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STRUCTURAL TRANSFORMATIONS IN CLUSTERS: THE CASES OF BIOMEDICAL AND CERAMICS

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1. INTRODUCTION

Structural transformations discussed in this special issue, due to globalisation and the financial crisis, have also affected clusters[1]. We examine two particular cases that illustrate the tendencies outlined in the literature regarding clusters and districts, and provide some insights on the conditions in which clusters implement different internationalisation strategies.

'Globalisation', intended as changes in the competitive conditions of the world markets in the last 20 to 30 years, has implied deep structural

1 This article is the result of a strong collaboration of the authors, yet in the phase of writing Sandrine Labory wrote the introduction, sections 2 and 4, and Giorgio Prodi wrote section 3. The conclusions were written by both authors.

changes for clusters, especially those in mature sectors, with two major implications. First, competition increases in all sectors, due to the arrival of new entrants from emerging and developing economies. Second, the extent of the market substantially increases for firms since the emerging economies represent large and growing markets. These opportunities exist for firms in all sectors and in all types of industrial organisation, including European clusters. However, they also represent a challenge for clusters' SMEs since they are very distant markets that are costly to reach.

The evidence in the literature is that the economic activities of clusters relate more tightly to world production, commercialisation and knowledge creation networks (Bathelt et al., 2004; Audretsch and Lehmann, 2006; De Propris et al., 2008; Hervàs-Oliver and Albors-Garrigòs, 2008; Bellandi, 2009). The literature on global value chains (Gereffi, 1994; Sturgeon, 2008) or global production networks (Dickens, 2001; Coe et al., 2004) highlights the growing geographic fragmentation of production processes in all industrial sectors. Many studies have analysed the effects of productive internationalisation on regional clusters (Christorpherson and Clark, 2007; Phelps, 2008). Some clusters concentrate on more intangible capital intensive phases, namely the upstream (R&D, design) and downstream (commercialisation, marketing) phases relative to assembly, and delocalise the other phases. The suppliers realising simple tasks are thus directly affected by the competition from lower cost countries and tend to exit the cluster and the industry. This leads to a reduction in the number of smallest firms in clusters and a rising average dimension of cluster firms.

Within clusters, these evolutions are often guided by small and medium firms that become leaders and provide impulse to strategic changes. In other cases the clusters evolve by creating relations with external leaders that induce changes but also often provide access to world markets thanks to specific world-wide commercialisation networks.

When clusters become part of global production networks dominated and managed by external leaders they risk becoming excessively dependent on these external leaders and loose own capabilities in the phases intensive in intangible assets, namely collection and creation of knowledge and its application to new products and processes (Christorpherson and Clark, 2007; Phelps, 2008).

Although the literature has identified global trends in clusters' structural transformations, less is known about the conditions and determinants for specific trends to prevail, in particular regarding internationalisation strategies. We choose two successful cases of each of the trends outlined in the literature to derive insights on these conditions. We focus on two clusters that have used inward and outward foreign direct investments (FDI) to develop in a peculiar way.

The two cases examined in this paper regard one mature sector, ceramic tile production, and one high tech sector, biomedical. These two sectors are extremely different and cannot be directly compared, but our aim is in each case to derive insights on the conditions for each of the internationalisation strategy to be successful, as an exploratory study that will be more systematically checked in subsequent research. The examined clusters are both located in the Emilia-Romagna region in Italy, which has been praised for its capacity to upgrade and develop, largely thanks to industrial policy (Bianchi and Labory, 2011).

One cluster is characterised by internationalisation through own capacity, the district leaders investing abroad. This is the case of the ceramic tiles district of Sassuolo. The other cluster, the Mirandola cluster, is characterised by internationalisation via alliances with external leaders, hence access to world market via the distribution channels of these leaders. The relationship between Mirandola SMEs and multinationals is a long-lasting one, since multinationals came to the district soon after its inception, in the 1970s.

The two cases examined in this paper regard autonomously developed clusters, in the sense that they were created by local entrepreneurs and not by deliberate policy. Both clusters are usually defined as districts. This term is not perfectly appropriate for both realities because the Sassuolo ceramics cluster is today characterized by firms that cannot be classified as medium or small, and Mirandola one, is characterised by the presence of large multinationals that develop relationships with local suppliers.

This paper is structured as follows. The general trends in clusters' structural transformations are analysed in section 2, while sections 3 and 4

respectively confront these general trends with the experiences of Sassuolo and Mirandola: Section 5 concludes.

2. GENERAL TRENDS IN CLUSTERS' STRUCTURAL TRANSFORMATIONS

An industrial cluster is a group of firms and other organisations for which cluster membership is a determinant of individual competitiveness. The other organisations can be industrial associations, technical institutes, universities, local authorities, and so on. The links within the cluster can be determined by supplying relationships, common technologies or distribution channels, or common labour markets (Enright, 1996).

The concept of clusters is wider than the concept of industrial district and puts together a variety of groups of firms, with different characteristics regarding the product, the organisation of production within and between firms, the types of relationships between firms, the extent of social capital and the nature of knowledge flows, and so on.

The literature outlines two types of structural transformations. In the first type, clusters develop autonomous capacity to react in that one or more firm(s) of the cluster adopt or create new technology and new products that allow the upgrading of the cluster. These cluster's leaders are not necessarily larger firms but they are more dynamic than the other cluster firms. When more leaders exist they generally act in teams or in groups (Cainelli and Iacobucci, 2005).

In the second type, cluster firms ally with an external leader in order to create new products or processes, and/or access to world commercialisation channels; this is the case for instance of high quality fashion clusters in Tuscany (Labory and Zanni, 2004).

In the first case, cluster firms remain independent and manage world production networks. One problem in this case arises when the leader(s) of the cluster decides to change headquarters' location and go outside the cluster. This happened in the ceramics cluster of North Staffordshire in the UK (Sacchetti and Tomlinson, 2009; Day et al., 2000), where leaders

have delocalised their headquarters to London, with the result of progressively loosing roots in the cluster, delocalising phases of the cluster's production abroad and questioning the very existence of the cluster. In the second case, the relationship with an external leader creates dependency and sometimes vulnerability, since the cluster depends on the strategic decisions of the leader. In this case it is important for the cluster to keep hold on the strategic phases of production, by maintaining and developing capabilities to innovate and adapt.

The effects of the relationship between the cluster and external leaders are determined by not only the cluster's characteristics, but also the degree of embeddedness of the external leaders in the local community: whether the external leader creates a local subsidiary or not; the type of activity created locally (production, R&D, marketing or all of them) and the objectives of the leaders in the creation of relationships with the local firms (acquire products or acquire competencies); the characteristics of the external leader (proprietary assets, organization, production system, and so on); the characteristics of the local cluster (capabilities, local factors that create external economies); the characteristics of transactions (frequency, trust and assets specificity). All these factors combine in different ways and imply different possible effects of the relationship of the cluster with an external leader (Labory, 2002).

These factors are important because they determine the control of the strategic phases of the production process. The strategic phases are often those more intensive in knowledge and intangible assets, and generating more value added. When the relationship between the cluster and the external leader is vertical, in the sense that the cluster is a supplier for the external leader, the latter is likely to control strategic phases of the production process, such as design and product development, as well as marketing and commercialisation. The supplier can become involved in the design of the parts or components which he is in charge of but, unless the component or part is a strategic one, he is unlikely to substantially contribute to value creation. In the case of horizontal types of relationship the cluster can have more negotiation power if it is able to significantly contribute to the product range of the external leader.

This analysis can be compared with the literature on global value chains (Gereffi, 1994; Sturgeon, 2008). Alliance with a leader is in fact insertion into a global value chain led by an external leader, while internationalisation via FDI is a case where the cluster sets up a global value chain. Agostino et al. (2013) in this issue review the different cases of insertion of suppliers into global value chains, and show that suppliers inserted into relational GVCs, where they are directly involved in the strategic phases of production, are much better-off than suppliers inserted into captive GVCs. As we will show below the firms in the Mirandola cluster have managed to be inserted into relational GVCs thanks to their capacity to innovate.

Industrial districts experience the same competitive challenges as clusters in general, but there are some peculiarities. The literature agrees that Italian industrial districts are experiencing deep structural changes, following the same evolutionary tendencies as clusters (Becattini et al., 2009). These tendencies are twofold. First, the whole district system evolves in a coherent and systemic way. Knowledge and competencies necessary for upgrading are found within the district, building on the knowledge base accumulated through time (for instance, the Santa Croce district in Tuscany or the Monte Belluna district in Veneto, or the ceramic tiles district of Sassuolo in Emilia-Romagna). In some cases this evolution is realised through the guidance of a leader firm belonging to the district, which can be single firms or groups of firms (Cainelli and Iacobucci, 2005; Bellandi, 2009). These firms guide the transformation of the district by taking the initiative in the search for new technologies, new products and new design (Corò and Grandinetti, 1999), and allow the realisation of economies of scale and risk sharing.

Second, district firms start a relationship with external leaders in order to access to new markets, to new technologies or new ideas and design. For instance, the leather good district of Scandicci in Tuscany initiated relationship with the fashion leader Gucci that lead to the use of new production technologies such as laser-cutting of leather.

Chiarvesio et al. (2007), empirically examine the role of leaders in Italian industrial districts and show that the dominant strategy appears to be that of insertion in global value chains. They also show that leader firms of the district play a primary role both in bridging the district with the

global economy and in the transformation of districts in nodes of global production networks. These authors identify a successful model, that of the "open networks" where the district, guided by the leader, becomes an active node in a global production network, hence being able to turn the GVC into a relational GVC.

These new strategies implemented to respond to a changing competitive context imply important changes in the organisation of the districts: the leaders grow in size, while the number of district firms reduces, with a significant reduction in the number of small suppliers that executed very simple tasks in the past.

This evolutionary process requires both a continuous improvement in the capabilities of teams of firms within the district and a systematic exploration and exploitation process, discovery and application of the new ideas. This structural change also implies a change in the local labour market, moving to higher skills, and implying a transformation of the social structure of the district. The entrepreneur trained on-the-job with low education level is no longer successful, rather entrepreneurs with high education levels and experiences abroad are required in order to have both capacities of new knowledge absorption and creation of relationships outside the district.

In addition industrial districts' structural changes require an appropriate regional "milieu", consisting in dynamic cities and districts and the coherent and sustainable development of the collaboration between firms' networks, research centres, services related to knowledge, infrastructure dedicated to international trade and pro-active regional policy-makers (Bellandi, 2009).

Locally-rooted competencies, capacities and knowledge allow structural changes to take place, implying a deep renewal and transformation in local knowledge, capacities and competencies, largely thanks to absorption of external knowledge.

In fact, Chiarvesio et al. (2007) conclude that district firms with highest performance are not those which invest abroad, but those which invest in tangible and intangible capital, namely technology, ICT, design, relationships with research centres and other stakeholders in the territory and abroad.

We show in the next sections that investing in tangible and intangible capital is also an essential condition for being able to invest abroad and internationalise.

3. THE CERAMICS TILE DISTRICT OF SASSUOLO

The ceramic tiles cluster developed in the Emilia Romagna province after the second world war. In early 1950s there were only a dozen of producers that became more than one hundred in the sixties. The engine of the growth process was the availability of capital accumulated in the agricultural and trade sector, the presence of local raw materials like red clays, and the proximity to fast growing markets as the North of Italy first, and subsequently Germany and France when the cluster was efficient enough to export. Growth continued in the following decades thanks to the interaction with the producers of ceramics tile production lines based in the same area that developed new technologies together with tile producers. The ceramic tile district reached the highest production in early 2000 with more than 600 million square meters. In 2011 this cluster produced 80% of Italian production, even 90% if firms located outside but near (less than 50 kilometers) the district are included.

Ceramics tile is a mature industry. New products are launched almost each year but differences are limited. The two main technology evolutions happened in the late 1960s and early 1970s with the introduction of single fire production[2] and in the 1990s with the introduction of grès tile.

Technologies are usually developed within the district with a cooperation between tile producers and production line developers. However technologies are relatively quickly available to all the players within and outside the district.

2 Previously tiles were fired a first time in an oven and subsequently colours and pigments were added on the top and tiles went into the oven for a second time. Single fire technology allowed to put pigment on the tile before going into the kiln the first time, thereby saving money and improving quality.

Ceramic tile is a heavy good compared to its value. Transportation costs are very high and this makes competition on foreign markets very difficult. Extra continental exports are less than 10% of total exports and exports are 20% of total production[3].

However Italy exports more than 70% of total production. Spanish producers also export more than half of their production because of the collapse in domestic demand induced by the explosion of the domestic real estate bubble, while before the percentage was less than 50% (Assopiastrelle). Italy is the first exporter in Europe with 168 sqm followed by Spain with 87 sqm.[4]

Sassuolo had to face globalisation probably before the word globalisation was invented both as far as new competitors and new markets are concerned. Since the late seventies Sassuolo had to face competition from several countries. The first competitor of Sassuolo has been Castellon de la Plana in Spain from the 1980s. The second big challenge that started in the late 2000 is China that is eroding Italian market shares in Asia, the Middle East, Eastern Europe and the US. Chinese products are also imported in European markets[5]. In 2010, China exported 60 million square meters in the EU, representing 13% of total EU imports. The third challenge is not from a single country but from a mix of countries including Turkey, the EUA, Poland and Russia, which compete with Italian producers both in their home markets and in export markets.

All these countries exploit cost advantages compared to Italy[6]: labour, energy, and sometimes raw materials. Being close to final markets give an extra advantage. Economies of scale are not very important in this industry. Production costs are minimized with a relatively small investment that includes two to four production lines. Economies of agglomeration are exploited by producing within the district but transportation costs easily offset them. Hence production lines are often set up outside the district.

3 Excluding China, which is a peculiar market and could be considered as a continent, the ratio of export to production rises at 30%.

4 2010.

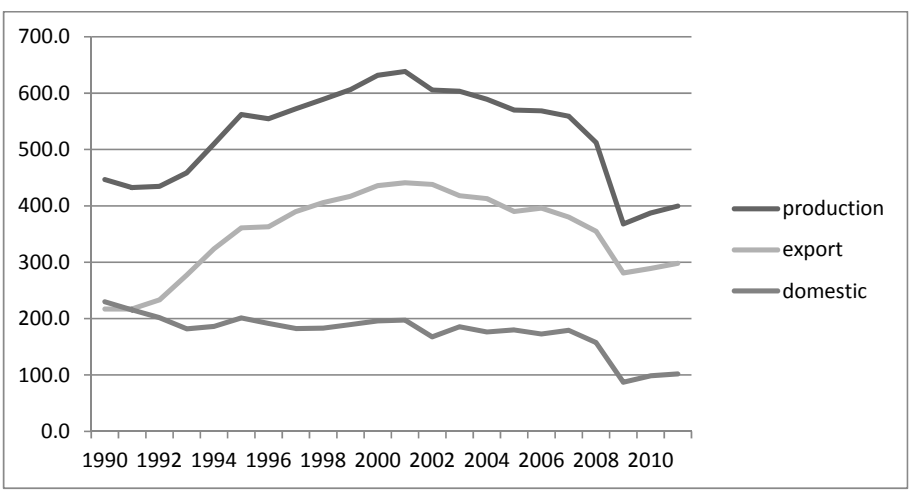
5 Chinese exports in Europe were growing very fast but were stopped in 2011 due to anti-dumping duties imposed By the EU Commission, that will last for 5 years.

6 For a cost comparison between Italy and China see Prodi (2006).

Demand for ceramic tiles grew constantly in the last 20 years from 3.300 million sqm of the mid-nineties to 7.000 million sqm in 2005 and almost 10.000 in 2012. However, the largest part of this growth happened in distant markets, primarily Asia but also the Middle East and Latin America.

Italy has therefore lost its supremacy in terms of production and exports. The country has been able to catch only a minor slice of the new bigger cake of the world ceramics tile market that grew by 200% in the last 30 years. Italy is today the fourth world producer and second world exporter (in volumes). Italy is third in terms of revenues and still first in terms of export values. Italy's world export market share is 16,3% in volume and 32% in value. The most important export markets are Germany, France and the US[7].

Figure 1. Production, exports and domestic demand, 1990 to 2011



Source: Confindustria Ceramica database.

Sassuolo implemented a multi-dimensional strategy in order to remain competitive, despite the lack of raw materials[8], the higher energy cost compared to many countries and the higher labour costs. This strategy involves products, production, distribution, and FDI.

7 Confindustria Ceramica.

8 The local red clays are not suitable for Grès tiles that require white clays that are imported from abroad or from the Sardinia Region.

Table 1. Country production of ceramics tile

		2011	2005	2000	1995	1990
1	China	4730	2870[1]	1918,2	990,1	309,4
2	Brazil	844	568,1	452,7	295	190
3	India	500	245,2	126,8	47,1	13,1
4	Italy	399	570	631,8	562,2	446,7
5	Spain	392	651	621	400	219
6	Indonesia	287	225	142,1	131,1	53,3
7	Turkey	260	250	175	107	35
8	Iran	244	125,1	65	40	20
9	Messico	219	195	134	70	35
10	Egipt	147	85,2	54,4	29,4	5,4
11	Russia	129	92,2	30	20	42
12	Tayland	128	129	63,3	85,2	34,1
13	Poland	121	94,5	34	19,7	12,6
14	EUA	85	60	36,5	19,9	13,8
15	Malaysia	83	74,3	55	41	10

Source: Confindustria Ceramica database.

Table 2. Export countries

		2011	2005	2000	1995	1990
1	China	650.0	265	50	31,1	10,4
2	Italy	298.3	390,3	436,3	361,4	216,9
3	Spain	263.3	341,3	311,5	188,1	92,1
4	Turkey	87.4	99	52	26,4	6
5	Messico	63.4	40	29	17	5
6	EUA	60.0	29,5	20	11	6,5
7	Brazil	59.0	113,8	56,7	29,4	16
8	Iran	49.0	9	6,5	3,6	0
9	Poland	36.0	19	2,5	0,9	0,1
10	Portugal	32.3	29,9	19,3	16,8	10,7

Source: Confindustria Ceramica database.

The strategy has focused on maintaining the leadership on the high end of the market. More Grès tile, more larger tiles, less defectiveness and innovative design characterise a high end product.

Italian producers are able to sell at a higher price compared to competitors thanks to investments in R&D (representing 5,5% of revenues on average in the last 10 years) and in design[9]. Tacit and explicit knowledge flows are very important in the Sassuolo district. The cooperation between ceramic tile producers and the Italian suppliers of machineries and equipments for Ceramics is crucial. Almost all the major innovations of the industry are developed within the district. However, R&D in products and processes are not enough to maintain leadership. Technological innovations are easily imitated by competitors. The Italian ceramic machinery industry exports 80% of total production.

Italian producers are very flexible and can accept small and very differentiated orders. This is possible thanks to both technologies that allow production lines to quickly change products and to large stocks. The ratio between stocks and sales constantly increased from 25-30% in the early 1990s to 40-45% in the last years. Efficiency is of course very important and Sassuolo constantly improved productivity thanks to new technologies, larger production plants and larger firms. This characteristic is not shared by other producers like the Spanish and Chinese producers who prefer focusing on larger order and lower stocks (Prodi, 2006). The changing relative importance of the different phases of production is shown by the changing number of employees in the different phases. Employees in marketing and distribution phases have thus grown in importance, while workers directly involved in production activities have reduced. Despite the rise in office automation, white collars and managers represented 26% of total employment in 2000, 32% in 2012.

The number of firms and of employees almost constantly decreased in the last 15 to 20 years even when production was still increasing. The importance of business groups also rose: in the mid-eighties the first 5 groups controlled only 16,6% of the market in revenue and the first 10 the 25,1%.

9 The technology for grès tile fires tiles at a higher temperature. This improves some tile characteristics like reduction of water absorption and a higher resistance to shocks.

In 2005 the first 5 business groups controlled 36% and the first 10, 50%. In 2009, the last year for which we have data, the Top5 controlled 41,6% of revenues and the Top10, 59,3%. Some of those went public on the Milano and NY stock exchange.

Business groups have changed the internationalisation strategy of the district from the 1990s onward. They have started to produce abroad through foreign direct investments (FDI), either mergers and acquisitions or greenfield investments. The first FDI was made by the Marazzi Group, one of the largest producers in the world. Most FDI however were made in the 2000s. Business groups invested in EU countries both to exploit growing domestic markets and to lower production costs. Sassuolo firms have productive units in the US, Poland, Ukraine, Russia, France Germany, Finland, Sweden, Spain and Portugal. About 20 firms are controlled by a dozen of business groups, that control 33 production sites with 7494 employees[10]. Foreign production of Italian enterprises reached 140 million square meters for a turnover of more than 1 billion €[11] in the last 15 years. This production compensates 50% of the loss in production in Italy and practically offsets all the loss in exports. More than 90% of foreign production is for the domestic market and less that 10% is exported. The US represent 25% of production (35% in value), all the rest is in Europe.

10 Confindustria ceramica 2012.

11 Confindustria ceramica 2011.

Table 3. Top 10 groups of Italian producers

	Revenue (mln. €)	Revenue in Italy	Revenue abroad	Production in Italy (mln. Sqm)	Production abroad (mln. Sqm)	Factories outside Italy
Marazzi	801	227	574	90		Spain, France, Russia, US
Concorde	544	190,4	353,6	30	8	France, Russia
Iris - Graniti Fiandre	385,5	n.a.	n.a.	23	6	Germany, US
Panaria group	289,9	87,9	202	8,3	6,6	Portugal, US
Cooperative Ceramica di Imola	278,7	82,6	196,1	24		None
Casalgrande Padana	275	98,5	176,5	23,9		None
FinFloor	259,7	78,8	180,1	11,7	6	US
Gruppo Ricchetti	195	38	157	8	10	Finland, Germany, Portugal
Gruppo Del Conca	134	44,2	90,3	11,9		San Marino
Gruppo Emilceramica	132,6	43,4	89,2	5,1	2,9	Ucraine

Source: CER/confindustria ceramica 2009.

Thus the main structural transformation of the Sassuolo district has been a shift from local production to a geographically extended production network, realised by FDI. This structural transformation has allowed the ceramic tiles cluster of Sassuolo to maintain a leadership at least in advanced markets. Production has been delocalised abroad, so that the "core" of the district could be weaker in terms of volumes; however, it is still crucial for several activities like design, innovation, distribution management and product variety.

Another change has occurred in the last 12 months, that could represent a new evolutionary trend in the district structure. For the first time two business groups have been acquired by non-Italian investors. The

Finquoghi group, a medium-sized group without production sites abroad, due to the difficulties related to the world economic crisis, was in financial distress and has been acquired by a Turkish competitor named Kale. But much more important has been the acquisition of Marazzi, the largest tile producer in the Western world, by Dal-Tile, a US company, after the death of the founder of the company. It is too early to see whether and how this acquisition may change the district and whether it will be followed by more mergers and acquisitions.

This case is therefore one of a district able to adapt to changing competitive conditions by structural transformations characterised by an extension of the production network to foreign countries by FDI. Business groups in Sassuolo have therefore started to create own GVCs to extend their production and sales capacity.

The second case is different, in that it is based on FDI attraction, hence insertion into global GVCs led by external leaders.

4. THE BIOMEDICAL CLUSTER OF MIRANDOLA

In contrast to the Sassuolo district, the Mirandola cluster is characterised by upgrading and access to the world market via alliances with large multinationals. We argue below that in this case it appears that the ability of district firms to build distinctive capabilities that attract leaders and induce them to set up relational GVCs is key for the long-term competitiveness of the cluster.

The biomedical sector is geographically concentrated in the Centre and North of Italy and in two regions in particular which together account for about 60% of the total employment. The most important region is Emilia-Romagna, which accounts for 32% of employment in the sector, followed by Lombardia (27%). The other regions are Tuscany, Veneto, Piemonte and Lazio. In Emilia-Romagna, the Modena province, where Mirandola is located, accounts for about 63% of the employees in the biomedical sector in the region.

The biomedical cluster of Mirandola in the Emilia-Romagna region is particular in that it is relatively recent, created in 1963, and in that it is specialized in a high-tech sector, contrary to most Italian industrial districts.

According to the consortium of firms of the cluster, the cluster comprises about 70 firms and 3000 employees in the core businesses of the area, namely the production of disposable products to be used in surgery, and the production of electro-medical equipment for diagnosis. The first product type accounts for about 84% of the district production and the second, about 16%; however, the share of electro-medical equipment has been growing over time.

The district is dynamic and growing, despite the financial crisis: the number of firms in the district increased by 15% over the period 2007-2009 and export grew by 1.2% between 2008 and 2009.

Table 4. Firm dimension in the Mirandola cluster, 2009

	% of firms
1-9 employees	80.4
10-49 employees	14.3
50-249 employees	4.0
250-499 employees	0,5
500 and more	0,8
Total	100

Source: Consobiomed ASRL and Osservatorio distretti italiani.
(http://www.osservatoriodistretti.org/node/274/distretto-biomedicale-di-mirandola)

The Mirandola district specialises in three health areas. First, renal healthcare area, which is also the main source of demand for electro-medical equipment produced in the district. Second, cardio-surgery, anesthesia and resuscitation, and third, blood transfusion.

The major competitors in the global market are Gambro (Sweden), Fresenius (Germany) and Baxter (USA). Baxter used to produce disposable products in the district but left in 2004 and shifted activities in Malta, where labour costs for this rather standardised product type are lower.

However, Baxter is still present in the cluster since it acquired Gambro in December 2012.

Overall, the activity of the district is led by 5 large multinational groups, operating in the three health areas of the district. The five groups are:

1. Gambro (Baxter): Swedish firm, leader in renal products and renal healthcare, founded in 1964 and with 7500 employees worldwide, with production centres in 9 countries. It has 350 employees in R&D activities, which is performed in Sweden (Lund), France (Meyzieu), Italy (Medolla) and Germany (Hechingen). The subsidiary in Mirandola is Gambro DascoSpA, which has announced this year a restructuring plan to focus on electro-medical equipment and terminate the production of bloodline disposable products in Medolla.

2. B. Braun: German group with more than 40,000 employees over the world. The subsidiary in mirandola is B. Braun Avitum Italy which specialises in extracorporeal treatments.

3. Mallinckrodt (now USA): leader in the imaging for diagnosis and pharmaceutical products, in Mirandola the Mallinckrodt Dar has about 331 employees. Mallinckrodt was purchased in 2001 by Tyco Healthcare; in 2007, the healthcare business unit was spun off under the name Covidien.

4. Fresenius: global German group with 337,552 employees in 2009 (2010 Annual Report). World leader in dialysis care and dialysis products (70% of total group activity), infusion and transfusion products (Fresenius Kabi) (20%) and Fresenius Proserve (10% of activity) dealing with engineering. The group has been in the biomedical valley since 1993, when it bought Biofil. The Italian company in Mirandola (Fresenius Hemocare Italia) is specialised in the production of filters for blood transfusion.

5. Sorin group (previously Sorin Snia but the two groups separated in 2003), world leader in the treatment of cardiovascular diseases, manufactures medical technologies for cardiac surgery and for the treatment of cardiac rhythm disorders. It is an Italian company with headquarters located in Milan. The group has about 3600 employees of which 14% are in R&D activities. R&D is performed in different location, including

Mirandola specialising in cardiopulmonary diseases. The Mirandola subsidiary (Dideco and Bellco) has more than 400 employees.

Structural transformations in this cluster are related to the increasing competition in the production of disposable, implying the emphasis on more personalised disposable products and the move towards more sophisticated products, such as electromedical machines used in diagnosis and treatment. Most firms recently created are in the latter sector, where production is more value-creating and where the region has different innovative capacities that can be used in this production: mechanics, electronics, IT, biochemistry and material sciences.

The cluster has developed innovative capacities in the latter area. An analysis of innovative output of Mirandola firms, using both patent and scientific publications data, shows this. The empirical identification of the manufacturing firms belonging to the districts was based on two dimensions: productive specialisation and localisation. Regarding productive specialisation, the district firms produce both disposables and electromedical equipment. The first type of products belong the 2007 sectoral classification of the Italian central statistical office (ATECO) 32.5, while the second type correspond to the 26.6 class, namely manufacturing of instruments for radiation, electro-medical and electro-therapeutic equipment. A sample of 143 firms was thus extracted, all in the Emilia-Romagna region, 34 of which in the Modena province. The size distribution of the firms are presented in the following table, showing that it is in line with the universe.

Table 5. Size distribution of firms in the sample and in the Mirandola district

	Sample	Modena	ER
Small firms (1-49 employees)	83.9%	83.9%	87.3%
Medium firms (50-249 employees)	12.6%	12.5%	10.9%
Large firms (more than 250 emp.)	3.5%	3.8%	1.9%

In order to provide evidence of the innovative capacity of Mirandola firms, data on patents were extracted from the EPO database, as well as scientific publications (publication of articles in scientific journals, denoting a research output new to the scientific community) from the ISI Web of Knowledge database. Figure 1 shows the total number of patents and of scientific publications obtained by the Mirandola firm in the years 2000.

Figure 2. Number of patents and scientific publications, 2000 to 2009

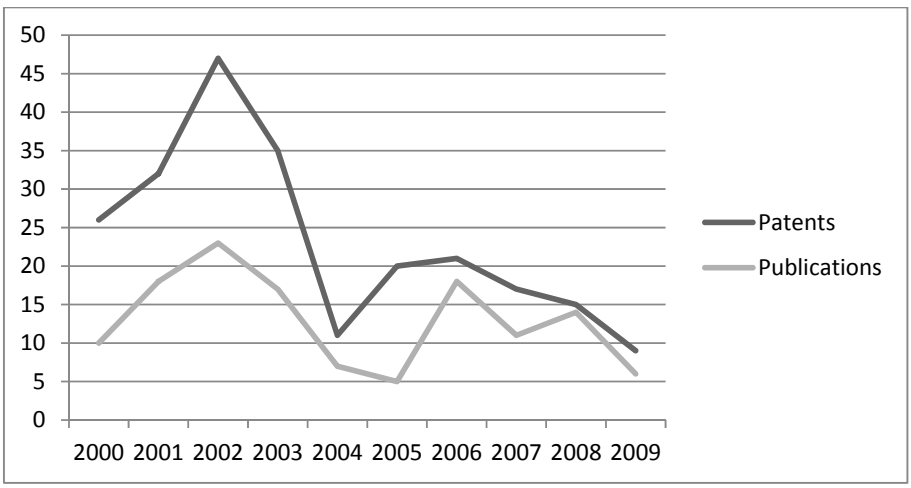


Figure 3. Patents by biomedical firms the ER region, 2000 to 2009

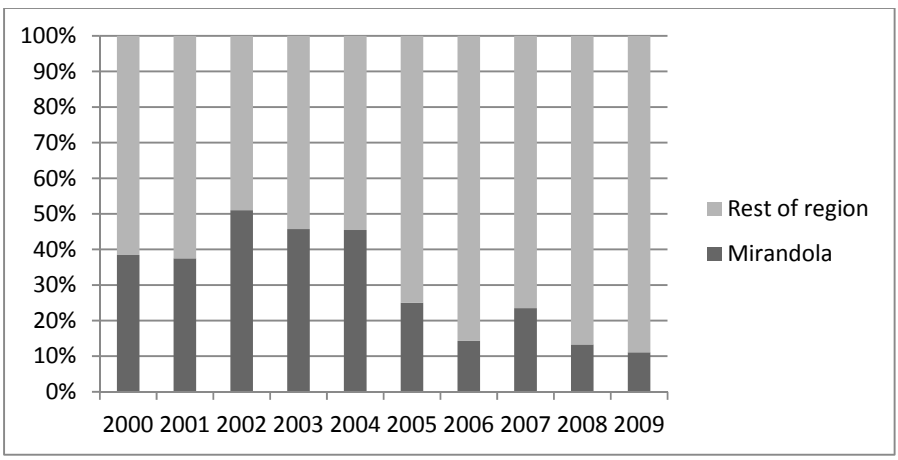
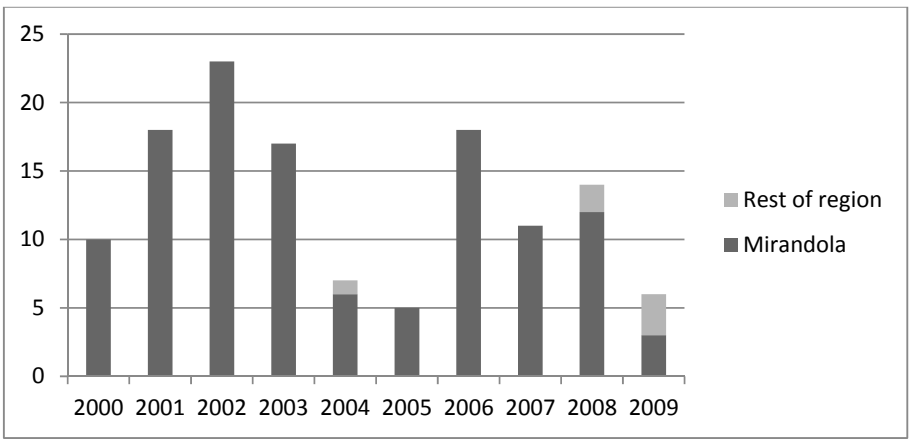


Figure 4. Scientific publications, 2000 to 2009



In the electro-medical machinery sector, the Mirandola district produces about half the patents produced in this sector in the ER region. The Mirandola cluster has produced about 70 out of the 663 patents registered by Italian biomedical firms in the last 10 years. The Mirandola cluster however produces almost all scientific publications produced by biomedical firms in the region. All scientific publications arise in the electro-medical machinery sector, not in the disposables. The firms producing scientific publications are the largest firms, namely the multinationals located in the cluster and some of the biggest cluster firms. Their scientific publications are usually the fruit of collaboration with other institutions, such as other firms related to the same group, or universities, research centres and hospitals, located in the region and more frequently in the rest of Italy and especially abroad. The multinationals located in the cluster therefore appears to represent bridges between the smaller cluster firms and institutions located outside the cluster, especially abroad.

Within the region, research collaborations as evidenced by co-authorship of scientific articles are mainly realised with institutions located in the same province as the cluster, and less with the rest of the region. The density of relationships appear therefore to primarily exist locally, within the cluster. However, collaborations with institutions (firms, universities, research centres or hospitals) outside the cluster's province but within the ER region are increasing in the last years, to a significant extent, which may be sign of extension of the critical mass of the cluster to the regional rather than provincial dimension.

Larger firms are more likely to set up relationships with external research institutions, because such research collaborations require funding, so that public researchers and academics are motivated to collaborate. Larger firms are more likely to have such funding at their disposal. In addition, university – business relationships require time and dedicated person that contact liaison offices and academics, which larger firms are more likely to be able to do.

In any case the distinctive feature of firms belonging to the Mirandola district relative to other firms in the same sector but still located in the ER region is that the former seem to be more active in scientific publication, being motivated either by the willingness to get a reputation for scientific quality within the research community, or to establish more relationships with universities and other research organisations.

The following table shows the percentage of publications which include a collaboration with a specific type of institution located in the region, in the rest of the country or abroad. The types of institutions considered are universities, public research centres, hospitals or other firms (private research centres were included in the firm category). Notice that very often the collaboration with another firm is in fact a collaboration with another subsidiary of the same group.

Table 6. Collaboration on scientific publications. Percentage of collaborations including the specific institution

Italian extra-regional hospital	36.0
University in the rest of Italy	14.8
Foreign university	9.9
Regional hospital	9.0
Foreign hospital	7.0
Regional university	6.4
Foreign firm	3.8
Foreign research centre	3.5
Italian extra-regional research centre	2.9
Regional firm	2.3
Regional research centre	1.5
Italian extra-regional firm	1.5
% of publications not including collaboration with any institutions	8.6

Most collaborations (52%) include hospitals, especially Italian hospitals located outside the region (36%). Very often a paper include a large number of collaborating hospitals, one or two of which are in the region and other are in other Italian regions. The machines produced in the district are used in dialysis or blood transfusion and are developed directly collaborating with the users. The second most important collaboration is university, since 31% of collaborations concern this type of institutions. University – firm relationships are geographically extended, since the percentage of publications with collaboration including regional universities is 6.4%, a bit less than foreign universities (9.9%) and less than universities located in other Italian regions (14.8%). Collaboration with public research centres and with other firms is less frequent, but still tends to primarily regard extra-regional locations.

Multinationals in Mirandola thus insert the local firms in GVCs of a relational type, since they are involved in the research phases of the production process. Multinationals also embed locally in order to develop local research networks.

The regional innovation policy has aimed at helping this process, including biomedical into the main specialisations of the regional innovation system to be potentiated. Policies aiming at building and developing this system have been implemented since the 1990s, with for instance a specific programme to help research and technological transfer (PRITT) since 2002, a network for high technology since 2008 (essentially using European structural funds). The mobilisation of the region after the 2012 earthquake which epicentre was in Mirandola is also significant in this respect, with a rapid and important implementation of measures to avoid multinationals go away from the district and helping rapid reconstruction and restart of factories. Most biomedical firms in the district started production again only three months after the earthquake.

However this restructuring process, like in all Italian districts, raises difficulties for the smallest firms in the district, especially those producing disposables. A local business association, Consobiomed, has tried to induce them to collaborate in order to pool resources and capabilities.

5. CONCLUSIONS (CAN BE IMPROVED)

This paper has analysed two Italian cases of structural transformations in clusters following the enlargement of the market due to globalisation. The cases are that of the ceramic tile district of Sassuolo and the biomedical cluster of Mirandola, both located in the Emilia-Romagna region. These cases illustrate the two main tendencies in terms of restructuring and internationalisation strategies of clusters, namely creation of own GVC or insertion into GVC led by external leaders, that has been outlined in the literature. They also highlight the conditions for each strategy to be successful.

Although this analysis is based on case studies and the results cannot be generalised, they provide a good starting point for further theoretical and more systematic empirical work.

These two clusters opted for a strategy that puts together innovation and internationalisation. Innovation strategies are different due to the different levels of maturity and the characteristics of these two clusters, namely a mature sector, that of the ceramic tile production, and a high tech sector, the biomedical one. In addition, internationalisation strategies are different not only within these clusters but also compared to other clustersanalysed in the literature. Internationalisation strategies of both clusters are motivated by the search for a new markets and not by the search for lower production costs. The internationalisation strategy of Sassuolo has been to realise foreign direct investments (FDI) in order to reach new markets at lower costs than exporting (the transport of ceramic tiles is costly). These FDI are not lower costs seeking or simply technology seeking; they are mainly market seeking.

The Mirandola cluster has internationalised early in its existence, since the 1970s, by alliance of its firms with international leaders, even acquisition since the first Mirandola firm acquired by a multinational was in the 1970s, whereas the cluster was created in the early 1960s. After that first acquisition the Mirandola cluster developed, new firms being created, that either were acquired by multinationals or set up formal relationships with multinationals.

Both clusters have strong capabilities in the manufacturing phases of production, but they have developed capabilities in other stages of their filiere. As shown in section 4, the Mirandola district has high innovative capacity.

It appears therefore that the successful strategies of districts that build global production networks or insert in global production networks is first and foremost to invest in specific capabilities, knowledge and competencies that provide them with a strategic advantage in the global competition.

Internationalisation is not per se a successful strategy, and can take several forms. Every district follow its own path. Upgrading and adapting capabilities should be the priority; then the district can internationalise either by investing on its own or by allying with external leaders.

The Sassuolo cluster has three main strengths: first, strategic advantage in production (capacity to innovate production, technology and design), although rapidly imitable; second, flexibility in production and distribution is another important factor of competitive advantages; third, evolution in market structure with the consolidation of market leaders that invest both within and outside the district in order to remain competitive.

Regarding the Mirandola cluster, competitive strength is based on innovative capacity, constantly renewed and expanded, leading to the arrival of different multinationals which have stayed in the district despite intense world-wide competition. The cluster appears now to be slowly but constantly moving towards higher value added products, namely electromedical machines and less disposable surgery products. Here the local knowledge and competencies are not easily copied, because it is complex knowledge, innovation is path-dependent (how much you have innovated in the past provides you with knowledge and competencies that give you higher probability of innovating again), and, last but not least, patentable. The cluster has therefore internationalised mainly through the attraction of external leaders, that have invested in the cluster and embedded in it, because they have found an appropriate milieu favouring constant upgrading.

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