ICT and labour productivity: evidence for the Italian regions

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ABSTRACT

The requirements of the current knowledge-based economy and the contribution of Information and Communication Technology (ICT) to socio-economic change are likely to have a significant impact upon regional differentials in the European Union. So far, however, the literature on the implications of the ICT paradigm for labour productivity has almost entirely neglected the sub-national (regional) dimension. Using experimental micro-data, this paper firstly provides a picture of the regional and sectoral contributions to labour productivity growth in Italy in the period 2001-05. Secondly, it explores the relationship between ICT-producing industries and regional labour productivity in the same reference period. In line with previous studies at the country level, our findings highlight a positive relationship between ICT-producing industries and regional productivity; additionally, some interesting trends emerge for what concerns the traditional North-South Italian divide.

1. Introduction

Since the mid-1990s Italy has experienced a pronounced labour productivity slowdown: the causes of this prolonged deceleration have not yet been clearly identified (Daveri and Jona-Lasinio, 2005). This issue, coupled with the historical geographical polarisation and the strong territorial imbalances observed among the Italian regions, has provided the underlying motivation of this work, which looks simultaneously at regional and national labour productivity growth.

The pervasiveness of general purpose Information and Communication Technologies (ICTs) and the contribution of intangible assets to socio-economic growth are among the main underlying explanations of regional growth differentials within the European Union. Yet, it is rather unclear whether the ICT paradigm is spurring greater socio-economic cohesion or, on the contrary, stronger territorial polarisation of wealth. The literature on new technologies and productivity levels and growth rates has substantially neglected the sub-national (regional) dimension, due mainly to the lack of adequate data allowing for dynamic territorial analyses.

In this paper we provide preliminary evidence on the relationship between ICT-producing industries and regional labour productivity in Italy in the period 2001-2005 – a period of particularly severe slowdown in the Italian economy – to have some insights about the possible determinants of the disappointing Italian productivity developments. The main research questions addressed in this work are the following: 1) What was the contribution of individual regions and industries to the Italian labour productivity growth in the first half of the 2000s? 2) Is there a relationship between ICT-producing industries and regional labour productivity? An ancillary question in the Italian case is obviously related to the extent to which the traditional dualism North-South is reflected in such labour productivity trends.

The experimental micro data used in this work are gathered from the Provisional Estimate of Value Added of Enterprises and the System of Accounts of Business Units (SABU), covering exhaustively all Italian firms with 100 or more employees. The analysis is conducted in two steps. The first one consists of decomposing labour productivity growth, measured at the firm level, by region and by sector within each region in order to obtain a picture of the relative contributions to the overall Italian productivity growth in the period considered. In the second step we explore whether a statistical relationship is found between ICT-producing industries and regional labour productivity. Our results indicate that, although the (rather feeble) national productivity growth between 2001 and 2005 has been mostly driven by the "usual suspects" – the technological regional cores in the North of the country – signs of convergence emerge, at least for some parts of the Italian Mezzogiorno. Furthermore, in line with most studies at the country level, ICT-producing industries overall show a strongly positive relationship with regional labour productivity levels in the observed period, displaying also some interesting interregional differences.

The paper is structured into six sections. The next section briefly summarises some of the literature background on new technologies and labour productivity levels and growth, with particular reference to its spatial dimension. Section 3 introduces the data, whilst Section 4 provides the picture obtained by decomposing the Italian labour productivity growth in the period 2001-05 by region and by sector within each region. Section 5 firstly describes the methodology applied to explore the relationship between ICT-producing industries and regional labour productivity; the results from our panel of firms are then discussed. Section 6 concludes indicating the next steps in our research.

2. The background: a synopsis

Productivity is both an outcome and a crucial measure of the contribution of technological progress to economic growth.[1] Yet, the relationship between technological paradigms and productivity has been extensively discussed, both theoretically and empirically, but only partially understood.[2] If, on the one hand, investment in innovation and technological progress are universally acknowledged as the major determinants of productivity, economic theories differ substantially in their respective interpretation of what technology and knowledge are, to what extent they influence productivity levels and growth, and how such relationships evolve over time. The copious empirical literature offers a myriad of examples – mostly at the aggregate level of countries and industries – which however are hardly conclusive due to the diversity of theoretical standpoints, methodologies and databases.

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[1] Though labour productivity and total factor productivity (TFP) differ to some extent, they are commonly used interchangeably as measures of technological level and change (see Daveri and Silva, 2004). In this work, the empirical investigation is carried out specifically on labour productivity levels and growth rates, as such an indicator seems more apt to reflect economic differences among regions in the same country.

[2] It is beyond the scope of this paper to provide a survey of the huge body of theoretical and empirical literature on ICTs and productivity growth at the firm level. Some seminal references are Bresnahan and Trajtenberg (1995), Olley and Pakes (1996), Brynjolfsson and Hitt (2003), Crespi et al. (2007).

Though, conclusive evidence on the link between technological progress – and in particular the ICT paradigm – and productivity is likely to remain a chimera as long as its determinants become more numerous and difficult to capture. The addition of explanatory variables other than traditional innovation input (e.g. R&D) and output (e.g. patents) indicators – such as capabilities, organisational change, investment in intangibles, just to mention a few – do provide an increasingly accurate picture of the relation between new technologies and productivity, at the same time introducing further complexity and creating major challenges for policy design. As rightly put by Bartelsman and De Groot (2004, 8-9) "a plethora of proxies for 'anything that can matter' has been tried", making increasingly tricky to build an integrated analytical framework able to provide guidelines for both empirical and policy analysis.

The difficulties in understanding such a multifaceted link lie in the multi-level and long-term adaptation process of industrial societies to the current technological paradigm, that is the 'information age' (e.g. Brynjolfsson, 1993; Jorgenson, 1995; Castells, 2000; Amendola et al., 2005). Indeed, analogies have been made to the electrification age, or even to the industrial revolution, in terms of magnitude of the impact and enduring gestation. The possibility of 'extended learning curves' implies that, for new investments in knowledge and technologies to fully deploy their benefits, it is necessary to develop complementary and related innovations – technical, organisational, social and institutional – which might require exceptionally long evolutionary processes of learning and adjustment (see, for example, Freeman and Soete, 1994; Wilson, 1995; David, 1990, 2000; Gordon, 2000; Pérez, 2002).

Another controversial point in the literature regards the distinction between ICT production and ICT adoption and use. Although both capital-deepening effects (i.e. the accumulation of ICT capital such as hardware, software and communication equipment) and acceleration effects (i.e. technical change brought about by the new technological paradigm) in principle apply to both ICT production and use and have been recognised as critical in the literature on productivity growth, divergence exists over the relative importance of ICT production versus ICT use (Daveri and Silva, 2004). On the one hand, some scholars have argued that productivity gains are mostly driven by industries classified as ICT-intensive – and in particular some business service sectors with high degrees of ICT adoption (e.g. Stiroh, 2002; Van Ark et al., 2002). On the other hand, other experts have claimed that the bulk of the benefits of the ICT paradigm in terms of productivity have to be ascribed to ICT productions (e.g. Gordon, 2003; Daveri and Silva, 2004).

Indeed, the range and weight of service activities are central when looking at productivity. Empirical studies (e.g. Guerrieri and Meliciani, 2005, Broadberry and Ghosal, 2005) show remarkable variation in terms of productivity levels and growth between traditional and highly regulated services (e.g. retail and wholesale trade, transports, telecommunications) and knowledge-intensive service activities (e.g. IT services or financial and insurance services). Some of these service industries are in fact ICT-producers (e.g. IT and software), though at the same time intensive users of the new technologies. The ICT industry as a whole requires comparatively wider access to specialised goods and services, which include laboratories, university research, legal and financial services among others (Barrios et al. 2008).

Again, on this user-producer controversy there is no conclusive evidence. It may be argued that the hypothesis of *ICT-adoption-led-growth,* and its emphasis on technological diffusion, cannot be so easily disentangled from that of *ICT-production-led-growth.* Most likely, productivity gains are achieved by the combination of the capacity to generate new goods and services and the capacity to transmit and diffuse new knowledge, which in turn are contingent on highly situated social and institutional structures and their response to change. In other words, more than mutually exclusive categories, ICT production and ICT adoption should be seen as complementary forces influencing productivity. As shown by Daveri and Silva (2004), productivity effects can actually differ not only between ICT-producing and ICT-using industries, but also within each of these two industry groups. The degree of interdependence and relatedness of knowledge, competences and capabilities in industrial and technological structures are all critical factors underlying productivity trends, accounting for the huge difficulties in reaching adamantine conclusions on productivity paradoxes and illogicalities.

Yet, contextualisation seems to undoubtedly matter, even though productivity is principally the outcome of micro-level decisions related to the choice of inputs to obtain a certain output. The basic unit of analysis is the firm, as the main economic agent, whose behaviour and productivity outcome is however strongly influenced by different external factors, such as geographical location and sectoral affiliation. High firm heterogeneity in productivity levels and growth translate, in the aggregate, into sharp and persistent differences in productivity across countries (e.g. Ahn, 2001; Barnes at al., 2001; Bartelsman et al., 2003) and industries (e.g. Bartelsman and Doms, 2000; Bottazzi et al., 2002), as well as across regions within the same national borders (e.g. Cingano and Schivardi, 2004; Di Giacinto and Nuzzo, 2006; Dettori et al., 2008).

Looking more specifically at the spatial dimension, technological gap approaches indicate social capability and technological congruence as main underlying factors of productivity differentials across space (see, among others, Ohkawa and Rosovsky, 1973; Abramovitz, 1986; Fagerberg, 1987, 1994; Fagerberg et al., 1994). While social capability refers to the overall ability of the region to engage in innovative processes and in the consequent institutional change, technological congruence points to the distance of the region from the technological frontier or, in other words, its capacity to implement the technical properties connected to the new technologies (Fagerberg et al., 1994). The first concept thus refers to the path-dependent evolution of the region as a socio-economic ‘whole’ or system, whilst the second concept points mainly to the regional industrial structure and the scope for convergence between old and new technologies (von Tunzelmann, 2009). Technological gap models stress the ambiguous effect of two different forces, both carrying strong spatial implications: on the one hand, the capacity to generate innovation, which tends to widen productivity differentials; on the other, the capacity to diffuse innovation, which tends to narrow them. Incidentally, such observations seem to point to some degree of complementarity between production and adoption of new technologies, particularly when looking at regional and local imbalances.

Following technological gap views, regions with a knowledge and production base more apt to adjust to technological change tend to attract the production of those goods and services that have higher inputs of knowledge and intangibles (for example human capital) along their value chain. Such regions are thus those likely to experience comparatively higher levels and growth rates of productivity, along with higher labour unit costs.[3] These regions are better equipped to exploit new opportunities, to adapt existing activities to changing business

[3] On the relationship between the evolution of cost advantages – and particularly labour unit costs – technology and productivity see for example Fagerberg (1988) and, more recently, Acemoglu and Shimer (2000).

models, and to learn faster how to build cutting-edge advantages. New and non-standardised types of goods and services are also prevalently produced, at least initially, in more diversified and open regions, which serve as hubs and often show the required magnitude, diversity and sophistication of both supply and demand to support the growth of new markets (e.g. Cheshire and Carbonaro, 1995; Dunford and Smith, 2000; van Winden and van der Meer, 2003; Duranton and Puga, 2004).

Productivity gaps among regions may thus be explained both by the local capacity to invest in innovation and to carry out the connected organisational and institutional changes, and by the attractiveness towards industries with a clear technological advantage, such as ICT-producing industries (Daveri, 2004; Barrios et al., 2008). ICT firms may favour regional locations that offer greater opportunities of developing new knowledge combinations and applications with other industries, facilitating inter-industry resource reallocation and, at the same time, innovation diffusion and cumulative causation mechanisms (see also Weterings and Boschma, 2009).

In conclusion, aggregate productivity is ultimately determined by innovation and technological progress, and its evolution affected by resource assets and allocation decisions of micro-actors, particularly firms, whose behaviour is shaped by external environment conditions. Relevant and persistent differences – in terms of both social capabilities and technological congruence – among regions and industries within a national economy may be expected to translate into differences in productivity levels and growth rates.

In what follows we carry out a first attempt to look at one side of the complex set of relationships discussed above, i.e. the relationship between ICT-producing industries and regional labour productivity. Before doing so we decompose labour productivity growth in sectoral contributions to the regional performance and regional contributions to the national one. This is deemed important in order to provide a picture of reference of the heterogeneity of regional structures and performances within the Italian economy.

3. The data

Difficulties in measurement have been at the core of explanations for the "productivity paradox".[4] Because information and knowledge are intangible, any increase of their content in goods and services is likely to be underestimated compared to any increase of traditional inputs (Brynjolfsson, 1993). Indeed, both ICT-producing and ICT-intensive industries face serious problems in accounting for changes in quality and variety. Nonetheless, progress has been made since the adoption, at the EU level, of the System of National Accounts (ESA95), allowing for the ease of some of the problems faced in the estimation of intangible activities, among which the reclassification of software as a capital good.

In regional analyses, the general problems of measuring ICT-related activities couple with those connected to the estimation of regional aggregates. In this respect, one of the most serious bias in territorial investigations concerns firm multilocation, as in most surveys the variables are estimated assuming that the firm is located in only one (headquarters) region, thus rendering impossible to control for multilocated (and multisectoral) firms. In what

[4] This refers to the famous claim by Nobel laureate Robert Solow: "we see computers everywhere except in the productivity statistics".

follows, this limitation is overcome, as aggregates on production activities are allocated to the region where the unit carrying out the relevant transactions (local kind-of-activity unit, i.e. KAU) is resident (Eurostat, 1996).

The data used in this work come from the Provisional Estimate of Value Added of Enterprises and the System of Accounts of Business Units (SABU), covering the whole population of Italian firms with 100 or more employees and providing the possibility for dynamic analyses. The Italian National Institute of Statistics (ISTAT) is among the few European statistical offices that release information about ICT capital goods at both sectoral and geographical level. In order to identify ICT firms at the regional level, micro data classified by economic activity (ATECO91, based on NACE Rev.1) are employed,[5] allowing for a detailed sectoral analysis, where production processes can be considered less heterogeneous and thus productivity changes may be more representative of underlying technological change. In accordance with the OECD definition (OECD, 2000) – compatible with ATECO91 – ICT-producing industries comprise three sectors: hardware, software and communication equipment.

The analysis is carried out with reference to the period 2001-2005 and the sub-national breakdown refers to the NUTS 2 level, corresponding to the 20 Italian administrative regions (see Appendix A.1). The variables covered in the dataset are the following: value added, investment, employment, employment class, sectoral code, regional code, multiregional code, labour costs. The number of firms included in the panel is 7,200 firms, representing the universe of Italian firms above 99 employees.

In line with the discussion in Section 2 above, the contribution of ICT-producing industries is likely to be greater the higher their relative weight in the regional economy. Map 1 provides an overview of the location of ICT-producing firms expressed in terms of their percentage share on the total number of firms by region in the period 2001-2005.

[Map 1 about here]

The following Section 4 illustrates the exercise of decomposing the Italian labour productivity growth by region and by sector within each region.

4. Decomposing labour productivity growth: regional and sectoral contributions

4.1. The decomposition method

The analysis of the contribution of Italian regions to national productivity growth is done by means of the aggregate productivity decomposition approach firstly devised by Oulton (1998), and subsequently applied to different units of analysis (i.e. firms, industries, countries) by Baily et al. (1996), OECD (2001, 2003), Bartelsman and De Groot (2004), Gozzi et al. (2005).[6] In our case here we apply such a decomposition approach to subnational units of analysis, i.e. the Italian 20 regions. We look both at regional contributions to national productivity growth and at sectoral contributions to each region's productivity growth.

[5] The economic activity classification (ATECO 91) follows the Nace Rev.1 up to the fourth digit level, while the fifth level, which is used in the present analysis, is a further breakdown of the fourth.
[6] For a slightly different approach to the decomposition of labour productivity growth in the case of the Dutch regions see Oosterhaven and Broersma (2007).

Aggregate productivity growth can be decomposed into the contribution of each region taking into account three different effects: within-region, level reallocation and growth reallocation. The effect on the aggregate productivity growth within each particular region depends in turn on the relative size of sectors making up the regional industrial structure. Thus, regional productivity is decomposed into the contribution of industrial sectors, i.e. looking at the same three components within-sector, level and growth reallocation.[7]

Throughout this paper, our measure of labour productivity[8] for each firm *i* at time *t* is as follows:

$$LP_{it} = \frac{VA_{it}}{EMP_{it}} \qquad i = 1, 2, ..., 7200$$

Labour productivity of each sector *j* in each region *k* is given by:[9]

$$LP_{jkt} = \frac{VA_{jkt}}{EMP_{jkt}} \qquad j = 1, 2, \ldots n \qquad k = 1, 2, \ldots, 21 \qquad t = 0, \ldots T$$

Thus, the aggregate regional productivity is:

$$LP_{kt} = \frac{\sum_j VA_{jkt}}{\sum_j EMP_{jkt}}$$

As stated above, the contribution of each sector to the aggregate regional productivity growth depends on the relative size of that sector within the region, which is measured in terms of employment share. Thus, in each region *k*, the size of each sector is:

$$w_{jt} = EMP_{jt} / \sum_j EMP_t \qquad \text{where} \qquad \sum w_{jt} = 1$$

The proportional growth of labour productivity in sector *j* between time 0 and *T* in each region *k* is given by:

$$\left(LP_{jT} - LP_{j0} \right) / LP_{j0} = \left(w_{jT} LP_{jT} - w_{j0} LP_{j0} \right) / LP_{j0}$$

This can be decomposed in the three different effects highlighted above:

[7] This is the same method applied by Gozzi et al. (2005), which differs slightly in the third term of the decomposition from that of Baily et al. (1996), without however affecting the total sum of the three effects (see Gozzi et al., 2005, 17).
[8] For the advantages (and disadvantages) of using labour productivity computed on value added see Gozzi et al. (2005).
[9] The regions here considered are 21, instead of 20, because the two autonomous provinces (Trento and Bolzano) that constitute the region of Trentino Alto-Adige are reported separately.

$$\left(LP_{jT} - LP_{j0} \right) / LP_{j0} = \frac{w_{j0}\left(LP_{jT} - LP_{j0} \right)}{LP_{k0}} + \frac{\left(w_{jT} - w_{j0} \right)\left(LP_{j0} - LP_{k0} \right)}{LP_{k0}} + \\ + \frac{\left(w_{jT} - w_{j0} \right)\left[\left(LP_{jT} - LP_{j0} \right) - \left(LP_{kT} - LP_{k0} \right) \right]}{LP_{k0}} \quad (1)$$

Ceteribus paribus, aggregate regional labour productivity growth increases if there is either one or a combination of the following effects: a) a rise in the productivity growth of a sector weighted by its share of regional employment in the initial year (first term on the right hand side of (1)), or within-sector effect; b) a rise in the employment share of a sector with productivity level higher than the regional average in the initial year (second term in (1)), or level reallocation effect; c) a rise in the employment share of a sector with a productivity growth higher than the regional average (third term in (1)), or growth reallocation effect.[10]

The contribution of each region k to the overall national labour productivity growth is obtained in the same way, by decomposing $\left(LP_{kT} - LP_{k0} \right) / LP_{k0}$ in the three effects with respect to the country as a whole $\left(LP_{ITALYt} \right)$.

4.2. Results

The results of the productivity growth decomposition for the Italian regions are reported in Table 1.[11]

[Table 1 about here]

As pointed out by other studies (Daveri and Jona-Lasinio, 2005), the slowdown of Italian economic growth since the mid-1990s and throughout the 2000s has been mainly attributed to a declining labour productivity, holding back in all industries but utilities (with manufacturing accounting for about one half of the slowdown). Looking at Table 1, Italy as a whole recorded a labour productivity growth of 2.94 in the period 2001-05, with a decreasing trend in the latest years here considered (2003-05). The regions that mostly contribute to the national growth are Lombardia, Emilia and Veneto, with the former experiencing a slowdown in 2003-05, whilst the latter two regions strengthening their positive contribution particularly in the second sub-period. On the negative side, the regions mostly holding back the country labour productivity performance are Lazio (with a strongly negative figure of –2.3, resulting from a steady deterioration over the 5 years here considered), Piemonte and, to a lesser extent, Campania, whose drop is particularly visible in the second sub-period. Some of the southern regions – such as Puglia, Abruzzo and, quite outstandingly, Sardegna (0.52, the highest contribution of the whole Mezzogiorno, increasing over the five years considered) – provide a noticeable input to national labour productivity growth, higher than that of the central regions and of some of the traditional northern industrial cores.

In the decomposition analysis at the regional level, the within-region effect, that captures the gain (or loss) in the aggregate labour productivity growth of each region weighted by its initial employment share,[12] accounts for the bulk of productivity trends. Conversely,

[10] The two reallocation components together are usually indicated as *between-effects*.
[11] Further details on the decomposition of labour productivity growth by sector within each region are available from the authors on request.
[12] Note that in Table 1 the regional shares provided in the last two columns refer to the last year, 2005, for both employment and value added.

reallocation effects are rather week, overall displaying a small negative level reallocation and a negligible positive growth reallocation. As stated above, reallocation (or between-regions) effects grasp the gain (or loss) in aggregate labour productivity stemming from a rise (or fall) in the employment share of a region with productivity levels/growth rates higher (lower) than the national average. This seems to indicate that, in the period considered, there was no substantial shift of employment away from higher productivity/faster growing regions to other less productive areas.

Turning to the decomposition by sector within each region, it is interesting to report a few observations for those regions that register the strongest (either positive or negative) productivity variation over the five years. The highest contribution to Lombardia's labour productivity growth comes from Other services (2.5), Metals (0.9) and Electrics (0.6), all showing a strongly positive within-sector effect, with only the former industry experiencing a small negative level reallocation effect.[13] Noteworthy, the contribution of the ICT-producing industry is positive for all three sectors, particularly for software and telecommunication (0.4 in both). In Veneto, the two most dynamic sectors in terms of labour productivity growth are Other manufacturing (4.4) and Wholesale and retailing trade (3.1), both registering a high within-sector effect, accompanied by relatively pronounced positive between-sector effects: in this region, therefore, some shift of employment to above-average productivity industries occurred over the period considered. In Emilia, remarkable within-sector effects characterise the positive contribution of Other manufacturing (4.0), Metals (3.5) and Wholesale and retailing trade (3.2): the ICT sector as a whole, and software in particular, also provide a positive contribution to the regional labour productivity performance.

The negative productivity growth recorded in Piemonte – not surprisingly given the crisis of FIAT during the period considered – is almost entirely attributable to Means of transport (-12.5), showing an exceptionally negative within-sector effect, yet accompanied by overall positive (though small) between-sectors effects. Lazio's drastic and persistent fall in productivity is concentrated in Wholesale and retailing trade (-19.1) and it is entirely of a within-type, whilst Campania follows Piemonte's fate in the sharp decline of labour productivity in Means of transport (-13.5), with similar (though higher) between-sector effects. Interestingly, in all these low-performing regions, the role of ICT, and particularly software, is anyway substantial and positive.

This first description of Italian labour productivity growth across regions and sectors within regions sheds light on two main facts. First, the (weak) growth of Italian labour productivity in the first half of the 2000s, although regionally polarised in some of the strongest regional innovation systems such as Lombardia, Emilia and Veneto, does not reflect a sharp North-South gap. Rather, the fall of some traditional industrial cores such as Piemonte, is counterbalanced by a small but positive contribution of most southern regions. The bulk of the total national growth over the period 2001-05 is due to the within-region type of effect. Secondly, the sectoral decomposition analysis within each region indicates some differences in the importance of within and between effects across industries, signalling that some reallocation components are at work. As also noted by Daveri and Jona-Lasinio (2005), this evidence seems to be somehow at odds with the common assumption of the rigidity of the Italian labour markets, and should be investigated further by taking into account specificities in regional factor markets.

[13] The reallocation here is exclusively the shift of employment between sectors. By construction, the within-industry reallocation between firms – clearly the most sizable inter-firm labour flow - is not considered here (see Bartelsman et al. (2002) on between-firm reallocation).

5. ICT and regional productivity in Italy: statistical evidence

In this section we firstly describe the conceptual framework and the empirical strategy underlying our analysis, and then present our main results on the relation between ICT-producing industries and regional labour productivity in Italy.

5.1 The production function framework

The firm's production function framework is here taken as a benchmark. Empirical research in the last fifteen years or so has made it clear that there is no such a thing as a "representative firm" in any given industry. As discussed in Section 2 above, industries and regions are made up of very heterogeneous individual firms, showing large and persisting differences in productivity performance. Moreover, large-scale reallocation of outputs and inputs between producers occurs over time, also and perhaps mostly within industries, and such a reallocation from less productive to more productive businesses has been shown to contribute significantly to aggregate productivity growth in a variety of OECD countries. Furthermore, most of the literature on ICT and productivity concludes that disaggregated data are needed to tie productivity performance to business practices (e.g. Greenspan, 2000; Stiroh, 2002). These considerations underlie the choice to implement our analysis firstly at the firm level and then replicating it at a more aggregate level by fitting the productivity model (eq. 2) to observations on the average productivity for each region.[14] For notational convenience, we embody in our specification the assumption of constant returns to scale (see Daveri and Jona-Lasinio, 2008).

We consider a value added production function, instead of an output-based one. The full-fledged production function underlying equation (2) would have (real) output on the left–hand side and capital, labour, intermediate materials and services on the right-hand side. Yet this more complete formulation would be subject to a well known empirical specification problem, i.e. the endogeneity of input demands. Namely, the optimal quantity of inputs demanded by the firm depends on the unobserved Solow residual that features as the error term in the output equation, thereby inducing a correlation between the error term and the explanatory variables of the regression. Yet, under the assumption of separability between the value added and the intermediates functions, the dependent variable may be (real) value added, that is real output minus (real) materials and services. This does not eliminate the endogenous input choice problem (capital and labour are still on the right-hand side), but makes it easier to handle. Subject to these preliminary remarks, in each period t, the constant returns to scale value added-based production function for firm *i* at time *t* is the following:

$$\ln(Y_{i,t}) = \ln(A_{i,t}) + \beta_K \ln(K_{i,t}) + (1-\beta_K)\ln(L_{i,t}) \qquad (2)$$

where firm value added Y (in logs) is a log-linear function of the labour input L, capital services K and the efficiency parameter A.

The estimates of the effects of ICT are based on a simple linear model for productivity. Denote the log of the efficiency parameter A of firm *i* in region *j* at time t by $\ln(A_i)$, and let D_S be an indicator of ICT (or, alternatively, manufacturing or service) firms. Then we can write:

[14] See Angrist (1990) for an illustration of efficient econometric methods to estimate grouped data.

$$\ln(A_i) = \beta_{A,i} + \beta_s D_s + \delta_t + u_{it} \qquad (3)$$

where $\beta_{A,i}$ is a firm effect, the coefficient β_s is the effect of ICT (manufacturing, services) on labour productivity, D_S identifies ICT (or, respectively, manufacturing and services), δ_t is a period effect common to all firms and u_{it} is a residual.

5.2 Empirical strategy

In our empirical analysis we exploit a balanced panel for the Italian large firms over the period 2001-2005. As explained in Section 3 above, our database covers 7200 firms with more than 99 employees classified by industry and by region, so that we are able to identify and to localise ICT-producing firms.

To evaluate the relationship between ICT production and productivity we relate labour productivity to per-capita investment (taken as a proxy for capital stock at the firm level) and to our main variables of interest: sectoral dummies representing respectively ICT, manufacturing and service firms (see Appendix A.2 and Table A.1 for variable description and summary statistics). We carry out this exercise both at the firm level for each region as well as for regional average values.

Our intended goal here is to identify some partial correlation between sectoral structures – with particular attention to ICT-producing sectors – and firm/regional productivity by estimating the coefficients of the dummy variables in equation (2). To obtain an empirically usable equation for estimating such a relation we substitute the expression for the log of A from equation (3) into equation (2), and subtract the labour input on both sides. Such a simple transformation provides an expression that relates labour productivity to both the capital-labour ratio and the sectoral dummies.

We estimate a panel regression that relate the value added per employee in each firm *i* (region *j*) at time *t* (LP_{it}; with *i*=1,..7200, and *t*=2001, ..,2005) to the firm capital labour ratios (KL_{it}) as well as the set of our industry (D_s) and (D_t) time dummies.

In short, our baseline specification is as follows:

$$LP_{it} = \gamma(KL_{it}) + \sum \beta s Ds + \sum \beta_t D_t + e_{it} \qquad (4)$$

where the last three terms indicate that the error term is decomposed into industry-invariant period-specific components, time-invariant firm specific components and a white-noise residual that varies across both time and firm dimensions.

The dependent variable in equation (4) is the level of firm value added per employee. On the right-hand side of the equation, the inclusion of industry and period fixed effects serves the purpose of allowing for the growth of A to differ across industry and over time. Period fixed effects are appended to capture unobservable influences on productivity that are common to all firms such as those stemming from business cycle fluctuations.

We start estimating equation (4) for 7200 firms over 2001-2005 by OLS with industry-specific dummy variables and heteroskedasticity-consistent standard errors. Even upon choosing value added as a dependent variable (as discussed above), a remaining key estimation issue of equation (2) is the possible endogeneity of right-hand side variables, namely the capital-labour ratio. As first pointed out by Hulten (1979), the demand of capital services depends on TFP, which is partly captured by the error term in equation (2). This induces a correlation between the error term and one of the regressors which makes the OLS estimates of the capital-labour coefficient potentially biased upwards.

To deal with the potentially endogenous variable on the right-hand side of our regressions, i.e. the capital-labour ratio, we resort to instrumental variables estimates. A good potential instrument is one that only affects productivity through the instrumented variable and, at the same time, is highly correlated with the variable to instrument. For this purpose our instruments for the capital-labour ratio are the log-levels of the same variable lagged twice, and our set of industry dummy variables.

For diagnostic purposes, we use the p-values of the Sargan-Hansen test to evaluate the validity of our instruments and the values of the Shea partial R-squared of each endogenous regressor to evaluate their relevance.

5.3 Results

Table 2 presents the results on regional average values from the OLS estimates with industry-specific dummy variables and from the 2-stages Least Square estimates.

[Table 2 about here]

As expected, our proxy for capital stock exerts a highly positive and significant impact on productivity in all the specifications of the model. More importantly for our purpose here, a strongly positive and significant relationship emerges between ICT-producing industries and labour productivity for the estimates on the regional means. Indeed, this result holds as well for both the LSDV and 2SLS estimates at the firm level for each region, whose results are reported in Table 3 only for those regions which contributed the most (i.e. Lombardia, Emilia and Veneto) or the least (i.e. Piemonte, Lazio and Campania) to the national productivity growth in 2001-05.

[Table 3 about here]

The results show in fact a highly significant (1% level) and positive association between ICT and productivity in nine Italian regions out of eighteen (as from Map 1, Molise and Basilicata were excluded because of the lack of ICT-producing large firms). In the remaining regions (Valle D'Aosta, Trentino Alto-Adige, Friuli Venezia-Giulia, Liguria, Marche, Abruzzo, Campania and Puglia), the coefficient is always positive but not significant. The only exception, showing a negative (though not significant) relationship between the ICT indicator and labour productivity, is Sicilia. Conversely, the variables for Manufacturing and Services display a strongly negative association with labour productivity levels, both for the regressions on the regional means and for those of individual regions. Indeed, in the latter case, although the negative coefficients are not always significant (see the case of Manufacturing in Emilia, Lazio and Campania in Table 3), the regions that display positive coefficients (never significant tough) are only Valle D'Aosta, Trentino Alto-Adige and Sicilia in the case of manufacturing, and Campania and Sicilia in the case of services.

6. Conclusions and research extensions (incomplete)

In this paper we have investigated some of the possible reasons underlying the slowdown of the Italian labour productivity since the mid-1990s by taking into account the relationship between ICT, productivity and regional performances. The first step of our analysis has shown that the weak growth of the Italian productivity in the first half of the 2000s, although still supported by some of the industrial cores of the country, namely Lombardia, Emilia and Veneto, reveals some positive role of the southern regions that, however, is not enough to counterbalance the rather poor performance of the rest of the country. To be noticed in particular the pronounced fall of the Centre (especially Lazio) and of regional industrial hearts such as Piemonte. Secondly, the sectoral decomposition analysis within each region indicates some differences in the importance of within and between effects across industries, signalling that some reallocation components are at work. The sectoral decomposition of regional productivity growth has also highlighted a positive contribution of ICT industries – and software in particular – in most of the Italian regions.

The preliminary analysis here presented is currently being developed in several directions. Firstly, estimates on regional productivity growth rates are in progress, as well as estimates on total factor productivity. Secondly, a further investigation of the role of ICT production is carried out by looking at the statistical relation between labour costs, labour productivity and ICT. The aim in this case is to check if the cross-effect between labour productivity and ICT on regional labour costs is significant. Thirdly, both firm dynamics in the five years observed (in this preliminary draft we have considered the balanced panel of Italian firms with more than 99 employees) and the role played by multi-located firms could shed further light on our understanding of regional productivity patterns and trends.

The analysis carried out in this paper presents some limitations. As discussed in Section 2, spillovers can be a side-product of technical progress in the ICT-producing sectors, but they also stem from complementarities with innovations generated in other sectors. On the one hand, the relationship between new technologies and productivity can be only partially captured by considering ICT-producing industries, as a major role is played by ICT-using sectors, for which we do not have regional data. The demand side of the relationship between new technologies and productivity is crucial and, at least at the aggregate level, some recent studies have shown that the Italian case is closer to a "falling behind" than to a "catching up" example (Daveri, 2008).

The exercise presented can nonetheless provide some insights for public policy. On the other hand, in fact, our results here have shown that new technology creation and diffusion cannot be easily disentangled and that adoption, diffusion and use – and the somewhat bigger emphasis put on the latter from some policy environments – may only partially display their benefits without a production base of some kind rooted in the regional/national industrial structure. Not all firms and regions are expected to be on the frontier of the prevailing technological paradigm, but some degree of production capacity may anyway be critical – particularly in supposedly advanced economies – to build the competence to participate in it and take advantage of its increasing social and economic rewards (Steinmueller, 2001).

References

Abramovitz M. (1986), “Catching up, forging ahead, and falling behind”, *Journal of Economic History*, 46, 385-406.

Acemoglu, D. and R. Shimer (2000) “Wage and Technology Dispersion”, *The Review of Economic Studies*, Vol. 67, No. 4, 585-607.

Ahn, S. (2001), “Firm dynamics and productivity growth: a review of micro evidence from OECD countries”, *OECD Economics Department Working Paper* No. 297, Paris

Amendola M., Gaffard J.L. and Saraceno F. (2005), Technical progress, accumulation and financial constraints: is the productivity paradox really a paradox?, *Structural Change and Economic Dynamics*, 16, 243-261.

Angrist, J.D., (1990), “Lifetime Earnings and the Vietnam Era Draft Lottery: Evidence from Social Security Administrative Records”, *American Economic Review*, June 1990.

Ark, B. van, J.Melka, N.Mulder, M.Timmer and G. Ypma (2002), “ICT investment and growth accounts for the European Union, 1980-2000”, Report to the European Commission, DG Economics and Finance, September

Baily, M. N., Bartelsman, E. J., and Haltiwanger, J., (1996), “Downsizing and productivity growth: myth or reality?”, in Mayes, D. G., (ed.), *Sources of Productivity Growth*, Cambridge, Cambridge University Press.

Barnes, M., Haskel, J. and M. Maliranta (2001), “The Sources of Productivity Growth: Microlevel Evidence for the OECD”, mimeo.

Barrios S., Mas M., Navajas E. and Quesada J. (2008), Mapping the ICT in EU Regions: Location, Employment, Factors of Attractiveness and Economic Impact, Institute for Prospective Technological Studies, Joint Research Centre, European Commission, MPRA Paper No. 6998: http://mpra.ub.uni-muenchen.de/6998/

Bartelsman E., Scarpetta S. & Schivardi F. (2003), "Comparative Analysis of Firm Demographics and Survival: Micro-Level Evidence for the OECD Countries" OECD Economics Department Working Papers 348, OECD, Economics Department.

Bartelsman E.J and De Groot H.L.F. (2004), Integrating evidence on the determinants of productivity, in: G. Gelauff, L. Klomp, S. Raes and T. Roelandt (eds.), *Fostering Productivity – Patterns, Determinants and Policy Implications*, Elseviers, Chapter 9, 159-183.

Bartelsman E.J. and Doms M., (2000), Understanding Productivity: Lessons from Longitudinal Microdata", *Journal of Economic Literature*, 38(3): 569-594.

Bottazzi G., E. Cefis E., Dosi G.,(2002) Corporate Growth and Industrial Structure. Some Evidence from the Italian Manufacturing Industry", *Industrial and Corporate Change*, 11, 4, 705-23.

Bresnahan T.F. and Trajtenberg (1995), General Purpose Technologies: Engines of Growth?, *Journal of Econometrics*, 65, 83-108.

Broadberry S. and Goshal S. (2005), Technology, organisation and productivity performance in services: lessons from Britain and the United States since 1870, *Structural Change and Economic Dynamics*. 16(4), 437-466.

Brynjolfsson E. And Hitt L.M. (2003), Computing productivity: firm level evidence, The *Review of Economics and Statistics*, 85, 4, 793-808.

Brynjolfsson E., (1993), "The productivity paradox of information technology", *Communications of the ACM*, 36, 2, 67-77.

Castells M. (2000), *The Information Age: Economy, Society and Culture*, 2nd ed., Blackwell, Oxford.

Cheshire P.C. and Carbonaro G., 1995, "Urban economic growth in Europe: Testing theory and policy prescriptions", *Urban Studies*, 33, 1111-1128.

Cingano F. and Schivardi F. (2004), "Identifying the Sources of Local Productivity Growth," *Journal of the European Economic Association*, MIT Press, 2(4), 720-742.

Crespi G., Criscuolo C. and Haskel J. (2007), Information technology, organisational change and productivity growth, CEPR Discussion Paper 6105.

Daveri F. and Silva O. (2004), Not only Nokia: what Finland tells us about new economy growth. *Economic Policy*, 19 (38), 117-163.

Daveri F., C.Jona-Lasinio, (2008), "Off-shoring and Productivity Growth in the Italian Manufacturing Industries", in CESifo Economic Studies; vol. 3/08.

Daveri F., C.Jona-Lasinio, (2005), "Italy's decline: getting the facts right", in *Giornale degli economisti e annali di economia*, Vol.64, n.4.

Daveri, F. (2004), "Delayed IT usage: is it really the drag on European productivity?", *CESifo Studies*, 397-421

David, P.A. (2000), "Understanding Digital Technology's Evolution and the Path of Measured Productivity Growth: Present and Future in the Mirror of the Past," Papers 99-011, United Nations World Employment Programme.

Dettori B., Marrocu E. and Paci R. (2008), Total factor productivity, intangible assets and spatial dependence in the European regions, *Working Paper CRENoS 2008/23.*

Di Giacinto and Nuzzo (2006); Explaining labour productivity differentials across Italian regions: the role of socio-economic structure and factor endowments, *Papers in Regional Science*, Volume 85 Issue 2**,** 299 – 320.

Dunford M. and Smith A. (2000), "Catching up or falling behind? Economic performance and regional trajectories in the new Europe", *Economic Geography*, 76, 2, 169-195.

Duranton G. and Puga D. (2004), "Microeconomic Foundations of Urban Increasing Returns", in J.V. Henderson and J.F. Thisse (eds), *Handbook of Regional and Urban Economics*, North Holland, Amsterdam.

Eurostat, 1996, Sistema europeo dei conti 1995 – SEC95, Luxembourg.

Fagerberg J. (1987), "A technology gap approach to why growth rates differ", *Research Policy*, 16, 2-4, 87-99.

Fagerberg J. (1994), "Technology and international differences in growth rates", *Journal of Economic Literature*, 32, 1147-1175.

Fagerberg J., Verspagen B. and von Tunzelmann N. (eds) (1994), *The Dynamics of Technology, Trade and Growth*, Edward Elgar, Aldershot.

Freeman C. and Soete L., 1994, *Work for All or Mass Unemployment: Computerised Technical Change into the 21st Century*, Pinter, London.

Gordon, R.J (2000), “Does the “new economy” measure up to the great inventions of the past?”, *Journal of Economic Perspectives*, 49-74

Gordon, R.J. (2003), “Hi-tech innovation and productivity growth: does supply create its own demand?”, *NBER Working paper* #9437, January.

Gozzi, G., L. Grossi, P. Ganugi C. Gagliardi (2005), Size, growth and productivity dynamics in Italian mechanical firms, mimeo, presented at the 2005 Conference “Monitoring Italy”, Rome, ISAE, June 7

Greenspan, A. (2000), "Business Data Analysis." Re-marks before the New York Association of Business Economics, New York, NY, June 13.

Guerrieri P. and Meliciani V. (2005), Technology and international competitiveness: The interdependence between manufacturing and producer services**,** *Structural Change and Economic Dynamics*, Vol. 16, No. 4, 489-502.

Hulten, Charles R. (2000), "Total Factor Productivity: A Short Biography." National Bureau of Economic Research (Cambridge, MA) Working Paper No. 7471, January 2000;

Stiroh J. (2002), “Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?”, *The American Economic Review*, Vol. 92, No. 5, 1559-1576;

Jorgenson D. (1995), *Productivity,* MIT Press.

OECD (2000), *Information Technology Outlook. ICTs, E-commerce and the Information Economy,* OECD, Paris.

OECD (2001a), *2001 Communication Outlook*, Paris

OECD (2001b), *The OECD Productivity Manual: A Guide to the Measurement of Industry-Level and Aggregate Productivity Growth*, OECD Statistics Directorate, Paris

OECD (2003), *ICT and economic growth: evidence from OECD countries, sectors and firms*, Paris.

OECD (2005), *Going for growth*, Paris.

Ohkawa K. and Rosovsky H. (1973), *Japanese Economic Growth: Trend Acceleration in the Twentieth Century,* Stanford University Press, Stanford, CA.

Olley G.S. and Pakes A. (1996), The dynamics of productivity in telecommunication equipment industry, *Econometrica*, 64, 6, 1263-1297.

Oosterhaven *J.* and Broersma L. (*2007*), Sector structure and cluster economies: a decomposition of regional labour productivity, *Regional Studies,* 41, 639-659.

Oulton, N., (1998), “Competition and the Dispersion of Labour Productivity”, *Oxford Economic Papers*, 50, pp 39-62.

Paul A. David (1990), The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox**,** *The American Economic Review*, 80, 2, 355-361.

Pérez C. (2002), *Technological Revolutions and Financial Capital*, Edward Elgar.

Steinmueller W.E., 2001, “Seven Foundations of the Information Society: A social science perspective”, *Journal of Science Policy and Research Management*, 16, 1/2, 4-19.

van Winden W., & van der Meer, A. (2003). The ICT sector: growth engine for urban regions?. In F. Helten & B. Fischer (Eds.), *Envisioning Telecity: Towards the urbanisation of ICT*. Frankfurt a/M: Peter Lang, 85-107.

von Tunzelmann, N. (2009a), "Regional Capabilities and Industrial Regeneration", in Farshchi, M., Janne, O. and McCann, P. (Eds), *Technological Change and Mature Industrial Regions: Firms, Knowledge and Policy*, Edward Elgar, Cheltenham, 11-28.

Weterings, A.B.R. and R.A. Boschma (2009), Does spatial proximity to customers matter for innovative performance? Evidence from the Dutch software sector, *Research Policy,* 38, 746-755.

Wilson D. (1995), "IT investment and its productivity effects: an organizational sociologist's perspective on directions for future research", *Economics of Innovation and New Technology*, Special Issue, 3, 235-251.

Map 1 - Location of ICT-producing firms by region (% on regional total; national average = 4.1%)

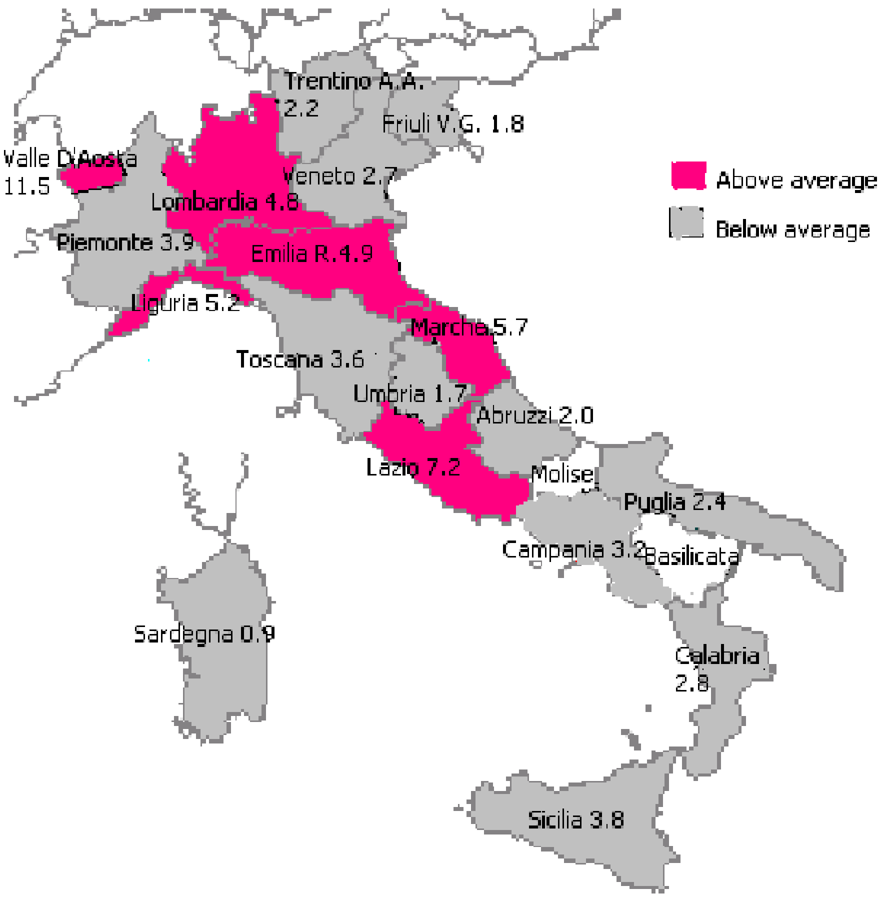

Table 1 - Regional contribution to national labor productivity growth (2001-2005)

Regions	Labour Productivity Growth*							Regional shares 2005 (%)	
	within-region	level-reallocation	growth-reallocation	total	sub-period (A)	sub-period (B)		Employment	Value added
	2001-2005	2001-2005	2001-2005	2001-2005	2001-2003	2003-2005	(B)-(A)		
Piemonte	-0.787	0.033	0.067	-0.688	-0.602	-0.094	0.508	10.9	9.3
Valle d'Aosta	0.221	0.006	-0.071	0.156	0.099	0.056	-0.043	0.1	0.3
Lombardia	1.471	-0.179	-0.031	1.262	1.296	-0.057	-1.353	27.6	31.5
Veneto	0.826	0.021	-0.009	0.837	0.222	0.601	0.379	10.1	9.5
Friuli	0.343	-0.017	0.012	0.337	0.093	0.240	0.147	2.5	2.3
Liguria	0.180	0.002	-0.002	0.180	0.041	0.137	0.095	2.3	2.3
Emilia	1.484	-0.070	0.067	1.481	0.395	1.070	0.675	11.3	11.3
Toscana	0.016	-0.015	-0.012	-0.011	0.290	-0.295	-0.585	5.0	4.7
Umbria	0.271	-0.021	0.022	0.273	0.178	0.093	-0.085	1.3	1.3
Marche	0.159	-0.043	0.008	0.124	0.013	0.111	0.098	2.1	1.6
Lazio	-2.277	0.015	-0.010	-2.273	-0.868	-1.354	-0.487	11.1	12.4
Abruzzo	0.225	-0.004	0.007	0.228	0.148	0.080	-0.068	1.8	1.8
Molise	0.055	-0.014	0.015	0.057	0.071	-0.013	-0.084	0.1	0.1
Campania	-0.360	-0.009	-0.005	-0.374	0.162	-0.528	-0.690	4.4	3.1
Puglia	0.376	-0.092	0.031	0.316	0.086	0.229	0.143	2.6	2.0
Basilicata	0.039	0.005	-0.001	0.043	0.029	0.012	-0.017	0.6	0.5
Calabria	0.185	-0.003	0.001	0.184	0.095	0.087	-0.007	0.7	0.6
Sicilia	-0.035	-0.048	-0.013	-0.096	0.039	-0.131	-0.170	2.4	1.9
Sardegna	0.509	-0.066	0.076	0.519	-0.105	0.614	0.719	1.3	1.3
Trento	0.383	-0.001	0.002	0.384	0.129	0.250	0.121	0.9	1.1
Bolzano	-0.012	0.012	-0.004	-0.004	-0.125	0.120	0.245	0.9	1.0
Italy	**3.271**	**-0.486**	**0.151**	**2.937**	**1.688**	**1.228**	**-0.460**	**100**	**100**

*Note: figures are multiplied by 100

Table 2 - Regional labour productivity and regional sectoral structure - LSDV and 2SLS estimates

Estimates on regional average values

	LSDV		2SLS	
k/L	0.159**	0.164**	0.069**	0.073**
	(0.002)	(0.003)	(0.004)	(0.004)
ICT	0.034**		0.033**	
	(0.004)		(0.006)	
Manifacturing		-0.022**		-0.023**
		(0.005)		(0.006)
Services		-0.046**		-0.044**
		(0.005)		(0.007)
Constant	3.635**	3.654**	3.881**	3.904**
	(0.007)	(0.008)	(0.010)	(0.012)
R-Squared^	00:12	00:13	0.018	0.021
Observations	35629	35629	21257	21257
RMSE	00:17	0.18	0.18	0.18
Shea partial R-Squared for first-stage regressions of endogenous regressors				
k/l			0.994	0.994
Hansen over-identification test				
Chi-sq( ): p-value			0.33	0.33
Estimation method			2SLS	2SLS
Instrumented:			k/l	k/l
Included instruments:			ICT	Manif. Serv.
Excluded instruments:			(k/l)-1, (k/l)-2	(k/l)-1, (k/l)-2

Robust standard errors in parentheses

* significant at 5%; ** significant at 1%

^ Centered R-squared for 2SLS estimates. The reported value of the centered R-squared refers to the second stage of each regression

Tab. 3 - Regional labour productivity and regional sectoral structures - 2SLS estimates

	Piemonte		Lombardia		Veneto		Emilia		Lazio		Campania	
k/L	0.313**	0.295**	0.268**	0.258**	0.259**	0.246**	0.299**	0.260**	0.286**	0.271**	0.257**	0.268**
	(0.018)	(0.022)	(0.012)	(0.015)	(0.017)	(0.019)	(0.016)	(0.021)	(0.025)	(0.029)	(0.032)	(0.039)
ict	0.364**		0.380**		0.405**		0.177**		0.290**		0.010	
	(0.074)		(0.047)		(0.081)		(0.062)		(0.087)		(0.104)	
manif		-0.301**		-0.351**		-0.348**		-0.059		-0.178		-0.080
		(0.078)		(0.049)		(0.081)		(0.063)		(0.099)		(0.122)
serv		-0.423**		-0.416**		-0.487**		-0.316**		-0.330**		0.018
		(0.073)		(0.051)		(0.082)		(0.063)		(0.086)		(0.109)
Constant	3.421**	3.785**	3.593**	3.977**	3.492**	3.902**	3.525**	3.723**	3.605**	3.901**	3.517**	3.523**
	(0.025)	(0.066)	(0.019)	(0.045)	(0.027)	(0.076)	(0.022)	(0.058)	(0.035)	(0.077)	(0.037)	(0.102)
Observations	1809	1809	4489	4489	2000	2000	2027	2027	1108	1108	617	617
R-Squared (centered)	0.132	0.164	0.024	0.038	0.077	0.105	0.100	0.184	0.029	0.057	0.079	0.068
RMSE	0.623	.612	.701	.696	.584	.575	.597	.568	.822	.810	.756	.761
Shea partial R-Squared for first-stage regressions of endogenous regressors												
k/l	0.406	0.358	0.376	0.334	0.372	0.355	0.414	0.361	0.339	0.311	0.362	0.318
Hansen over-identification test												
Chi-sq( ): p-value	0.26	0.35	0.23	0.25	0.01	0.01	0.31	0.37	0.12	0.12	0.49	0.42
Estimation method	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Instrumented:	k/l	k/l	k/l	k/l	k/l	k/l	k/l	k/l	k/l	k/l	k/l	k/l
Included instruments:	ict	manif serv	ict	manif serv	ict	manif serv	ict	manif serv	ict	manif serv	ict	manif serv
Excluded instruments:	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2	(k/l)t-1, (k/l)t-2

Robust standard errors in parentheses

* significant at 5%; ** significant at 1%

The reported value of the centered R-squared refers to the second stage of each regression

APPENDIX A.1

THE ITALIAN REGIONS

MACROREGION	**REGION (NUTS 2)**
NORTH-WEST	PIEMONTE
	VALLE D'AOSTA
	LOMBARDIA
	LIGURIA
NORTH-EAST	TRENTINO ALTO ADIGE (TRENTO + BOLZANO)
	FRIULI VENEZIA GIULIA
	VENETO
	EMILIA ROMAGNA
CENTRE	TOSCANA
	LAZIO
	UMBRIA
	MARCHE
SOUTH (MEZZOGIORNO)	ABRUZZI
	MOLISE
	CAMPANIA
	PUGLIA
	BASILICATA
	CALABRIA
	SICILIA
	SARDEGNA

Table A.1 (TO BE ADDED)

APPENDIX A.2

Dependent Variable		
Labour productivity	Value added per employee	
Independent variables		
Regions	See Appendix A.1	
Sectors	**ICT**	
	Hardware	Manufacture of office machinery and computers
	Software	IT, computer and related service activities
	Communication equip.	Manufacture of radio, television and communication equipment and apparatus
	MANUFACTURING	
	Food and beverages	Manufacture of food products, beverages and tobacco
	Textiles	Manufacture of textiles and textile products
	Leather	Manufacture of leather and leather products
	Wooden products	Manufacture of wood and wooden products
	Paper, Pulp and Printing	
	Electrics and electronics	Manufacture of electrical machinery and apparatus n.e.c. - Manufacture of industrial process control equipment - Manufacture of optical instruments and photographic equipment - Manufacture of watches and clocks
	Chemicals	Manufacture of chemicals, chemical products and man-made fibres
	Refined petroleum	Manufacture of coke, refined petroleum products and nuclear fuel
	Plastic	Manufacture of rubber and plastic products
	Metal	Manufacture of other non-metallic mineral products, Manufacture of basic metals and fabricated metal products
	Transport equipment	Manufacture of transport equipment
	Machinery	Manufacture of machinery and equipment n.e.c.
	Other manufacturing	Other manufacture n.e.c.
	SERVICES	
	Constructions	
	Trade	Wholesale and retail trade; Repair of motor vehicles, motorcycles and personal and household goods; Hotels and restaurants; Transport, storage and communication
	Financial intermed.	Financial intermediation, Real estate activities, Renting of machinery and equipment without operator and of personal and household goods
	Other services	Research and development, Other business activities, Education, Health and social work, Other community, social and personal service activities
Investment	Log (investment per employee)	
Labour cost	Log (wages per employee)	