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INNOVATION DYNAMICS AND INDUSTRIAL DYNAMICS IN A LOCAL PRODUCTION SYSTEM.
Changes in the agents/artifacts space in tile decoration: from silk screen to laser engraved silicon cylinder

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Abstract

The primary objective of the research is to reach a deeper understanding of innovation theory by: formally describing the structure of the agents/artifacts space, as well as the dynamics of changes within this structure; defining the concept of "network of competence"; tackling the problem of measuring generativeness potential in a relationship between agents. The research is grounded on empirical descriptions of concrete cases of innovation processes

The secondary objective of the empirical studies (which will be presented in two distinct monographs) is to outline a general method for describing empirically, in concrete cases, the structure of the agent/artifact space, for analysing the dynamics whereby structural and cognitive changes come about, and for evaluating the generativeness of the relationships in the agent/artifact space.

Questions addressed at the present stage of the research:

- How could one define a concrete case to be studied in order to collect significant elements (qualitative and quantitative information) useful for a deeper understanding of innovation theory?
- In particular, how could we choose the particular agents and artifacts space whose structure we intend to investigate empirically?
- What do we mean by "formal description" when we declare that our research aims at a "formal description of the structure of the space in which agents and artifacts interact"?
- How could we manage an analysis of changes within that structure when we find that changes occur at a multiplicity of levels?
- In which way does the analysis move from micro-micro level to micro-, meso- and macro-level
- How do we take account of changes in agents' identities?
- How does the concept of "network of competence" help in interpreting the way competences emerge as the outcome of an informal process of personal interactions?
- How could the potential of generativeness be measured?

1. Introduction

This draft is one of the contributions to the research project on "innovation dynamics and industrial dynamics" put forward by the research unit of Modena University. The goal of this unit is to develop the innovation theory along the line proposed by Lane, Maxfield, Malerba and Orsenigo (cf. Lane et al. 1996; Lane and Maxfield, 1997). This theory aims to describe and explain an important empirical phenomenon: the dimensions of the space in which artifacts are produced, exchanged and used are continuously increasing. Agents space is defined as the pattern emerging from the recurring interactions among agents: such interactions are directed at the transformation of the agent/artifact space. The theory has both a cognitive and a structural component: it recognises a central role to the "attributions" agents assign to the other agents and the artifacts with whom they interact. New attributions that allow the emergence of new entities (artifacts or agents) stem from within a particular kind of interaction that Lane and Maxfield have called "generative relationships". A crucial point that must be discussed by the theory is in what conditions relationships among agents and artifacts may become generative.

This research considers three basic developments of the theoretical work:

- describing the formal structure of the agent/artifact space and the dynamics of such structure;
- deepening the notion of competence network (introduced by Lane et al. 1996);
- measuring the potential of generativeness (introduced by Lane and Maxfield 1997).

The theoretical analysis is developed together with an empirical investigation of concrete innovation processes. In particular, we have chosen two quite different case studies: one is on the distributed control technology emerging from one new firm of Silicon Valley, Echelon (this case study is conducted by David Lane); the other is on innovation processes in tile decoration emerging in a local production system in Italy, the ceramic tile districts of Sassuolo-Scandiano (conducted by Margherita Russo). Both cases refer to innovations affecting worldwide users, but while the study on Echelon distributed control regards the emergence of a "high tech" innovation, the decoration techniques concern "traditional products". Given the limited resources for an empirical research, we believe that these two contrasting case studies offer interesting insights for a comparative analysis which is crucial for a grounded theory of innovation.

The empirical investigation is still ongoing and – with regard to the decorating techniques in tile production – this draft presents the main results so far reached and some indications for further developments. In particular, section 2 illustrates what we know about the main features characterising the industrial dynamics and the innovation

dynamics in the local production system of ceramic tiles in the Sassuolo-Scandiano tile district. This broader description helps in defining the particular agents and artifacts space investigated in the empirical inquiry. Section 3 outlines the main issues of the research methodology. With regard to both the methodological issues and the theoretical perspective, section 4 summarises the main results so far emerging from the analysis of the 25 interviews already conducted, and points out some further research lines to be developed both through other interviews and from theoretical investigation on some methodological issues.

2. Industrial dynamics, networks dynamics and innovative dynamics: an overview

This section illustrates what we know about the main features characterising the industrial dynamics and the innovation dynamics in the local production system of ceramic tiles in the Sassuolo-Scandiano tile district. This broader description helps in defining the particular agents and artifacts space investigated in the empirical inquiry.

The case presented in this paper regards changes in an agent/artifact space – centred on the ceramic tile district – that shows inter-sectoral and intra-sectoral dynamics of great interest because of:

- the rate of growth of the world market, both tile market and the ceramics machine market;
- the strong spatial concentration of agents involved in the innovation process;
- the growing importance of competitors external to the production system.

In illustrating the main features characterising the industrial dynamics and the innovation dynamics in the local production system, we need a temporal perspective, and my presentation will run along time, going back many times in trying to single out the origin of particular developments relevant to highlighting that dynamic.

Let us start by considering that, starting in the 1960s, the production of ceramic tiles in the provinces of Modena and Reggio Emilia has become a very intense industrial activity, concentrating over 70% of Italian production in some eight Communes of the two provinces. The development of this industry can be summarised at a glance by looking at figures 1-3 that illustrate the time series of the number of employees, the number of companies, total output and exports (both expressed in physical units of square metres), and a measure of productivity (in terms of physical output per employee).

In the period 1958-1997 we can clearly identify 4 sub-periods (cf. table 1) defined as regards the major changes in the course of employment: 1958-1966, 1967-1976, 1977-1986, 1987-1997. The first period (1958-1966) is characterised by a modest increase in all the variables considered, as for the Italian economy as a whole, also ceramic tile production experienced a fall in 1963 that implied a reduction both in the number of

companies and employees. From 1967 until 1975 there is a continuous and sharp increase in output, largely made possible by an expansion of the number of companies and the number of employees (respectively: 13,4, 16,8 and 12,4 percentage average annual increase); less marked is the increase in exports. After having recovered in 1976 the 1974 level, since 1977 there has been a massive annual increase in productivity (8%, on average), and a lower increase in output and exports (respectively 2,9 and 6,4%); the employment and the number of companies being, at the end of the period, equal to the level of fifteen years before. The third period is in fact characterised by a radical change in labour organisation and the restructuring of many factories is also accompanied by the reorganisation of ownership and control of several groups of firms that began to be formed during the 1970s. Finally, the last ten years are marked by a continuous increase in exports, output and productivity, while employment in the industry still continues to decline.

Figure 4 shows the average size of the tile firms expressed in terms of employment and annual physical output[1]. While at the beginning of the 1950s the average size was almost 200 employees, in the next 20 years the average size halves, remaining in the range 80-100 employees. These data do not reveal the general process, starting in the 1970s, of strong concentration in this industry. I have discussed this phenomenon in a previous research[2]; what interests me here is the comparison with the continuously increasing average size of the firms in terms of annual output: another way of looking at the increases in labour productivity. What helps to explain the continuous increase in productivity is the adoption of more mechanised techniques (starting in the mid-1970s) and the change in the composition of output due to the adoption of new production techniques. Let us consider the latter phenomenon (shown in figure 5). Although data are available only since 1979, we can observe that during the 1980s “twice-firing”, the traditional technique for producing ceramic tiles, has a declining trend, while “single firing” becomes the major product of this sector. Apart from technical or aesthetic differences, it is worth mentioning that the single firing techniques, as well as the production of porcelain stoneware (sharply increasing in the 1990s), skip some stages of production processes required in the twice firing technique: *ceteris paribus*, this by itself has a direct effect in increasing productivity.

In general, during the past thirty years, the tile industry has shown an impressive increase in output and exports, marked by large increases in productivity and radical changes in output composition. Although the data so far commented referred to the tile

[1] Available data do not provide information on dispersion measures around the average size. More detailed considerations on the changes in the minimum efficient size of firms have been discussed in a previous work (cf. Russo, 1996a).

[2] *Ibid.*

industry at national level, the enormous increase in the production of ceramic tiles was mainly and increasingly concentrated in the Sassuolo district: over the last thirty years that concentration has brought about a proliferation of firms which produce machines and specialized services for this industry.

Let us consider the Census data on employment and establishments, now available in a comparable time series from 1951 to 1991. Figure 6 shows the data for the 8 Communes of the tile district[3]: we can observe that the decades 1961-1971 and 1981-1991 are those marked by a greater increase in employment, while the number of establishments has a major increase in the decade 1971-1981[4] (as shown in figures 8 and 9, the main concentration of establishments and employees is in two communes: Sassuolo and Fiorano). By examining the data disaggregated by industry (figures 10 and 11), we see that in 1951 the ceramic tile industry was already the main source of employment of the district, but – since 1961 – there has been a marked increase in the mechanical industry, both in the number of establishments and in employment; moreover, since 1981, two other ceramic tile related activities appear in the district: "paper, publishing and photography" and "chemicals, rubber and plastic". Although the Census data do not enable us to single out the data on the mechanics for the tile industry, and for the other manufacturing and services activities related to tile production, from other previous research[5] it emerges that the district witnesses a strong concentration of the majority of the vertically integrated sector of tile production: machines, colours and glazes, graphics, silk screen, dies, maintenance and repairs, packaging materials and even transport, to quote only the most important activities.

With regard to ceramics machine producers, their number has increased in the last thirty years and, in the 1990s, in Italy there were over 200 firms specialising in such activity, mostly located in the Sassuolo district, with almost 8000 employees, a total turnover of about 3000 billion lire and a percentage of exports of about 70% of sales[6] (cf. figures 12 and 13). Representing something like 3% of the total sales of the Italian mechanical sector, during the first half of the 1990s, the ceramics machine sector has had a dynamic comparable to other sectors of mechanical industry (cf. figures 14 and 15

[3] The Communes considered are the following: Fiorano, Formigine, Maranello and Sassuolo, in the province of Modena; Castellarano, Casalgrande, Rubiera and Scandiano, in the province of Reggio Emilia. These are the core communes of the ceramic tile district, classified according to the specialization of the local production system. For the definition of "specialization of the local production system" and "local labor system" cf. Sforzi (1995-Geotema). [Complete the footnote by listing the other communes of the "local labour system" and the reasons for their exclusion (cf. Castelvetro, Viano).]

[4] [Insert and comment figure 7 "Unità locali e addetti delle industrie manifatturiere delle provincie di Modena e Reggio Emilia" (cf. SAS-elaboration-Giardino).]

[5] Cf. Russo (1991, 1996, 1998).

[6] Data refer to 1996 [insert the 1998 data].

showing data on the major sectors[7]). After 1995 sales declined, recovering in 1997 the share of exports of 1993. Owing to the Far East crisis (and to other changes we shall discuss later), in the last few years the number of ceramics mechanical firms has been reduced: in Italy, in 1997, the association of ceramic tile producers (Acimac) recorded only 182 firms producing machines for the tile industry.

The data so far commented refer to the "final firms" and to those firms that declare more than half of their sales devoted to the ceramics machine sector. From our interviews it emerged that these firms have recourse to a network of mechanical and electro-mechanical sub-suppliers present in the tile district[8] and more generally in the central area of the Emilia-Romagna region. In this region, the existing local production system[9] of mechanical firms constitutes an important technological and productive resource for a variety of machine producers specialising in various sectors such as machine tools, packaging machines, agricultural machinery or wood working machines[10]. In particular, we have collected information on several firms, sub-suppliers and even final producers not included in the Acimac survey[11]. Although marginal in terms of employees and sales, the existence of a wider group of firms discloses a crucial point of the present investigation on the emergence of innovations: the inter-firm interactions across several machine sectors. In particular, three important developments of the evolution within the district will be examined: the changes of levels of vertical integration of ceramics machine producers, the diversification of producers of non-standard components across several branches of the machine sector, and the interactions between ceramics machine producers and firms offering specialized services for the tile industry (such as graphics companies and producers of colours and glazes).

Once again, let us take a long-term perspective on the past changes occurring in the district. In the 1960s, within the ceramic tile district, there were basically a few small metalwork companies which produced equipment used by ceramic tiles firms to mechanise the transfer of tiles between the various phases of the production process. In

[7] Please note that figures 16 and 17 do not represent a "residual" aggregate of the mechanics industry (called "Meccanica Varia") that consists of almost 60% of the sales of the entire sector. Cf. table 2.

[8] Often such relationships are based on family or joint ownership connections. It should be noted that this kind of arrangement is considered typical of industrial districts (cf. Brusco, 1989, Capecchi, 1990, Dei 1994). In the present research I have built a data set to check ownership inter-linking among firms producing machines for the ceramic tile production and ceramic tile firms, and it has emerged that cases of interrelationships between the ceramic tile firms and the machine producers are quite rare. [Expand with the data on groups (cf. Masci's up-to-date of Malaguti's data set).]

[9] For the notion of local production systems adopted here see Brusco (1990), Bellandi (1994), Russo (1996b).

[10] Cf. Brusco (1989), Capecchi (1990).

the 1970s several firms emerged within the district specialising in producing kilns (first tunnel kilns and then fast firing kilns), screen-printing machines, glazing lines and machines for tile sorting and grading. Moreover, three larger firms producing machines (Sacmi, Siti and Welko) – located outside the district and originally producing other machines (respectively: packaging machines, kilns for the cement industry and presses for the metalworking industry) – became very active in supplying technologies specific to ceramic tile production.

The firms producing ceramics machines have always enjoyed a continuous information exchange with the ceramic tile firms and, in the 1960s and 1970s, the tile producers used these machine producers as a kind of research and development department which, though external to the company, was in daily contact with the technical problems which gradually emerged in the production process. Once a particular technical solution had been found, this was offered via the machine producers to all the other firms in the tile industry, thus giving rise to a process whereby the innovations were distributed so efficiently that by the end of the 1970s, the mechanisation of many of the phases of moving material within the factory was already widespread inside the tile firms located in the district. The interrelations between producers of machines for the tile industry and tile firms themselves have made possible a high level of technical change in a sector, that of the ceramic tile, in which only a few firms carry out their own internal R&D programmes[12]. And this high rate of technical change has enabled Italian ceramic tile firms to achieve a position of world leadership owing both to the excellence of the quality of the products and the supply of new products.

In the 1980s the most important innovations produced by the machine producers had to do with the introduction of microprocessors in production line machinery (mills, presses, kilns, glazing, the selection of materials), as well as in all of the transportation equipment. Apart from completing the mechanisation process of the various phases of production, techniques relating to single firing production were more widely adopted and firms were thus enabled to offer at lower prices a new product with improved technical features which extended the market for tile products. Finally, the heavy pressures from local authorities and trade unions made it necessary to develop and introduce technologies for dealing with pollution and environmentally harmful emissions. As is the case for many technologies used in the ceramic tile production process, here too it was necessary to adapt technologies used in other sectors to the tile

[11] For example, Feab, Ge-tech, Marchetti e Ronchi, Mitor, SCE, Tecno-Italia are the firms we have interviewed and that do not belong to the data set so far commented. [Complete the list from interviews.]

[12] Cf. Russo (1996a).

industry. This has often created original solutions to specific technical problems posed by the transfer of each particular technology[13].

It was during the 1980s, that leading firms in the machine sector reorganised their internal structure by increasing the subcontracting of components, and even of the entire machine, and increasing their internal research and development activity. Moreover, some of these firms started research projects with university centres, both within the region and at national level. In this way, the range of technical competences, the technical solutions that might emerge and the opportunities of alternative uses for their machines were greatly widened and became less dependent (as they were in the past) on the interrelationships with the ceramic tile firms of the Sassuolo district.

In general, the relations between machine producers and ceramic tile producers have changed over the last fifteen years. Until the mid-1980s, the presence of machine producers within the district gave Italian ceramic tile firms a competitive edge over their foreign rivals. This was due not only to a technical advantage in terms of the rate of innovation, but also to the fact that Italian ceramic tile firms were able to procure machines, services and know-how on favourable terms. This condition no longer persisted when, during the 1980s, the Italian machine producers began to export to Europe, Latin America and Asia, often opening workshops abroad to give technical support to their clients. As a result, foreign ceramic tile producers became more competitive. In particular, as was the case of the Spanish ceramic tile firms, access to the technologies – until then used exclusively by Italian producers – was an important factor in enabling them to establish themselves on the European market.

The order of magnitude of the changes in the tile world market can be summarized on the basis of data presented in the following four figures. Figures 16a and 16b show the size of world production in 1990 and 1997[14]: in the seven years considered the size of world production of tiles doubled and although Italy increased the absolute volume of production, her share in the world market decreased from 25% to 17%. While other producing countries almost maintain their share (cf. Spain and Brazil, of about 11-14%), the increase of China's production is impressive: by increasing its productive capacity from 40 to 460 million square metres, China is now the third world producer and the first world user of ceramic tiles. But, apart from China, also a series of other countries (such as India, Indonesia, Thailand, Malaysia, Mexico, Russia, South Korea and Portugal, not highlighted in the figure[15]) has almost doubled its output, largely directed towards the home market.

[13] Cf. Russo *et al.* (1998).

[14] Data are expressed in physical units (millions of square metres)and refer to a period where composition of output has not greatly changed.

[15] Data by country are available in the file \agosto\dati osservatorio.xls.

Alongside the analysis of the changed composition of output by country, it is useful to observe data on market size, exports and imports by country (cf. figures 17a and 17b): it emerges that although Italy has increased its share of ceramic tile exports (now over 70% of sales), Spain is increasingly pushing her sales abroad in sharp competition with Italian producers. And the emergence of stronger competitors marks a turning point in the relations between the Italian machine producers and the tile firms in the Sassuolo district. In fact, the machine producers operating abroad found the export markets more advantageous because they were growing at a faster rate and, moreover, they were able to fix prices at higher levels than in the home market, substantially dominated by the users who continuously exploit a cut-throat price competition among machines producers.

All these changes have affected not only the relationships among ceramic tile firms and machine producers, but also the internal structure of the ceramics machine industry. It is worth noting that the increase in exports of machines for the ceramic tile industry has given impetus to the rise of a market for complete plants, substantially controlled (95% of the sales) by Italian firms: at the highest point of development of sales, in 1995, there were four large firms – Sacmi, Siti, Nassetti and Welko (with a turnover of more than 50 billion lire in 1994[16]) – market leaders both in terms of their ability to generate technical innovations as well as in their commitment to opening up new markets. They planned the design of the whole plant according to the particular needs of the client and co-ordinated the production of the individual machines, integrated to different degrees within the firm. Until Nassetti's bankruptcy[17], the four biggest complete plant sellers accounted, directly or indirectly, for 30% of the total employment of the whole ceramics-machine production sector, and had a share of 44% of its total turnover (cf. table 3, data refer to 1994). An up-to-date picture of these data, that takes into account the changes due to the now different position of Nassetti, will be presented in the final version of the paper. Here it is interesting to observe the picture the mid-1990s, before the Nassetti bankruptcy that has shaken up the entire ceramics machine industry.

These four firms are located outside the Sassuolo district. This is largely explained by the historical background of these firms and by the fact that, even though the local producers of the district are excellent producers of single machines, they have not had great success in the plant sector: the ceramic tile plant is extremely complex and relies on specialised skills which draw on widely varying technologies. The only other firm in

[16] [Insert here also the 1997 data.]

[17] In the past two years, the Nassetti group has been involved in upheavals due to the bankruptcy of the leading firm in the group, that has moved abroad a large part of its financial activity. This event generated many difficulties both to its sub-suppliers, some of which were forced to close, and to ceramic tile firms, that were left without supply of the machines ordered.

this market is IPG – run by engineer Mauro Poppi, a leading figure in the ceramic tile technological field – whose share in the world market is less than one per cent. In general, the entry of new firms into the tile plant sector is extremely rare. The four biggest firms operating in this market were first producing specific machines and only in the 1980s started selling complete plants[18]. These four market leaders were quite different with regard to their internal and external organisational structure (see figure 18). Sacmi, a co-operative company, has its head office at Imola (in Bologna province) and uses sub-suppliers, predominantly in the Sassuolo area, that do not work for its competitors; it also imposes on them the prices at which they can sell their product to the end market. Sacmi is the biggest of these four firms (with an overall sales volume, including those for the packaging sector, of almost 1000 billion lire in 1998) and it has had a continuous growth: the peculiar Italian legislation on co-operative firms has provided this large enterprise with the opportunity for internal financing of pricing policies[19] pointing at the displacement of competitors. Siti has its head office at Novara (in Piedmont region) and has several sub-suppliers in the Sassuolo area, but also in Lombardy; the sub-suppliers are not required to sell exclusively to Siti. Nassetti had its head-office in Milan and relied on sub-suppliers in the Sassuolo area; it generally had a shareholding in its sub-suppliers. Welko has its head-office in Milan and several factories in Sassuolo; all work is carried out internally and it buys in only some non-standardised components. All these firms have significant internal research and development activity, and, in the case of Sacmi, this is partly linked to some joint projects together with public research centres in Italy.

In general, the growth of machine producing firms has taken place within the Sassuolo district. This has also been the case with the biggest producers located outside the district, who have increased their production within the district either directly, by opening new establishments, or indirectly, by increasing the volume of output subcontracted to firms of the district. It should be noted that hitherto in Italy policy measures to stimulate de-location of production have not worked. Public incentives for new investments in the South of Italy were not effective because, in the case of machine producers, the necessary pre-conditions for production processes based on mechanical

[18] Though the world market in the ceramics plant sector is in rapid expansion, all of the plant firms are trying to produce technologies for the bathroom sector where a higher growth rate is predicted, even if the processes of moulding, firing and transporting are still difficult to standardize because the variety of forms for each series of bathroom suite requires a particular kind of modelling and involves internal transport techniques which are not yet very automated. The only foreign competitors are the German ceramics plant producers who now exclusively produce plant for bathroom suites; this is the case of Dorst, which from the Fifties onwards had already been an important producer of presses, but which now produces very little for the ceramic tile sector.

expertise are not strong enough to stimulate the growth of tile machine firms organised like those in the Sassuolo area. However, a limited de-location has taken place towards an albeit small tile development pole in the Modenese lowlands, at a distance of forty kilometres to the North of Sassuolo. However, there does not appear to be a critical mass sufficient to create an alternative pole of services in that area.[20] It is worth noting that even an operation such as die maintenance, which is one of the maintenance activities regularly carried out as a function of normal wear and tear, does not seem able to locate near the tile firms even abroad. It is sufficient to recall that in 1994 the turnover from sales of presses abroad was 240 billion lire and that for the maintenance of presses abroad the turnover was 130 billion lire. Neither has Germany seen the development of die maintenance activity, which continues to be carried out in Sassuolo. In Spain, too, a big market for Italian machine producers, non-routine maintenance is entrusted to the Italian producers who supplied the plant.

The critical mass, the way of working, the convenience of having personnel on hand who instantly understand the nature of the problem continue to have a decisive influence on the location of machine producers in the district. For these machine producers, in fact, what matters is a dual contact: that with ceramic tile firms – the users of their machines who, despite the growing importance of many other producers abroad, still remain the focal centre in the generation of new fashions in the tile market – and that with the mechanical and electro-mechanical firms supplying them with particular components and intermediate processes. However, the economic importance of that dual contact cannot be interpreted only in terms of lower transaction costs, but should also be considered in the social and institutional environment in which those interrelationships take place.

The mechanical firms of the Sassuolo district have in fact a crucial role in enhancing a general process of innovation and then in the process of quantitative and qualitative development of the tile industry at world level. The location of the machine producers within the district is largely explainable in terms of the history of the development of this activity in response to the increasing demand for machines within the district and in terms of the more general advantages they now derive from recurrent relationships, not

[19] E.g.: the terms of payment generally offered by Sacmi are 24 months, whereas the competing firms may sustain at most 18 months.

[20] It should be noted that transport costs are not such as to encourage a growth of machine producers outside the territory of the industrial district. For example, in the case of sales directed to China, a country where it is predicted that there will be a heavy expansion in demand for ceramic tile plants in the coming years, the cost of sea transport, based on the Cif rates, has only a 5-6% impact on the total cost of the plant. In such a case, provided that no import barriers are set up, it is not economical to produce in China. Also, at present, the demand for plants comes from the South of this country. In the future, for any export to the North of the country the transport costs would be the same as those from Italy.

only with their clients but also with their suppliers, which are located in the district and in the central area of Emilia Romagna. These advantages are such that even the biggest producers located outside the district, who could resort to subcontractors located in other areas with significant agglomerations of metalworking firms (like Lombardy or Piedmont), are trying to increase their presence within the district.

The case we are considering cannot be schematised in terms of an industrial structure with several leading firms, their network of subcontractors, and other small marginal producers. Here we have a production system in which the recurrent interrelationships between firms are based not only on the exchange of goods and services, but also on an inter-firm, multilevel, cross-fertilization of ideas. All this provides locational advantages in terms of lower transaction costs. However, the analytical benchmark in considering the emergence of innovations is not so much a transaction cost model, as one that focuses on the inter-firm relationships within the production system. What we want to highlight here is that these interactions lead to an overall return which is higher than we might have supposed if the firms were merely aggregated on the basis of their individual physical capitals and of their technical and organisational competences[21]. The overall return we wish to highlight here is not so much the global physical output realised within the production system. It refers, rather, to the innovative output that might be generated by the system.

3. Research methodology

In order to reach a deeper understanding of innovation theory, the empirical research must provide elements to focus on three main issues:

- to provide a formal description of the structure of the agents/artifacts space, as well as the dynamics of changes within this structure;
- to define the concept of "network of competence";
- to tackle the problem of measuring generativeness potential in a relationship between agents.

This section presents the main methodological frame of the research with regard to: the ethnographical method (section 3.1); the definition of the agent/artifact space focused in the investigation (section 3.2); the themes of the interviews (section 3.3).

With regard to the main methodological frame of the research, section 3.1 presents the ethnographic method; section 3.2 singles out the agent/artifact space focused in the empirical research; section 3.3 discusses the general frame adopted in the interviews.

[21] For a discussion of the systemic nature of the industrial district cf. Becattini (1991).

3.1 Ethnographic method and grounded theory of innovation

In this research I consider that: innovation assumes many different guises; there are a multiplicity of agents which interact among themselves; there are differences in technical complexity, target markets, the international competition and these differences all shape the agent/artifact space and influence the rate and the direction of the innovative process. These elements may well seem self-evident: for instance, the idea that innovation assumes many forms is implicit in the now widely accepted idea that knowledge is only partially codified. However, when we consider how to analyse tacit knowledge we discover that, as a rule, experts treat this component as a residual. Empirical enquiry thus poses interesting problems as to how we obtain, classify and analyse our quantitative and qualitative information on innovation processes.

To tackle such problems it is necessary, first and foremost, to construct the relational data base necessary to describe and interpret the social processes which have led to innovation. Hence we need to analyze not only the agent characteristics, but also the history of interactions between those agents: it is thus necessary to reconstruct the social, technical and economic processes within which the dynamics of change in the agent and artifact space – brought about by the innovations taken under consideration – can be described and interpreted.

In this ambit, the methods of enquiry traditionally used by economists in empirical studies on innovation do not offer an adequate range of research tools. One type of analysis I adopt in the empirical research is that put forward by ethnographers who, making use of open question interviews, portray both subjects and artifacts in the socio-economic environment in which they operate. In such studies, the social, economic and institutional environment in which agents and artifacts interact to produce change – that is, empirical reality – is observed from an internal perspective, in other words from the cultural point of view of the persons interviewed[22]. Every effort is made on the part of the researchers to avoid imposing their own conceptual categories in an attempt to "view the world through the eyes of the interviewees". If the objective of the research is an understanding of innovation as a series of changes both on the cognitive as well as structural level, an ethnographic analysis can help in defining an enquiry method to understand how the actors in the innovation process perceive and categorize reality.

[22] One helpful reference for setting up this enquiry method is work done by Spradley (1979) who outlines a methodology for ethnographic research: it ranges from how to decide on who to interview to specifying the various phases of data collection and the elaboration of relevant information. For a discussion of the use of the ethnographic method in analyzing *situated actions* (in which the context the action develops in is modified by that action) see Suchman (1987). A wide overview on the characteristics of the ethnographic method is presented by the challenging new first chapter of the second edition of Agar's *Professional Stranger* (1996). Edwards and Lampert (1993) offer useful insights for interview transcription.

Such a method enables us to perform a historical analysis of the interactions which constitute the relationships between the agents who initiated the innovation process.

Note that an ethnographic analysis must utilize different types of data from several sources so as to have a "massive over-determination of pattern", without which it would be impossible to construct and interconnect the multiple «frames» (understood as «knowledge structures») needed for the analysis and interpretation of the phenomena of study. For, as Agar (1993) reminds us, ethnography is not merely description, but also analysis and interpretation. The ethnographic method thus entails a multiplicity of data sources and the use of first-hand sources, which involves entering into relationship with who is being studied, participating in what they do, and observing what happens. Doing this from scratch is very hard work and I choose to focus on the tile district because my previous research has provided many background analyses and has allowed me to contact many relevant actors in the district. Moreover, my research assistant Gianluca Masci has helped me in finding tips and personal contacts very useful for the research[23].

Sometimes interviews were only partly recorded because it was firstly necessary to obtain the confidence of the interviewee, or because the final part of the conversation was made standing up close to the door or visiting the plant. Around 55 hours of conversation were recorded during 25 different sittings[24]. After a preliminary literal transcription of the recorded interviews (made by 5 persons)[25], I listened to the tapes again to revise and corrected the transcription. These revisions were necessary in order to give greater definition to themes developed in later questioning. But they were also necessary in order to verify that in the literal transcriptions of the interviews the punctuation had not altered the sense of the written text in respect of the spoken original[26]. The revised texts are printed, while the original transcriptions are stored in

[23] In the initial stage of the research, Masci came to ask for a thesis and I rejected the idea of allowing him to work on this new project: it was opening up many fascinating research fields, but the adventure was too risky for a student's thesis. He insisted with polite firmness and, after a couple of months in which I let him work on a related topic, I finally accepted his request: only after that did I realize that he was born within a tile firm, so to speak, and knows "what is in the air". Not in the sense that he had a deep knowledge of the issues examined in the research, but he still lives in the tile district and is immersed in a network of personal relations centred on the district, where his friends and relatives live and work (some of them have offered generous help in providing tips useful for the research). On a couple of occasions, during the interviews, I had to contrast Masci's strong involvement and curiosity in what we were discovering, but – apart from his contributions on the extraction of the patents data set and on the revisions of the data set on groups in the ceramics machine industry – his participating perspective was exactly what I needed in the ethnographic research. The importance of participating observation is a theme familiar to ethnographers and acutely reviewed by Agar (1996, pp. 35-38).

[24] Annex A lists the detailed information on the 22 interviews (date, duration, people interviewed, their position in the firm, etc.).

[25] Two-thirds of the tapes have been already transcribed and the rest will be ready by next September.

[26] For a couple of interviews (SCE and SRS) I have both an original version, with the literal transcription, and my revised version. In these case, the original texts might be used to further an

word text files. The preliminary texts are an important part of the ethnographic work, as regards both method and ethical level. Processing the material collected in the interviews brought out some unexpected elements – what ethnographers call "rich points" – which became crucial in focusing our understanding of both the context in which the innovations emerge and the working hypotheses.

3.2 Themes discussed in the interviews: the general frame

In the interviews, several themes are approached via «descriptive», «structural» and «contrast» questions in order to delineate the cultural context of the interviewees as they themselves perceive it (Spradley, 1979). The «descriptive» questions ask the interviewees to describe people, artifacts, situations and experiences which they have had directly or observed. Such questions are helpful to our research in contextualizing the interviewees' personal and professional history inside the firms where they have worked. In these descriptions reference is made to people and artifacts for which it is necessary to specify the attributions assigned them by the interviewees. The description requires temporal and spatial rigour (when, in what sequence, where?). The «structural» questions are more technical than those above and require the interviewees to specify technical and conceptual aspects which enable us to understand the meaning of the terms they use. In general, the structural questions are designed to focus on technical and economic aspects of the artifacts discussed, but also on aspects of the relationships between agents and artifacts which are mentioned in the descriptive part. These questions help to define the identity of the agents and the «attributions» that they assign to themselves, to other agents, and to the artifacts that populate their technical, economic and social space. The «contrast» questions are designed to highlight possible differences in the use of certain conceptual categories or expressions: they help to clarify the meaning of the terms used – that is, the meaning of both technical terms, but also of the picture that emerges from the way the interviewee represents the agent and artifact space.

analysis of linguistic type that – as Edwards and Lampert (1993) illustrate – must take account of pauses, intonation, exclamations, background noise, etc., but this is really far beyond the scope of the present research; there still remains a curiosity produced by one very zealous transcriber that I have preserved. In general, the texts still maintain the original linguistic flavour of the interviews, but, in revising them, my aim has been to produce texts that can be used to focus on the main issues of the research. For example, it might happen that during the interview I occasionally repeat the answer: to be sure that I have grasped the point under discussion, or simply to take time to think or to write down my notes. In the revised texts I have eliminated this kind of repetitions, unless they were generated by previous misunderstandings or in the cases in which they generated answers on different issues. Even the linguistic style has been changed in all the cases where the literal transcription made the reading of the texts very ponderous. In any case, the personality, cultural level, relative position of the interviewees – but also my strength and weakness in posing questions or my caution in introducing some topics – differ in the various interviews: all these idiosyncrasies might be caught in the written texts.

By addressing these issues – to delineate the cultural context of the interviewees – I intend to focus on the theoretical model to which the interviewee refers in defining innovative practice and production practice. Although the interplay between production and innovative practice has been given a central position in discussions of the innovation process over the last thirty years, the divergence between the theoretical model and innovative practice still remains a critical point in empirical research on innovation. In general, such enquiries are based on a hypothesis, never made explicit, that the interviewee shares the model as well as the terminology of the interviewer[27]: actually such a hypothesis often influences the chances of defining the context in which agents operate[28]. To avoid this trap, we need to practise a finding of social network analysis, now generally recognized, according to which a single agent is not, as such, in a position to interpret the structure which emerges from the pattern of recurrent relationships with other agents. The outside observer must, however, be able to collect data from the internal viewpoint of the agents and their interrelations, but he/she must also decide which of the many coherent interpretations is the one to be recounted[29].

Provided with the elements to characterize the cultural context, in the interviews I have tried to identify the process by means of which innovations come about. In this respect I have looked for: a complete description of the innovation process of at least two innovations; and a complete description of the production process of at least one product. This information – relative to a time span that has been defined case by case – helps in outlining a qualitative and quantitative description of the streams of interactions between agents and artifacts, involved in such processes, which gave rise to the innovations under examination and to those which typify "normal" production practice. From a careful analysis of these two processes that it is possible to highlight, on the one hand, the perception on the part of agents of the environment in which they operate and, on the other hand, the changes in the agent/artifact space brought about by such interaction streams.

Initially, I intended to collect a complete analogous frame for each of the sub-suppliers of each focal firm, but this takes a long time and this level of accuracy in data collection is not crucial for this research.

3.3 The agent/artifact space: how to cut into a seamless web?

One critical problem of the empirical research has been the delimitation of the agent/artifact space on which I had to focus my investigation in order to collect

[27] [References and comments on Istat-innovation survey and IDEA-project.]

[28] This point emerges in my previous empirical research (cf. Russo, 1996a) and in Cattani's interviews (1996).

[29] [More has been developed on this point in the notes on the interviews, see also Lane's notes, last May]

information for a formal description of the streams of interactions generating innovations. Having defined the general area of the empirical research, *i.e.* some innovations in the tile production, I first decided to focus on some main features of the ceramics machine industry reproduced in figure 18 that highlights the role of different vertical relations based on exclusive contracts, ownership relations or relationships internal to a vertically integrated company.

In the initial project I wanted to examine three types of ceramics machine firms, differing in terms of the specialization of the company within a particular market segment: firms which sell complete plant; producers who specialize in single machinery or equipment; producers of components or equipment for single machines. From background research it emerged that the three kinds of firms behave differently in the innovation process because: a) their linkages both with the end-user market and with the intermediate goods market are different, b) their organizational structures are different, and c) although they operate in the same institutional environment, they have different forms of access to, or benefit in different ways from, the opportunities (or constraints) which prevail in this environment. Given the limited resources available in the research, I discarded the idea of an in-depth comparative analysis of the firms directly operating in the complete plant market, and I decided to pick up a couple of firms belonging to each of the four vertical models described in figure 18 and for each of the two sets of producers grouped in the ovals and rectangles, symbolising, respectively, the producers of individual type of machines and the producers of non-standard components. But even that was too big a space for the empirical investigation.

Let us zoom on these two groups of firms, as shown in figure 19. On the top, the phases of the production process of ceramic tiles are listed horizontally and for, each box, the number in italics corresponds to the relative share of sales, in 1995[30], for the machines destined for each phase. In the middle of the figure, the oval symbolizing the producers of individual types of machines has been partitioned in vertical sections corresponding to families of machines (and in some cases also the relative share of sales is indicated); horizontal lines delimit groups of machines related to various stages of the production process, such as “movement and warehousing plant” or “purification plant”. The lines that partition the machines set are not straight, nor the boxes indicating the main groups of machines are strictly contained in each partition: if we consider companies’ specializations we do indeed find cases in which firms produce machines for more than one stage of the production process (contiguous stages, generally).

Now the zoom can help in explaining my choice on the production of “decoration and glazing plant” (marked in the figure with a grey background). Of the five main

groups of machines[31], two account for a larger share: "pressing" and "drying and firing", respectively 18,5 and 26,7 per cent of sales. But I discarded these two groups because are controlled by a few companies; in particular, firms operating directly in this specialization are Sacmi and Siti, so this choice would have driven me back to considering directly the biggest firms[32]. In a preliminary stage of the research I had collected information on the machines for "preparation of raw materials for the mixture to be pressed" discovering that, even though the emergence of an interesting innovation could be investigated ("the continuous mill"), the number of agents involved was really too limited. The stage of "selection, packaging and palletizing" had a wider number of agents, but no impressive innovations to investigate. Finally, the stage I have chosen, "glazing, screen-printing and decorating plant", presents a larger number of firms located within the tile district, some large (over 200 employees, even if also producing other types of machines) and several medium and small firms. This dimensional variety has provided opportunities for investigating differences in internal organization and in vertical and horizontal relations among firms.

In the lower part of figure 19 a large rectangle encloses many boxes indicating the many specializations of a hundred firms[33] producing non-standard components for the machines belonging to the group considered (a grey line links the large rectangle to the grey box above). Even in this case there are borderline specializations (e.g. "plastic die-stamping", "zincing" or "electrical components"), but – as will be discussed later – in general sub-supplier specializations are dedicated to the ceramics machine set. At the bottom of figure 19, a large flat oval reminds us of an indefinite group of standard components and parts produced by firms of different size, located outside the tile district that often have their specialized retailer in the area (sometimes in Modena itself).

Figure 19 is a work-in-progress of a first elaboration of the interviews, but at the present stage of the research it seems a quite satisfying representation of a background agent/artifact space within which to single out the one to be investigated in the empirical research. After a preliminary set of meetings with the representative of the producers association and with experts in ceramic tile technology, I decide to focus the empirical investigation starting from two firms producing decorating machines: TSC and System,

[30] [1997 data will be used when data in figure 18 will be up-to-dated.]

[31] I have not found data on the "glaze preparation" that I have included in the group "glazing, screen printing and decoration". [This point must be checked and corrected, if necessary, in figure 19 and in the related table; see Acimac]

[32] In this case they would have been considered with regard to their internal production and not with reference to their operating in the complete plant market.

[33] Official data on the number of firms specialized in the production of non-standard components are not available. This rough estimate is based on the interviews but will be made more accurate when the interviews will be fully elaborated.

both located in the tile district, whose sales in 1998 were respectively 20 and 100 billion lire in this market niche[34].

The empirical investigation has provided data to amplify both the technical and the economic spectrum of the debate as well as accounts of the types of agents involved in the innovation process. It has been necessary to interview several persons (owners, technicians, workers) within the firms under investigation and, in the course of the interviews, other agents have been identified who have had a hand in the innovation process.

4. Main results so far emerging from the interviews

With regard to both the methodological issues and the theoretical perspective, section 4 summarizes the main results so far emerging from the analysis of the interviews already conducted. Section 4.1 illustrates the rich points emerging in the interviews and points out the main theoretical issues under investigation; section 4.2 presents a way of summarizing some information on the agent/artifact space

4.1 The interviews so far conducted: the emergence of reach points

The interviews were made in four periods: May-June, October-December, in 1998, January-March and May-July in 1999. Each period corresponds to a specific focus of the research.

The first group of interviews allowed a preliminary investigation on two focal firms (TSC and System) and on background information on two topics: the technical links among producers specialized in the production of machines for the tile industry and for the sanitary industry (Garoll) and an in-depth inquiry on "kervit"[35]. This first group of interviews allowed the setting of the stage of both the ethnographic method and the collection of other sources of information. In particular, for each of the firms mentioned

[34] Leader in this market, System is followed at a big distance by Omis, with only 30 billion lire of sales in 1998, immediately followed by TSC. I discarded Omis from the group of focal firms because – just when I was starting to contact firms for interviews – I received a call from an old university friend: as financial director of Omis, he was proposing a sweeping change in the innovation program of the firm and was calling me for advice. His proposal was really intriguing because it could help me in looking inside a firm during a process of change, but that position would also have shut all the doors of the other firms under investigation. This is why I refused to be involved in that program and did not contact Omis for this investigation.

[35] Kervit is a very innovative technology to produce tiles that emerged in the 1940s and went out of use after two decades of successful use on an industrial scale. Kervit technology was abandoned even though several basic characteristics featured in its processes became standard in subsequent decades. The case study on kervit is presented in a companion paper focusing on complementarities, cf. Russo (1999). In reconstructing the events that took place between the 1920s and the 1960s, I have been able to draw on the first-hand experience of Antonino Dal Borgo, the kervit inventor, whose readiness to co-operate enabled me to compile a large part of the documentation needed for this case study. Around 8 hours of conversation were recorded during four different sittings. The several other sources examined (technical articles, interviews with technicians) are cited in the kervit-paper.

in every interview, where relevant interrelations are mentioned (of technical, economic or personal nature), I have collected the information registered in the Chamber of Commerce Register[36], and the patents registered[37].

Starting from the information collected in these interviews, I was able to set up a second group of interviews devoted to investigating the interrelationships among one of the focal firms (TSC) and some of its sub-suppliers (Mitor, Marchetti e Ronchi, GV-meccanica). Along these interviews, it was possible to have a second meeting with the System's "man number two", engineer Elis Maffei[38], who presented us an innovation, introduced by System in 1995 and called "Rotocolor", for decorating tiles by means of an engraved silicon cylinder reproducing images with high definition. The meeting was decisive in singling out the innovations on which to focus: after decades of improvements in the technique of mechanical serigraphy a radical shift had occurred in the techniques of decoration, from serigraphy in positive to printing in negative. There also emerged a very clear picture where the changes in the agent/artifact space seemed clearly highlighted: new agents were "created" (such as the services firms to engrave the silicon cylinder) and new functionalities were accompanied by the creation of new artifacts. Links with complementary technologies (such as laser engraving, computer graphics) and other agents (such as graphic firms) enlarged the perspective on the agent/artifact space to be investigated.

The third group of interviews, in January-March 1999, started by visiting a glazing department of a ceramic tile plant (Ricchetti group). The idea was to look at Rotocolor in action in the work place, whereas in System I had seen them in the testing department before the delivery to clients. During the visit, Paolo Cuoghi (the person in charge of the glazing lines of that plant of Ricchetti) explained to us the technical characteristics of the multitude of decorating machines and devices installed in the department: the picture I had imagined from the interview to Maffei had a big shock because Rotocolor was not so much a clear-cut alternative technology as one device adopted in combination with

[36] The "visura camerale" contains the date of registration, the locations of the various establishments of the firm, the number of employees, the societal nature of the firm, the names of the owners, and of the members of the administrative board (if any), all the changes in denomination, location, ownership, administrative board that must be registered by law.

[37] All this information was stored and elaborated in a directory of HTML files to check the missing information and to update the general framework of the research project.

[38] That meeting confirmed to me that there are no conditions for collecting information regarding System as detailed as those for TSC. Notwithstanding I had been introduced to him by a common friend, an expert in the ceramic tile technology, the contacts with Maffei were extremely difficult and several times the meeting was cancelled because he was too busy. Those difficulties had convinced me that System should not be considered as a focal firm in my investigation because I needed: interest in my research project, confidence, trust in my discretion in divulging reserved information, and time. In-depth investigation, in fact, requires time from the interviewees. But time is not only an absolute matter, it also depends on interest, confidence

many others. Almost certainly, according to System, that would not be an orthodox use of Rotocolor, but it emerged that what we saw was not an isolated case. Moreover, I discovered that Rotocolor was not the only machine for decorating tiles by printing in negative. At least a couple of alternatives were available, but the reticence of our interviewee was puzzling: he advised us that we were looking at something very "hot", a judicial action was under way, taken by System against other firms, so he did not care to tell us anything more that might be used against any of the litigating parties. I then started the interviews to firms specialized in engraving the silicon cylinders of Rotocolor (Tosi and Poligraph) and visited another ceramic tile firm (Omega), whose administrative director had told me of a new plant Omega was installing with a new decorating department. But I also went ahead interviewing other sub-suppliers of TSC (Feab and Carpiplast).

The interviews to Tosi and Poligraph highlighted another point obscured by my interpretation of the interview with Maffei: the "creation" of new agents specialized in engraving silicon cylinders. The two firms, even though with marked differences that will be discussed later, had three decades of experience in graphics for ceramic tiles and were collaborating with System, but were also in competition with System because, after four years, System was still offering something like 50 per cent of total engraving services, with all the graphics related to the start-up of a new decorating line. This mechanism of technical and economic co-operation and competition was then investigated along multiple dimensions and further focused in the other interviews as a central theme in the discussion of network dynamics and innovation dynamics.

The visit to the new glazing department of Omega added a shift to my perspective on alternative technologies in printing in negative: I had interpreted the multitude of machines installed in the Ricchetti plant as an obvious outcome of past investments that do not always replace the older machines, but might be set side by side with the older ones, especially in cases where the relative cost of new capital equipment is relatively low. Let us recall that we are considering one machine in the glazing line, and even though it is the most important machine in the whole line, it represents a very low share of the total capital equipment of a tile factory[39]. In Omega there were no Rotocolor machines, nor other machines for printing in negative – at least not at that moment, when the lawsuit was at its peak: local newspapers had in fact just published[40] a piece of

and trust. I had already decided to give up with System, but after five months of several attempts, Maffei was at last available for a meeting of no more than an hour.

[39] [Insert investment costs of the decorating machines in the glazing department and of the entire plant producing ceramic tiles, at the minimum efficient size.]

[40] The first publication date is of the 23rd January 1999. I do not know why – although the reclaimed firms were Tecno-Italia (the producer) and Emilceramica – in its article System quotes only Tecno-Italia. Emilceramica had obtained a patent (cf. EP patent n. 829 333A1), on an

news from System recalling an injunction by the Judicial Court of Modena[41]. All the machines called "Laser Roll" were put under legal seizure (judicial attachment). A few days after our visit to Omega, Tecno-Italia published its answer to the System newspaper article, explaining that in its interpretation the judicial seizure is to be referred only to those machines having a bascule doctor[42]: another injunction (dated 7 January 1999 and quoted in the article) in fact recognizes in the bascule doctor the original element characterizing the Rotocolor. That was the argument that allowed Tecno-Italia to feel confident in ensuring its clients that the use of Laser Roll machines with fixed doctor was not under legal seizure.

What a detailed story! one might think. Why should it be so important to discuss a bascule doctor – which is no more than a small metal bar fixed to a machine in only one point (so allowing it to bascule) or screwed in two points to the machine (so as to fix it) – while laser technology and computer graphics have enlarged our perspective in the analysis?

Not to worry: the doctor is a marginal difference between the two machines, not the one originating the lawsuit, but certainly the one taken by the Court as the legal device to settle the issue. In fact the social, technical and economic issue seems to be another one. On the one side, there is a machine, Rotocolor, invented by the biggest firm in the sector, System, that with 277 employees produces this machine – as well as other types of machine for tile production – almost entirely inside its own plants and also produces all the related equipment, and has also patented: laser engraving machines, silicon cylinders, and software to run all these machines. System has spent billions of Italian lire in research and development related to this invention and finally the price of Rotocolor is around 60 million lire[43].

The other machine, Laser Roll, is produced by a small mechanical firm, Tecno-Italia, that with 18 employees out-sources all the production process except the assembly stage and has produced in the last six months around 60 machines per month at the price of about 20 million lire each. The patents related to these machines are those on the cylinder and line movement synchronization (by Tecno-Italia) and that on the silicon cylinder (by Emilceramica).

invention adopted in the Laser Roll. [The involvement of Emilceramica in this innovation must be investigated further.]

[41] The date of the injunction is of one month previously, the 18th December 1998, and the official publication in newspapers had already been made, as indicated by the Court, at the charge of the plaintiff firms.

[42] "Bascule smoother".

[43] Pricing of innovative products has had the effect of allowing an increase even of the traditional serigraphic machines sold by Systems' competitors. [Insert the number of Rotocolor machines annually produced by System.]

One element of the visit to Omega must now be mentioned: seeing Tecno-Italia's machine, within the Omega department, I had the impression that the difference is not only the type of doctor; the difference that really matters is inter-changeability between the use of the machine such as a serigraphic machine decorating in positive and its use, with a silicon cylinder, for printing in negative. To some extent, the System–Tecno-Italia comparison might be summarized as a case of "leap-frogging" – well known in the literature on innovation – where the leader is jumped over by the follower who has gained from the leader's previous actions (*e.g.* in opening the new market, in setting up some complementary activities, and so on). Even within this background, it still remains to be understood what has enabled the follower to leap-frog the leader, where the former has acquired the competences needed to generate an innovation that has substantially changed the artifact's functionalities, and which changes in the agent/artifact space have been brought about by this leap-frogging.

These are the main questions addressed in the last group of interviews so far conducted. The first was with the owner of Tecno-Italia, Valdo Elmetti, who accepted to discuss at length his personal experience and the particular adventure into engraving machines. The interview enabled one to enter the stage of a couple of other agents relevant to understanding the pattern of changes in the agent/artifact space: SCE, an electronic company, contributing in a decisive way to the setting up of Laser Roll's flexibility; a small British firm producing a machine for the laser engraving of silicon cylinder; a series of specialized producers of components and, lastly, a group of graphics companies (almost the same as operating with System) able to produce the required graphics and to engrave the silicon cylinders. No reference to Emilceramica, a ceramic tile firm that many agents describe as a "mine of inventions" (and we have found several patents, in various ceramic tile technologies, obtained by this company). Its role in setting up Laser Roll seems crucial, but I still have no first-hand information to characterize its contribution: hitherto – because of the ongoing litigation – interviewees have made only elusive references to Emilceramica. Next Autumn I will contact it directly.

Having interviewed Tecno-Italia's owner, I could not omit an interview with the System's owner, Franco Stefani, a leading figure in the district for forty years now. In the interview he is, deliberately, System-centred: no reference to other agents external to System, and only very parsimonious references to agents inside System, apart from himself.

The interviews completing this last group are the following. The one with Silvio Lusuardi was a sidetrack linked with the kervit case study, but also a case in which a niche product, the "bell", invented forty years ago by Antonino Dal Borgo, is still produced only by one firm, *i.e.* by Lusuardi (who bought Dal Borgo's patent) with the

help of his wife and his son: a close team, able to keep a secret. Keeping secrecy is so important that even during the visit to the workshop we were not allowed to see some machines performing the critical operations. "Well away from indiscreet eyes" seems to be a general rule, not limited to the case of Lusuardi. Every firm we have interviewed is aware that the great availability of specific technical competences within the tile district is a crucial resource for their flexibility in the vertical disintegration of their production process, but the operations they judge strategic for their products are performed by outsiders, "well away from indiscreet eyes". In the interviews the reference to these agents was explicitly made with no other specification that could identify them.

Secrets are difficult to keep within the district and what was puzzling to me was the patent activity of some actors. Innovative activity in small businesses systems is generally described as a cumulative process of incremental innovations that come about as a result of the continual improvement of production processes[44], but in the case of the ceramic tile district the changes in production techniques were actually accompanied by a long series of patents, of which we can find traces in the data base of the European Patent Office. From the analysis of the technical content of some hundred patents extracted[45] I have found cases where firms operating in the Sassuolo-Scandiano district obtained from the US Patent Office (regarded as one of the most authoritative institutions in this field) patents on production techniques so similar as to utilize – in the technical annexes – exactly the same drawings (so identical as to carry the same numbering of the details specified)[46]. This was the reason why I decided to interview engineer Mauro Poppi, inventor of one of the "twin" patents I found. The peculiar case in question was made clear by the different technological areas in which the same artifact was patented by two actors (Poppi and engineer Francesco Albonetti), who in some way had co-operated in setting up the invention. But the analysis of the patents and the discussion on this topic in the interview enabled the formulation of a working hypothesis on patent activity within the district. It might be considered as an opportunity to apprise the technical and scientific community of the potential interest, on the part of agent who has patented, in undertaking that particular line of technical development. The patent, thus, takes on a different value from that ascribed to it in economic literature, which regards it as a legal tool – more or less effective according to the

[44] [Insert appropriate references]

[45] This research, in collaboration with Gianluca Masci, intends to analyse in a systematic way the technical areas in which the firms in the tile district have patented. To get this information, the EPO data base has been examined and all the patents referring to ceramic tile production have been extracted.

[46] Cf. patents US4888143 ("Fast tempo firing process for ceramic materials such as tiles") and US4828489 ("High speed firing method and kiln, in particular for ceramic materials such as tiles and the like")

current appropriation regime – allowing the innovator to acquire the profits accruing from the innovation. In other words, patents are one of the strategic resources through which the innovative process takes shape[47]. As regards the ceramic district, these strategies are the outcome of what the actors have learnt not only in the technical, but also in the economic, institutional and social sphere. It is as well to remember that lawsuits for undue appropriation of techniques covered by patent are very rare in the ceramic district: owing to the relative ease of "inventing around" many patented innovations, those who patent and those who copy are aware that the sphere of personal relations is more important than that of legal defence. This does not signify that considerations of friendship override the dire economic reality of company profits: as long as the market is expanding, imitation, even of patented innovations, is generally tolerated; but when the market contracts or growth slows down, the lawsuit is regarded as a feasible protection device: not so much to recover lost profits as, at least, to signal that the game has changed. Patent activity thus enters as one of artifacts shaping the agent/artifact space under investigation and, in all the interviews, information on patent activity has been collected in order to make clearer the way in which agents perform this activity.

Of the last three interviews, the one with SRS was related to the "bridging" services between System and Tecno-Italia, while the one with Poligraph was an opportunity to focus on the competences needed for laser engraving. In the meanwhile, we met Ormes Corradini, who heads an electronic company, SCE, considered a strategic resource for many firms in the district: specializing across several final user-sectors in the mechanical industry (machine tools, agricultural machines, packaging machines) both inside the district and in the Lombardy area, this company offers dedicated services not only to Tecno-Italia, but also to some leading ceramics mechanical companies of the district (such as Barbieri & Tarozzi, leader in "warehousing equipment"; Nuova Fima, leader in the niche of "machines for selecting and packaging"), and it is also sub-supplier of Emilceramica. The case of SCE helps in accounting for the peculiar interaction stream generating the set-up of Laser Roll. But the case of SCE – together with the other cases here examined of other sub-suppliers interviewed – also helps in singling out which are the conditions enabling close co-operation among firms operating in the various stages of the vertical disintegrated production process, and which are the conditions preventing co-operation between the sub-supplier and its customer from fostering competition between them or enabling this to happen.

[47] References here are to the contributions by Misa (1992), Bowker (1992) and Carlson (1992).

4.2 From silk screen to laser engraved silicon cylinder: how to summarize the agent/artifact space in tile decoration?

In a companion paper, the history of kervit and its inventor, Antonino Dal Borgo, provided the narrative device to describe my observations of how innovation comes about in a local production system. Here, I need to combine both narrative and synthetic representation to describe the joint dynamics of industries, firms and networks to which they belong. In such a description, I will refer to the vocabulary proposed by David Lane (cf. Lane and Maxfield,1997, and Lane's note, presented last May 1999[48])

At this stage of analysis of the material so far collected, I propose a very schematic representation of some results of the research. I suggest referring to the following elements, summarized in figure 20:

- *Agents*: ceramic tile firms, individual inventors, mechanical firms, graphic firms (which specialize in graphics, engraving of silicon cylinders and serigraphic screens);

  focal agents: TSC, System, Tecno-Italia

- *Artifacts*: ceramic tiles, serigraphy in positive techniques, printing in negative techniques; all the other non-decorating techniques;

  focal artifacts: Rotocolor, Laser Roll;

- *Events external* to the action of individual agents, such as: institutional changes, changes in consumer tastes or fashion, increase in the demand, economies of scale in specific types of tile products (due to technical changes: in stages of the production process different from the one focused in the present investigation, or in complementary productions)

- *Interaction streams* highlighted in figure 20 are those from which:
  - innovations emerge
  - a possible effect of an artifact, an agent, an event occurs on other artifacts, agents, events
  - licensing of patents is agreed
  - a set of "actions", contrasting or changing the previous structure of the agent/artifact space, is generated
  - a new company springs, or competences of individual technicians are originated.

Lastly, when relevant in activating further interaction streams, the failure of an artifact in fulfilling the desired functionality is highlighted in the figure.

This schema is no more than a *memorandum* that will support the narrative descriptions of the changes in the agent/artifact spaces: only the most relevant

[48] [Expand the references to Lane's note]

interaction streams are reproduced in the figure; moreover, the different levels at which interaction streams occur are only roughly depicted (*e.g.* individual technicians vs. the company in which they operate, or the individual graphics companies vs. the "cartel"-level characterizing some of their actions; or the interplay of events " external" to the space we consider and interaction events internal to that space). The scheme is a work-in-progress but so far has been a useful exercise, forcing a clearer definition of the elements required to confer narrative on "narrative logic". It could be interesting to compare the schema I prepared for the Venice meeting, last January, with the one presented in this draft. At a glance, the main difference is that the number of relevant agents involved has greatly increased, and this has been accompanied by a better definition of the research focus. But differences among the two schemas are not merely a matter of greater accuracy due to the use of several sources of data: the critical interpretation of the relevant interaction streams has in fact changed. In January I thought that the deadline of the rocket patent could provide a coherent interpretation of the interaction streams leading to the emergence of Rotocolor. But, although all the agents refer to rocket as a patented innovation, in the interview Stefani said that this machine was never patented. System maintained a monopoly in this market niche only until an increase in demand for the rotatory glazing machines stimulated many other companies to explore alternative solutions. Following these changes, some agents were able to compete on the new technology introduced by System (such as Tecno-Italia) because in that experience they had acquired the relevant competences in decorating techniques. According to Stefani, System decided to focus on printing in negative because "by-gone is by-gone" and he never turns back to improve past artifacts.

Just few comments offering a key to read the picture.

The left side of figure 20 reminds us of the temporal dimension of the changes examined: time starts from the very beginning, in 1953 when only a few ceramic tile companies were operating in the district, and stops in 1999. Marked by an equal height, since 1990 the space assigned to the various years is represented in an expanded size, so as to allow us a zoom into the most recent decade.

The boxes regarding agents and innovative artifacts are located in the time dimension: the top of each box starts in the year in which the company was set up[49], or the innovative artifact emerges as a patent, or as a commercial good. The size of the boxes varies according to the length of the text written inside. All the other boxes are broadly located in the time dimension with no date indicated inside, to mark phenomena that emerge at varying degrees of intensity, according to the different perceptions of the agents. The interaction streams are only roughly depicted in their temporal dimension:

one would need a greater zooming at the more micro level of the investigation – not represented in the schema but crucial in our interpretation.

In a companion paper I am developing the interpretation of the changes in the agent/artifact space, schematized in figure 20, whose full exploitation requires both complete revisions of the interview texts and a wider discussion of the vocabulary and the framework adopted in the research.

[49] When relevant, the expiry date is indicated.

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List of tables and figures

Table 1 Elaboration to comment on growth 1958-1997.
Firms, employees, production, exports and product per employee: absolute values and mean annual variations in the four sub-periods (1958-1966; 1967-1976; 1977-1986; 1987-1997)

Years	Firms	Employees	Output (millions sqm)	Export (millions sqm)	Output per employee (sqm)	firms	emplo-yees	output	export	output per employee	
						MEAN ANNUAL VARIATIONS IN THE FOUR SUB-PERIODS					
1958	62	9.700	21,900	0,374	2.258						*phase I* 1958-1966
1959	67	10.100	27,500	0,720	2.723						
1960	55	8.906	37,800	1,320	4.244						
1961	79	12.250	47,200	3,066	3.853						
1962	115	14.000	51,600	3,709	3.686	11,0	6,8	20,8	67,5	15,1	crescita moderata
1963	84	13.619	36,300	3,883	2.665						
1964	111	14.669	34,600	5,525	2.359						
1965	111	14.450	58,000	7,767	4.014						
1966	115	15.450	78,900	17,349	5.107						
1967	148	19.160	97,100	19,308	5.068						*phase II* 1967-1976
1968	179	20.950	107,700	22,720	5.141						
1969	221	23.500	139,200	28,443	5.923						
1970	316	30.550	150,000	35,763	4.910	16,8	12,4	13,4	19,5	1,3	crescita quantitativa
1971	405	36.000	178,000	38,618	4.944						
1972	413	36.500	181,000	50,860	4.959						Aumentano: molto sia le imprese che gli addetti
1973	432	38.000	214,800	67,590	5.653						
1974	465	44.823	230,100	73,735	5.134						
1975	485	46.115	191,600	59,931	4.155						
1976	509	48.115	255,600	91,417	5.312						
1977	500	45.760	263,970	115,444	5.769						*phase III* 1977-1986
1978	470	43.650	273,743	134,598	6.271						
1979	470	44.650	291,000	157,135	6.517						crescita qualitativa
1980	470	45.880	355,568	149,443	7.750						
1981	468	43.642	339,031	143,266	7.768	-3,4	-4,8	2,9	6,4	8,0	Diminuiscono: imprese, addetti
1982	433	40.708	323,228	138,132	7.940						
1983	413	37.731	310,000	156,783	8.216						Aumentano: produttività produzione, esportazioni
1984	382	34.469	334,932	174,280	9.717						
1985	362	31.886	311,100	157,600	9.757						
1986	360	29.303	328,989	160,210	11.227						
1987	355	29.402	350,000	165,000	11.904						*phase IV* 1987-1997
1988	352	30.274	385,896	195,960	12.747						
1989	355	30.881	434,011	216,359	14.054						
1990	347	31.488	446,697	216,918	14.186						
1991	351	30.848	432,436	217,270	14.018						aumento della concorrenza sui mercati esteri
1992	347	30.271	434,649	232,881	14.359	-1,2	0,7	5,3	8,6	4,5	
1993	343	29.774	458,666	276,731	15.405						
1994	345	30.778	510,229	324,917	16.578						
1995	340	32.386	562,207	361,429	17.360						Aumentano: produzione, export produttività
1996	320	31.507	554,483	363,287	17.599						
1997	315	31.487	572,241	389,060	18.174						

Table 2 Total turnover and exports in the main mechanical equipment sectors, 1991-1997
(Source: our elaboration of data from Interceramica and Acimac)

	TOTAL TURNOVER							Percentage change of total turnover						Share of export out of total turnover						
	miliardi di lire correnti																			
	1991	1992	1993	1994	1995	1996	1997	92/91	93/92	94/93	95/94	96/95	97/96	1991	1992	1993	1994	1995	1996	1997
Macchine per ceramica	1.740	2.069	2.631	2.995	3.237	3.111	2.673	18,9	27,2	13,8	8,1	-3,9	-14,1	63,9	65,2	71,2	68,2	65,8	72,2	71,3
Macchine per lavorazione legno	1.856	1.800	1.928	2.335	2.905	2.700	2.889	-3,0	7,1	21,1	24,4	-7,1	7,0	69,0	68,8	76,3	79,2	77,8	81,4	81,3
Macchine per l'industria grafica	1.680	1.630	1.830	1.930	2.360	2.440	2.590	-3,0	12,3	5,5	22,3	3,4	6,1	59,6	61,2	71,2	74,3	76,7	75	78,3
Macchinario per l'industria tessile	4.094	4.250	4.618	5.310	6.600	6.900	7.170	3,8	8,7	15,0	24,3	4,5	3,9	57,9	62,8	74,2	65	65,1	67,3	67,0
Meccanica varia	36.800	36.800	35.250	36.395	41.272	42.510	51.977	0,0	-4,2	3,2	13,4	3,0	22,3	53,2	55,4	38,7	40,4	42,5	44	46,3
Macchine per materie plastiche e gomma	3.300	3.200	3.300	4.000	5.100	5.550	5.950	-3,0	3,1	21,2	27,5	8,8	7,2	51,3	52,4	65,7	67,7	68,6	66,6	66,8
Macchine per calzature e pelletteria	785	791	920	1.050	1.500	1.410	1.670	0,8	16,3	14,1	42,9	-6,0	18,4	52,8	56,1	59,7	59,5	60,8	58,8	60,4
Macchine per confezionamento e imballaggio	2.480	2.550	2.870	3.160	3.800	4.300	4.500	2,8	12,5	10,1	20,3	13,2	4,7	68,5	69,2	81,8	84,1	85,6	83,7	85,2
Macchine utensili lavorazione metallo e automazione	4.305	3.810	3.560	4.135	5.820	6.310	6.398	-11,5	-6,6	16,2	40,7	8,4	1,4	46,8	49,8	60,5	57,6	53,8	55,3	58,2
Totale	57.040	56.900	56.907	61.310	72.594	75.231	85.817													

Composizione percentuale del fatturato

	1991	1992	1993	1994	1995	1996	1997
Macchine per ceramica	3,1	3,6	4,6	4,9	4,5	4,1	3,1
Macchine per lavorazione legno	3,3	3,2	3,4	3,8	4,0	3,6	3,4
Macchine per l'industria grafica	2,9	2,9	3,2	3,1	3,3	3,2	3,0
Macchinario per l'industria tessile	7,2	7,5	8,1	8,7	9,1	9,2	8,4
Meccanica varia	64,5	64,7	61,9	59,4	56,9	56,5	60,6
Macchine per materie plastiche e gomma	5,8	5,6	5,8	6,5	7,0	7,4	6,9
Macchine per calzature e pelletteria	1,4	1,4	1,6	1,7	2,1	1,9	1,9
Macchine per confezionamento e imballaggio	4,3	4,5	5,0	5,2	5,2	5,7	5,2
Macchine utensili lavorazione metallo e automazione	7,5	6,7	6,3	6,7	8,0	8,4	7,5
	100	100	100	100	100	100	100

Table 3
Employment, sales and degree of vertical integration of the major Italian sellers of complete plants for the ceramic tile production, 1994
(data refer both to complete plants and to machines and components sold separately)
Source: Russo et al. (1998)

firm	employment		total sales (billions It. Li		exports	what the firm produces internally or within the group	firm's subcontractors	
	direct[a]	total[b]	total	*per capita*[c]			number	type
SACMI[d]	700	1100	650	0,591		plant building and utility services design and produces: atomizers, presses, kilns, cogenerators	various	dependent
SITI[d]	370	555	316	0,569		presses, dryers, kilns	various	independent
NASSETTI[d]	250	500	254	0,508		glazing machines, serigraphic machines, selec lines	various	owned or controlled
WELKO[d]	270	270	110	0,407		everything, except standardized components	only a few	independent
Total	1590	2425	1330	0,548				
Tile machine production sector[e]		7953	2995	0,377				

[a] Number of employees directly employed within the firms of the group
[b] Number of employees directly employed by the firms of the group plus those employed by the subcontractors
[c] Total sales divided by total employment (direct plus indirect employees)
[d] Source: our interviews with firms
[e] Source: Acimac (1995)

Figure 1 Number of employees and number of companies in the ceramic tile sector in Italy, 1953-1997 (Source: Assopiastrelle)

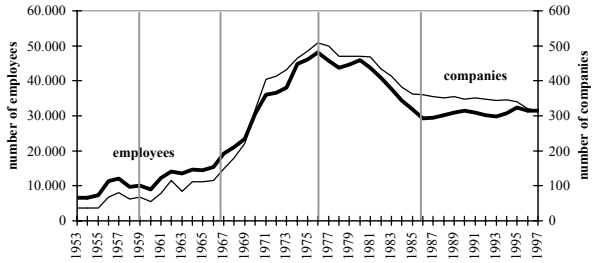


Figure 2 Total output and export in the ceramic tile sector in Italy, 1958-1997
(Source: Assopiastrelle)

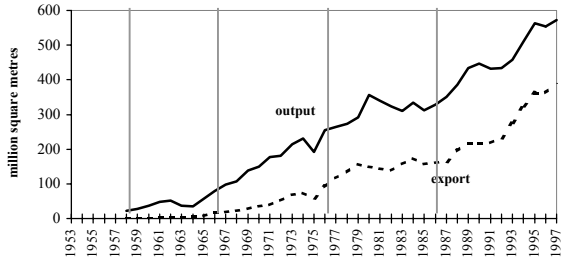


Figure 3 Output per employee in the ceramic tile sector in Italy, 1958-1997 (Source: Assopiastrelle)

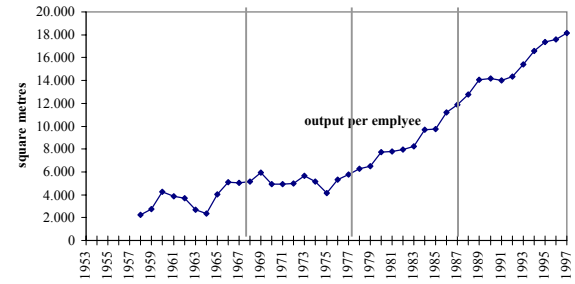


Figure 4 Ceramic tile sector: average size of the enterprises in terms of employees and annual production (in sq. m.), 1953-1997
(Source: our elaboration of Assopiastrelle data)

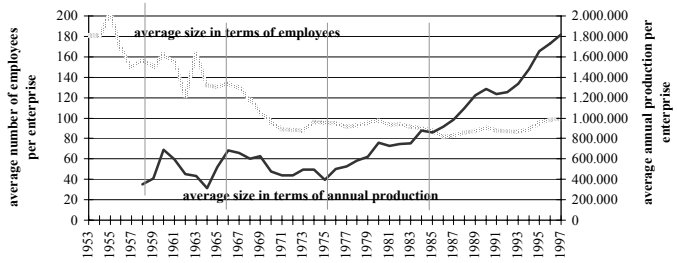


Figure 5 Output by type of product in the ceramic tile sector in Italy, 1958-1997
(Source: Assopiastrelle)

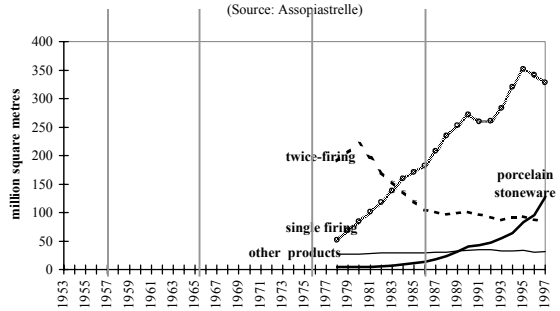


Figura 6 Local units and employees of manufacturing firms in the 8 communes of the ceramics district, 1951-1991
(Source: Istat, Censuses)

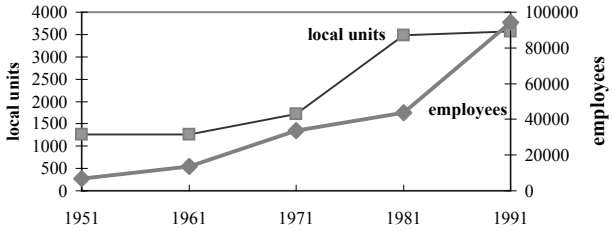


Figure 7 Local units and employees of manufacturing firms in the provinces of Modena and Reggio Emilia, 1951-1991(Source: Istat, Censuses) insert

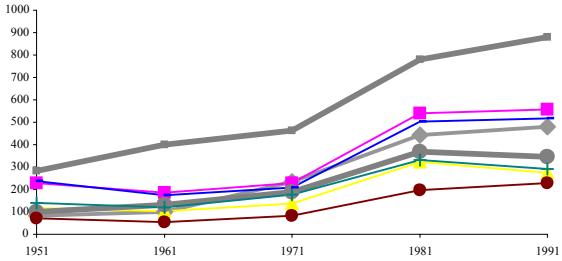


Figure 8 Local units of manufacturing firms of the communes in the ceramics district, 1951-1991
(Source: Istat, Censuses)

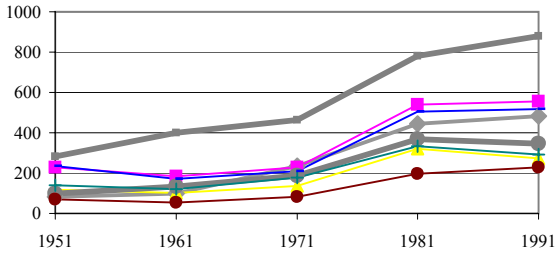


Figure 9 Employees of the local units of the manufacturing firms of the communes of the ceramics district, 1951-1991
(Source: Istat, Censuses)

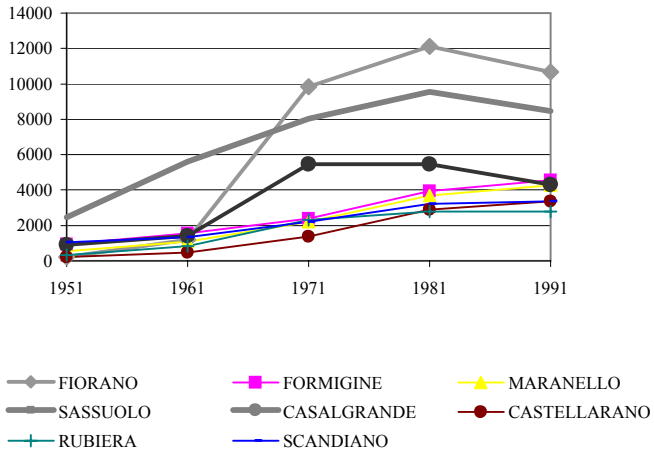


Figure 10 Local units of the manufacturing industry of the 8 communes of the ceramics district, 1951-1991 (Source: Istat, Censuses)

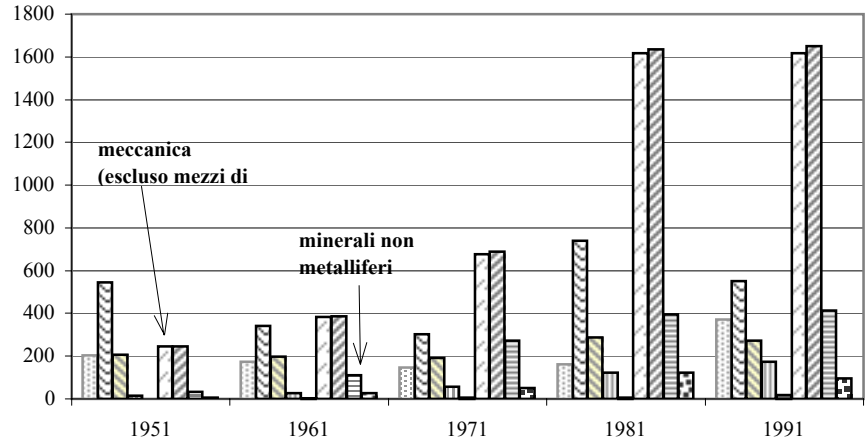
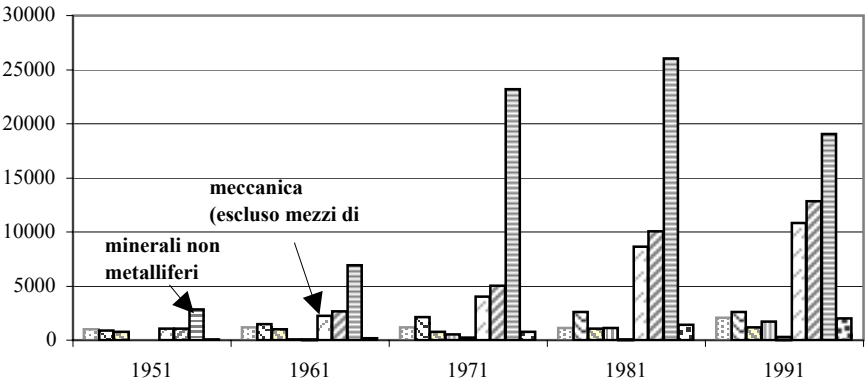


Figure11 Employees of the local units of manufacturing industry in the 8 communes of the ceramics district, 1951-1991 (Source: Istat, Censuses)



ALIMENTARE
PELLI, CUOIO E TESSILE-ABBIGLIAMI
LEGNO E MOBILI
CARTOTECNICA, EDITORIA E FOTOGI
METALLURGIA E 1a FUSIONE
MECCANICA (escluso mezzi di trasporto)*
MECCANICA (incluso mezzi di trasporto)*
MINERALI NON METALLIFERI
CHIMICA, GOMMA E PLASTICA

Figure12 Number of employees and number of companies in the ceramics machines sector in Italy, 1988-1997 (Source: Acimac)

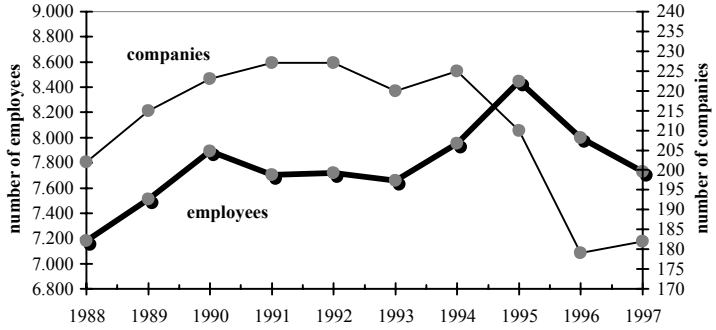


Figure 13 Total sales and exports in the ceramics machines sector in Italy, 1988-1997 (Source: Acimac)

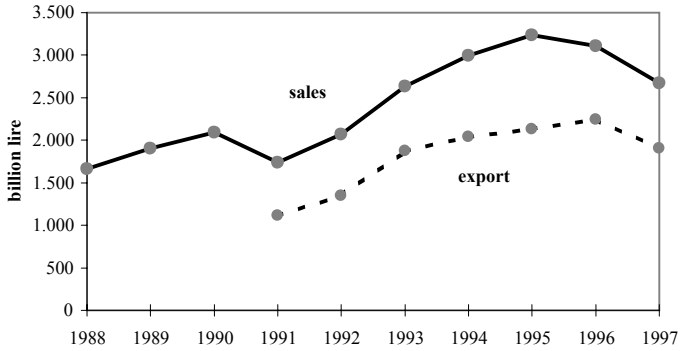


Figure 14 Turnover of the main segments of mechanical industry in Italy, 1991-1997
(Source: our elaboration of data from Interceramica-Acimac)

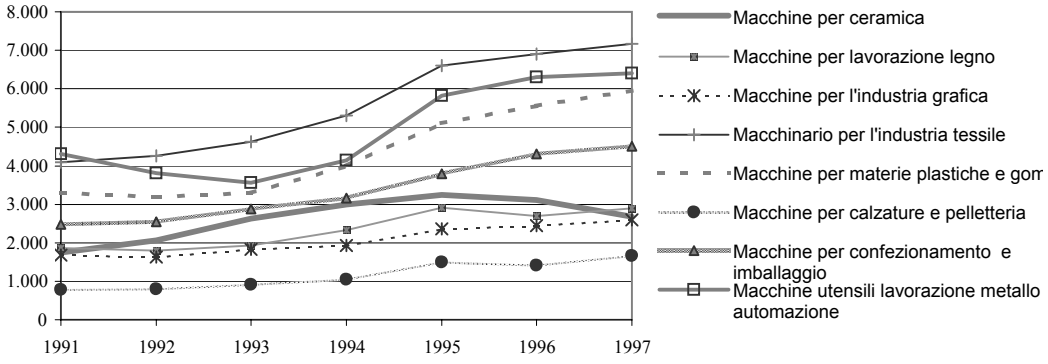


Figure 15 Share of exports over total turnover in the main segments of mechanical industry in Italy, 1991-1997 (Source: our elaboration of data from Interceramica-Acimac)

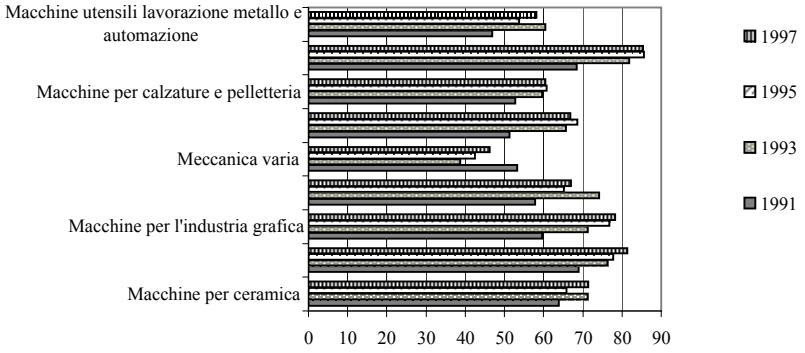


Figure 16a World production of tiles in 1990
(1,781 millions sq.m)
(Source: our elaboration of data from Prometeia-Assopiastrelle, 1998

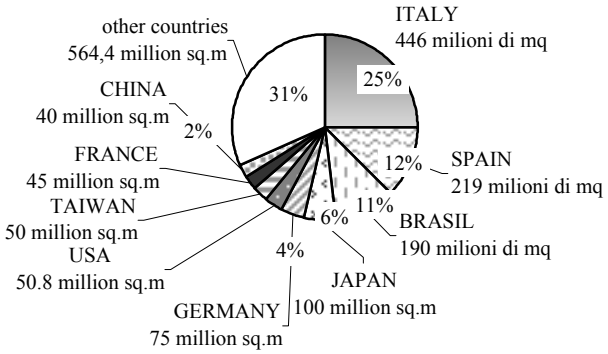


Figure 16b World production of tiles in 1997
(3,462 millions sq.m)
(Source: our elaboration of data from Prometeia-Assopiastrelle, 1998

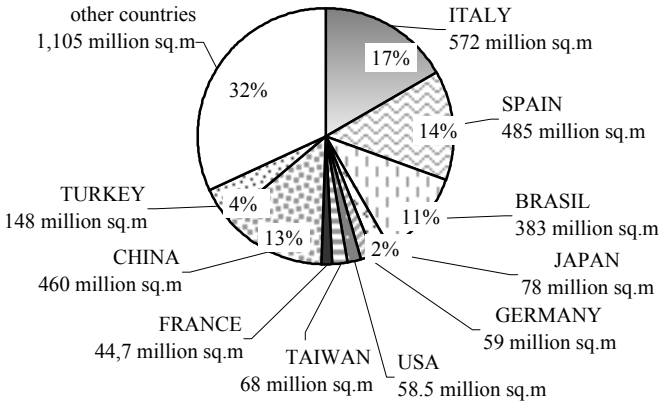


Figure 17a Production, exports, imports and domestic market for ceramic tiles in the main produce countries, 1990 (millions of sq.mt.)
(Source: our elaboration of data from Prometeia-Assopiastrelle)

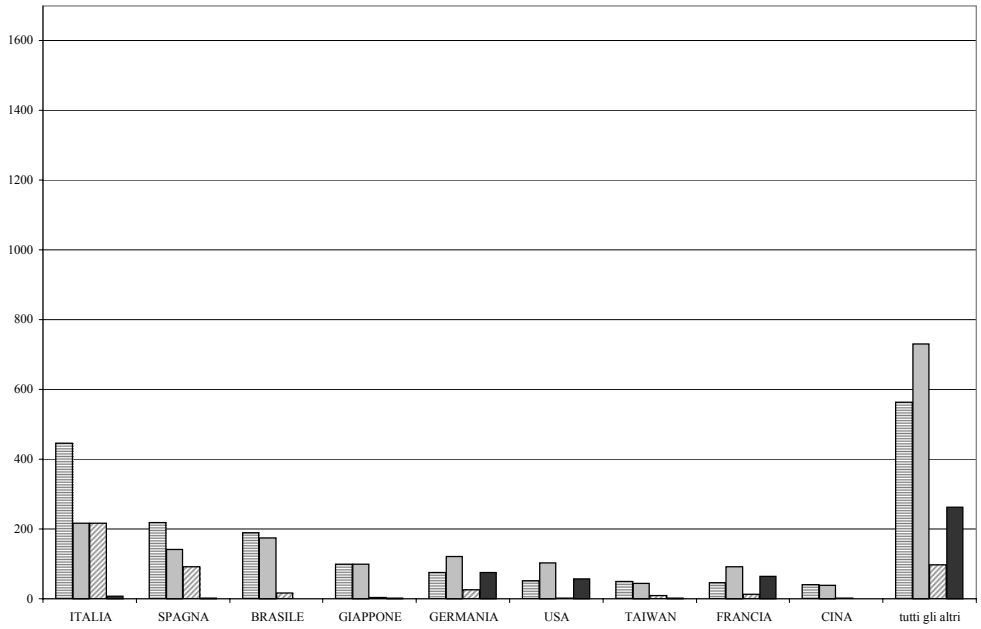


Figure 17b Production, exports, imports and domestic market for ceramic tiles in the main produce countries, 1997 (millions of sq.mt.)
(Source: our elaboration of data from Prometeia-Assopiastrelle)

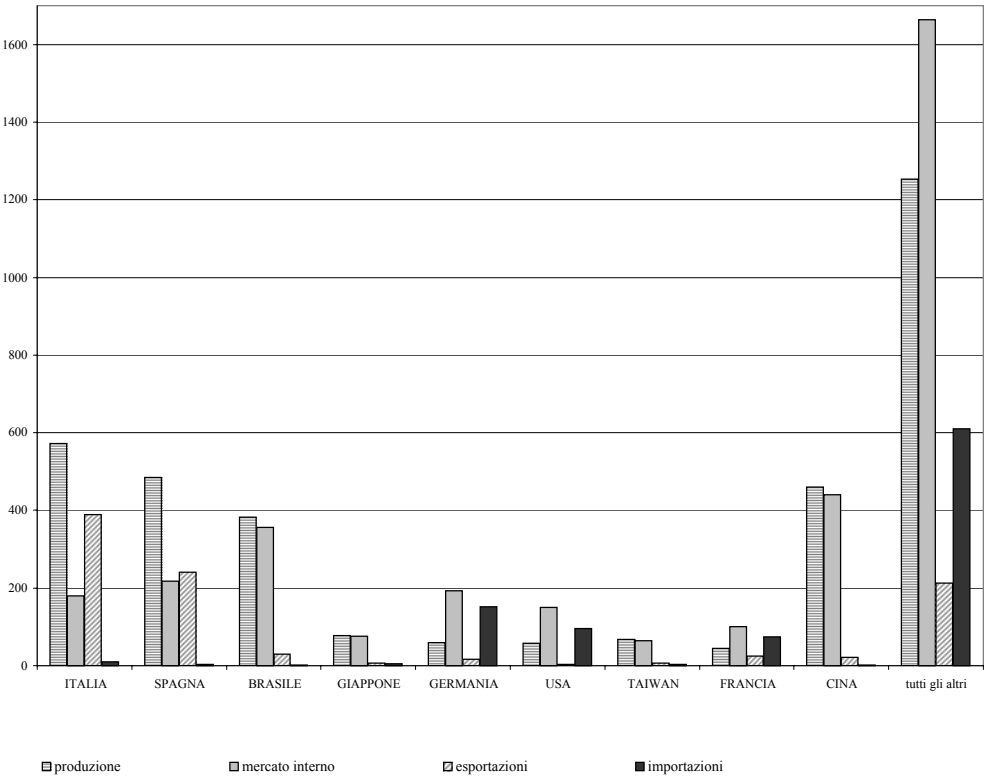
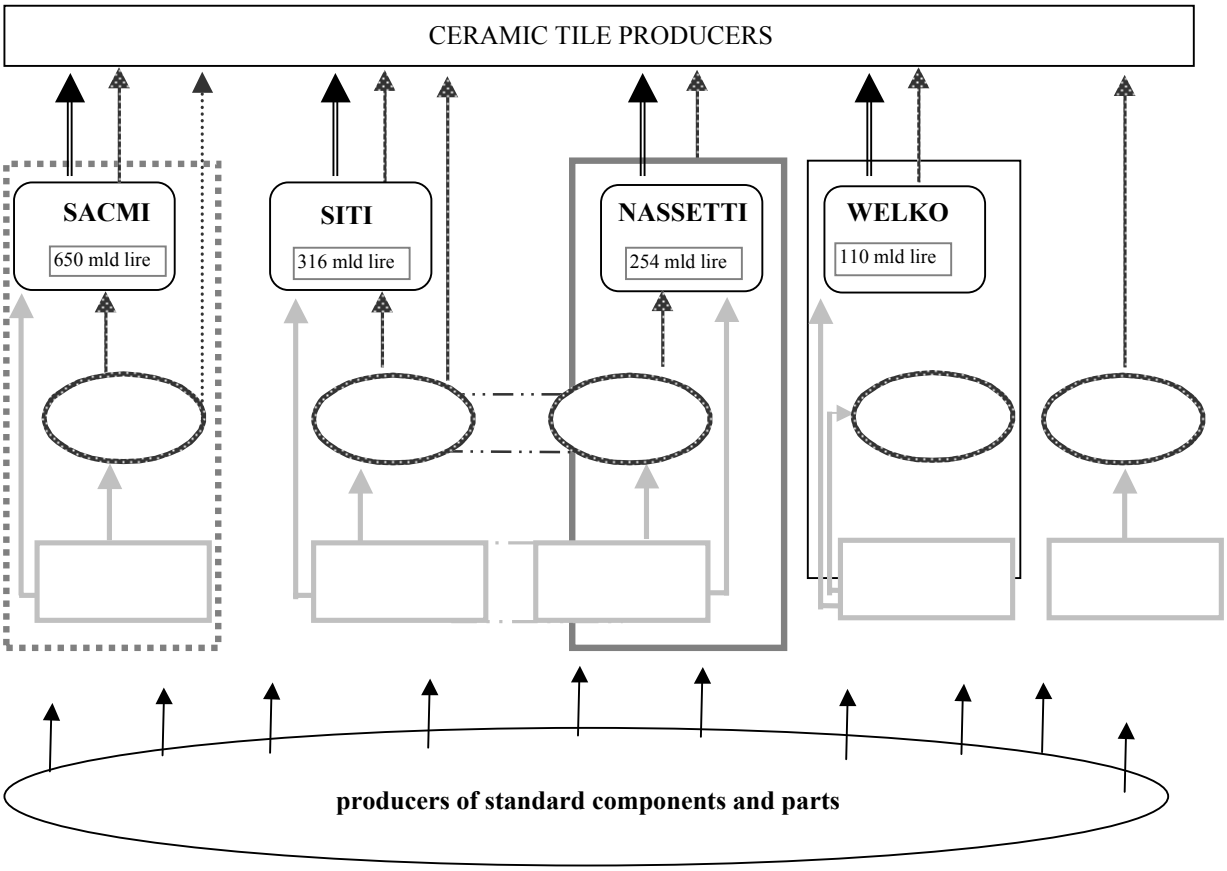


Figure 18
Italian ceramics machine producers: vertical integration and interfirm relationships
(Fonte: mie elaborazioni delle interviste)



LEGENDA:

- **sale of complete plants, only abroad**
- **sale of machines, both domestic and foreign market**
- direct export of machines, few cases
- **sale of non-standard components and semifinished goods, mainly home market**
- **sale of standard components and parts**
- **feasible contractual relationships**

exclusive contracts

ownership relations

vertically integrated company

seller of complete plant

sales in 1994

producers of individual type of machines

producers of non-standard components, semifinished goods

Figure 19
Specializations in the production of machines for the ceramic tile industry

NB: i numeri in corsivo indicano la quota sul fatturato del 1995 di ogni gruppo di macchine Acimac)

(Fonte: nostra elaborazione su dati Acimac)

(Fonte: mie elaborazioni sulle interviste)

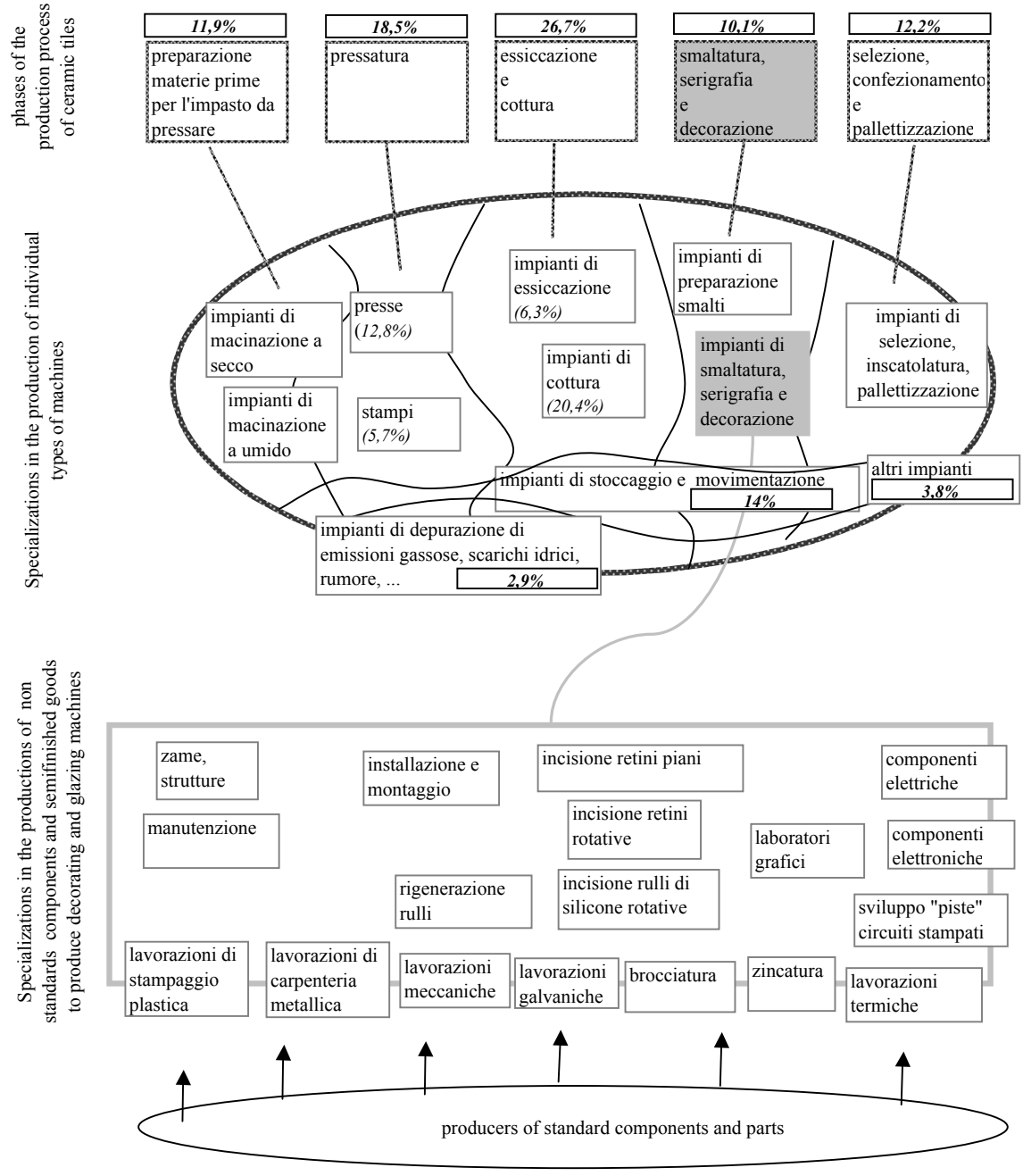
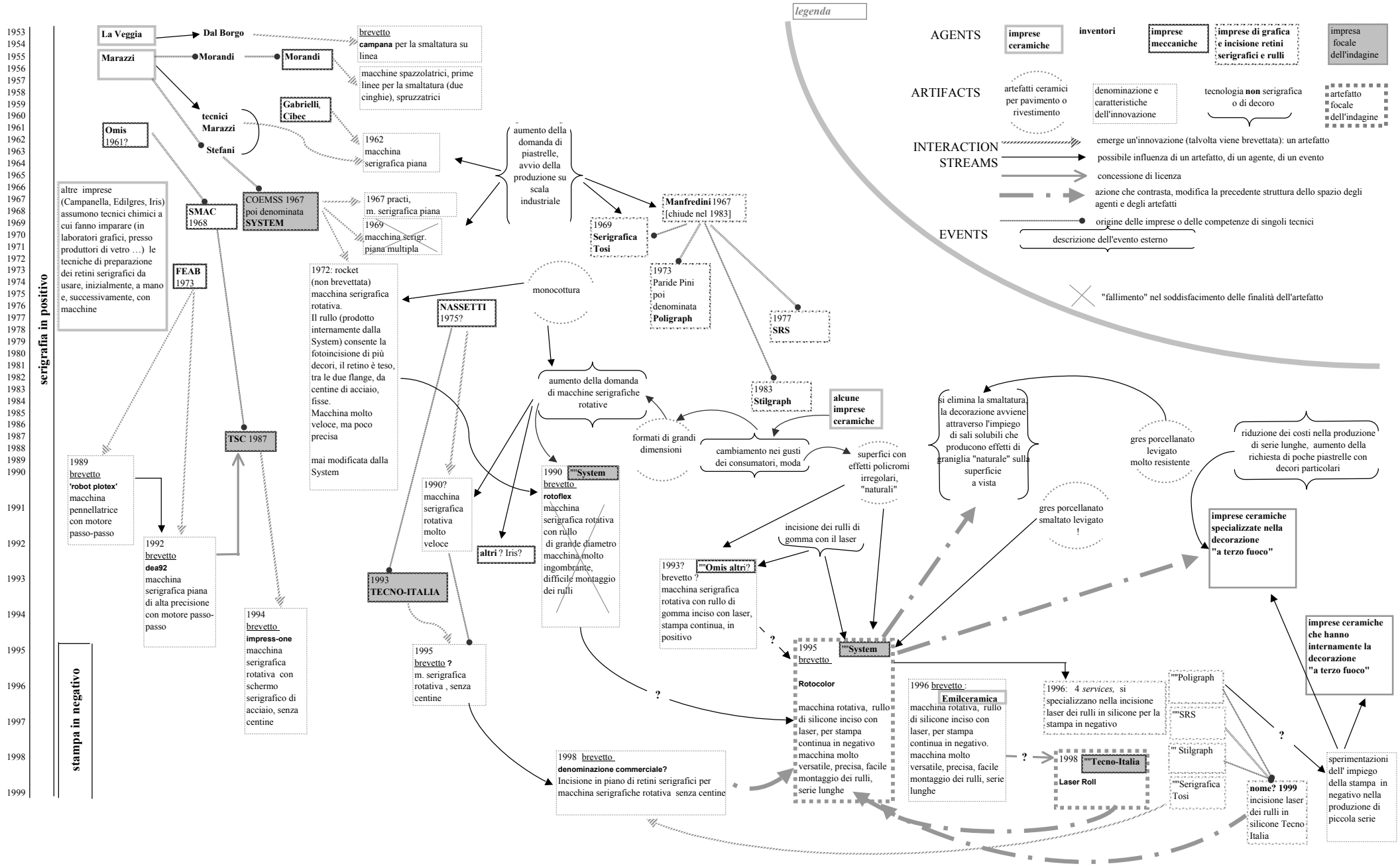


Figura 20
Promemoria delle principali interazioni nello spazio degli agenti e degli artefatti: serigrafia in positivo vs. stampa in negativo



Appendix A1 Calendar of interviews

	intervista	data	durata minuti	durata ore	periodi di interviste
1	TSC-Schianchi	21/05/1998	120		
2	Dal Borgo	02/06/1998			
3	GARROLL-Piccina	04/06/1998	120		
4	Dal Borgo	10/06/1998		4,75	38 gg (maggio-giugno e settembre 1998)
5	Dal Borgo	29/06/1998		8	
6	SYSTEM-Maffei	29/06/1998	45		
7	Dal Borgo	09/09/1998			
8	Carnevali	28/10/1998	270		
9	MITOR-Toni	24/11/1998	150		
10	MARCHETTI E RONCHI	25/11/1998	120	12	41 gg (ottobre-dicembre 1998)
11	GV-meccanica	27/11/1998	120		
12	SYSTEM-Maffei	09/12/1998	60		
13	RICCHETTI-Cuoghi	11/01/1999	120		
14	TOSI-Tosi	13/01/1999	300		
15	POLIGRAPH-Pini	15/01/1999	120	18	55 gg (gennaio-marzo 1999)
16	FEAB-Abbatecola	18/01/1999	210		
17	OMEGA-Ferrari-Grandi	26/02/1999	150		
18	CARPIPLAST-Cuoghi	05/03/1999	180		
19	TECNOITALIA-Elmetti	12/05/1999	230		
20	SYSTEM-Stefani	20/05/1999	120		
21	Lusuardi	24/05/1999	75		
22	Poppi	24/05/1999	120	17,5	14+1 gg (maggio e luglio 1999)
23	SRS-Fontanini-Corradini	25/05/1999	170		
24	SCE-Corradini	26/05/1999	160		
25	POLIGRAPH-	06/07/1999	175		
	totale ore di interviste		52,25	60,25	
	interviste già trascritte		37,92		

include le 8 ore di interviste a Dal Borgo

Appendix A2 Persons interviewed

Paolo Gambuli (ACIMAC)	Direttore
Sandra Cuoghi (CARPIPLAST)	Impiegata amministrativa, socia
Mauro Cuoghi (CARPIPLAST)	Tecnico, socio
Franco Carnevali (ECOGEO)	Consulente della ricerca
Gianni Abbatecola (FEAB)	Socio
Daniela Piccina (GARROLL)	Presidente
Claudio Grigioni (GV MECCANICA)	Titolare
Antonino Dal Borgo (KERVIT)	
Silvio Lusuardi (LUSUARDI)	Titolare
Loredana Andreoli (MARCHETTI E RONCHI)	Impiegata
Fausto Dalle Donne (MARCHETTI E RONCHI)	Programmatore
Romano Ronchi (MARCHETTI E RONCHI)	Socio
Raffaele Zanchetta (MARCHETTI E RONCHI)	Socio
Mario Toni (MITOR)	Titolare
Giuseppe Ferrari (OMEGA)	Direttore amministrativo
Paolo Grandi (OMEGA)	Direttore di produzione
Paride Pini (POLIGRAPH)	Titolare
Grazia Righi (POLIGRAPH)	Responsabile commercio estero
Laura Grilli (POLIGRAPH)	Impiegata commercio estero
Luisa Sighinolfi (POLIGRAPH)	Impiegata, socia
Fabrizio Miglioli (POLIGRAPH)	Responsabile per la 626 e le norme Iso
Maurizio Zapparoli (POLIGRAPH)	Responsabile gestione CED e incisione rulli con lase
Monica Ori (POLIGRAPH)	Grafica
Mario Poppi (IPEG)	Titolare
Paolo Cuoghi (RICCHETTI)	Responsabile manutenzione smalteria
Ormes Corradini (SCE)	Titolare
Sergio Tosi (SERIGRAFICA TOSI)	General Manager
Corrado Fontanini (SRS)	Socio
Rubens Corradini (SRS)	Responsabile commerciale
Elis Maffei (SYSTEM)	Direttore generale
Franco Stefani (SYSTEM)	Presidente
Valdo Elmetti (TECNOITALIA)	Titolare
Sergio Tosi (TOSI)	Titolare
Roberto Marchesani (TSC)	Responsabile acquisti
Mario Schianchi (TSC)	Titolare