Discussion Papers on Entrepreneurship, Growth and Public Policy

2904

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Evidence for the Emilia-Romagna Region of Italy

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Number of Pages: 16

The *Papers on Entrepreneurship, Growth and Public Policy* are edited by the Group Entrepreneurship, Growth and Public Policy, MPI Jena.
For editorial correspondence, please contact: egppapers@mpiew-jena.mpg.de

ISSN 1613-8333

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PATENTS AND THE TECHNOLOGICAL PERFORMANCE OF DISTRICT FIRMS. EVIDENCE FOR THE EMILIA-ROMAGNA REGION OF ITALY*

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Abstract

This paper investigates some crucial aspects of the recent development of industrial districts in the Emilia-Romagna region of Italy, where this type of spatial agglomeration of industrial firms has flourished since the period immediately after the Second World War. In particular, it is aimed at comparing the technological strength (in terms of patents registered with the European Patent Office) of innovative firms located within and outside industrial districts, in order to determine whether the prediction that innovative activity favors those firms or industries with direct access to knowledge producing inputs applies also to the case of industrial districts in the Emilia-Romagna region. The analysis deals with the population of firms with their headquarters in the region which registered at least one patent with the European Patent Office during the 1986-1995 period. Results from panel model estimates show that being located within an industrial district resulted in a technological advantage during the overall 1986-1995 period. However, on breaking down this period into two sub-periods (1986-1990 and 1991-1995) it is found that such advantage was strong in the first one, whereas it was lost in the first half of the 1990s.

Version: April 2004

JEL classification: **R11; R12; R15**

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* I am indebted to Leonardo Becchetti, Emanuele Giovannetti, Francesca Lotti, and Roberta Piergiovanni for helpful suggestions; to Chiara Cassi for assistance in data collection and statistical computation. All remaining errors are my own.

1. INTRODUCTION

This paper investigates some crucial aspects of the development of industrial districts in the Emilia-Romagna region of Italy - one of the most dynamic areas in the country, with a GDP per capita and an annual growth rate of GDP above the national average - where this type of spatial agglomeration of industrial firms has flourished since the period immediately after the Second World War. Industrial districts are so intimately bound up with modern economic growth in this region that the typical organization of industrial activities characterized by the widespread presence of such spatial clusters and of Small and Medium Sized Enterprises (SMEs) is usually labeled, after Brusco (1982), the "Emilian model". The paper is organized as follows.

Firstly, in Section 2.1, in depth analysis of the biomedical cluster allows considerations to be drawn about knowledge transfer and the development of product innovations in a district characterized by the presence of Multi National Corporations (MNCs) and an increasing amount of inward Foreign Direct Investment (FDIs). In depth analysis of the ceramic tile cluster carried out in Section 2.2 confirms the importance of large firms in the recent development of local agglomerations, whereas comparison of the economic performance of a sample of firms in the ceramic tile district and one in the whole industry in Italy shows that over the 1998-2000 period the former performed better than the latter in terms of average annual growth rate of the value of total sales, whereas non-district firms displayed a most favorable dynamics in terms of net income, return on equity, and cash flow.

On the basis of such hints then performed (Section 3) is an econometric analysis aimed at comparing the technological strength (in terms of patents registered with the European Patent Office) of innovative firms located within and outside industrial districts, in order to determine whether the prediction that innovative activity favors those firms or industries with direct access to knowledge producing inputs applies also to the case of industrial districts. The analysis deals with the population of firms with their headquarters in the Emilia-Romagna region which registered at least one patent with the European Patent Office during the 1986-1995 period. Results from panel model estimates show that being located within an industrial district resulted in a technological advantage during the overall 1986-1995 period. However, on breaking down this period into two sub-periods (1986-1990 and 1991-1995) it is found that such advantage was strong in the first one, whereas it was lost in the first half of the 1990s. The concluding section makes some considerations on the future of spatially concentrated industrial districts *vis-à-vis* the diffusion of Information and Communication Technologies (ICT).

2. EVIDENCE FROM CASE STUDIES

The revival of the industrial district as a unit of investigation in economic analysis owes a great debt to the Italian economists Giacomo Becattini (1979, 1989), and Sebastiano Brusco (1982, 1986), who respectively describe the industrial district as *i)* a local system characterized by the active integration between a *community of people* and a *community of industrial firms*; and *ii)* a flexible specialization system - typical of the Emilia-Romagna, Marche, Tuscany, and Veneto regions of Italy - characterized by the widespread presence of firms with fewer than 200 employees that by subcontracting many stages of production to other (equally small) firms are able to mobilize a labor-force ten times larger than the labor-force on their wage-books. These local systems are characterized by a strong incentive to invest in advanced production machinery which is usefully employed thanks to a strong polarization of skills. Accordingly, Brusco (1986, p. 90) identifies a further and highly significant feature of industrial districts, namely "the presence, in an area that produces a certain commodity, of *firms that produce the machinery necessary for the production of the commodity*" (italics added).

This "romantic" portrait, mostly centered around the key role played by SMEs in traditional industries substantially immune from competition by mass-production industries, has been partly changed following the works by Gianni Lorenzoni and his co-authors (Lorenzoni and Ornati, 1988; Lazerson and Lorenzoni, 1999), who focused in-depth on the recent evolution of industrial districts. Lorenzoni contends that "focal firms" - defined as those firms that occupy strategically central positions in the industrial district thanks to the great number of relationships that they have with both customers and suppliers - look decisive in expanding the district's horizons by enabling incorporation of new technologies, organizational skills, and markets (Lazerson and Lorenzoni, 1999, p. 362). These quite large leading firms are strategic centers that enable the emergence of a form of hierarchy more akin to the generation and transfer of new knowledge (Lorenzoni and Baden-Fuller, 1995; Boari and Lipparini, 1999).

2.1 - The biomedical district of Mirandola

As aptly pointed out by Biggiero (2002), the bio-medical district of Mirandola represents a challenge to the commonly held ("romantic") view of industrial districts in Italy. In fact, it differs from the traditional industrial districts as regards its two main features: *i)* it is specialized in high-tech activities (namely, the production of health-care products, with the exception of those for pharmaceutical use); *ii)* it was started relatively recently, in 1963.

This district specializes in the production of disposable sterilized products (and the relative equipment) for hemodialysis, infusion, and the circulation of the blood outside the body in general (47% of value added) - an activity in which it is the international leader - cardio-surgical devices (16.2%), sterilized disposable products for respiratory use in anesthesia and reanimation (13.2%). It is localized in 15 municipal areas comprised in the territory of the province of Modena. More than 50% of firms (36 out of 70) and 90% of employment are in the area of Mirandola, where the district originated. With respect to the industry as a whole, the Mirandola district accounts for more than 16% of total employment in Italy. Approximately 50% of local firms are small subcontractors, all of them with fewer than 50 employees. Among firms producing for the final market, "local" ones, which account for 70% of the total number of firms of this type, all have fewer than 50 employees. Total employment in the district is 3660 employees, with total sales exceeding €500 million, of which 59% derive from exports (mostly to the other EU countries and the United States). Exports are led by the excellent performance of the leading firm (the Swedish-owned Gambro-Dasco), which is expanding its market shares in non-EU European countries and increased its total sales by 30% between 1997 and 2000 (R&I, 2001).

A further peculiarity of the Mirandola district with respect to the traditional view of industrial districts as comprising small firms that developed in opposition to large firms is the presence within it of multinational corporations (MNCs) and large national companies. These companies have taken over the most important firms in the Mirandola area and specialize in the production of both disposable goods and machinery. Thus, contrary to the usual idea of FDIs as driven by the availability of credit facilities, reduced labor costs or foreign market penetration, in the case of the Mirandola biomedical district, foreign firms making acquisitions have been attracted by possibilities to access to locally-available skills, technology, and know-how.

Table 1: The biomedical industry in the Mirandola district

	1997	2000	2001
Total sales (billion lira)	775	998	1,104
% of sales from export	49.8	60.7	57.0
Number of firms	74	70	71
of which subcontractors	*39*	*35*	*35*
Number of employees	3,209	3,660	3,941

Source: R&I (2001).

This phenomenon has resulted in a relatively high degree of seller concentration, with the first four producers (Gambro-Dasco, Mallinckrodt, B. Braun Carex, and Biofil) accounting for 63% of employment and 73% of total sales. Among the 10 non-district firms (only 4 of which are

domestic firms) 6 have between 50 and 249 employees, whereas 4 have more than 250. These firms account for nearly 83% of total production, and employ 75% of total workers. They entered the district after 1980, through the acquisition of incumbent local firms (all founded by Mr. Mario Veronesi together with two partners[1]) unable to withstand competition by large firms because of their financial and technological weakness. Consistently with the view of leading firms put forward by Lorenzoni and his co-authors, entry by MNCs and large national companies fostered the adoption of process innovations (such as the introduction of the first CAD systems) and quality control procedures, as well as the more careful selection of materials. Besides, it brought in the synergies and the superior coordination skills of the group organization, and eventually acted as a driver for innovation and growth of al firms in the district (Boari and Lipparini, 1999). The quality-upgrading effect resulting from the emergence of these leading firms and groups set in motion a learning process among local firms and subcontractors, which in turn made major improvements to their procedures. The Mirandola district operates as a group of companies able to take a product from design to prototype to development of specialized machinery, to production, and beyond. Dozens of highly specialized firms offer services such as molding, extrusion, subcontracting, assembly, sterilization, instrument manufacture, and consulting (cf. Lichtman, 2002).

Product innovation is the crucial competitive factor for firms in this industry. However, since only 43% of firms in the district produce for market clients, the innovation process in the Mirandola area is mostly the result of close co-operation and interaction among firms, characterized by the presence of a hierarchical structure within which larger firms promote the achievement of higher levels of efficiency and competitiveness (Boari and Lipparini, 1999). Thus, not only are the largest bio-medical firms actively involved in innovative activities, but they also include both local independent firms and subcontractors in the overall innovation process. The resulting local system of innovation is one in which MNCs and large national companies control the strategic phases of R&D, design, production of machinery with embodied technological change, and final control, whereas small local firms are responsible for the intermediate phase of production and handle the assembly process. Crucial in this networking process is production of specialized machinery and devices for specialized machinery which set off a learning process involving all the players (either foreign or domestic, either producing for the final market or subcontractors) in the biomedical district. In this process, production machinery - mostly for the assembly of plastic disposable-

[1] A pharmacist by training, as early as 1962 Mr. Veronesi began to prepare the ground for what was eventually to become the Mirandola district. In the course of his work with local hospitals, Mr. Veronesi saw a nascent market for plastic disposable. During the years that followed, he founded numerous companies (including Miraset, Sterilplast, Dasco, Bellco, and Dideco) to supply the medical market with components for infusion, hemodialysis, oxygenation, and related applications (cf. Lichtman, 2002).

represents *dedicated assets* in Williamson's (1985) sense, namely resources designed for specific purposes and which cannot be easily re-deployed to alternative uses. In effect, the innovative process technologies employed in the Mirandola district are so specific to the production of certain disposable goods that their design and development requires close cooperation among all the firms involved in the local biomedical *filiere*. Interaction among producers and users of machinery and capital equipment is therefore a factor favoring the creation of specific knowledge which contributes to the overall technological competitiveness of the district. It is therefore not surprising that, according to Ceris (cf. CNEL/Ceris-Cnr, 1997), the second specialization of the Mirandola district is in the production of specialized industrial machinery.

To summarize, the Mirandola district displays the features of what Lipparini and Lomi (1999) called an "organizational community", one in which the district's various areas of competence constitute a sort of *tacit knowledge* which diffuses among all local players. The glue that joins everything together and enables the circulation of information among all firms in the local arena is the coordination skills brought in by the advent of exogenous forces (multinationals from other countries and large national companies) and interaction between producers and users of machinery. In this case, too, as is typical of the Emilia-Romagna districts, exchange of information among players within the focal *filiere* and embodied technological change are the engines of knowledge dissemination at the local level. And this is consistent with the original idea of the industrial district. As implied in Marshall's original formulation of "external economies", spillovers do not stem from producers of similar products but are related to the input-output or customer-supplier relationship that arise from interaction between firms producing specialized capital equipment and machinery and firms using those devices (Forni and Paba, 2002). The case of the "biomedical valley" in the Emilia-Romagna region proves that it is the 'right' agglomeration of industries at local level that is crucial for industrial district development.

2.2 - The ceramic tile district of Sassuolo

When comparing the distinctive features of two industrial clusters that dominate the global ceramic tile industry - Sassuolo in Italy and Castellón in Spain - Meyer-Stamer, Maggi and Seibel (2001) stress that whereas it is the capital goods producers that drive technical change and innovation in the Italian district, what drives competitive advantage in the Spanish one is innovation in downstream activities. Meyer-Stamer, Maggi and Seibel's paper also helps reassessment of the competitiveness of tile clusters in the developing world. Tile firms in Brazil's leading cluster, located in Santa Catarina, benefit from the fierce rivalry amongst Italian producers (most of which are located in the Sassuolo district), amongst Spanish producers and between Italian and Spanish producers. Although

Brazilian firms are technology followers, they are innovative in downstream activities, experimenting with concepts which are not yet used by Italian or Spanish manufacturers.

As well known, Italy has been the leader in the ceramic tile industry since the Middle Ages. Today, the industry is mostly located around the town of Sassuolo, in the province of Modena. The industry is made up of companies of various sizes, most of them SMEs, ranging from small crafts enterprises producing hand made products according to centuries-old traditions to large publicly traded corporations producing the latest in porcelain material. According to Assopiastrelle, the employers' association for the Italian tile industry, Italy accounts for 40% of the entire world trade in ceramic tiles, employing approximately 37,000 people and manufacturing more than 630 million square meters of tile annually in nearly 600 firms. The industry is characterized by a relatively low level of concentration, with the largest 5 firms accounting for about 17% of total production (cf. Prometeia, 2002).[2] Only 29 firms have total sales exceeding €50million (21 of which in the Sassuolo district!), whereas 353 micro-firms fall below the €2 million threshold. Italian producers of ceramic tiles are deeply integrated in international trade, with 70% of total sales represented by exports to foreign markets. According to CNEL/Ceris-Cnr (1997), the second specialization of the Sassuolo district is the production of specialized machinery for the ceramic tile industry. The Sassuolo district started up during the 1950s as an industrial agglomeration within which final firms were also directly involved in the development and refinement of production machinery and raw materials. It was however only in the 1960s that, as a consequence of the specialization and division of labor among district firms, a group of specialized suppliers of machinery and capital equipment came into being (cf. Russo, 1985). Another important organizational change in the industry occurred during the late 1980s, when the leading firm[3] and the industrial group became the main forces of growth in the local system.

Nowadays, this industrial cluster still maintains its leadership in the production of ceramic tiles, although its recent economic performance has been only slightly better than that of other Italian firms not located in the same area. In fact, comparison of the economic performances of two samples of ceramic tiles producers, one located in the Sassuolo district, the other outside the district, gives a somewhat controversial picture (Table 2), although within a generally positive framework. Both samples exhibit favorable dynamics of total sales, with district firms performing on average better in the four final years of observation.

[2] Of the 32 largest producers of ceramic tiles in Italy, 30 are located in Emilia-Romagna, either in the Sassuolo district or in the districts of Faenza and Imola.

[3] The largest producer of ceramic tiles in the Sassuolo district is Iris Ceramica. Set up quite recently, in 1961, this company attained market leadership thanks to direct control of production cycles and experience in advanced manufacturing technologies.

Table 2: The economic performances of Italian firms in the ceramic tile industry*

	District firms (Sassuolo)					
	1995	1996	1997	1998	1999	2000
ΔSales	15.5	-1.5	6.0	7.1	5.6	11.0
Net income (%)	4.6	2.0	2.2	2.8	3.4	1.9
Gross Operating Surplus (%)	16.2	11.8	12.5	12.7	13.3	11.7
ROE (after tax)	12.8	5.3	5.9	7.7	9.3	5.3
Fixed investments (%)	10.4	6.5	5.2	8.0	7.1	5.9
Cash flow (%)	11.2	8.2	8.6	8.7	9.5	8.2
	Non-district firms					
	1995	1996	1997	1998	1999	2000
ΔSales	14.0	-0.3	5.7	3.2	5.2	8.6
Net income (%)	5.1	3.0	3.1	4.0	4.5	3.1
Gross Operating Surplus (%)	16.2	12.9	13.6	14.4	15.7	14.1
ROE (after tax)	12.3	6.6	7.1	8.8	9.7	6.5
Fixed investments (%)	9.7	7.2	4.6	5.7	7.9	6.1
Cash flow (%)	10.6	8.9	9.2	9.9	10.4	10.1

* all % values are in percent of total sales.
Source: Prometeia (2002).

Conversely, non-district firms performed better than firms in the Sassuolo district in terms of Net income, gross operating surplus, ROE, and Cash flow. District firms were instead characterized by a more aggressive investment strategy which should result in a greater likelihood that they will benefit from embodied technological change more than non-district firms in the following years.

Nevertheless, the non-substantially different economic performances of district and non-district firms is probably also connected to the capacity of the former to leave the narrow boundaries of the local system and becoming more integrated with the latter. This might be an indirect indication of the emergence of the "multi-located" industrial district as a productive aggregate in which an appropriate network of suppliers, sectoral externalities, contracting and subcontracting with other firms belonging to the same or related industries, spillovers and knowledge originating from outside the local system are instrumental in determining the path and intensity of innovation activities carried out by industrial firms within a given portion of territory. This kind of agglomeration might have been favored by the diffusion of faster means of communication enabled by the Information & Communication Technology (ICT) revolution, which provided viable alternatives to the various kinds of face-to-face communication that characterized the spatially concentrated industrial district. In this connection, the transaction cost advantages

resulting from exploitation of ICT enable the relocation process of productive activities to be implemented without determining any significant additional cost for the firm.

3. EVIDENCE FROM ECONOMETRIC ANALYSIS

This section explores whether, for firms already able to realize and patent their innovations abroad, being located within an industrial district is a factor positively affecting innovative capability. Employed for this purpose was the IMPERO database developed at Aster (the Agency for Technological Transfer of the Emilia-Romagna region). IMPERO contains micro-level data on patenting activity by firms located in the region, including balance sheet figures and a full range of qualitative and quantitative information.

3.1 – Patents, firm size, and firm location

Analysis of the innovative performance of firms in the Emilia-Romagna regions took account of all firms with at least one patent registered with the European Patent Office (EPO). In particular, the analysis dealt with the patent activity of firms in industrial districts compared to a control sample of non-district firms that had also patented with EPO. Their limited heuristic value notwithstanding, patents are widely employed in the studies of the output side of the innovation (for a critical survey, cf. Piergiovanni and Santarelli, 1996). In this connection, the use of data comprising 'high quality' patents, such as those provided by EPO, represents a viable alternative to the data collected through the national patent system. Nevertheless, it remains true that firms of different sizes have a different propensity to use patent protection and that firms in traditional industries are more likely to develop non-patentable innovations than are firms in technologically progressive industries. As a consequence, in this more than in other cases, the empirical results are likely to reflect the partial inadequacy of the innovation data that are employed.

The period considered was 1979 to 1997, which was characterized by the increasing integration of Emilia-Romagna firms into the global economy, with a significant process of partial relocation of manufacturing activities in least developed and transition economies (cf. Barba Navaretti *et al*., 2002). Several firm-specific factors were taken into account when attempting to explain inter-firm differences in patenting activity:

- the fact that a firm is/is not located within an industrial district (DIST). Adopted for this purpose was the classification proposed in the CNEL/Ceris-Cnr (1997) report, which is the one most akin to the guidelines developed by the Ministry of Industry;
- firm size (total number of employees in each year during the relevant period) (SIZE);

- total net value of property, plant and equipment (as a proxy for the stock of total fixed assets) (PPE);
- the dynamics of the gross operating surplus (as a measure of the economic performance of the firm) (ΔGOS);
- the fact that the firm operates with one or more plants (as a proxy for the organizational structure) (MULTI);
- the fact that the firm is part of an industrial group (GROUP);
- the fact that the firm is an exporting firm (EXP);
- the fact that the firm belongs to one of the categories (specialized suppliers (SSUP), supplier dominated (SDOM), scale intensive (SINT)) in Pavitt's (1984) taxonomy.

Firms for which no balance sheet data were available and firms which exited before the end of the period were dropped from the original list of those with at least one patent with EPO. Since complete balance sheet data were available only for the years comprised between 1986 and 1995, the econometric analysis performed in section 4.2 focuses on this period only, taking the total number of patents granted to the firm between 1979 and 1985 as the cumulated stock of patents in the base year 1986.

The rationale for choosing most of the variables listed above is intuitive. First, the district variable allows one to determine whether the external economies typical of the district *do* affect the innovative output of the firm. Accordingly, it was determined for each firm localized in a municipality comprised within a certain industrial district whether the firm's productive specialization was the same as that characterizing the industrial district.

Second, employment size was included in the analysis in order to seek confirmation for the so-called second Schumpeterian hypothesis, according to which innovative capability increases with firm size.[4]

Third, the value of property, plant and equipment is both a measure of firm scale and the stock of capital (including intangibles such as software) which can be usefully employed in the production process, under the hypothesis that the larger the stock of capital the higher the innovative capability of the firm.

Fourth, the gross operating surplus is a measure of the wealth produced by the firm once the variable costs have been subtracted. The idea behind the introduction of this variable is that firms achieving better economic performance are more able to raise the financial resources needed to

[4] As a consequence of the lower propensity of smaller firms to undertake those R&D activities which have been shown to result in patented innovations.

carry the costs connected with patent registration and protection. For this reason, used in the econometric analysis was the annual growth rate of the gross operating surplus rather than its level.

Fifth, multi-plant firms are likely to employ professional managers and to possess more sophisticated organizational capabilities than is usually the case of single-plant firms. Managerial skills are likely to result in the more efficient organization of the innovation process, with a greater likelihood of obtaining patentable inventions.

Sixth, firms belonging to an industrial group are involved in a process of information sharing that is likely to generate positive external economies. As a consequence, also firms devoid of autonomous innovative capability may be able to extract patentable innovations from a combination of knowledge freely available within the group.

Seventh, export-oriented firms have to cope with international competition. Thus, in order to obtain larger shares of foreign markets they are forced to undertake innovative activities likely to result in more patents.

Eight, for nearly twenty years Pavitt's (1984) classification of firms according to their attitude towards innovation has been one of the most widely used taxonomies of innovating firms. Since all but two (biomedical) of the firms in the sample used for the present study are in the scale-intensive, specialized supplier, and supplier dominated categories of Pavitt's scheme, the use of dummy variables for such categories may be helpful in identifying whether belonging to one category or another affects the likelihood of obtaining more patents.

4.2 – Results from panel model estimates

The availability of longitudinal data allowed estimation of a fixed-effects panel model. Thus, the analysis started by postulating restrictions on the parameters, namely overall homogeneity of both slopes and intercepts. Since this hypothesis was not rejected by the data, the next step was to perform a pooled regression by means of Generalized Least Squares Estimators.

The functional form of the model was the following:

$$[1]\quad y_{it} = \alpha^{*}_{it} + \boldsymbol{\beta}'_{it}\mathbf{x}_{it} + u_{it},$$

where i denotes the firms, t the years comprised in the analysis, α^{*}_{it} is a 1x1 scalar constant representing the effects of those time-invariant variables peculiar to the ith firms and $\boldsymbol{\beta}'_{it} = (\beta_{1it}, \beta_{2it}, ..., \beta_{Kit})$ is a $1 \times K$ vector of constants, and $\mathbf{x}'_{it} = (x_{1it}, x_{2it}, ..., x_{Kit})$ a $1 \times K$ vector of

exogenous variables, the regressors employed in the analysis, and u_{it} is the error term with mean zero and variance σ_u^2.

Two different methodologies were used to deal with the panel. Firstly, standard panel techniques were used to run model [2]:

[2] $PAT_{it} = \beta_o + \beta_1 \text{DIST}_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 \text{PPE}_{it} + \beta_4 \text{SIZE}_{it} + \beta_5 \Delta\text{GOS}_{it} + \beta_6 \text{MULTI}_{it} + \beta_7 \text{GROUP}_{it} + \beta_8 \text{EXP}_{it} + \beta_9 \text{SSUP}_{it} + \beta_{10} \text{SDOM}_{it} + \beta_{11} \text{SINT}_{it} + x_{it}\beta + \beta_i + \beta_{it}$

where x is a vector of controls, which can be either time variant or firm specific, υ_i is the firm specific residual and ε_{it} is the usual error term with the usual properties.

Model [2] assumes the existence of firm-specific effects. Thus, also due to the nature of the available data, the Fixed Effect technique is the preferred estimation for the model, with inclusion of cross section weights. Accordingly, model [2] was firstly estimated over the entire ten-year period between 1986 and 1995, for which data on 34 firms with patents registered with the European Patent Office were forthcoming (Table 3).

The results show a negative impact of location within an industrial district on patenting, and also larger firm size seems to be an impediment rather than a stimulus to patenting[5]. Conversely, belonging to an industrial group, a higher value of property, plant and equipment, and the fact that the firm operates with more than one plant are all factors that positively affect patenting. The negative and significant coefficients of the three dummy variables for Pavitt's taxonomy instead suggest that patenting is an activity more typical of science-based firms than of specialized supplier, supplier dominated, and scale intensive ones.

By breaking down the ten-year period into two sub-periods, it was then possible to see whether the determinants of patenting changed from the 1980s to the 1990s (Table 4). In this respect, it has to be put forward that for the two sub-periods data were available for a larger number of firms that in the case of the ten-year period. The value of the coefficient of determination adjusted for the degrees of freedom (R^2 adjusted) was much higher for the estimate carried out for the 1986-1990 period (0.923) than it was for the one concerning the overall ten-year period (0.373). In fact, analysis carried out for 44 firms between 1986 and 1990 showed that being located in an industrial district is a factor positively affecting patenting at the firm level, along with holding more than one plant and belonging to a group. Conversely, exporting firms and firms belonging to *scale*

intensive industries exhibited a disadvantage in terms of patents, whereas the coefficient for the size variable was not significantly different from zero.

Table 3: Panel model estimates 1986-1995

Dependent variable: PAT (number of patents)			
Variables	**Coeff.**	**Stand. Err.**	**Prob.**
Intercept	4.078996***	0.935913	0.0000
DIST (Industrial district)	**-0.552322****	**0.190322**	**0.0040**
SIZE (Number of employees)	-0.001223*	0.000499	0.0148
PPE (Property, plant and equipment)	6.09E-05***	9.19E-06	0.0000
ΔGOS (Δ Gross Operating Surplus)	-0.025410	0.032817	0.4393
MULTI (Multi-plant)	2.262991***	0.305794	0.0000
GROUP (Industrial group)	0.271824*	0.144838	0.0614
EXP (Export)	-0.092256	0.135558	0.4966
SSUP (Specialized suppliers)	-3.362484***	0.933043	0.0004
SDOM (Supplier dominated)	-3.231630***	0.926493	0.0006
SINT (Scale intensive)	-4.137798***	0.954777	0.0000
Number of observations			*340*
F test			*21.137*
R^2 Adjusted (overall)			*0.373*

***, **, * mean statistically significant at 99%, 95%, and 90% confidence level, respectively.

Table 4: Panel model estimates 1986-1990

Dependent variable: PAT (number of patents)			
Variables	**Coeff.**	**Stand. Err.**	**Prob.**
Intercept	1.632256*	0.670751	0.0158
DIST (Industrial district)	**0.820574*****	**0.129919**	**0.0000**
SIZE (Number of employees)	-0.000370	0.000389	0.3430
PPE (Property, plant and equipment)	3.11E-06	8.75E-06	0.7229
ΔGOS (Δ Gross Operating Surplus)	-0.007564	0.023257	0.7453
MULTI (Multi-plant)	0.828130***	0.077712	0.0000
GROUP (Industrial group)	0.593138***	0.126037	0.0000
EXP (Export)	-0.847035***	0.085835	0.0000
SSUP (Specialized suppliers)	-0.629776	0.670310	0.3485
SDOM (Supplier dominated)	-0.772766	0.667994	0.2487
SINT (Scale intensive)	-1.320390*	0.714658	0.0661
Number of observations			*240*
F test			*264.264*
R^2 Adjusted (overall)			*92.3*

***, **, * mean statistically significant at 99%, 95%, and 90% confidence level, respectively.

[5] Although the coefficient of the SIZE variable is statistically significant only at the 90% confidence level. In any case, this result is consistent with the empirical regularity emerged from a number of studies concerning the independence of the firm's innovative intensity on the firm's size (cf. Klette and Kortum, 2002).

The picture changes significantly when one focuses upon the 53 firms for which data were available in relation to the 1991-1995 period (Table 5).The value of property, plant and equipment, the fact of possessing more than one plant, and being export-oriented are all factors which enhance the innovative (patented) output of the firm.

Conversely, the district dummy has a negative and statistically significant coefficient, whereas non-significant are the coefficients of both the group and the size variables. Evidently, innovative activity for firms in the sample is market-driven, and location within an industrial district is no longer a factor that, other things being equal, is able to enhance significantly the innovativeness of the firm. The goodness of fit of this regression is still satisfactory, with R^2 adjusted = 0.627.

Table 5: Panel model estimates 1991-1995

Dependent variable: PAT (number of patents)			
Variables	**Coeff.**	**Stand. Err.**	**Prob.**
Intercept	9.889254***	2.234583	0.0000
DIST (Industrial district)	**-0.522237*** **	**0.127098**	**0.0001**
SIZE (Number of employees)	-0.000217	0.000461	0.6381
PPE (Property, plant and equipment)	1.90E-05**	6.79E-06	0.0055
ΔGOS (Δ Gross Operating Surplus)	-0.015699	0.027120	0.5632
MULTI (Multi-plant)	2.753913***	0.194963	0.0000
GROUP (Industrial group)	0.135377	0.163996	0.4099
EXP (Export)	0.308499	0.161900	0.0578
SSUP (Specialized suppliers)	-9.315202***	2.233547	0.0000
SDOM (Supplier dominated)	-9.019210***	2.234540	0.0001
SINT (Scale intensive)	-9.328195***	2.237762	0.0000
Number of observations			*265*
F test			*45.432*
R^2 Adjusted (overall)			*0.627*

***, **, * mean statistically significant at 99%, 95%, and 90% confidence level, respectively.

A possible interpretation of the differing importance of industrial districts as drivers of innovation and technological change between the second half of the 1980s and the first half of the 1990s is that only during the first sub-period firms located in industrial districts *did* benefit, as regards their innovative activities, from the agglomeration economies that characterize local clusters. This advantage was probably lost when, as a consequence of globalization and market integration, these firms became more involved in a relocation process which pushed down total production costs and made innovative capability a secondary element in the strength of firms specialized in the productions typical of Emilia-Romagna districts. In this connection, the resulting "multi-located" district (as defined by Santarelli, 1988) appears to be a new form of industrial

agglomeration, one in which spatial concentration is no longer a factor shaping the competitive advantage of industrial districts.

5. CONCLUSIONS

The long-term evolution of industrial districts, in particular those in Emilia-Romagna, has been punctuated by increasing enlargements of the type and number of activities carried out by firms belonging to this industrial agglomeration. What has remained unchanged is the circulation of information and the close relationships among firms that led to increasing inter- and infra-sectoral integration (Garofoli, 1987). In this connection, the emergence of specialized suppliers of capital equipment in the 1960s, the advent of leading firms belonging to industrial groups during the late 1980s, and, likely, the efficient relocation of the most labor-intensive phases of the overall production process consequent upon the availability of more reliable devices for exchange of information since the 1990s, are the three crucial events in the history of industrial districts. The resulting "multi-located" district (as defined by Santarelli, 1988) of the last few years is therefore nothing but a new form of industrial agglomeration in the age of globalization: whereas spatial concentration is no longer the most crucial factor enabling the prosperity of the modern district, its distinctive organizational features and the flows of information that it is able to set in motion are substantially unchanged. What Harrison (1994) saw as a point of strength of MNCs - namely, the ability to relocate manufacturing throughout the world to exploit diminishing tariff and transportation costs besides escaping increasing competition by low-wage countries - is now a point of strength also of industrial districts.

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