INSIDE THE BLACKBOX: ECONOMIC PERFORMANCE AND TECHNOLOGY ADOPTION WHEN SPACE AND PRODUCT RELATIONSHIPS MATTER

Leonardo Becchetti*
University of Rome Tor Vergata

Annalisa Castelli*
University of Rome Tor Vergata

Il lavoro sottolinea l'importanza di studiare la performance delle imprese considerandone il posizionamento nello spazio (distretto/non distretto) e nella catena del valore (indipendente/subfornitrice). Le imprese distrettuali indipendenti registrano maggiore valore aggiunto e migliore efficienza rispetto alle non distrettuali indipendenti, mentre l'investimento in ICT sembra migliorare solo l'efficienza di queste ultime.

I risultati suggeriscono che: i) la qualità della relazione spaziale (distretto) influenza positivamente l'accumulo di forme di capitale umano e sociale che sfuggono alla misurazione del bilancio; ii) l'investimento in ICT e il miglioramento delle relazioni virtuali risulta maggiormente produttivo per le imprese (non distrettuali) caratterizzate da bassa qualità di relazioni spaziali.

We highlight the relevance of studying the performance of productive units by considering space and product relationships. By applying the district/no district and independent/subcontractee status taxonomy, we find that district independent firms have higher value added and are more efficient than non district independent firms, but that ICT investment improve efficiency only for the latter.

Our findings suggest that: i) the quality of space relationships (district location) positively affects unmeasured forms of human and social capital; ii) ICT adoption has a stronger impact on non district independent firms as the improvement of electronic links is more beneficial for productive units with poorer space relationships.

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* Dipartimento di Economia e Istituzioni, Facoltà di Economia.
Corresponding author: Annalisa Castelli, Dipartimento di Economia e Istituzioni, Facoltà di Economia, Università di Roma Tor Vergata, Via Columbia 2 – 00133, Roma. Tel. 0672595714, fax: 062020500, e-mail: annalisa.castelli@uniroma2.it.
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1. Introduction

The economic literature usually considers the firm as an atomistic entity without much regard for its space and product relationships with other productive units.

In this paper we argue that the limit involved in this choice is significant, especially when we examine value added, productive efficiency and effects on it of ICT investment after the technological revolution of the last decades which has dramatically changed the relationship between the firm and its environment.

Such revolution, by greatly improving the technology for transferring data, images and voice has reduced space and time barriers but, at the same time and somehow paradoxically, has enhanced the role of space for productivity and competitiveness.

This occurred because the ICT revolution increased electronic contacts, and in the meanwhile, also their complements (face to face contacts) for which geographical distance is a fundamental constraint (Gaspar and Glaeser, 1998). Geographical externalities, nondiminishing returns for human capital and infrastructural bottlenecks are all factors which contribute to explain why space still matters and industrial and urban agglomerations persist and become stronger (Easterly, 2000).

The importance of looking at space and product relationships of productive units is enhanced by the related increased speed of globalisation of product and labour markets. By looking at the Italian experience, we find that the more intense price competition from the Far East in traditional sectors, in which most Italian districts historically developed their competitive advantage, has created strong competitive pressure on these firms. The reactions have been that of delocalising the production of non strategic components in the Far East, or, in some cases, of incorporating in the Italian district component producers from the Far East[1].

These changes in the value chain structure are likely to have increased heterogeneity of productivity and performance of firms according to their position in the value chain itself, with district independent firms gaining advantage from the delocalisation process and local subcontractees being in difficulty for the competition from foreign manufacturers.

Our paper aims to provide an empirical contribution in this direction showing that space and product relationships are, today more than ever, a significant source of heterogeneity in performance and in patterns and effects of physical and ICT investment.

[1] Feenstra, R.C. (1998) documents the phenomenon of disintegration in production by showing a significant rise: i) in the ratio of imported to domestic intermediate inputs; ii) in the ratio of merchandise trade to merchandise value added; iii) in the ratio of imported to domestic intermediate inputs in the textile industry in OECD countries in the last decades. Other authors refer to the phenomenon as de-localisation (Leamer, 1987), vertical specialisation (Hummels, D. et al. 2001), kaleidoscope competitive advantage (Bagwati, J. and Deheija, V. 1994) and slicing the value chain (Krugman, P. 1995).

The rest of the paper is organized as follows. The rationale for focusing on space and product relationships is explained in section 2 which also provides additional theoretical support for it from several contributions in the industrial economics literature. In section 3 we describe our database and provide some descriptive findings on firm characteristics when productive units are classified according to a taxonomy which takes into account both geographical agglomeration and the position in the value chain. The methodhology and econometric findings illustrated in section 4 and 5 show the importance of such taxonomy when measuring value added, productive efficiency and the effects on it of ICT investment.

2. The role of product and space relationships when measuring firm productivity and competitiveness

The idea that the entire value of complex products which are sold today in the markets is generated by an atomistic individual firm without considering its product and space relationships is far from the reality. In this short survey we provide some theoretical indications on how these two dimensions may matter separately and how they can interact with each other.

2.1 Product relationships

Most of contemporary goods and services are "systemic products" conceived, implemented and manufactured by a large number of different and independent productive units. The strategic interplay between producers of different components and their interaction with a systemic firm which controls the architecture of the final assembled product is crucial for understanding how the value is generated and shared among the different productive units which contributed to it (Holmstrom and Roberts, 1998).

In this framework, the position in the value chain and the strategic relationship with other "participants to the product project" crucially affects investment and performance of individual productive units. This issue has been investigated more in depth by looking at the specific case of high-tech products. In this field theoretical models have often conceptualized products as "*systems made up of core technologies and associated linkage technologies*"(Tushman and Anderson, 1986).

System companies (also SCs) have been shown to shape contractual relationships with *component producers* (also CPs) by developing optimal "separating equilibrium" contract designs which enhance their productive incentives (Becchetti and Paganetto, 2001). These contract designs create two types of dilemmas. A static dilemma is between releasing property rights to component producers to increase their incentives and maintaining more control on "strategic" components to improve her "systemic" capacity. An intertemporal dilemma is about the optimal share of property rights on component products to maintain in a framework where the "strategic/non strategic" feature of individual components varies over time. Both static and intertemporal dilemmas have effects on efficiency and value added of SCs and subcontractees being part of the same value chain.

Sako (1996) indirectly recognises the existence of an incentive trade-off between SCs and CP innovators showing that associate relationships between Japanese CP innovators, in which SCs rarely hold equity stakes, increase learning, R&D effort and technological spillovers, avoiding R&D duplication.

By broadening the scope of original make or buy models, Kende (1998) evaluates the relationship between the chosen form of vertical integration and market demand. Farrel et al. (1998) examine the relationship between make or buy decisions and market structure showing that competition does not always lead to the socially efficient form of vertical organisation with a bias toward closed vertical organisation with more than two competitors.

2.2 Space relationships

A literature completely different from that of product relationships has analysed how space relationships may affect productivity and performance of productive units by looking mainly at the experience of Italian industrial districts.

The most relevant empirical results obtained by this literature are related to the superior export performance and access to foreign markets of geographically agglomerated firms which belong to industrial districts (Bagella et al. 1998; Becchetti and Rossi, 2000; Bagella and Becchetti, 1999). Other important results on the effects of geographical agglomeration are the positive relationship with ROE and productive efficiency (Fabiani et al., 1998), the negative relationship with R&D expenditures but not with other forms of innovation (Bagella and Becchetti, 2002), the measurement of higher informative spillovers in industrial districts (Guiso and Schivardi, 1999) and the easier access to credit of district firms, even though in limited time spells (Russo and Finali, 2001).

Finally, a recent empirical analysis on the universe of Italian firms in specific industries confirms and extends the above mentioned results showing the superior export and productivity performance of district firms and its association with a significantly stronger propensity to choose more "advanced" forms of corporate ownership, and, specifically, a significantly higher share of limited liability ownerships (Becchetti et al., 2003).

These empirical findings are the result of testing a variety of theoretical models on the comparative advantage of agglomerated versus non agglomerated firms. In such models the main sources of this comparative advantage have been identified in: i) the presence of a monopolistic competitive service industry selling differentiated goods to firms competing on product markets (Rivera-Batiz and Romer, 1991; Abdel-Rahman and Fujita, 1990; Dobkins, 1996); ii) a form of district-wide learning by doing, where district firm cost functions are assumed to be decreasing in the stock of the district output produced in the past (Soubeyran and Thisse, 1988); ii) the positive and self-reinforcing relationship between productivity growth and geographical agglomeration driven by knowledge externalities (Ottaviano et al., 2002).

Another branch of theoretical analysis on industrial districts examined the relationship between the cooperative/competitive attitude and the structure of the competitive race of district firms. This line of research identifies a competitive advantage for geographically agglomerated firms in *multiwinner races* in which cooperation is superior to competition (i.e. access to foreign markets for small and medium sized firms with limits in productive capacity) (Bagella et al., 1998). On the other hand, it evidences limits of agglomeration in *winner-takes-it-all races* (i.e. patent races) in which only one winner survives and therefore costs of cooperation tend to be higher than benefits (Bagella and Becchetti, 1999 and 2001; Vaessen and Keeble, 1995)[2].

If the two strands of the literature presented in this and in the previous section have to be taken into serious consideration, some effort needs to be done to join the two perspectives. Space and product relationships must therefore become two fundamental coordinates for a new taxonomy of productive units which may represent a new benchmark for the investigation of their productivity and competitiveness.

2.3 Space and product relationships

A theoretical and empirical approach integrating in a common perspective space and product relationships is still at its infancy. At the moment most contributions come from managerial literature. Sturgeon (2001) crucially argues that "*Industrial districts are related to value chains and production networks because they often rely on groups of spatially proximate firms that tend to specialize in a particular component, process, or service required to bring a product to market*." The author recognises that a second crucial dimension of value chains and production networks is geographical space. Trying to integrate space into the traditional value chain literature Gereffi (2004) develops the concept of "global

[2] Models of patent races for break through innovations are typical examples of this kind (Dasgupta, P. and Stiglitz, J. 1980; Flaherty, M.T. 1980; Beath, J. and Ulph, D. 1990).

commodity chains" (GCCs) from the traditional concept of "value chains", by stating that GCCs embody an explicit international dimension.

The same taxonomy of industrial districts proposed by Markusen (1996) implicitly integrates space and product relationships. Among the four identified models of i) *Marshallian districts*, ii) *state anchored districts*, iii) *satellite platforms*, iv) *hub and spoke districts*, the last two clearly embody the problem of the interaction between these two dimensions. In the *hub and spoke district* the clear identification of a district leader, subcontracting part of the production to component producers with low bargaining power, paves the way, under the competitive pressure of manufacturers with low labour costs, to the *satellite platform* when the district leaders find it convenient to outsource the less strategic parts of their production to manufacturers located outside the district's original borders. In the *satellite platform* many component producers compete with each other on labour costs and sell intermediate products to the leader firm located outside in the traditional industrial district area[3].

This delocalisation process tends to differentiate always more the performances of independent and subcontractee firms within the traditional district borders. While the former can still survive and take advantage from reallocation of manufacturing activities in low labor cost countries, traditional component producers in high labor cost countries find it hard to compete with new manufacturers.

This process in which "*distance networks*" different from traditional *locales* (in which independent and subcontractees firms were located in the same area) start being created, may generate a dilemma given that the reduction of production costs through cheaper labour, undermines, at the same time, an important source of productivity related to industrial density, geographical proximity and knowledge externalities (Basevi and Ottaviano, 2002). In this perspective the main threat to the survival of the industrial district is the risk of a delocalisation which involves not just the non strategic manufacturing parts of the production process, but also the strategic and high value added innovative components of it (Conti and Menghinello, 1998)[4].

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[3] To provide just an example from a case study, the district of Manzano (Udine) produces 80% of the Italian production of chairs and 50% of the total European chair production. The expression "The Chair Triangle" refers to a geographic area, which covers the areas of Manzano, San Giovanni al Natisone and Corno di Rosazzo in the Udine Region in Friuli Venezia Giulia. On 100 km², 1.200 companies with 15.000 employers are concentrated: 37% of the firms produce finished products, 27% semi-finished and components, while 26% of all firms produce products for third parties. The results of a recent OECD survey on producers of this area concludes that "this district would simply not exist without foreign exchanges for purchase, sale and delocalisation" (OECD, 2002).

[4] Mistri, M. (2003) observes that, even though delocalisation is inevitable on many points of view, industrial districts must not cease to be centers for the strategic definition of the production process. In this perspective they should qualify as areas in which the strategic parts of the production and strategic services related to it should be located.

In the following section we will test whether the taxonomy based on product and space relationships will evidence or not the significant differences in value added, productive efficiency and effects on it of ICT adoption loomed by the above mentioned theoretical contributions.

3. Data

Data come from the Mediocredito Centrale Survey which is one of the most important qualitative-quantitative information source on Italian firms. The Survey has been repeated each three years, starting from 1989, on a sample of around 4500 firms. In order to maintain representativeness and take into account the high exit/entry rate of firms in the Italian market, the original sample has been reshaped for each wave. Any sample has been stratified by size classes (based on the number of employees), geographical areas (North-East, North-West, Central Regions, South and Isles) and sectors (according to Pavitt classification)[5]. Each stratum has been obtained using the Neyman formula with value added per employee as stratifying factor[6].

More specifically, we first focus on the last wave of the Survey, conducted in the 1998 - 2000 period, on a sample of 4680 Italian manufacturing firms with more than ten employees.

Balance sheet and income statement data come from the CERVED database, which collects the information from the official source Italian Chambers of Commerce. The collection of qualitative data is based on questionnaires filled in by a representative of each firm and then accurately checked for inconsistencies.

From the total sample we select firms for which complete balance sheet and income statement data are available. Moreover, we choose firms with positive values of total assets, net worth and net sales. In order to eliminate the influence of the extreme values, following the procedure adopted by Cleary (1999), we winsorize the data according to the following rules: (i) value of ROE greater (lower) than 100% (-20%); (ii) value of ROA greater (lower) than 30% (-20%); (iii) value of total sales/total assets ratio greater (lower) than 300% (20%). The result is a restricted sample of 3903 firms.

Given that one of the purposes of our study is to test if ICT investment has some effects on productive efficiency by evaluating whether this type of investment, carried out in the previous period (1995-97), has positive and significant impact on productive efficiency in the

[5] See Pavitt, K. (1984).

[6] Size classes: 11-20 employees; 21-50 employees; 51-250 employees; 251-500 employees; more tha 500 employees. Macroareas: North East (Trentino Alto Adige, Veneto, Friuli Venezia Giulia and Emilia Romagna), North West (Piemonte, Valle d'Aosta, Lombardia and Liguria), Central Regions (Toscana, Umbria, Marche and Lazio), South and Isles (Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia and Sardegna). Sectors: Scale Economies, Specialised, Traditional and High technology.

following period (1998-00), we take the earlier 1995-97 wave, which is composed by 4497 observations and, by matching it with the last wave, we obtain a data set of 1121 firms that have been surveyed in both periods. The reduction to almost on third of the original size of the last wave sample is due to a significant attrition among the two different sample periods.

We then use this new data set to perform the "difference in distance" estimates explained in section 6.

Since we want to investigate space and product relationships of individual productive units, we divide the full sample using our proposed taxonomy based on geographical agglomeration and position in the value chain as explained in the following sections.

3.1 Methodology for district classification

The consolidated literature on district classification identifies three groups of criteria for defining industrial districts: i) quantitative; ii) quali-quantitative and iii) administrative. In this paragraph we explain why we prefer the first type of classification.

Quali-quantitative indicators (Censis, Cnel-Ceris-CNR, Sole24Ore, Districts Club) have the advantage of integrating statistical indicators with interviews and field research, which leads to the identification of a subset of super-districts. On the other side, though, they risk to confuse identity with performance, since they fail to consider endogeneity problems (in some cases district success might have been one of the main elements for the identification of district areas).

Administrative definitions of industrial districts may contain upward and downward biases. On the one hand, regions might tend to overestimate the number of their own district areas (for example, Piemonte identified 25 districts against the 16 found by Istat, and Lazio 6 against none) in order to maximise political consensus and the inflow of government subsidies available for this purpose. On the other hand, some regions did not define yet any industrial district for administrative delays.[7]

The strength of quantitative indicators of the Istat source is that of adopting clear-cut and a-priori defined objective criteria.[8] Moreover, the Istat quantitative definition has in itself something that may help to catch immaterial determinants of industrial districts. Self-

[7] For Censis classification see X Forum economie locali, April 2001; for Cnel-Ceris-CNR classification see 3rd Survey of Cnel-Ceris-CNR; for Sole24ore classification see for example Moussanet and Paolazzi, (1992); for District Club classification see the Club newsletter n. 8, November 1998. Administrative definitions are identified by regional regulations.

[8] We are well aware of the recent vast and stimulating literature on the limits of the ISTAT dichotomous indicator (Paniccia, I. 1998 and 2002; Tattara, G. 2001 and 2002; Iuzzolino, G. 2004). Nonetheless we find relevant in this paper to evaluate the explanatory power of a definition which has legal implications and is considered as a benchmark for district based industrial policies.

containment, contiguity and space-time relationship needed to define Local Labour Systems partially include sociocultural factors into the Istat definition[9].

ISTAT determination of districts is a two-stage procedure. In the first stage, Italy's territory is divided into Local Labour Systems (LLSs) and, in the second stage, a subset of them is identified as an industrial district if it satisfies the following four criteria: i) a share of manufacturing employment higher than national average; ii) a share of employment in SMEs' local units higher than national average; iii) a share of manufacturing employment in the main industry of the LLSs (the one with the maximum coefficient of concentration) higher than the national average; iv) a share of employment in local units of SMEs in the LLSs main industry higher than national average[10].

3.2 The identification of the position in the value chain

In the previous paragraph we have explained why we use the industrial district concept as a proxy for "space relationship". The positioning of each productive unit in the value chain gives then the other fundamental coordinate of our proposed taxonomy allowing us to take into account simoultaneously both space and product relationships.

To take into account product relationships we use the qualitative information on subcontracting activity contained in the questionnaire.[11]

In the base version of our empirical estimates we define as subcontractees those firms having more than 70 percent of their net sales subcontracted and as independent firms the complementary subset. In a second step we perform a sensitivity analysis on this threshold and test alternative benchmarks for identifying the two categories. More specifically, the additional criteria used for the robustness check are the following: (a) subcontractee (independent) if the subcontracted net sales are more than 50% (less than 50%); (b)

[9] Local Labour Systems (LLS) are aggregations of elementary administrative units (municipalities) defined according to a methodology developed by Istat, Irpet, and the University of Newcastle Upon Tyne, which takes into account Census data on commuting for work purposes. Municipalities are aggregated according to self-containment; contiguity, and space-time relationships criteria. Self containment refers to a concentration of productive and service activities sufficient to provide work and housing opportunities to most of the local population, i.e. able to contain most of the human relationships occurring between productive (working places) and social reproductive activities (housing). Such a territorial unit is a local system when the relationships among such activities can be deployed on daily basis (taking into account their location, time length and transport technologies available - i.e. time-space relationships), and when its component areas are contiguous. LLS are thus changing in number and borders over time. This methodology applied to the 1991 census data led to a partition of Italy into 784 LLS.

[10] A similar approach to define LLSs exists in many other countries. EU countries with full national coverage include Austria, Czech Republic, Denmark, Finland, France, Germany, Italy, Norway, Poland, Portugal, Sweden Switzerland, United Kingdom, the only relevant exception being Hungary, Belgium and Spain. Almost all of the above mentioned countries share the same or very similar criteria for aggregation with the exception of Poland, Austria and Switzerland while in Belgium this work is in progress (OECD, 2002).

subcontractee (independent) if the subcontracted net sales are greater than 0 (equal to zero); (c) subcontractee (independent) if the subcontracted net sales are more than 50% (equal to zero)[12].

At the end of the process we decompose our sample according to a taxonomy which takes into account geographical agglomeration and position in the value chain. We therefore identify four subgroups: i) district independent firms, ii) district subcontractees, iii) non district independent firms and iv) non district subcontractees.

4. Descriptive findings

We inspect the properties of our balanced sample by looking at firms characteristics by size classes (using the traditional taxonomy in which small firms are below 50 employees, medium firms are between 50 and 250 employees and large firms are above 250 employees).

Our descriptive findings show (Table 1), as expected, that large firms are much older than small firms (38 against 23 years). Small firms prevail in the traditional sector (according to the Pavitt taxonomy), large firms in the scale sector and medium firms in the specialised sector. Firms are also generally smaller in the Center and South of Italy. As expected, large firms are more affiliated to groups (around 84 percent against around 12 percent) and export in a much higher proportion than small firms (around 94 percent against around 63 percent). Significant differences arise also in quality certification (78 percent against 32 percent) and in the implementation of procedures for evaluating customer satisfaction (78 percent against 68 percent).

The reader can verify that medium firms are somewhere in the middle between these two extremes for each of the above mentioned variables, except for the macrosector classification.

When we look at the bank-firm relationship we find that large firms have on average relationship with 10 banks, while small firms only with 4. As expected, the share of debt held by the first lender is larger in small firms (41 against 32 percent) and relationship with the borrower is older for large than for small firms (19 years against 17 years).

If we look at capital stock investment flow of funds we do not find very strong differences between small and large firms in the proportion of the investment financed by bank lending, subsidies and internal finance. On the contrary, we find strong differences in sources of R&D investment financing with much higher share of bank financing for large firms.

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[11] For subcontracting we mean an industrial relationship by which a firm entrusts another with the execution of a step of its own productive process or of an activity linked to the productive process itself, or of the provision of intermediate inputs or components which will be integrated in a more complex product.

4.1 Descriptive evidence on sample heterogeneity driven by space and product relationships

To take into account the impact of space and product relationships we look inside the blackbox of the firm and decompose it according to a taxonomy which takes into account geographical agglomeration and position in the value chain. We therefore identify four subgroups: i) district independent firms, ii) district subcontractees, iii) non district independent firms and iv) non district subcontractees. Table 2 presents descriptive evidence on relevant variables for the four subgroups of firms.

Significant differences among sugroups are found for several of them. Both district and non district independent firms exhibit higher value added per employee than district and non district subcontractees (49 against 41 and 44 against 40 respectively in district and non district areas). Since value added incorporates a physical productivity and marketability component this evidence may be interpreted either in terms of higher physical productivity or, simply, in terms of higher bargaining power along the value chain, consistently with our assumption on the effects of globalisation which increases opportunities for district independent firms, while increasing competition among subcontractors located in different parts of the world. We will try to disentangle in the next sections the various determinants of these differences in productivity with OLS and with stochastic frontier estimates in which relative efficiency will be evaluated net of rent extraction and other control factors.

Descriptive evidence also shows that independent firms belong for a higher share to the large size class (13 percent against 4 percent in the district and 10 percent against 4 percent outside the district) and exhibit higher values in group affiliation and leverage (around 18 percent against 14 percent and around 17 percent against 12 percent in district and non district areas respectively).

Independent firms are also almost six year older than subcontractees (about 29 against 23 years both in districts and non district areas) and are more likely to export (about 79 against 67 and 73 against 66 in district and non district areas respectively).

A slight difference between district and non district firms seems to exist for ROE which is higher for the former, no matter if they are independent firms or subcontractees, while ROA and ROS are almost the same among the 4 different subgroups.

The different capacity of financing R&D with bank debt seems to be affected by the district/non district location since both district independent and subcontractee firms have a

[12] As explained in section 6, results of the sensitivity analysis are not substantially different from those presented here and are available upon request.

much higher share of R&D investment financed with bank debt than their non district counterparts.

A direct evaluation of the impact of our proposed space and product relationship taxonomy on the heterogeneity of sample production units is provided in Table 3. The interesting result is that, when we consider leverage and some representative performance variables such as ROE, ROA, ROS and value added, we find that the district independent subgroup has the relatively lower variability, followed by the subgroup of non district independent firms. The group of nondistrict subcontractees has much higher variation than the others with values which are above those of the overall sample.

An interesting issue is to evaluate how much these differences depend on age, size and monopoly rents, on the one side, and on space and product relationships, on the other side. The difficulty in answering to this question lies in the fact that the two classes of variables are strictly correlated. To disentangle the two effects we regress value added per worker on age, size and other traditional controls in order to test whether the role of space and product relationship is significant (see Table 4). We find that district firms have significantly higher value added net of considered controls. When we repeat the estimate in subgroups of independent and subcontractee firms we find that all the effect is due to the significantly higher value added of district with respect to non district independent firms.

5. The role of space relationships among the determinants of productive efficiency in a stochastic frontier approach

As stated in the previous section, OLS regressions on value added per worker give a first indication on the significance of product and space relationship effects, net of other control factors included in the estimates, but have several limits. They in fact do not discriminate between rent extraction and productive efficiency and do not simultaneously take into account distances from the efficiency frontier for a given production function.

To test whether space and product relationships affect productive efficiency we estimate a stochastic frontier production function. This approach allows to distinguish between production inputs and efficiency/inefficiency factors and to disentangle distances from the efficient frontier between those due to systematic components and those due to noise. This parametric approach is preferred to nonparametric ones since it avoids that outliers are considered as very efficient firms (Signorini, 2000).

The stochastic frontiers methodology has been firstly proposed by Aigner et al. (1977) and Meeusen and van der Broeck (1977). The idea is that the frontier, which represents the maximum output level for a given input set, is assumed to be stochastic in order to capture exogenous shocks beyond the control of firms. Since all firms are not able to produce the frontier output, an additional error term is introduced to represent technical inefficiency that, in turn, is in the control of the firms[13].

After these early studies the stochastic frontier methodology has been extended in many directions using both cross-sectional and panel data. The availability of panel data allows to study the behaviour of technical inefficiency over time. Among others, Pitt and Lee (1981), Schmidt and Sickles (1984) and Kumbhakar (1987) treated technical inefficiency as time invariant while for example Cornwell, Schmidt and Sickles (1990), Kumbhakar (1990), Battese and Coelli (1992) and Lee and Schmidt (1993) allowed technical inefficiency to vary over time even if they modelled efficiency as a systematic function of time.

The search for the determinants of efficiency changes has been firstly pursued by adopting a two stage approach in which the efficiencies estimated in the first stage were then regressed against a vector of explanatory variables. Further development of this technique led to the adoption of a single stage approach in which explanatory variables are incorporated directly into the inefficiency error component[14]. In particular, Kumbhakar, Gosh and McGuckin (1991) - from now on KGM - noted the inconsistency between the i.i.d. assumption on the inefficiency effects at the first stage and the non identical distribution of the predicted inefficiency effects in the second stage, and proposed a model in which the inefficiency effects were explicit functions of a vector of firm-specific factors and the parameters were estimated in a single stage maximum likelihood procedure.

The KGM model is specified as follows:

(1) $$\ln y = \ln f(x_i;\beta) + v_i - u_i$$

(2) $$u_i = \delta' z_i + \varepsilon_i$$

where random noise in the production function is introduced through the error component v_i which is i.i.d as $N(0,\sigma^2_v)$ and where the second error component, which captures the effects of technical inefficiency, has a systematic component $\delta' z_i$ associated with the exogenous variables and a random component ε_i. By combining (1) and (2) we obtain the single stage production frontier model:

(3) $$\ln y = \ln f(x_i;\beta) + v_i - (\delta' z_i + \varepsilon_i)$$

[13] We follow the Farrel, M.J. (1957) measure of firm's efficiency consisting in two components: technical and allocative. The former reflects the ability of a firm to obtain maximal output from a given set of inputs while the latter reflects the ability of a firm to use the inputs in optimal proportions given their respective prices.
[14] For a review see Kumbhakar, S. C. and Knox – Lovell, C. A. (2000).

Assuming that v_i is i.i.d as $N(0,\sigma^2_v)$ and $u_i \sim N^+(\delta' z_i,\sigma^2_u)$ and that the two components are uncorrelated, the parameters can be estimated using the maximum likelihood estimator. Then firm-specific estimates of technical inefficiencies are obtained using the Jodrow et al. (1982) decomposition and the effect of each environmental variable on technical inefficiency can be calculated[15].

Other developments of the KGM contribution where then proposed by Reifschneider and Stevenson (1991), Huang and Liu (1994) and Battese and Coelli (1995).

The Battese and Coelli model is almost equivalent to the KGM[16] and consists of equation (3) with the condition $u_i = (\delta' z_i + \varepsilon_i) \geq 0$ modeled as $\varepsilon_i \sim N(0, \sigma^2_\varepsilon)$ with the distribution of ε_i bounded below by the variable truncation point $-\delta' z_i$, since this distributional assumption on ε_i is consistent with the one on u_i that $u_i \sim N^+(\delta' z_i,\sigma^2_u)$. The z_{it} is a vector of exogenous variables which may influence individual inefficiencies and δ' a vector of unknown parameters to be estimated.

The simultaneous maximum likelihood estimation of the two equation system is expressed in terms of the variance parameters $\sigma^2=\sigma^2_v+\sigma^2_u$ and $\gamma=\sigma^2_u/\sigma^2_v+\sigma^2_u$, to provide asymptotically efficient estimates[17]. Hence, it is clear that the test on the significance of the parameter γ is a test on the significance of the stochastic frontier specification (the acceptance of the null hypothesis that the true value of the parameter equals zero implies that σ^2_u , the non random component of the production function residual, is zero).

The technical efficiency of the i-th firm in the t-th time period is given by

(4) $$TE_i = e^{(-u_i)} = e^{(-\delta' z_i - \varepsilon_i)}$$

5.1 Our methodology

We adopt the 1995 Battese and Coelli specification and estimate the model by using the computer program FRONTIER 4.1. We perform our estimations using both a three year panel than a cross-section in which all quantitative variables are included as three year averages in order to smooth potential, year specific, measurement inaccuracies[18]. In both specifications

[15] For a detailed analysis of the model see Kumbhakar, S. C., Gosh, S. and McGuckin, J.T. (1991) or Kumbhakar,S.C., Knox – Lovell, C. A. (2000)

[16] Battese and Coelli, in contrast with KGM, remove first order profit maximising conditions, impose allocative inefficiency and allow for the use of panel data.

[17] The log-likelyhood function and the derivatives are presented in the appendix of Battese, G. E. and Coelli, T. J. (1993).

[18] For a discussion on the choice between panel and cross-sections see Schmidt, P. and Sichel, R.C. (1984).

we reject the null hypothesis of the insignificance of the non random component of the production function residual.

By assuming that the production function takes the log - linear Cobb-Douglas form, our stochastic frontier production model is specified as follows:

$$\ln(Y/L)_{it} = \alpha_0 + \alpha_1 \ln(K/L)_{it} + \sum_{j=1}^{m-1} \beta_j \ln(K/L)_{it} * Ind_j + v_{it} - u_{it} \tag{5}$$

where the dependent variable is the value of output of the i[th] firm at time t (i=1,...,N; t=1,...,T), divided by a scale variable (the number of workers) in order to remove potential problems of heteroskedasticity, multicollinearity and output measurement (Hay-Liu, 1997) and K/L is the capital stock per worker. To take into account industry specific shapes of the production function we add m-1 dummies accounting for differences in the output per worker/capital per worker elasticity between the reference sector and all other sectors[19].

The second equation of our model, containing a vector of observable explanatory variables is the following:

$$\begin{aligned} u_{it} = {} & b_0 + \sum_{j=1}^{m-1} b_j Ind_j + \sum_{k=1}^{h-1} \gamma_k Macroarea_k + \delta_1 Rents + \delta_2 Presfi + \delta_3 Small + \delta_4 Large + \\ & + \delta_5 Old + \delta_6 Young + \delta_7 Group + \delta_8 Qtnosep + \delta_9 Exp + \delta_{10} Distrind + \delta_{11} Distrsubc + w_{it} \end{aligned} \tag{6}$$

where *Ind* are the previously defined industry dummies and *Macroarea* are h-1 geographical dummies (h=1,..,4) which account for firm localisation.

Industry effects are needed to control for distorsions arising when comparing value based performance indicators across different industries. Such distortions may be of three types. First, measures based on comparisons between values of output and values of input, if not deflated by the specific (output and input) price indexes, may create biases in comparisons across time. Second, heterogeneity in market structures across sectors generate dispersion of prices above the competitive price level. As a consequence, industry driven differences in productivity may signal not efficiency gains of individual productive units, but industry

[19] The firms have been classified in industries according to the Italian Ateco classification, covering the following industries: (1) Food, Beverage and Tobacco; (2) Textile, knitwear and clothing; (3) Leather and Shoes; (4) Wood and wooden furniture; (5) Paper and printing; (6) Chemicals; (7) Rubber and Plastics; (8)Glass and ceramics; (9) Construction Materials; (10) Metal Extractions; (11) Metal Products; (12) Mechanical Materials, (13) Mechanical Equipment; (14) Electronics; (15) Electrical equipment (16) Precision instruments and apparel (17) Vehicles and Vehicle components; (18) Other Transports; (19) Energy; (20) Other Manufacturing.

specific differences in competitive environments. Third, performance indicators should be adjusted, for input quality adjustment even though quality adjustment may in this case generate two offsetting effects (i.e. some firms may have higher quality inputs which are more costly but allow to generate higher value output).

The first type of bias does not affect our cross-sectional estimates. The second is partially corrected by industry controls and by the inclusion of a proxy of monopoly rents among regressors, as explained below. The third can be particularly relevant, but may also be partially avoided in our estimates of the determinant of ICT investment if heterogeneity in quality is mainly industry specific.

To these variables we add controls traditionally considered in the literature (Hay-Liu, 1997; Nickell, 1996 and Nickell and Nicolitsas, 1999) such as *Rents* (EBT+depreciation and amortisation+net interest payment-value of capital stock)/value added) and *Presfi* (Interset payments / (interest payment+cash flow). We then add four dummies picking up potential effects on efficiency of size and age (*Small, Large, Old and Young)*. These four variables identify respectively the older, the younger, the smaller and the larger 20 percent of sample firms. *Group* is a dummy that accounts for group affiliation and *Qtnosep* a measure of the total share of ownership of the controlling shareholders which controls for effects of ownership structure on efficiency. In addition, following a well established literature[20] in the field, we control for access to foreign markets (*Exp*).

Our test on the effects of space and product relationships on production efficiency is performend by adding two dummies, *Distrind* and *Distrsubc,* picking up firms located into industrial districts. *Distrind* is for firms with less than 70 percent subcontracted output and *Distrsubc* for the complementary set.

5.2 Empirical findings from the stochastic frontier model

As shown in table 5 geographical dummies show that firms located in Southern (North-West) Italy are significantly less (more) efficient than the rest of the sample. The fact that small and young firms result to be relatively more efficient is an expected outcome of competitive selection which requires that, ex post, survived small and young firms must have grown more than the rest of the sample.

The positive impact on productivity of the group dummy supports the hypothesis that groups are efficient solutions to the make or buy dilemma or to the trade-off between transaction costs in intermediate input and in labour markets (Camacho, 1996; Liu and Yang,

[20] See**,** among the most relevant**,** Aw, B.Y. and Hwang, A. (1995), Clerides, S. K., Lach, S. and Tybout, S. (1998), Delgado, M.A. and Farinas, J.C. (1999).

2000). It is also consistent with other results on the same sample period showing the relatively higher productivity and superior competitiveness performance of groups with respect to individual firms (Becchetti, 2002). The variable *Exp* that accounts for export activities confirms the consolidated result of a positive effect on efficiency. Export activities consist in fact in a learning process that improves firms productivity with the result that only the most efficient firms are selected by foreign markets (Delgado and Farinas, 1999).

An apparently counterintuitive result is the positive effect of rents on productive efficiency in the cross-sectional (but not in the panel) estimates. Since rents may be the result of the capacity of creating sustainable competitive advantages, they may be associated in static estimates to more efficient firms. The disappearence of the significance of this effect in panel estimates confirms that, consistently with the literature, rents are dynamically expected not to increase productive incentives[21].

Finally, our findings show that space relationships significantly and positively affect productive efficiency since district firms, whatever their position in the value chain, are significantly less distant from the efficient frontier (significance of *Distrind* and *Distrsubc* variables). A likely intepretation is that space relationships may help to accumulate hidden and unmeasured social and human capital components which significantly affect the productivity of visible and measurable labour and capital inputs. The result is a significantly higher productive efficiency of the two observable inputs.

The inclusion of *Rents* among regressors helps to discriminate between the above mentioned interpretation and the alternative that higher added value of district independent firms depends from their higher bargaining power along the value chain. The widespread opinion of the popular press is that Italian industrial districts are in deep crisis in the new globalised markets under the strong competitive pressure of Far East producers. Our results qualify and challenge this belief showing that, net of industry specific and other concurring effects, geographical agglomeration still enhances productive units' value added, even in the globalised more competitive arena.

6. The impact of ICT adoption on efficiency when space and product relationship are taken into account

A first simple option for testing the effect of ICT investment on productive efficiency is to evaluate whether ICT investment in the previous wave (1995-97) has positive and significant effects on productive efficiency in the following wave (1998-00).

[21] See Short, H. (1994), Nickell, S. (1996) and Vickers, J. (1995).

By following this approach, though, we cannot distinguish whether a positive impact of ICT investment on efficiency is a dynamic effect induced by the decision to invest in ICT, or an unobserved difference in quality between ICT and non ICT firms which preexisted even before the decision, (ex ante heterogeneity).

To distinguish between the two hypotheses we perform a "difference in distance" estimate. The approach is necessarily in two steps. In the first we estimate, including observations from both waves, a common (interwave) stochastic frontier model represented by equation (5) and an estimate of the determinants of the distance from the frontier (second equation) which includes only industry dummies. In the second step, we regress changes in the estimated distance from the efficient frontier in the two periods on a series of regressors traditionally used in the second equation of the stochastic frontier model[22].

The choosen specification is:

(7)
$$\Delta u_{it} = b_0 + \sum_{k=1}^{h-1} \gamma_k Macroarea_k + \delta_1 \mathrm{Re}nts + \delta_2 \Pr esfi + \delta_3 Small + \delta_4 L\arg e + \\ + \delta_5 Group + \delta_6 Consorz + \delta_7 Exp + \delta_8 Ndictind + \delta_9 Ndictsubc + \delta_{10} Psurv$$

where $\Delta u_{it} = u_i98\text{-}00 - u_i95\text{-}97$ is the difference in distance from the efficient frontier of the i-th productive unit in the 1998-2000 period and in the ICT investment period (1995-97). *Consorz* is a dummy which accounts for affiliation to consortia. All other regressors are defined as in (6). Among them we consider the interaction betwen ICT investment and participation to one of the four subgroups of our space/product relationship taxonomy (district independent, district subcontractee, non district independent, non district subcontractee).

We prefer to estimate a joint frontier for the two periods (instead of two different frontiers) to make comparable distances from the frontiers in the two periods. Nonetheless, we repeat our experiment by focusing not only on percent distances from productive efficiency, but also on ordinal changes in the productivity ranking across observed firms in the sample. We therefore rank firms in a given wave in terms of distance from the frontier and, in a second estimate, we consider as dependent variable the change in ranking between the first and the second period. This second measure has the advantage of evaluating productive improvement not in terms of physical distances but in terms of relative performance with respect to sample firms.

[22] This approach is superior to others - such as the Heckmann, J.J. and Holtz, V.J. (1989) solution - which is the only available opportunity when information on performance on the period of ICT investment is not available.

Our findings show that, among the four subgroups of ICT investing firms, only non district independent firms *(Ndictind)* exhibit a significant reduction in distance from the efficient frontier. The result is confirmed when we estimate the specification which has relative changes in rankings as dependent variable (Tables 6 and 7).

The apparently counterintuitive result on the effects of ICT on efficiency is consistent with the effects of geographical agglomeration evidenced before. According to the theoretical literature on the field, district location significantly fosters hidden or not entirely measurable forms of (human and social) capital by reinforcing informal networks and technological spillovers. The underestimation of the stock of overall (physical but also human and social) capital justifies and explains the observed difference in mean and variability of productive efficiency between the district/non district subgroups. In this perspective, by considering that electronic links are a substitute of space in fostering networks, we are not surprised that ICT adoption has a stronger and significant impact on non district independent firms and that ICT is more beneficial for those firms with poorer space relationship.

Since there is significant attrition between the two panels (many firms present in the first are not recorded in the second) we need to control whether our result is robust to the survivorship bias. More specifically, our results may not signal the significant increase in efficiency for non district independent firms after ICT investment but the following alternative scenario. A hidden "negative performance" variable (such as financial distress) affects the survival of ICT investing non district independent firms. The same variable is negatively correlated with changes in productive efficiency. Therefore we only observe the positive side of the phenomenon (good quality surviving ICT investing non district independent firms realise significant efficiency gains) and not the negative side (bad quality ICT investing non district independent firms fail or have a negative performance and are not recorded in the second survey).

To control for this effect we estimate in a logit specification the determinants of survival from the first to the second survey. We then add the Mill's ratio in our difference in distance estimate. After the introduction of this variable results on additional regressors should properly measure the effect of difference in distance, net of the effect of the probability of survival on the same dependent variable.

If the coefficient on ICT investing non district independent firms is still significant, it will tell us that the difference in distance for this subgroup of firms depends on ICT investment and not on hidden carachteristics (absence of financial distress, good performance ex ante) which significantly affect the probability of their survival in the sample.

Our empirical findings confirm that the significant improvement in productive efficiency of non district independent firms investing in ICT is robust to the survivorship bias (column 2 in Tables 6 and 7).

As explained in the data section we test alternative benchmarks for identifying the two categories of independent and subcontractee firms. Results of this sensitivity analysis are not substantially different from those presented here and are available upon request.

7. Conclusions

Measuring firm intangible assets is becoming of increasing relevance in a framework of global integration in which innovation plays a decisive competitive role.

Three types of intangibles are generally considered: i) human capital assets which represent a combination of knowledge derived from education, innate abilities, local spillovers and learned on the job skills; ii) the organizational capacity of the company, the processes, logistics and other systems, crucially affected by the quality of relational goods within the firm; iii) the quality of the relation with suppliers and customers that generate competitive advantages for the company. The second and the third factors may be respectively considered as a form of "internal social capital" and of "external social capital" concerning the firm relationship with its stakeholders.

We argue that an important dimension of these intangibile assets may be incorporated by space and product relationship of individual productive units. This is because quality of space relationship, which is proxied by district agglomeration, by stimulating the creation of social capital and by generating productive externalities and quality of product relationship (position in the value chain), represents in itself one of the dimensions of the above mentioned intangibile assets (relation with suppliers and clients).

Within this framework global integration and the ICT revolution represent, by definition, two shocks to the existing equilibria of space and product relationships across productive units. The first provides a delocalisation option to firms which are leaders in their value chain, thereby reducing bargaining power of local subcontractees. The second improves virtual relationships among geographically distant productive units, with the possible reduction of the comparative advantage of geographically agglomerated firms.

The goal of this paper has been that of trying to measure the impact of these intangible assets under the form of space and product relationships on efficiency and productivity and to check whether ICT technological innovation has generated significant changes in relative efficiency of productive units, conditional to their quality of space and product relationship.

Our findings show that quality of space relationships crucially affects firm productivity in both value added per worker and firm efficiency, when we correct productivity for various controls including firm relative market power. We also find that ICT adoption generates significant improvement in efficiency only for the subgroup of non district independent firms.

We interpret our results by arguing that district location significantly stimulates accumulation of hidden and unmeasured forms of (human and social) capital and that ICT acts as a partial substitute for these factors in firms which do not benefit of local agglomeration economies.

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Table 1: descriptive features of the Mediocredito sample in the 1998-2000 period

	Small	**Medium**	**Large**	**Total**
Pavitt taxonomy				
Traditional	55.26	45.73	40.74	52.73
Scale Economies	18.74	14.39	23.87	18.32
Specialised	22.08	32.08	27.98	24.16
High Technology	3.92	7.80	7.41	4.79
	100	100	100	100
Localisation				
North-West	35.38	41.68	45.27	37.07
North-East	26.96	29.99	36.63	28.08
Centre	23.15	14.69	11.93	21.01
South & Islands	14.51	13.64	6.17	13.84
	100	100	100	100
Main features				
Age*	23.10	30.57	38.20	25.32
Export	62.85	86.92	94.24	68.92
Group	12.15	31.73	83.88	19.95
Consortium	10.03	12.2	9.05	10.34
Quality Certification	32.97	60.45	78.22	40.32
Customer satisfaction	68.85	73.86	78.47	70.23
High Skilled labour	7.93	5.87	7.28	7.36
Bank relationships				
N. of banks*	4.47	7.18	10.42	5.27
Share of debt*	41.21	34.80	31.94	39.54
Local	65.41	57.25	46.43	63.02
Duration*	16.88	19.65	18.75	17.44
Financial Indicators				
Roe*	7.41	6.80	8.07	7.35
Roa*	2.02	2.05	2.53	2.06
Ros*	1.41	1.82	2.70	1.56
Value Added x employee*	40.52	45.79	56.02	42.39
Leverage*	12.34	22.86	20.91	14.67
Financing of Physical Investments				
Internal Finance*	40.96	46.40	46.29	42.22
Bank debt*	11.99	14.10	15.93	12.60
State*	14.73	19.38	12.69	15.40
Financing of R&D investments				
Internal Finance*	24.10	43.37	48.76	28.93
Bank debt*	35.03	31.24	21.72	32.19
State*	3.61	7.84	11.54	4.83

Total Sample is 3903 observations. Percentage values except * which are averages. Age is the difference between 2000 and firm's year birth. Export, Group, Consortium, Quality Certification and Customer satisfaction are the % of firms that respectively export part of their production, belong to a group, belong to a consortium, have been Quality Certified according to ISO rules and processes Customer Sastisfaction. High Skilled labour is the % of employees with Laurea. N. of banks is the mean number of banks with which the firm has commercial relationship, Share of debt is the mean % of debt held by the main lender, Local is the % of firms whose main lender is located in the same province and Duration measures the number of years of the main banking relationship. Roe is net earnings to net worth ratio (%), Roa is net earnings to total asset ratio (%), Ros is net earnings to net sales ratio (%) Value added per employee is total value added to number of employees ratio and Leverage is total debt to total liabilities and net worth ratio. The last six variables of the table account for the % of investment in Physical capital (in R&D) financed respectively by Internal finance, bank debt and state subsidies.

Table 2: descriptive features of the Mediocredito sample according to our taxonomy

	District		Non District		Total
	Independent (obs. 212)	Subcontractee (obs. 440)	Independent (obs. 1216)	Subcontractee (obs. 2035)	(obs. 3903)
Pavitt taxonomy					
Traditional	55.66	57.50	54.44	50.37	52.73
Scale Economies	17.45	14.09	18.34	19.31	18.32
Specialised	23.58	23.41	21.38	26.04	24.16
High Technology	3.30	5.00	5.84	4.28	4.79
	100	100	100	100	100
Localisation					
North-West	30.66	22.95	38.57	39.90	37.07
North-East	39.15	30.23	26.81	27.22	28.08
Centre	25.94	44.32	15.79	18.57	21.01
South & Islands	4.25	2.50	18.83	14.30	13.84
	100	100	100	100	100
Size					
Small	70.28	80.00	72.20	79.31	76.68
Medium	16.98	16.36	18.01	16.71	17.09
Large	12.74	3.64	9.79	3.98	6.23
	100	100	100	100	100
Main features					
Age*	28.90	22.90	28.60	23.40	25.32
Export	78.77	66.82	73.14	65.83	68.92
Group	25.00	18.49	22.51	18.21	19.95
Consortium	12.32	10.07	12.36	8.98	10.34
Quality Certification	32.85	31.12	42.38	41.87	40.32
Customer satisfaction	65.69	68.26	67.71	72.60	70.23
High Skilled labour	6.44	6.73	8.03	7.16	7.36
Bank relationships					
N. of banks*	6.26	5.65	5.46	4.97	5.27
Share of debt*	37.17	37.78	39.72	40.03	39.54
Local	62.81	61.12	62.13	63.97	63.02
Duration*	19.44	16.88	17.96	17.06	17.44
Financial Indicators					
Roe*	8.64	8.32	6.13	7.74	7.35
Roa*	2.64	2.13	1.75	2.17	2.06
Ros*	1.86	2.39	1.37	1.52	1.56
Value Added x employee*	49.19	41.29	44.12	40.87	42.39
Leverage*	18.12	14.25	17.13	12.93	14.67
Financing of physical inv.					
Internal Finance*	40.79	44.43	44.08	40.78	42.22
Bank debt*	16.95	12.05	14.24	11.28	12.60
State*	14.18	13.77	16.69	15.11	15.40
Financing of R&D inv.					
Internal Finance*	29.70	30.33	30.09	27.85	28.93
Bank debt*	41.63	40.06	32.64	27.27	32.19
State*	5.54	4.30	5.57	4.42	4.83

% values except* which are averages. Age is 2000 - firm's year birth. Export, Group, Quality Certification and Customer satisfy. are % of firms that respectively export, belong to a group or consortium, have been Quality Certified and processes Customer Sastisfaction. High Skilled labour is the % of employees with Laurea. N. of banks is the mean n. of banks with which the firm has commercial relationship, Share of debt is the mean % of debt held by the main lender, Local is the % of firms whose main lender is in the same province, duration is the duration of main banking relationship. Roe is net earnings/net worth (%), Roa is net earnings/total asset (%), Ros is net earnings/net sales(%), Value added x employee is value added/n. of employees, Leverage is total debt/total liabilities and net worth. The last six variables account for the % of investment in Physical capital (in R&D) financed respectively by Internal finance, bank debt and state subsidies.

Table 3: Relative heterogeneity of district and non district subgroups with respect to the overall sample

		District		Non district		All
		Independent	Subcontractee	Independent	Subcontractee	
		σ/μ	σ/μ	σ/μ	σ/μ	σ/μ
Roe	1998	1.9719	2.1724	2.1795	2.4613	2.2443
	1999	1.9834	2.1702	2.6194	2.6872	2.5402
	2000	1.8162	2.0305	2.2245	2.8423	2.3287
Roa	1998	1.8539	2.4325	2.4483	2.6157	2.4505
	1999	1.6862	2.0594	2.3045	2.3657	2.2517
	2000	2.1375	2.3757	2.5854	3.2644	2.7014
Ros	1998	2.1889	4.6195	5.3964	5.9200	5.0200
	1999	2.0144	2.7354	3.9214	3.9373	3.6351
	2000	2.2037	4.0652	4.2597	5.3877	4.3447
Value Added x Employee	1998	0.4777	0.5415	0.6569	0.6847	0.5924
	1999	0.4688	0.5921	0.6122	0.6310	0.5977
	2000	0.4757	0.5788	0.6315	0.6915	0.5982
Leverage	1998	1.0258	1.0291	1.2220	1.2671	1.1669
	1999	1.0656	1.0715	1.2138	1.2843	1.1916
	2000	1.0613	1.0892	1.2393	1.3243	1.2123

Total Sample is 3903 observations. Roe is net earnings to net worth ratio (%), Roa is net earnings to total asset ratio (%), Ros is net earnings to net sales ratio (%) Value added per employee is total value added to number of employees ratio and Leverage is total debt to total liabilities and net worth ratio.

Table 4: The role of space and product relationships among determinants of per capita value added

	All sample firms						Independent firms						Subcontractee firms					
	coeff	**t**	**coeff**	**t**	**coeff**	**t**	**coeff**	**t**	**coeff**	**t**	**coeff**	**t**	**coeff**	**t**	**coeff**	**t**	**coeff**	**t**
Age	0.118	5.750	0.124	6.070	0.126	6.140	0.139	4.130	0.149	4.460	0.153	4.560	0.070	2.650	0.071	2.710	0.071	2.710
Size	0.004	2.980	0.004	2.800	0.004	2.780	0.001	0.690	0.001	0.510	0.001	0.510	0.008	3.140	0.008	3.010	0.008	2.980
District	1.738	1.700	1.966	1.940	1.899	1.860	4.018	2.000	4.330	2.180	4.125	2.070	0.770	0.680	0.938	0.830	0.955	0.840
Group	11.409	11.730	10.822	11.170	10.824	11.110	15.851	8.800	14.937	8.360	14.816	8.270	8.159	7.260	7.686	6.850	7.722	6.830
North West	3.355	3.220	2.128	2.030	2.034	1.930	2.001	0.970	0.462	0.220	0.389	0.190	3.750	3.250	2.676	2.290	2.614	2.230
North East	2.188	2.030	1.697	1.580	1.617	1.500	1.028	0.480	0.668	0.310	0.550	0.260	2.301	1.930	1.710	1.430	1.684	1.400
South	-3.037	-2.320	-2.690	-2.060	-2.628	-2.010	-4.556	-1.870	-3.620	-1.500	-3.644	-1.510	-2.640	-1.740	-2.533	-1.670	-2.440	-1.600
Traditional sect.			-6.436	-6.880	-6.349	-6.760			-10.184	-5.800	-9.864	-5.580			-4.210	-3.960	-4.235	-3.970
Specialised sect.			-1.791	-1.660	-1.699	-1.570			-4.725	-2.270	-4.478	-2.140			0.317	0.260	0.326	0.270
Consortium					-1.513	-1.240					-2.243	-1.050					-0.851	-0.580
_cons	35.052	35.640	39.375	32.620	39.470	32.570	36.212	18.550	43.230	18.430	43.259	18.430	35.518	32.130	38.210	28.030	38.304	27.880
obs.	3895		3895		3881		1425		1425		1422		2470		2470		2459	
F(i.v., obs)	41.12		38.61		34.47		21.49		21.02		18.70		17.42		16.58		14.80	
Prob > F	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
R-squared	0.07		0.08		0.08		0.10		0.12		0.12		0.05		0.06		0.06	
Adj R-squared	0.07		0.08		0.08		0.09		0.11		0.11		0.04		0.05		0.05	
Root MSE	23.13		22.97		22.99		26.53		26.22		26.23		20.78		20.68		20.72	

Dependent variable is value added per employee. Age is the difference between 2000 and firm's year birth. Size is the number of employees. District, Group, Consortium are dummies that accounts for firms respectively located in an industrial district, belonging to a group and belonging to a consortium. North West, North East and South account for geographical location. Traditional sect. and Specialised sect. account for Pavitt classification.

Table 5: Factors affecting efficiency in the 1998-2000 period

		Model 1 (cross section)		Model 2 (panel)				Model 1 (cross section)		Model 2 (panel)	
		Coeff.	***t***	***Coeff.***	***t***			***Coeff.***	***t***	***Coeff.***	***t***
Const	β_0	4.8455	131.6821	4.9662	77.3556	Const	b_0	0.2836	2.0550	0.5228	6.2175
K/L	β_1	0.1281	7.1994	0.1213	9.1279	Sect1	b_1	-0.2726	-1.9300	-0.4698	-4.5081
K/L*sect1	β_2	0.0863	4.4961	0.0284	1.4849	Sect2	b_2	0.9385	6.7014	0.1337	1.5833
K/L*sect2	β_3	0.1942	8.7675	0.0534	2.9156	Sect3	b_3	0.6080	3.4288	0.2393	2.4337
K/L*sect3	β_4	0.1254	3.9196	0.0863	3.7405	Sect4	b_4	-0.1184	-0.6910	-0.0084	-0.0943
K/L*sect4	β_5	-0.0052	-0.2372	0.0003	0.0164	Sect5	b_5	-0.1730	-1.0272	-0.1640	-1.7190
K/L*sect5	β_6	-0.0041	-0.1836	-0.0309	-1.6240	Sect6	b_6	-0.0511	-0.2667	-0.1645	-1.4042
K/L*sect6	β_7	0.0717	2.7543	0.0416	1.8270	Sect7	b_7	-0.1854	-0.8494	0.2081	1.9480
K/L*sect7	β_8	-0.0149	-0.6284	0.0478	2.1946	Sect8	b_8	-0.7212	-1.6083	1.1255	7.3708
K/L*sect8	β_9	-0.0759	-2.6166	0.2474	7.2620	Sect9	b_9	-0.1408	-0.6554	0.4739	3.8075
K/L*sect9	β_{10}	-0.0019	-0.0709	0.1165	4.3861	Sect10	b_{10}	0.0093	0.0379	-0.3556	-2.5977
K/L*sect10	β_{11}	0.1287	3.7827	0.0582	2.2440	Sect11	b_{11}	-0.0689	-0.4798	0.2780	3.4348
K/L*sect11	β_{12}	-0.0380	-1.9295	0.0369	2.1968	Sect12	b_{12}	-0.2628	-1.0778	-0.1027	-0.7416
K/L*sect12	β_{13}	-0.0114	-0.3943	-0.0129	-0.5380	Sect13	b_{13}	-0.1903	-1.0796	0.1556	1.9113
K/L*sect13	β_{14}	-0.0073	-0.3326	0.0459	2.6626	Sect14	b_{14}	-0.0454	-0.2637	-0.2960	-3.0576
K/L*sect14	β_{15}	-0.0159	-0.6204	-0.0933	-4.5670	Sect15	b_{15}	0.9715	2.3839	0.4117	1.8178
K/L*sect15	β_{16}	0.2292	2.4765	0.1525	2.8092	Sect16	b_{16}	-2.0316	-2.8749	-0.3066	-1.4916
K/L*sect16	β_{17}	-0.1126	-3.6724	-0.1352	-5.3081	Sect17	b_{17}	-0.6802	-4.3255	-0.4461	-2.8358
K/L*sect17	β_{18}	-0.0210	-0.9471	-0.0560	-1.8539	Sect18	b_{18}	0.4918	1.4198	0.2127	1.1471
K/L*sect18	β_{19}	0.1000	1.4924	0.0417	0.9867	Sect19	b_{19}	-1.7469	-2.6821	-0.8013	-3.6200
K/L*sect19	β_{20}	0.0832	1.6459	-0.0192	-0.4653	Nwest	γ_1	0.1127	2.6581	0.0430	1.9329
						Neast	γ_2	-0.0461	-1.0514	0.0048	0.2183
						South	γ_3	0.5112	9.6400	0.3105	13.0794
						Rents	δ_1	-0.0935	-14.8752	-0.0024	-1.2754
						Presfin	δ_2	-0.0194	-1.5079	-0.0042	-0.9364
						Small	δ_3	-0.4790	-11.7182	-0.2940	-16.5111
						Large	δ_4	0.2483	6.1318	0.1491	7.1395
						Old	δ_5	0.1051	2.8913	0.0669	3.4054
						Young	δ_6	-0.2027	-5.0853	-0.0538	-3.0139
						Group	δ_7	-0.1416	-3.7889	-0.1350	-6.5121
						Qtnosep	δ_8	0.0001	0.1003	0.0001	0.3059
						Export	δ_9	-0.4562	-11.3549	-0.2498	-16.0865
						Distrind	δ_{10}	-0.1524	-2.6057	-0.1289	-3.9870
						Distrsubc	δ_{11}	-0.1891	-3.8424	-0.0689	-2.9118
Obs.		3731		11187							
σ sq.		0.3081	43.1339	0.2596	47.1061						
Gamma		0.3638	24.0709	0.3465	0.5083						
Log likelih.		-2598.53		-8400.49							

Dep. Var is Y/L (net sales/n. employees); K/L is capital stock/n.of employees; sect1 … sect19 are dummies accounting for different sectors as defined in reference 18; Nwest, Neast and South account for geographical location. Rents is (EBT+depreciation and amortisation+net interest payment-value of capital stock)/value added; Presfin is Interest payment/(interest payment+cash flow). Small, Large, Old and Young identify respectively the smaller, the larger, the older and the younger 20 % of sample firms. Group and Export are dummies that account for group affiliation and export activity. Qtnosep measure the total share of ownership of the controlling shareholders. Distrind and Distsubc pick up firms located in industrial district with respectively less than 70 percent subcontracted output and the complementary set.

Table 6: Determinants of changes in efficiency

Dependent Variable: difference between the distance from the efficient frontier in the 98-2000 sample and in the 1995-1997 sample

	coeff	t	coeff	t
North West	0.00224	0.44	0.00227	0.44
North East	0.00190	0.37	0.00198	0.39
South	0.00535	0.83	0.00566	0.88
Rents	-0.00175	-0.63	-0.00183	-0.65
Presfi	0.00055	0.42	0.00056	0.42
Small	0.00076	0.24	0.00089	0.28
Large	0.00137	0.42	0.00119	0.33
Group	-0.00273	-0.89	-0.00283	-0.75
Consortium	-0.00168	-0.47	-0.00193	-0.53
Exp	-0.00210	-0.77	-0.00229	-0.82
Ndictind	0.00674	2.24	0.00679	2.14
Ndictsubc	0.00459	1.72	0.00455	1.53
Psurv			-0.00234	-0.06
Constant	-0.03912	-7.31	-0.03822	-2.96
obs.	1121		1114	
F(i.v., obs)	0.750		0.700	
Prob > F	0.707		0.763	
R-squared	0.008		0.008	
Adj R-squared	-0.003		-0.004	
Root MSE	0.038		0.038	

North West, North East and South account for geographical location. Rents is (EBT+depreciation and amortisation+net interest payment-value of capital stock)/value added; Presfi is Interest payment/(interest payment+cash flow); Small (Large) identify the smaller (larger) 20 % of sample firms. Group, Consortium and Export are dummies that account for group and consortium affiliation and export activity. Ndictind (Ndictsubc) are firms located in industrial districts, ICT investing in 1995-97 and independent (subcontractors). Psurv is the mill's ratio of survivorship.

Table 7: Determinants of changes in efficiency

Dependent variable: difference in efficiency ranking between the 98-2000 sample and the 95-97 sample. The ranking is measured in terms of distance from the efficient frontier.

	coeff	**t**	**coeff**	**t**
North West	0.00500	0.00	0.41288	0.04
North East	-5.35991	-0.49	-4.86020	-0.44
South	-11.97965	-0.86	-12.33527	-0.88
Rents	-0.32929	-0.05	-0.20820	-0.03
Presfi	-1.28133	-0.45	-1.33703	-0.47
Small	5.18325	0.76	5.20841	0.76
Large	5.11086	0.73	4.33979	0.55
Group	-1.65407	-0.25	-2.46565	-0.30
Consortium	9.37694	1.21	9.77940	1.25
Exp	8.68336	1.48	9.17175	1.51
Ndictind	-16.72157	-2.57	-16.26118	-2.37
Ndictsubc	-7.72784	-1.34	-6.86843	-1.07
Psurv			-20.17874	-0.23
Constant	1.24653	0.11	6.88382	0.25
obs.	1121		1114	
F(i.v., obs)	1.090		1.02	
Prob > F	0.368		0.4295	
R-squared	0.012		0.0119	
Adj R-squared	0.001		0.0002	
Root MSE	81.940		82.203	

North West, North East and South account for geographical location. Rents is (EBT+depreciation and amortisation+net interest payment-value of capital stock)/value added; Presfi is Interest payment/(interest payment+cash flow); Small (Large) identify the smaller (larger) 20 % of sample firms. Group, Consortium and Export are dummies that account for group and consortium affiliation and export activity. Ndictind (Ndictsubc) are firms located in industrial districts, ICT investing in 1995-97 and independent (subcontractors). Psurv is the mill's ratio of survivorship.