CONTRIBUTI DI RICERCA CRENOS

CRENoS
CENTRO RICERCHE
ECONOMICHE NORD SUD
Università di Cagliari
Università di Sassari

REGIONAL DISPARITY IN ICT ADOPTION: AN EMPIRICAL EVALUATION OF THE EFFECTS OF SUBSIDIES IN ITALY

Gianfranco E. Atzeni

Oliviero A. Carboni

WORKING PAPERS

CUEC

2006/08

CENTRO RICERCHE ECONOMICHE NORD SUD
(CRENoS)
UNIVERSITÀ DI CAGLIARI
UNIVERSITÀ DI SASSARI

Il CRENoS è un centro di ricerca istituito nel 1993 che fa capo alle Università di Cagliari e Sassari ed è attualmente diretto da Raffaele Paci. Il CRENoS si propone di contribuire a migliorare le conoscenze sul divario economico tra aree integrate e di fornire utili indicazioni di intervento. Particolare attenzione è dedicata al ruolo svolto dalle istituzioni, dal progresso tecnologico e dalla diffusione dell'innovazione nel processo di convergenza o divergenza tra aree economiche. Il CRENoS si propone inoltre di studiare la compatibilità fra tali processi e la salvaguardia delle risorse ambientali, sia globali sia locali.
Per svolgere la sua attività di ricerca, il CRENoS collabora con centri di ricerca e università nazionali ed internazionali; è attivo nell'organizzare conferenze ad alto contenuto scientifico, seminari e altre attività di natura formativa; tiene aggiornate una serie di banche dati e ha una sua collana di pubblicazioni.

www.crenos.it
info@crenos.it

CRENoS – CAGLIARI
VIA SAN GIORGIO 12, I-09100 CAGLIARI, ITALIA
TEL. +39-070-6756414; FAX +39-070- 6756402 / 6753760

CRENoS - SASSARI
VIA TORRE TONDA 34, I-07100 SASSARI, ITALIA
TEL. +39-079-2017301; FAX +39-079-2017312

Titolo: REGIONAL DISPARITY IN ICT ADOPTION: AN EMPIRICAL EVALUATION OF THE EFFECTS OF SUBSIDIES IN ITALY

ISBN 88 – 8467 – 335 – 6

Prima Edizione Luglio 2006

Via Is Mirrionis, 1
09123 Cagliari
Tel./Fax 070291201
www.cuec.it

REGIONAL DISPARITY IN ICT ADOPTION: AN EMPIRICAL EVALUATION OF THE EFFECTS OF SUBSIDIES IN ITALY[1]

Gianfranco E. Atzeni
University of Sassari and CRENoS
Department of Economics (D.E.I.R.)
Via Torre Tonda, 34, 07100 Sassari – ITALY
Tel: +39 0792017332 - Fax: +39 0792017312
e-mail: atzeni@uniss.it

Oliviero A. Carboni
University of Sassari and CRENoS
E-mail: ocarboni@uniss.it

ABSTRACT

This paper investigates on a marked case of regional inequality concerning the information and communication technology adoption process and the role of subsidies in Italy. There is a consolidated and persistent gap between the industrialized North and the sensibly backward South. Econometric results show that adoption of ICT is affected by the geographical location, the industry and firm characteristics. A matching estimator is applied to explore subsidies effectiveness. We find that subsidies have a significant impact but only for small firms. Given the firm system in Italy, we conclude that, to limit the acceleration of Italian North-South dualism, subsidies should only be granted to small firms.

Keywords: *information and communication technologies; regional disparities; digital divide; subsidies; treatment effect; nearest neighbour matching estimator.*

***JEL classification**: C21, D21, L2, O18.*

[1] We wish to thank the participant at the workshop 'Competition, Innovation and Productivity: Empirical Evidence from Firm-level Data', Nice, 19-20 December 2005, where this paper has been discussed.

Introduction

The revolutionary use of ICT in the last decade has resulted in the spread of new opportunities and challenges in many economic regions of the world. While the benefits of this ICT paradigm are already evident in US, they are still being quantified in Europe. Available evidence highlights substantial differences in the extent of IT adoption, not only between the EU and the US, but also within the EU (Bassanini et al., 2000, Schreyer, 2000, Daveri, 2001 among others). The adoption and diffusion of ICT capital goods throughout the productive system has assumed a core position in the new economy. New technology and internet can have effects which are comparable to reductions in transport costs, facilitating access to more developed markets for marginal regions. This might favour the reduction of disparities among areas. From this perspective, it is of foremost importance to pinpoint any constraint that might discourage or slacken the rate of ICT adoption. Although the global characterization of ICT, public policy should have a significant local scope (Iammarino et al., 2004)

In Italy several studies have been made as new national data has become available. Becchetti et al. (2003) investigated the determinants of ICT investment and the impact of the ICT component on labour productivity and efficiency. They find that ICT investment is affected by the industry, the geographical location and the characteristics of the firm.

Bugamelli and Pagano (2004) find a positive correlation between ICT investment, human capital and reorganization. They argue that the relatively low value of ICT capital among Italian firms is due to certain barriers to investment, such as the low level of human capital and firm organization.

In Atzeni and Carboni (2004) we investigate the impact ICT has on total factor productivity and its contribution to output growth. We conclude that, rather than being paradoxically under-productive, ICT have a disproportionately wide impact on output growth compared to their share in total investment. We also find that the impact of ICT on productivity is significant and helps to explain North-South performance differentials in Italy. In Atzeni and Carboni (2006) we find that computers have more effect on output growth than conventional capital.

When analysing ICT investment behaviour, it is worth noticing at least three factors of Italian manufacturing system: sector specialization, size, and geographical location (see also Fabiani et al., 2005).

The first feature that deserves attention is the limited role of firms in the ICT producing sectors in the Italian economy, particularly when compared to other industrialized economies. The second is the Italian specialization in traditional sectors (essentially textiles, clothing, leather and shoes) that are notoriously not information intensive and in general benefit little from adopting ICT. Finally such specialization is territorial, since in the South firms are smaller and more traditional than in the North.

ICT typically reduces co-ordination and communication costs within the firm. However in order to fully exploit their adoption a minimum operational scale is required. ICT modifies the optimal firm size and its internal organization. From this perspective it is reasonable to think that benefits from ICT might be less important for small firms. This is particularly true with respect to the process of reorganization (firm vertical disintegration for instance). Reorganization implies fixed costs that might be precluded in the case of small firms.

The South, with on average sensibly smaller firms, is likely to be disadvantaged in its ICT investment decisions. Small firms are also more likely to be financially constrained, and hence to have more difficulties in obtaining funds to expand. In this respect Southern firms, once again, appear particularly constrained in their attempts to grow through the introduction of ICT capital goods. Duality is likely to hold.

In this work the Italian North-South ICT divide is analysed, using a large sample of Italian manufacturing firms. Our contribution is twofold. We first question whether specificities in terms of dimension, sectoral specialization and geographical location play a role in the firms' decisions on ICT investment. Then we further explore whether state subsidies affect this process, and whether they affect the two regions differently. Although there are several empirical investigations on the impact of subsidies on R&D investment at firm level, no research has been specifically oriented to the effect of public aid on ICT. This study attempts to advance our knowledge on this issue.

The Heckman selection model procedure is applied to distinguish between determinants of ICT adoption choice on the one side, and what induces firms to invest in ICT on the other. Our results highlight regional differences and the important role of subsidies, as well as other factors.

We then question whether there are correlations between subsidies and ICT adoption within the firms in the sample. The target of the subsidy policy is fairly simple. By granting a subsidy, one hopes that additional investment will take place that would not have occurred without public support. Moreover, the private return on investment has a very important role to play in the efficiency of a subsidy policy. The rationale of the subsidy is that the private return is too low (costs too high) to justify private investment expenditure. This is likely to be particularly true for small sized firms. Given the few benefits they receive from ICT, they are less keen to adopt it. In this case granting a subsidy would partly compensate for their investment disincentives.

A matching estimation method for the average treatment effect is employed to measure the impact of subsidies on ICT adoption. This allows us to determine whether the supported firms would have invested the same amount of ICT if they had not received the grant. In line with a priori expectations we find evidence that subsidies are effective in promoting ICT. On average they improve ICT investment by roughly 21% per worker. Interestingly, we find that subsidies boost ICT investment by 25% for firms in the South and by 20% for those in the North. Investigation shows that in this case the size of the firm is a critical factor. Regardless of their geographical origins, small firms are more affected by public grants while for large firms benefits are not clear. Given the number of small firms in the South, it is more dependent on public aid for ICT investment decisions (as well as for traditional investment).

The paper is structured as follows. The next section briefly describes certain Italian stylised facts. Section 2 illustrates data characteristics and descriptive statistics. Section 3 contains the methodology. Section 4 outlines the econometric results. Conclusions and policy implications are drawn in Section 5.

1 – Regional inequality in Italy

One characterizing aspect of the Italian economy is the strong duality between the South and the rest of the country. All measurements of the economic gap have shown such duality to be remarkably persistent (Pigliaru, 2001). The per capita income regional disparities in Italy, for instance, are the highest among the European countries (Paci and Saba, 1998). In the industrial sector *stricto sensu*, about 70% of added value is produced in the North (IRES, 2002). Productivity differentials are found to be greatly biased in favour of the Northen regions[2] and they do not appear to be compensated for by corresponding wage differences. This might be a sign of low productivity in specialised activities and the generally small size of firms in the South (IRES, 2002).

The capital output ratio is generally higher in the South, implying a negative correlation between capital accumulation and development level. This is actually contrary to most international evidence. The South appears to be backwards both in relation to manufacturing level, and in software production, which is dominated by non-local firms.

The same dynamics also emerge in the extent to which ICT is adopted. Recent evidence on Italian industry reveals that there is both a dimensional and a territorial aspect to the diffusion of ICT. The survey carried out by the Bank of Italy on firm investment in the industrial sector highlights that the number of PC's or expenditure on ICT related activities per worker is consistently greater for firms with more than 1000 employees, and for firms in the North. The South appears backward in almost all ICT indicators: investment, PC's, and Internet connections (Trento and Warglien, 2001).

However, despite the persistent gap between the two areas, there has been a non-negligible ICT sector dynamics in the South. Between 1996 and 2001 almost one third of the 17,544 ICT firms created in Italy were located in the South. At the beginning of 2002 about 43.5% of the total number of effective firms in the computer sector were located in the South (IRES, 2002). It is worth mentioning that St Microeletronics, Nokia and Tiscali decided to invest in this area.

2 – Data and variable description

-The data used in this paper comes from the Survey of Manufacturing Firms (SMF) carried out by Capitalia (2002). The SFM considers a stratified sample of Italian firms with 11 to 500 employees. It also includes all manufacturing firms with more than 500 employees. Given the consistently high number of very small firms in Italy

[2] Comparing the average of the 4 most productive regions (all in the North), with the average of the 4 least productive ones (all in the South), they find that productivity differentials are close to 40%, capital output ratio is 14% smaller and human capital is 3% bigger in the advanced regions.

(particularly considering the zero employee firms) and also bearing in mind that service industries are not included in the survey, one should be cautious about making generalizations based on this information. The SMF has been used in other ICT studies (Bugamelli and Pagano 2004; Becchetti *et al*, 2003; Atzeni and Carboni, 2004, 2006; Piga and Vivarelli, 2004).

The data is stratified according to the number of employees, the sector, and the location, taking as a benchmark the Census of Italian Firms. The SMF contains questionnaire information about firm structure and behaviour and twelve years of data on their balance sheets (1989-2000). Information about ICT expenditure is displayed at a three-year level (1998-2000). For the empirical exercises we use the 2001 survey which reports figures from 1998 to 2000, while for lagged variables the previous wave has been employed (1995-1997). Since only a fraction of the observations overlap in the two waves the available data comes from 2290 firms.

Table 1 shows the descriptive statistics for the whole sample and various sub-groups. A marked regional divide is immediately evident. Firms from the Centre-South [3] (South in the following) employ less workers, generate half of the added value and invest 32% less than do northern ones. In the South firms employ a relatively higher level of blue-collar workers and are less oriented to R&D. No remarkable regional differences emerge when normalising the data for the added value or the number of workers, particularly for ICT and total investment.

Relevant dissimilarities are found in the financial market. In the South access to credit is hampered by a riskier financial environment. This is due to smaller firm size and uneven business opportunities available at the local level, as well as certain specific effects in the credit market. These aspects are reflected in the percentage of credit rationed firms and in the short term regional interest rate. These are both significantly higher in the South.

In this context a relevant role is played by incentives for fixed capital. SMF data reports the sources of investment financing, with information about public grants and fiscal incentives. The dummy subsidies show that 44% of firms in the South received an investment

---

[3] North comprises 7 regions (Lombardia, Piemonte, Liguria, Trentino, Friuli, Veneto, Emilia), Centre-South 12 regions (Toscana, Umbria, Marche, Lazio, Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia, Sardegna).

subsidy, compared to 35% of those in the northern regions. These differences may be important when describing the processes governing technology adoption, especially when one considers that one sixth of investment is financed by various kind of incentives.

Subsidised firms are larger than the average, both in terms of employees and added value, and they also invest more in terms of added value. ICT investment per worker is 31% higher for firms with grants. This data is confirmed in the sample split by firm size. Medium-large firms (MLF) are more subsidised than small ones (49% vs. 33%).

The last row of table 1 shows the amount of subsidised investment per worker. The sample average is € 3,500 per worker, including the zero subsidised firms. On average a subsidised firm receives € 9,230 incentive per worker, while no differences are found between small and medium-large firms. Firms in the South receive public resources which are more than double those of the North. This may be the reason for the substantial similarity in the level of total and ICT investment per worker in the two areas.

The Pavitt classification (Tab. 2) shows that firms in the South are more traditional and less scale intensive. A similar pattern applies to small firms. There are no relevant differences between the subsidised and non-subsidised groups.

3 - The determinants of ICT adoption

In this section we formulate an equation focusing on a range of firm-specific profiles that can help to explain the intensity of ICT investment. Several cross-sectional analyses (Lichtenberg, 1995, Brynjolfsson and Hitt, 1995, Lehr and Lichtenberg, 1999, Black and Lynch, 2001, and Bresnahan, Brynjolfsson and Hitt, 2002, Hollenstein, 2004), find strong relationships between ICT and other factors within the firms. We highlight several groups of factors that may influence a firm's decision to adopt new technology at a certain time. The relevance of micro analysis is supported by huge differences in behaviour, productivity, size and performance across firms and industries (e.g. ICT is not normally distributed). Firm level data is better for measuring specific aspects that are very difficult to capture at the aggregate level, such as size, industry, age, location, etc.

Following the Heckman (1979) procedure we estimate a two-equation ICT investment model in which the dependent variable in the

selection process is a dummy with ones for firms adopting ICT and zeros otherwise. This allows us to check whether the determinants of adoption are different from the determinants of how much to invest and to check for *sample selection* problems, which typically arise when a non-randomly sampled set of observations is used to make inferences about the whole population.
The selection equation is:

(1)

$$DUICT_i = \alpha_1 + \alpha_2\ AGE + \alpha_3\ RATION + \alpha_4\ INNORG + \alpha_5\ SUBS + \alpha_6\ R\,\&\,D + \varepsilon_i$$

The dependent variable is a dummy equal to 1 if firm *i* invested in ICT in the period. Among the regressors we employ firm age (*AGE*), a proxy of financial distress (*RATION*), and dummies for reorganization (*INNORG*), subsidies (SUBS) and R&D.
The investment equation is:

(2)

$$\log(I^*_{ICT} / L)_i = \beta_1 + \beta_2 \log(K / N)_i + \beta_3\ INT_j + \beta_4\ WCBC_i + \beta_5\ MKUP_i + u_i$$

The dependent variable is the three-year ICT investment flow over the number of workers. Among the regressors we include capital per worker (*K/N*), average white collar-blue collar ratio (*WCBC*) and a measure of market structure (*MKUP*). On a regional basis we also include the short term interest rate (*INT*, j =1, 2,…,20). ICT and capital variables are divided by labour units in order to avoid dimensional effects and log-transformed (see appendix for variables construction).

The capital intensity (*K/N*) is important since more capital-intensive firms may have a higher demand for ICT investment, assuming complementarity between ICT and non-ICT capital.

The variable *WCBC* is used to capture absorptive capacity linked to ICT. Since the knowledge required to master ICT is rapidly changing, a variable reflecting the level of skills within the firm may be an opportune indicator. In order to make use of computers and related technologies, firms need a well-trained labour force. There is plenty of evidence (Autor et al., 1998, Johnson, 1997, Bresnahan, T., E. Brynjolfsson and L. M. Hitt (2002), among others) that ICT goes hand-in-hand with a significant and generalised up-skilling of the workforce.

This is reflected in the percentage increase in staff with upper-secondary education, which is higher than the change in the l total working-age population. Greenan and Mairesse (2000), Greenan, Mairesse and Topiol-Bensaid (2001) for example, found that there was a positive correlation between the number of computers, and the percentage of administrative managers in France.

We explicitly include a measure of mark-up (*MKUP*) to see the link between ICT adoption and firm market power. The expected sign is not unequivocal, as, depending on the industry, firms with a certain degree of competitive advantage may find they do not need to increase their level of technology.

AGE is employed as an explanatory variable in most studies of adoption behaviour (see Karshenas and Stoneman, 1995). One reason for including age is that there might be a positive impact on adoption in the case of older firms as specific (technological) experience might be accumulated (learning dynamics).

Some recent studies reveal the complementarity of the adoption of new models of workplace organisation (*INNORG*) and the introduction of ICT (Brynjolfsson and Hitt, 2000; OECD 2001a; 2001b; McKinsey, 2001; Breshnahan et al., 2002; Bertschek and Kaiser, 2004). Organisational advances directly increase productivity. Thus one may expect that the adoption of new work practices goes together with the intensification of ICT. A major problem of investment in ICT capital goods may be the high degree of uncertainty of the results. Reorganizing the productive activities (as well as workforce reskilling) helps to fully exploit the potentialities offered by the new technologies and to mitigate aleatority in their use. However, the need for complementary investment might increase the costs to be faced when investing in ICT. Adjustments may result in low ICT accumulation.

Financial constraints (*RATION*) are in general a good candidate for explaining under-investment. Here we try to assess if these also constrain in the adoption of ICT capital. We also use this variable to capture financial distress on a regional basis, since it represent a proxy of a firm's capability to access the credit market (see appendix for variable construction).

For similar reasons we also include government subsidies (*SUBS*) to investment. These are usually very influential and significant in the general investment activities of firms and sectors.

The model is estimated as a cross-section. For reasons of endogeneity *K/N* and *MKUP* and *WCBC* are time lagged. The intercept term has been replaced by 14 industry dummies using the ISTAT-ATECO classification. Even if not completely satisfactory, this allows us to pick up some sectoral heterogeneity. The null hypothesis of independence is not accepted, suggesting the presence of a selection process.

Econometric analysis shows that labour composition, age, financial constraints, reorganization, subsidies and R&D are good predictors of ICT invest decisions. The North-South differences are mainly in the magnitude of parameters rather than their significance. The results are shown in Table 3. Interestingly for our next analysis, subsidies appear to be far more important in the South and are far less important for large firms.

The investment equation results show that the decision about how much to invest in ICT depends positively on the capital output ratio and the white collar/blue collar ratio as proxy of labour composition, and negatively on the regional interest rate, and the mark-up. North-South differences are related to the non-significance of the regional interest rate and mark-up parameters in the North. One plausible interpretation is that the greater sensibility to the interest rate in the South is linked to the availability of less onerous financial substitutes, such as firm incentives to invest. The mark-up coefficient suggests that the weaker propensity to invest in new technologies the bigger the market power for firms in the South. This is likely to be a symptom of weaker competition in these regions, while this is not the case in the North, even though the mark-up indices are higher.

In line with what is expected small firms are more sensitive to regional interest rates. It is worth mentioning that the variables RATION, SUBS and INT, are not significant for large firms. This is likely to be a sign of less severe financial constraints, giving an interesting base for analysing the role of subsidies on ICT adoption.

4 - The effect of subsidies on ICT adoption

The Investment equations show that technology adoption may be strictly dependent on the availability of financial sources. The smaller the firm is, and the more it belongs to a region with a less developed financial system, the more it is sensitive to the cost and the availability of credit. Given its economic and financial duality and the presence of a pervasive system of small and medium firms, Italy is a litmus paper for testing the effectiveness of investment subsidy policies on ICT adoption across regions and industries.

We want to address three main issues when evaluating the efficiency of the public policy:

(1) how much does subsidy to overall investments affect ICT spending? Even if a subsidy is not specifically granted to boost ICT adoption, does the access to free financing spill over into various type of investment included ICT?

(2) Do subsidies induce or replace ICT spending?

(3) Are there any regional differences in the impact of the subsidy policy?

There are several empirical attempts to estimate the impact of subsidies on R&D investment at firm level, and, to our knowledge, none on ICT. One common approach is to employ a simple regression model in which an outcome variable (e.g. R&D or ICT spending) is regressed on the value of the incentive. In the presence of significant and positive elasticity of the outcome variable with respect to the subsidy one may assert that such a link exists.

The regression approach has at least one substantial drawback. To get the subsidy the firm need to apply for it, and the decision to grant it is taken by the government, taking into consideration a set of firm and project characteristics. It may happen that some unobservable variables influence both the outcome and the decision to give a subsidy, giving rise to a non-zero correlation between public funding and the error term.

In order to address this issue one needs to model the participation of the firm in the incentive program, considering that the outcome "receiving a subsidy" depends on a decision of the firm to apply for it and on the decision of the government. In the case of ICT, this means that, conditional on obtaining the incentive, the firm then decides the level of ICT spending:

$$
(4) \quad \begin{aligned} A &= f_A(L,u) \\ G &= f_G(Z,v) \\ Y_1 &= g_1(W_1,\varepsilon_1) \\ Y_0 &= g_0(W_0,\varepsilon_0) \end{aligned}
$$

where A is the expected probability of applying for an ICT subsidy, G the probability the incentive is awarded while Y_1 and Y_0 represent the ICT effort in the two states, where the states associated with receiving the incentive and not receiving it are 1 and 0 respectively. L, Z and W are vectors of explanatory variables and u, v and ε the errors terms. A and G are usually unobserved. The first two equations become:

$$
(5) \quad \begin{aligned} & D = D_A * D_G = f_D(X,\phi) \\ & \text{where} \\ & D_A = 1 \text{ if } A > 0 \text{ and } D_A = 0 \text{ otherwise} \\ & D_G = 1 \text{ if } G > 0 \text{ and } D_G = 0 \text{ otherwise} \end{aligned}
$$

This formulation implies that when D=1 a firm has received the subsidy having applied for it. In equation (4) X is the set of firm characteristics affecting the decision of the firm to join the public funding program and of the government to grant it. ϕ is an error term.

Moreover, Y_1 and Y_0 are observed only for participant and non-participant firms respectively. The evaluation problem is then a problem of missing data (Heckman et al, 1998). The benefit of receiving the subsidy can be measured as the difference $\Delta = Y_1 - Y_0$ if we observe the two outcomes (ICT investment effort) for the same firm. Observational data does not contain sample counterparts for the missing counterfactual Y_0 for subsidised firms, which need to be inferred in some way from the sample.

A method which is often used is matching (Heckman *et al*, 1998; Heckman and Navarro-Lozano, 2004). In the absence of experimental data, matching estimators have the convenient feature of approximating a randomised experiment *ex post*. Angrist and Hahn (2004) show that matching is more efficient than the propensity score technique, while Smith and Todd (2005) provide a detailed evaluation of the performance of different matching estimators such as nearest neighbour matching, kernel and local linear matching, and difference-in-differences matching.

In general, matching estimation is characterized by the type of algorithm and the distance measure chosen (Augurzky and Kluwe, 2004). However, some source of bias is difficult to eliminate, depending on the characteristics of the data. Smith and Todd (2005) show that with high quality data, rich in variables related to participation and outcomes, matching results are the best choice.

The most common evaluation parameter is the mean effect of treatment on the treated, which gives us information about how much a treated firm (receiving the incentive) benefits compared to what it would have done if not treated (not receiving the subsidy). The parameter is given by:

$$(6) \qquad E(Y_1 - Y_0 \mid X, D = 1) = E(\Delta \mid X, D = 1)$$

Using non experimental data the parameter estimation is obtained assuming that conditional on *X*, (Y_1, Y_0) and *D* are independent:

$$(7) \qquad (Y_1, Y_0) \perp D \mid X$$

where $\perp$ denotes independence. This assumption is required so that, conditional on *X,* the non-subsidised firms's outcomes have the same distribution as firms would have achieved if they had not participated in the public funding programme. This restriction, also known as "selection on observables" or unconfoundness, requires that the choice of participation is "purely random" for similar individuals (Abadie and Imbens, 2002).

In terms of our analysis this means that, given firms characteristics, if receiving the subsidies affects only the level of ICT but not the distribution of ICT efforts across firms, we may construct the missing counterfactual (i.e. the behaviour of firms which are in the programme if they were not in the programme) using the outcomes (ICT investment) of non-subsidised firms.

An identification assumption is also required, because if all individuals with given characteristics choose to participate in the programme, there would be no observation on similar individuals that choose not to participate (Abadie and Imbens, 2002). Formally:

(8) $c < \Pr(D=1 \mid X=x) < 1-c$ for some $c > 0$

In the terms first used by Rosenbaum and Rubin (1983), when both condition are satisfied, the treatment is said to be 'strongly ignorable', so that the non-randomised experiment can be treated as if it were a randomised one.

As pointed out by Abadie and Imbens (2002), these conditions are in many cases not satisfied, giving rise to some bias in the estimation. However, various studies make extensively use of matching methods (Rosenbaum and and Rubin, 1985; Rosenbaum, 1995; Heckman *et al*, 1998). Imbens (2004) reviewed various methods used to estimate the average treatment effect under the above assumption, discussing the plausibility of the exogeneity assumption in economic application.

In order to consider the bias arising in the estimation of average treatment effect we employ the *routine* provided in Abadie *et al* (2004), which implements the specific bias-corrected matching estimator developed in Abadie and Imbens (2002). The methodology employs "nearest neighbour matching" for average treatment effect.

As discussed above, only one potential outcome is observed for each firm. Nearest neighbour matching calculates the missing potential outcome by taking average outcomes for firms with similar values for the covariates[4]. We use matching with replacement which allows a given non-subsidised firm to be matched to more than one subsidised one. Allowing replacement improves the quality of matches at the expense of the number of observations used to calculate the counterfactual mean, increasing the variance of the estimator (Smith and Todd, 2005). Although matching on a multidimensional set of firm characteristics (*X*) may give rise to a non-negligible bias, the matching approach combined with the bias adjustment procedure leads to estimators with little remaining distortion.

---

[4] Let $\|x\|_V = (x' V x)^{1/2}$ be the vector norm with positive definite weight matrix *V*. $\|z - x\|_V$ is defined as the distance between the vectors *x* and *z*. Let $d_M(i)$ be the distance from the covariates for unit *i*, X_i, to the *Mth* nearest match with the opposite treatment. This is the distance such that strictly fewer than *M* units are closer to unit *i* than *dM(i)*, and at least *M* units are as close as *dM(i)* (Abadie *et al*, 2004).

We estimate the average treatment effect for the treated firms using as outcome variable ICT investment per worker. The treatment is a dummy $D_i = 1$ if the firm received a subsidy and $D_i = 0$ otherwise. Information about the level of the incentives devoted specifically to ICT is not available in the data set. The exercise we carry out aims to check whether the availability of costless financial resources has a significant effect on technology adoption.

The outcome variable is the logarithm of ICT investment per worker. The choice of the matching variables is based on these criteria:

1. firm specific variables that at the time of application were observable by the public agency and relevant for the decision to grant the subsidy;

2. variables that indicate regional location and capture financial market disparities (i.e. regional interest rate);

3. variables that are statistically significant in the estimation of ICT adoption determinants.

Differently from a propensity score approach, in which covariates need to determine the probability of receiving the treatment, the matching estimator only considers those characteristics which affect the outcome variable (the level of ICT investment).

The variables used for the matching come from the two-stage investment equation of section 3. They are: logarithm of the average capital per worker in the previous period (1995-97), the average white collar blue collar ratio (1995-97), the level of mark-up in 1997, the average regional short term interest rate during the triennium, a dummy R&D equal to 1 if the firm is engaged in R&D projects, dummy North equal to 1 if the firm is located in a northern region and dummies for Pavitt industry classification. This procedure gives a more homogeneous distribution of ICT efforts among subsidised and non-subsidised firms, since firms are matched only with those similar in terms of ICT determinants. Thus, we impose the dummy North to be constrained as an exact match, so that no firm from the North can be matched with a similar one located in the South.

In Table 4 the average treatment effect for the treated (ATT) is reported (row 1). Given that data are expressed in millions of euros, the coefficient has an immediate interpretation: receiving the subsidy has a positive effect on the treated firms, increasing ICT investment per employee by € 248. The estimation confirms that aids to investment have a positive and significant effect on ICT. Had the subsidy not be granted the treated firms would have invested less in ICT.

To test how much of the unspecific incentive spills over into ICT investment, we estimate the average treatment effect on the level of total investment per worker, using the same set of covariates (see Tab. 5). The overall effect of the treatment amounts to € 14,700 per employee. The impact of subsidies on ICT is only 1.3% of the overall effect, which is rather small considering that ICT outlays represent 16% of total investment (see Table 1 for descriptive statistics).

The main concern of our research is, however, that of checking for the existence of possible regional disparities in the effect of subsidies. To do this we split data in two sub-samples, depending on the firm's geographical location. Table 4 reports the results (rows 2 and 3). For firms in the South the ATT is € 261 per employee, showing an effect of subsidies, which is 5.2% above the average for the whole sample. Incentives to investment have an impact on ICT adoption of € 247 for firms located in the North. In detail, grants improve ICT investment by roughly 25% for firms in the South and by 20% for those in the North, suggesting that the investment incentive policy is more effective in the South.

Interesting results are obtained when the firm's dimensions and geographical location are combined (Table 4, rows 4 and 5). Splitting the sample according to the firm's dimensions, we find that subsidies are particularly effective for those with less than 50 employees (small firms), while they are totally irrelevant for medium and large firms. These results are confirmed by the estimation of ATT for large firms in both macro-regions. Subsidies are shown to have a positive effect on ICT for small firms (SF) in the South, and appear to be particularly important for the same group in the North (row 6 and 7). Incentive to total investment does not seem to have any impact on ICT if granted to medium and large firms (MLF), regardless of their geographical location.

These results support the idea that the regional technological duality is linked to firm dimensions and it may be significantly affected by the incentive policy, whose regional pattern clearly appears from the estimations.

While for SF incentive impact is always positive, it is not the case for MLF. The non-significance of parameter for these latter firms can be interpreted as partial crowding out effect. Since they are not sensitive to the incentives, this implies that they would have invested the same amount of ICT without the grant. In this case the public support is not effective and it turns out to be a mere 'premium'.

The overall effect of subsidies is relevant for the level of total investment per worker, while they poorly spill-over on ICT.

5 – Conclusion and policy implications.

Recent evidence suggests that ICT is a relevant factor in growth performance. It is of paramount importance to pinpoint any constraint that might friction the process of adoption. ICT produces effects that are similar to transport cost reduction, since it ameliorates market access for peripheral regions. This might potentially turn into new opportunities for backward areas.

Using a sample of Italian firms, this paper provides evidence on the determinants of ICT spending and the effects of subsidies on it. We find that the decision to adopt is positively correlated to age, workplace organisation, R&D and subsidies, while it is negatively affected by severe credit constraints. Decision of how much to adopt is positively linked to capital per worker ratio, worker structure proxied by the white-collar blue-collar ratio and negatively by regional interest rates and mark-up.

Data and regression results confirm the a priori evidence that the firms in the South, though equipped with a higher capital output ratio, are not those adopting more ICT. The weaker penetration of ICT in the South is associated with a lower reorganisation of work practices, size and sector specialization. In this part of the country firms are negatively affected in their ICT investment decisions by their market position. A dominant position in the market seems to slow the introduction of new technologies.

Belonging to a less developed financial system does not favour a leaning to technology. In our analysis this can be seen from the higher sensitivity to regional interest rates in the South. This higher price elasticity may be due to the greater availability in the area of costless financial substitutes such as subsidies.

The South also appears to lag behind in sector specialization. Traditional sectors, which are dominant in this area, are notoriously less information intensive and their capital stock is probably less adaptable to ICT. These sectors normally have a low human capital level, which also strongly discourages ICT investment.

One important finding is that differences in ICT adoption are closely related the firm size. Small firms show, in fact, less propensity to new technologies. However, what makes the story interesting is that there is a significant territorial coincidence, since the average firm size in the South is sensibly smaller. There is plenty of available evidence that large firms have been more dynamic in the process of reorganization. Those firms have, in fact, advantages in the use of ICT which are only partially linked to their greater financial endowments. ICT benefits for these firms come particularly from communication, coordination and *routines*. Moreover, ICT diffusion is faster when large firms are present, as these normally generate positive externalities to the system and reduce the uncertainty on new investment.

This reinforces the idea of a geographical cluster in Italy: subsidies have a greater impact on small firms in the North, which are more keen to invest in new technologies. Conversely, the South appears be trapped by its own structural weakness, particularly concerning its low level of ICT use and diffusion and the prevalence of small sized firms operating mostly in the traditional sector. Moreover, the need for complementary investment increases the cost of ICT spending. Once again, small firms will presumably be more disadvantaged. North-South duality in this case is likely to become stronger.

Within this framework, government support may be an effective tool. The rationale for the subsidy is that the private return is too low to stimulate private investment. In general, it is true that the less the private return on investment, the more a subsidy is useful.

Exploring the effect of subsidies on the level of a company's ICT expenditures, we find that the global effect of incentives is positive, which means that firms would have adopted more had they all received grants. Furthermore, there is no crowding out effect on small firms' private investment, while this does not apply to medium-large firms, since they are likely to adopt ICT regardless of government support. In this case the public support is not effective and it represents a 'premium' to firms regardless of their geographical location.

Given the few benefits that small firms generally receive from new technologies, they would be little keen to invest in ICT, especially considering the amount of complementary investments that ICT requires. Overall ICT costs would probably prevent small firms from adopting technology. In this case granting a subsidy would compensate for these investment disincentives. Firms in the South may reap particularly benefits from this and partly overcome their external and internal constraints.

According to our results duality would be sounder if subsidies were not given. This may supply a reasonable partial explanation of the fact that despite higher interest rates, heavier credit constraints and more pronounced system structural weakness, firms in the South invest an amount of ICT per worker which is not very different from that in the North. Financial constraints and higher interest rates are normally good candidates for explaining under investment. It might be the case that incentives substitute funds from the market, relieving financial market imperfections.

Public aid ought to be granted in order to mitigate the Italian North-South economic dualism. They should be granted to small firms particularly if localized in the South. Given a prevailing small size of firms, this area is more dependent on public aid when making investment decisions. Furthermore because firms are disinclined to invest in ICT rather than traditional investment, subsidies should be specifically ICT oriented.

Appendix

Selection equation:

$$DUICT_i = \alpha_1 + \alpha_2\ AGE + \alpha_3\ RATION + \alpha_4\ INNORG + \alpha_5\ SUBS + \alpha_6\ R\ \&\ D + \varepsilon_i$$

AGE: firm age at the end of period (2000)
RATION: in the SMF there are three questions that can be used to directly evaluate the firm's access to the credit market: 1) whether at the current market interest rate the firm wants an additional quantity of credit; 2) whether the firm is willing to pay a higher interest rate to obtain that additional quantity; 3) whether the firm applied but the credit was denied. *RATION* is a dummy=1 if the firm answer yes to the second or to the third question. It is a proxy of firm financial distress.
INNORG: dummy = 1 if firm declares to have completed processes of reorganisation during the period.
SUBS: dummy=1 if firm received a subsidy or a tax reduction.
R&D: dummy =1 if firm has positive R&D outlays.

Investment equation :

$$\log(I^*_{ICT}/N)_i = \beta_1 + \beta_2 \log(K/N)_i + \beta_3\ INT_i + \beta_4\ WCBC_i + \beta_5\ MKUP_i + u_i$$

I_{ICT}/N: ICT investment per worker. N is the average number of employees during the period.
K/N: gross book value of fixed assets per worker.
INT: average short term interest rate at regional level during 1998-2000.
WCBC: white collar-blue collar ratio.
MKUP = Firm mark-up in 1997.

$$= \frac{(sales_{i,1997} + \Delta inventories_{i,1997} - intermediate\ inputs_{i,1997})}{(sales_{i,1997} + \Delta\ inventories_{i,1997})}.$$

References

ATZENI, G. E. and CARBONI O. A. (2004) ICT productivity and Human capital: the Italian North-South duality *International Review of Economics and Business* **51**, 265-284.

ATZENI, G. E. and CARBONI O. A. (2006). ICT productivity and firm propensity to innovative investment: evidence from Italian micro data *Information Economics and Policy*, forthcoming.

ABADIE, A., DRUKKER, D., LEBER HERR, J. and IMBENS, G. W. (2004) Implementing matching estimators for average treatment effects in Stata *The Stata Journal* **4**, 290-311.

ABADIE, A. and IMBENS, G. W. (2002) Simple and bias-corrected matching estimators for average treatment effects, NBER, Technical Working Paper No. 283.

ANGRIST, J.D. and HAHN, J. (2004) When to Control for Covariates? Panel-Asymptotic Results for Estimates of Treatment Effects *The Review of Economics and Statistics* **86**, 58-72.

AUGURZKY, B. and KLUWE, J. (2004) Assessing the Performance of Matching Algorithms When Selection into Treatment Is Strong, IZA DP No. 1301.

AUTOR, H., KATZ, L.F. and KRUEGER, A.B. (1998) Computing inequality: Have computers changed the labour market? *Quarterly Journal of Economics* **113**, 1169–1213.

BASSANINI, A. and SCARPETTA, S., VISCO, I. (2000) Knowledge, Technology and Growth: Recent Evidence from OECD Countries, National Bank of Belgium, Working Paper No. 6.

BECCHETTI, L., LONDONO BEDOYA, D. A. and PAGANETTO, L., (2003) IT Investment, Productivity and Efficiency: Evidence at Firm Level Using a Stochastic Frontier Approach *Journal of Productivity Analysis* **2**, 143-167.

BERTSCHEK, I. and KAISER, U. (2004) Productivity Effects of Organizational Change: Microeconometric Evidence *Management Science* **50**, 394-404.

BLACK, S.E. and LYNCH, L.M. (2001) How to compete: the impact of workplace practices and information technology on productivity *Review of Economics and Statistics* **83**, 434-445.

BRESNAHAN, T., BRYNJOLFSSON, E. and HITT, L. M. (2002) Information Technology, Workplace Organization, and the Demand for Skilled Labour: firm level evidence *Quarterly Journal of Economics* **117**, 339-376.

BRYNJOLFSSON, E. and HITT, L. M. (1995) Information Technology as a Factor of Production: The Role of Differences Among Firms *Economics of Innovation and New Technology* **3** (Special Issue on Information Technology and Productivity Paradox), 183-200.

BRYNJOLFSSON, E. and HITT L. M. (2000), Beyond Computation: Information Technology, Organizational Transformation and Business Performance *Journal of Economic Perspectives* **14**, 23-48.

BUGAMELLI, M. and PAGANO, P. (2004) Barriers to Investment in ICT *Applied Economics* **36**, 2275-2286.

CAPITALIA (2002) Indagine sulle imprese manifatturiere. Ottavo rapporto sull'industria italiana e sulla politica industriale. http://www.capitalia.it/dwload/studiericerche/INDAG_MANIFATT_RAPPORTO_8.pdf.

DAVERI, F. (2001) Information Technology and Growth in Europe. Università Bocconi, IGIER Working Paper No. 168.

FABIANI, S., SCHIVARDI F. and TRENTO, S. (2005) ICT Adoption in Italian Manufacturing: Firm-Level Evidence *Industrial and Corporate Change* **14**, 225-249.

GREENAN N. and MAIRESSE J. (2000): Computers and Productivity in France : Some Evidence *Economics of Innovation and New Technology* **9**, 275-315.

GREENAN, N., MAIRESSE J. and TOPIOL-BENSAID, A.(2001) Information Technology and Research and Development Impacts on Productivity and Skills: Looking for Correlations on French Firm Level Data, NBER Working Paper No. 8075.

Heckman, J. J. (1979) Sample Selection Bias as a Specification Error, Econometrica **47**, 153-162.

HECKMAN, J. J., ICHIMURA, H. and TODD, P. (1998) Matching as an Econometric Evaluation Estimator *Review of Economic Studies* **65**, 261–294.

HECKMAN, J. J. and NAVARRO-LOZANO, S. (2004) Using Matching, Instrumental Variables, and Control Functions to Estimate Economic Choice Models *The Review of Economics and Statistics* **86**, 30-57.

HOLLENSTEIN, H., (2004) Determinants of the Adoption of Information and Communication Technology: An Empirical Analysis Based on Firm-level Data for the Swiss Business Sector *Structural Change and Economic Dynamics* **15**, 315-342.

IAMMARINO, S., JONA-LASINIO, C., MATEGAZZA, S., (2004) Labour productivity, ICT and regions: The revival of Italian "dualism"?, SPRU, Electronic Working Papers Series No. 127.

IMBENS, G.W. (2004) Nonparametric Estimation of Average Treatment Effects Under Exogeneity: A Review *The Review of Economics and Statistics* **86**, 4-29.

IRES (2002) II Rapporto sul Mezzogiorno. Scenari, dinamiche del lavoro e dell'impresa, Ires.

JOHNSON, G. (1997) Changes in Earnings Inequality: The Role of Demand Shifts *Journal of Economic Perspective* **11**, 41-54.

KARSHENAS, M. and STONEMAN P. (1995) Technological Diffusion, in P. STONEMAN (Eds.) *Handbook of the Economics of Innovation and Technological Change*, Oxford, Blackwell.

LEHR, B. and LICHTENBERG, F. (1999) Information Technology and Its Impact on Productivity: Firm-Level Evidence from Government and Private Data Sources, 1977-1993 *Canadian Journal of Economics* **32**, 335-362.

LICHTENBERG, F. (1995) The Output Contribution of Computer Equipment and Personnel: a Firm Level Analysis *The Economics of Innovation and New Technology* **3**, 201-217.

MCKINSEY (2001) US Productivity Growth 1995-2000. Understanding the contribution of Information Technology relative to other factors, McKinsey Global Institute, Washington, D.C.

OECD (2001a) Knowledge, Work Organisation and Economic Growth, Paris.

OECD (2001b) The New Economy: Beyond the Hype, Paris.

PACI, R. and SABA, F. (1998) The empirics of regional economic growth in Italy 1951-1993 *Rivista Internazionale di Scienze Economiche e Sociali* **45**, 515-542.

PIGLIARU, F. (2001) Analisi della convergenza regionale: troppa o troppo poca?, CRENoS contributi di ricerca, No. 01/7.

PIGA, C. A. and VIVARELLI, M. (2004) Internal and External R&D: A Sample Selection Approach *Oxford Bulletin of Economics and Statistics* **66**, 457-482.

ROSENBAUM, P. (1995) Observational Studies, Springer–Verlag, New York.

ROSENBAUM, P. and RUBIN, D. (1983) Central Role of the Propensity Score in Observational Studies for Causal Effects *Biometrika* **70**, 41–55.

ROSENBAUM, P. and RUBIN, D. (1985) Constructing a control group using multivariate matched sampling methods that incorporate the propensity score *American Statistician* **39**, 33-38.

SCHREYER, P. (2000) The Contribution of Information and Communication Technology on Output Growth: a Study of the G7 Countries, STI Working Paper, No. 2, OECD, Paris.

SMITH, J.A. and TODD, P.E. (2005) Does Matching overcome LaLonde's critique of Nonexperimental Estimators? *Journal of Econometrics* **125**, 305-353.

TRENTO, S. and WARGLIEN M. (2001) Nuove tecnologie e cambiamenti organizzativi: alcune implicazioni per le imprese italiane, Temi di discussione, No. 428, Bank of Italy.

Tab. 1 - Descriptive statistics – thousand euros

	Whole sample			*South*			*North*		
variable	N	mean	sd	N	mean	sd	N	mean	sd
Number of employees (average 1998-2000)	2290	83.54	253.09	803	60.14	175.53	1487	96.18	285.62
Value added (average 1998-2000)	2290	4339.61	19001	803	2856.75	12247	1487	5140.3	21757.2
Value added (average 1995-1997)	2290	3519.95	12116	803	2396.72	9134	1487	4126.5	13418.3
Fixed capital per worker (average 1995-1997)	2261	179.12	230.64	785	190.36	291	1476	173.14	190.75
Fixed capital per worker (average 1998-2000)	2290	195.96	212.41	803	195	220.91	1487	196.47	207.76
Total investment (1998-2000)	2290	2096.46	9813.6	803	1593.33	7548.6	1487	2368.1	10834.4
Total investment on value added (1998-2000)	2290	0.17	0.41	803	0.19	0.31	1487	0.16	0.45
Total investment per worker (1998-2000)	2290	20.82	30.93	803	21.07	33.45	1487	20.68	29.49
ICT investment (1998-2000)	2290	114.81	408.78	803	76.75	314.38	1487	135.36	450.39
ICT investment on value added (1998-2000)	2290	0.01	0.02	803	0.01	0.02	1487	0.01	0.01
ICT investment per worker (1998-2000)	2290	1.17	1.8	803	1.05	1.74	1487	1.24	1.83

	Small firms			*Medium-Large firms*			*Subsidized firms*			*Not subsidized firms*		
variable	N	mean	sd	N	mean	sd	N	mean	sd	N	mean	sd
Number of employees (average 1998-2000)	1609	24.71	10.09	681	222.54	433.4	868	107.16	345.25	1422	69.12	172.93
Value added (average 1998-2000)	1609	1006.	649.0	681	12214.5	33555.7	868	5942.6	28202.3	1422	3361.12	9684.6
Value added (average 1995-1997)	1609	879.1	636.8	681	9759.28	20922.0	868	4677.49	17230.9	1422	2813.38	7349.3
Fixed capital per worker (average 1995-1997)	1581	162.2	233.1	680	218.35	219.97	864	199.8	237.87	1397	166.33	225.19
Fixed capital per worker (average 1998-2000)	1609	182.5	207.8	681	227.71	219.74	868	220.09	212.61	1422	181.22	211.02
Total investment (1998-2000)	1609	472.1	789.6	681	5934.21	17370.0	868	3244.23	13964	1422	1395.85	5904.8
Total investment on value added (1998-2000)	1609	0.17	0.46	681	0.17	0.23	868	0.24	0.3	1422	0.13	0.46
Total investment per worker (1998-2000)	1609	19.07	29.13	681	24.94	34.5	868	30.77	36.9	1422	14.74	24.76
ICT investment (1998-2000)	1609	26.48	49.04	681	323.5	703.37	868	154.16	504.24	1422	90.79	335.44
ICT investment on value added (1998-2000)	1609	0.01	0.02	681	0.01	0.01	868	0.01	0.02	1422	0.01	0.01
ICT investment per worker (1998-2000)	1609	1.05	1.75	681	1.47	1.9	868	1.38	1.9	1422	1.05	1.73

variable	*Whole sample* N	mean	sd	*South* N	mean	sd	*North* N	mean	sd	*Small firms* N	mean	sd	*Medium-Large firms* N	mean	sd	*Subsidized firms* N	mean	sd	*Not subsidized firms* N	mean	sd
ICT investment on total investment (1998-2000)	2063	0.16	0.27	705	0.16	0.3	1358	0.16	0.26	1405	0.17	0.29	658	0.13	0.22	855	0.1	0.19	1208	0.2	0.31
Average short term regional interest rate (1998-2000)	2290	6.58	0.85	803	7.39	0.82	1487	6.14	0.43	1609	6.61	0.86	681	6.5	0.81	868	6.72	0.93	1422	6.49	0.78
Mark up 1997	2251	0.26	0.87	780	0.25	0.18	1471	0.27	1.07	1571	0.24	1.04	680	0.32	0.15	861	0.29	0.16	1390	0.25	1.1
White collar blue collar ratio (average 1998-2000)	2290	0.72	1.22	803	0.64	0.96	1487	0.77	1.34	1609	0.77	1.28	681	0.62	1.08	868	0.68	1.25	1422	0.75	1.2
Firm Reorganization (dummy=1 if firm has carried out a process of reorganisation)	2290	0.09	0.29	803	0.07	0.26	1487	0.1	0.3	1609	0.06	0.25	681	0.16	0.37	868	0.14	0.34	1422	0.07	0.25
R&D (dummy=1 if firm is engaged in R&D programs)	2290	0.41	0.49	803	0.36	0.48	1487	0.44	0.5	1609	0.32	0.47	681	0.63	0.48	868	0.48	0.5	1422	0.37	0.48
Firm age	2290	25.15	18.24	803	22.07	16.42	1487	26.82	18.94	1609	22.44	15.84	681	31.57	21.62	868	26.19	19.11	1422	24.52	17.66
Credit rationing (dummy =1 if firm is credit rationed)	2290	0.09	0.29	803	0.12	0.33	1487	0.08	0.27	1609	0.09	0.29	681	0.09	0.29	868	0.1	0.3	1422	0.09	0.29
Subsidies (dummy=1 if firm received subsidies to investment)	2290	0.38	0.49	803	0.44	0.5	1487	0.35	0.48	1609	0.33	0.47	681	0.49	0.5	868	1	0	1422	0	0
Subsidised investment per worker	2290	3.50	10.51	803	5.23	14.40	1487	2.57	7.49	1609	3.50	10.80	681	3.50	9.83	868	9.23	15.47	1422	0	0

Tab. 2 – Sectoral composition according to Pavitt classification.

	Whole sample	South	North	SF	MLF	Subsidised	Non Subsidised
Supplier dominated	54%	69%	46%	60%	41%	55%	54%
Specialised suppliers	17%	15%	18%	17%	17%	18%	15%
Scale Intensive	24%	12%	30%	20%	34%	23%	26%
Science based	5%	3%	5%	4%	8%	5%	5%

Tab. 3 - ICT adoption

	Whole sample	South	North	SF	MLF
	# obs. 2290 # Cens. Obs. 520 #Unces. Obs. 1770	# obs. 803 # Cens. Obs. 212 #Unces. Obs. 591	# obs. 1487 # Cens. Obs. 308 #Unces. Obs. 1179	# obs. 1609 # Cens. Obs. 437 #Unces. Obs. 1172	# obs. 681 # Cens. Obs. 83 #Unces. Obs. 568
Selection equation	**Wald Chi ^{2} (18) = 774**	**Wald Chi ^{2} (18) = 186.4**	**Wald Chi ^{2} (18) = 614.7**	**Wald Chi ^{2} (18) = 399.2**	**Wald Chi ^{2} (18) = 346.7**
AGE	0.0049 (0.001)	0.006 (0.029)	0.004 (0.011)	0.001 (0.374)	0.007 (0.006)
RATION	-0.215 (0.012)	-0.217 (0.098)	-0.251 (0.034)	-0.207 (0.038)	-0.186 (0.260)
INNORG	0.652 (0.000)	0.533 (0.033)	0.750 (0.000)	0.582 (0.001)	0.815 (0.001)
SUBS	0.359 (0.000)	0.543 (0.000)	0.246 (0.001)	0.428 (0.000)	0.076 (0.468)
R&D	0.491 (0.000)	0.534 (0.000)	0.481 (0.000)	0.484 (0.000)	0.357 (0.001)
Depend. Vbl. log INVICT/N					
Log K/N $_{1995\text{-}97}$	0.070 (0.000)	0.066 (0.030)	0.078 (0.001)	0.055 (0.019)	0.078 (0.014)
INT $_{1997\text{-}2000}$	-0.060 (0.046)	-0.115 (0.039)	-0.006 (0.927)	-0.077 (0.032)	-0.030 (0.570)
WC/BC $_{1995\text{-}97}$	0.145 (0.000)	0.209 (0.000)	0.123 (0.000)	0.156 (0.000)	0.135 (0.001)
MKUP $_{1997}$	-0.407 (0.013)	-0.554 (0.030)	-0.260 (0.221)	-0.373 (0.059)	-0.258 (0.377)
Rho	-1.112 (0.000)	-0.989 (0.000)	-1.161 (0.000)	-0.987 (0.000)	-0.919 (0.030)
L.R. of indep. equat. (Rho=0) Chi ^{2}	82.89	16.91	61.47	40.51	42.88

MLE cross-section estimation.

Dependent variable in the selection equation ICT adoption dummy =1 if firm invested in ICT during the 1998-2000 period. Dependent variable log INVICT/N= log ICT investment per employee. AGE: firm age. RATION: dummy =1 if firm declared to be credit rationed (see appendix for further details). INNORGA: dummy = 1 if firm carried out a process of reorganisation. SUBS: dummy =1 if firm received investment subsidies. R&D: dummy =1 if firm is engaged in R&D process. Log K/N: log average capital per employee during 1995-97. INT: short term average regional interest rate during 1998-2000. WC/BC: average white collar blue collar ratio during 1995-97. MKUP: firm mark up in 1997 (see appendix for further details). Intercept terms replaced by industry dummies. P-values in parenthesis.

Tab. 4 - Average treatment effect on ICT investment for subsidised firms.*

	Sample	# obs.	ATT	Std. Error	z	P >| z |
1	Whole sample	2251	**0.248**	0.087	2.86	0.004
2	South	771	**0.261**	0.131	1.94	0.047
3	North	1480	**0.246**	0.117	2.10	0.036
4	Medium and Large firms (MLF)	689	**0.054**	0.161	0.34	0.737
5	Small Firms (SF)	1562	**0.336**	0.099	3.37	0.001
6	SF – South	594	**0.273**	0.149	1.83	0.068
7	SF – North	968	**0.387**	0.148	2.6	0.009
8	MLF - South	177	**0.099**	0.249	0.40	0.691
9	MLF – North	512	**0.041**	0.214	0.19	0.848

* ATT obtained with nearest neighbour matching estimator, with bias correction and controlling for heteroskedasticity (Abadie *et al*, 2004). Treatment variable: dummy=1 if firm received a subsidy to total investment and 0 otherwise. Outcome variable: logarithm of ICT investment per worker [log (I_{ICT}/N)]. Matching variables: logarithm of the average capital per worker in the previous period (1995-1997) [log (K/N) $_{1995\text{-}97}$]; the average white collar blue collar ratio in the previous period [WC/BC $_{1995\text{-}97}$]; the level of mark-up in 1997[MKUP $_{1997}$]; the regional average short term interest rate during the period 1997-2000 [INT $_{1997\text{-}2000}$]; a dummy R&D=1 if the firm is involved in R&D projects and 0 otherwise; dummy North=1 if the firm is located in a northern region; dummies for Pavitt industry classification. North is constrained to be an exact match when applicable.

Tab. 5- Average treatment effect on total investment for subsidised firms.*

# obs.	ATT	Std. Error	z	P >| z |
2251	**14.89**	1.48	10.03	0.000

* ATT obtained with nearest neighbour matching estimator, with bias correction and controlling for heteroskedasticity (Abadie *et al*, 2004). Treatment variable: dummy=1 if firm received a subsidy to total investment and 0 otherwise. Outcome variable: logarithm of total investment per worker [log (I/N)]. Matching variables: logarithm of the average capital per worker in the previous period (1995-1997) [log $(K/N)_{1995-97}$]; the average white collar blue collar ratio in the previous period [$WC/BC_{1995-97}$]; the level of mark-up in 1997[$MKUP_{1997}$]; the regional average short term interest rate during the period 1997-2000 [$INT_{1997-2000}$]; a dummy R&D=1 if the firm is involved in R&D projects and 0 otherwise; dummy North=1 if the firm is located in a northern region. North is constrained to be an exact match.

Ultimi Contributi di Ricerca CRENoS

I Paper sono disponibili in: http://www.crenos.it

- **06/07** *Isabel Cortés-Jiménez*, "Tourism and economic growth at regional level: the cases of Spain and Italy"
- **06/06** *Maria Gabriela Ladu*, "Total Factor Productivity Estimates: some evidence from European Regions"
- **06/05** *Gerardo Marletto*, "La politica dei trasporti come politica per l'innovazione: spunti da un approccio evolutivo"
- **06/04** *Elisabetta Strazzera,* "Application of the ML Hausman approach to the demand of water for residential use: heterogeneity vs two-error specification"
- **06/03** *Silvia Loddo,* "Structural Funds and Regional Convergence in Italy"
- **06/02** *Fabio Cerina,* "Tourism specialization and environmental sustainability in a dynamic economy"
- **06/01** *Emanuela Marrocu, Raffaele Paci e Francesco Pigliaru,* "Gli effetti del capitale pubblico sulla produttività delle regioni italiane"
- **05/14** *Rinaldo Brau and Davide Cao,* "Uncovering the macrostructure of tourists' preferences. A choice experiment analysis of tourism demand to Sardinia"
- **05/13** *Barbara Dettori, Raffaele Paci and Stefano Usai,* "Technological activity in European regions"
- **05/12** *Rosina Moreno, Raffaele Paci and Stefano Usai,* "Innovation clusters in European regions"
- **05/11** *Luca Deidda and Bassam Fattouh,* "Bank, financial markets and growth"
- **05/10** *Fabio Cerina and Francesco Pigliaru,* "Agglomeration and growth in NEG: a critical assessment"
- **05/09** *Maurice Kugler and Rossella Oppes,* "Collateral and risk-sharing in group lending: evidence from an urban microcredit program"
- **05/08** *Adriana Di Liberto,* "Convergence and divergence in neoclassical growth models with human capital"
- **05/07** *Maria Gabriela Ladu,* "Growth and employment: a survey on the demand side of the labour market"
- **05/06** *Maria Gabriela Ladu,* "Total factor productivity growth and employment: a simultaneous equations model estimate"
- **05/05** *Silvia Balia,* "Health and economic behaviour: a critical survey of the literature"

05/04 *Gianna Boero, Tiziana Laureti and Robin Naylor,* "An econometric analysis of student withdrawal and progression in post-reform Italian universities"

05/03 *Vittorio Pellagra,* "Banking with sentiments. A model of fiduciari interactions in micro-credit programs"

05/02 *Margarita Genius and Elisabetta Strazzera,* "Modelinf elicitation effects in contingent valuation studies: a Monte Carlo analysis of the bivariate approach"

05/01 *Fabio Cerina,* "Marshall's *ceteris paribus* in a dynamic frame"

04/20 *Rinaldo Brau and Carlo Carraio,* "The economic analysis of voluntary approaches to environmental protection. A survey"

04/19 *Cristina Murroni,* "ICT and local development: a case study of the metropolitan area of Cagliari"

04/18 *Adriana Di Liberto,* "Convergence clubs and the role of human capital in Spanish regional growth"

04/17 *Stefano Usai and Marco Vannini,* "Banking structure and regional economic growth: lessons from Italy"

04/16 *Silvia Balia and Andrew M. Jones,* "Mortality, lifestyle and socio-economic status"

04/15 *Rosina Moreno, Raffaele Paci and Stefano Usai,* "Geographical and sectoral clusters of innovation in Europe"

04/14 *Gianfranco Atzeni and Oliviero Carboni,* "ICT productivity and firm propensity to innovative investment: learining effects evidence from Italian micro data"

04/13 *Fabrizio Ariani and Luca G. Deidda,* "Few bad apples or plenty of lemons: which makes it harder to market plums?"

04/12 *Giovanni B. Concu,* "A choice modelling approach to investigate biases in individual and aggregated benefit estimates due to omission of distance"

04/11 *Giovanni B. Concu,* "Effects of distance aon non-use values"

04/10 *Antonio Sassu and Sergio Lodde,* "Le tecnologie dell'informazione e della comunicazione nelle piccole imprese dei settori maturi"

04/09 *Riccardo Marselli e Marco Vannini,* "L'efficienza tecnica dei distretti di Corte d'Appello italiani: aspetti metodologici, benchmarking e arretrato smaltibile"

04/08 *Rinaldo Brau, Matteo Lippi Bruni and Anna Maria Pinna,* "Public vz private demand for covering long term care expenditures"

04/07 *Matteo Bellinzas,* "Dinamiche demografiche, agglomerazione e determinanti economiche. Il caso italiano"

04/06 *Giuseppe Medda, Claudio Piga,* "R&S e spillover industriali: un'analisi sulle imprese italiane"

04/05 *Adriana Di Liberto, Roberto Mura, Francesco Pigliaru,* "How to measure the unobservable: a panel technique for the analysis of TFP convergence"

04/04 *Vittorio Pelligra,* "How to incentive Who? Intr-personal and inter-personal mechanisms"

04/03 *Domenica Giovanna Dettori, Antonello Paba, Manuela Pulina,* "European rural Tourism: agrotouristic firms in Sardina and their life cycle"

04/02 *Giovanni Sulis,* "Wage dispersion and Equilibrium search models: some evidence from Italy"

04/01 *Silvia Loddo,* "Old and new intervention policy: A survey of empirical studies for the Mezzogiorno"

03/13 *Raffaele Paci, Ernesto Batteta,* "Innovation Networks and Knowledge Flows across the European Regions"

03/12 *Antonio Sassu, Sergio Lodde,* "Piccole imprese e tecnologie della comunicazione: un'indagine empirica"

03/11 *Antonio Sassu, Sergio Lodde,* "Tradizione e innovazione nel settore vinicolo in Sardegna"

03/10 *Rosina Moreno-Serrano, Raffaele Paci, Stefano Usai,* "Spatial distribution of innovation activity. The case of European Regions"

03/09 *Rinaldo Brau, Alessandro Lanza, Francesco Pigliaru,* "How fast are the tourism countries growing? The cross-countries evidence"

03/08 *Margarita Genius, Elisabetta Strazzera,* "The copula approach to sample selection modelling: an application to the recreational value of forests"

03/07 *Guido Ascari, Emanuela Marrocu,* "Forecasting inflation: a comparison of linear Phillips curve models and nonlinear time series models"

03/06 *Alessandro Lanza, Matteo Manera, Massimo Giovannini,* "Oil and product price dynamics in international petroleum markets"

03/05 *Rinaldo Brau, Gianluca Fiorentini, Matteo Lippi Bruni, Anna Maria Pinna,* "La disponibilità a pagare per la copertura del rischio di non autosufficienza: analisi econometrica e valutazioni di policy"

03/04 *Gianfeanco Atzeni, Claudio Piga,* " Credit Rationing in High-Tech Firms and Sample Selection"

03/03 *Manuela Pulina,* "Quantitative forecasting for tourism: OLS and ARIMAX approaches"

03/02 *Gianna Boero, Riccardo Pinna,* "Durata degli studi e voto di laurea: un'indagine econometrica su alcune facoltà dell'Università di Cagliari"

03/01 *Anna Maria Pinna, Miriam Manchin,* "Border Effects in the Enlarged EU Area. Evidence from Imports to Applicant Countries"

02/12 *Gianna Boero, Riccardo Pinna,* "La performance esterna dell'Università di Cagliari: il caso delle facoltà del polo giuridico-economico"

02/11 *Sergio Lodde,* "Patti territoriali e specializzazione produttiva nel Mezzogiorno"

02/10 *Maria Grazia Curreli, Sergio Lodde,* "Saperi tradizionali e sviluppo locale: il comparto della produzione del miele in Sardegna"

02/09 *Gianna Boero, Jeremy Smith, Kenneth F. Wallis,* "The properties of some goodness-of-fits tests"

02/08 *Gianna Boero, Emanuela Marrocu,* "The performance of SETAR models: a regime conditional evaluation of point, interval and density forecasts"

02/07 *Anna Maria Pinna, Carla Fancello,* "How far do we trade intermediate inputs?"

02/06 *Sonia Deidda, Raffaele Paci, Stefano Usai,* "Spatial Externalities and Local Economic Growth"

02/05 *Elisabetta Strazzera, Rinaldo Brau, Silvia Balia, Simone Atzeni,* "La disponibilità a pagare e le preferenze dei turisti per i siti del Parco Geominerario della Sardegna: il caso di Porto Flavia"

02/04 *Rinaldo Brau, Massimo Florio,* "Privatisations as price reforms: Evaluating consumers' welfare changes in the UK"

02/03 *Luca Deidda, Fabio Cerina,* "Do we need more time for leisure?"

02/02 *Luca Deidda, Bassam Fattouh,* "Concentration in the Banking Industry and Economic Growth"

02/01 *Raffaele Paci, Silvia Saddi,* "Capitale pubblico e produttività nelle regioni italiane"

01/14 *Gianfranco E. Atzeni, Oliviero A. Carboni,* "The Economic Effects of Information Technology: Firm Level Evidence from the Italian case"

01/13 *Stefano Usai, Raffaele Paci,* "Externalities and Local Economic Growth in Manifacturing Industries"

01/12 Ma*rzio Galeotti, Alessandro Lanza, Matteo Manera,* "Rockets and Feathers Revisited: An International Comparison on European Gasoline Markets"

01/11 *Gianna Boero, Abigail McKnight, Robin Naylor, Jeremy Smith,* "Graduates and Graduate Labour Markets in the UK and Italy"

01/10 *Gianna Boero, Emanuela Marrocu,* "Evaluating Non-Linear Models on *Point* and *Interval* Forecasts: An Application with Exchange rate return"

01/09 *Robin A. Naylor,* "Firm Profits and the Number of Firms under Unionised Oligopoly"

Finito di stampare nel mese di Luglio 2006
Presso Editoria&Stampa
Zona Industriale Predda Niedda str. n. 10
07100 Sassari