9815,    Adjusted R-squared:  0.9707
F-statistic: 90.93 on 7 and 12 DF,  p-value: 1.923e-09
```

ANNEX 9.MODEL VARIATION 2007-2015

```
> dif<-lm(dres_exc~dvar_im+dfix_lia+dcur_lia+dass_fix+dcur_ass)
> summary(dif)

Call:
lm(formula = dres_exc ~ dvar_im + dfix_lia + dcur_lia + dass_fix +
    dcur_ass)

Residuals:
    Min      1Q  Median      3Q     Max
-3.8043 -1.3838  0.0056  0.9307  4.4440

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -1.67396    0.66256  -2.526  0.02419 *
dvar_im      0.08179    0.02432   3.363  0.00465 **
dfix_lia    -0.07976    0.02495  -3.196  0.00647 **
dcur_lia    -0.03777    0.04673  -0.808  0.43249
dass_fix     0.06622    0.05149   1.286  0.21929
dcur_ass     0.11792    0.04774   2.470  0.02698 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.425 on 14 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.7436,    Adjusted R-squared:  0.652
F-statistic: 8.119 on 5 and 14 DF,  p-value: 0.0008873
```