CONTRIBUTI DI RICERCA CRENOS

INTANGIBLE CAPITAL AND FIRMS PRODUCTIVITY

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WORKING PAPERS

2009/16

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Titolo: INTANGIBLE CAPITAL AND FIRMS PRODUCTIVITY

ISBN: 978 88 84 67 556 9

Prima Edizione: Novembre 2009
Seconda Edizione: Febbraio 2010

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09123 Cagliari
Tel./Fax 070 291201
www.cuec.it

Intangible capital and firms productivity

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Abstract

Firms competitive strategies and performances in industrialised countries is increasingly based on assets, labelled as "intangible capital", such as the inventions of new processes and products, the improvements of the employees skill, the creation of a reputation for company's products.

The aim of this paper is to evaluate the role of internal intangible capital on firms productivity in addition to the well-known one played by traditional inputs. Moreover, firms productivity is crucially affected by the external socio-economic conditions; thus, we control for the availability of intangible assets specific to the region (human, technological and social capital) as well as for the regional infrastructural endowments.

In our empirical application we analyse a large panel of European companies belonging to 116 regions of six countries, considered over the period 2002-2006. The estimation results - robust to various ways of disaggregating the sample data (by country, macro-sector and firms dimension) and to different econometric methodologies (IV, Olley-Pakes, Levinsohn-Petrin) - show the positive influence of the internal intangible capital on firms productivity levels and also the crucial role played by the intangible assets at the regional level. These results remark the importance of policies designed to stimulate the accumulation of intangible capital stocks internal to the firms through appropriate fiscal policies and to create a favourable external environment based on high endowments of human, social and technological capital.

Keywords: firms productivity, intangible capital, local externalities, Europe
JEL: D24, O30, C33, R10

Acknowledgments

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 216813.

We thank Francesca Alberti, Giuliana Caruso and Barbara Dettori for valuable assistance in preparing the database. We also thank participants to 56° NARSC in San Francisco for valuable comments.

1. Introduction

There is a large consensus among scientists and policymakers on the growing role played by intangible assets on firms productivity and, consequently, on the performance of local economies. This is true especially in the industrialised countries where competition is essentially based on ideas and innovations which represent the main ingredients of the modern knowledge society. Therefore it is not surprising that the economic literature is devoting an increasing effort to define properly what is to be meant by "intangible factors" and to detect adequate methodologies in order to assess their role in the production process. So far this has been pursued by following two distinct approaches, one at micro and the other at macro level.

The first approach, based on firms data, considers the intangible assets as part of the company business investment (OECD, 1998). One of the key issues addressed by this literature is the accurate definition and measurement of intangibles within the company balance sheets. As a matter of fact, it is not straightforward in the accounting procedure whether elements like software, R&D expenditure, patents, economic competencies and employee training have to be considered as current expenses or capital accumulation. Indeed, the definition of intangible capital is a controversial task and there are various differences in the international accounting procedure (Stolowy and Jany-Cazavan 2001; Wyatt, 2005; Siegel and Borgia 2007). Some costs (advertising, formation, start-up) are very discontinuous and uncertain and the procedures for their capitalisation are subject to managers' discretion so that they are often recorded as current expenses.

In any case, it is important to remark that all empirical studies show that intangible capital represents an important and growing component of total capital stock, therefore confirming the importance of including intangibles assets as determinants of firms productivity. For instance Corrado et al. (2006) for the US firms estimate that total business investment in intangibles has roughly the same value of investment in tangible capital. A similar result is found by Hulten and Hao (2008) for the case of R&D intensive US firms where the value of total assets increases by 57% when R&D expenditures and organizational capital is considered in addition to conventional financial accounts. For the Italian manufacturing firms Bontempi and Mairesse (2008) calculate that intangible capital amounts to one third of tangible stocks.

Starting from the seminal contribution by Griliches (1979), within the micro approach another stream of research has developed the so-called *knowledge-capital* model where firm's knowledge (usually measured by R&D expenditures, patents or new products) is included as an input in the enterprise production function in addition to physical capital and labour. A recent contribution in this vein applied to five OECD countries is found in O'Mahony and Vecchi (2009). However the knowledge capital of a firm does not include only technological elements but also other forms of intangible capital, such as human and organisational capital which cannot be overlooked any longer given their increasing effects on firms' performance (see the interesting survey on firm's intangible capital by Webster and Jensen, 2006).

The macro approach investigates the effects of intangible capital endowments available in a given region on the performance of both firms and the local economy. Several kinds of intangibles have been considered (human capital, social capital, technological capital, institutional capital; entrepreneurship capital) and their effects are usually interpreted as localised externalities which influence positively the agglomeration of economic activities and the economic performances at the local level. A comprehensive survey on the empirical studies on agglomeration economies can be found in Rosenthal and Strange, 2004. Starting from the original contributions by Glaeser et al. (1992) and Henderson et al. (1995) for the United States, the literature has investigated the determinants of employment growth, as a proxy for local economic performance, at both the city and the sectoral level. This approach has been applied to various countries and several indicators of local characteristics and factors endowments have been considered in the empirical studies (see among many others, Combes (2000) for French labour systems; Paci and Usai (2008) for the Italian local labour systems). However, the use of the employment growth rate as a proxy for the local economic performance is subject to various shortcomings and thus other measures, like labour productivity or TFP, have been used as the dependent variable. In some studies the economic performance is based on firms data (Cingano and Schivardi, 2004 for Italy; Henderson, 2003 for the US), in others on aggregate regional data (Dekle, 2002 for Japanese prefectures; De Lucio et al., 2002 for Spanish regions, Artis et al., 2009 for UK counties; Dettori et al., 2008 for the European regions).

In general, this empirical literature encounters a serious weakness in the lack of connection between the micro and the macro approaches. In other words contributions aimed at studying the effect of intangible assets internal to the enterprises do not usually consider how the local external environment at the same time might also affect firms performance and vice versa.

Therefore, the main aim and novelty of this paper is to analyse together the internal and the external channels discussed above. More precisely, using micro data, we assess the effect on firms productivity of the intangible capital directly cumulated by the enterprises and of the regional intangible assets which are supposed to enhance firms productivity as positive externalities. Investigating the two channel together is very important since one of the key element stressed by the literature is the necessity for the enterprises to build up internal knowledge capabilities in order to absorb the external, often codified, technological opportunities (Cohen and Levinthal, 1989). This aspect is especially relevant for small firms (Macpherson and Holt, 2007).

Another important and novel feature of our analysis is that we investigate how the effect of intangible assets differs according to various firms characteristics; to this aim we disaggregate our sample data by country, firms dimension and sectors covering both manufacturing and service activities. This allows us to provide a more comprehensive and general set of results with respect to previous studies, in which the analysis has been confined to a particular country or to a specific economic sector/branch.

Moreover, different econometric methodologies - Instrumental Variables, Olley-Pakes and Levinsohn-Petrin – are adopted to deal with the well-known endogeneity issue related to the production function estimation. The empirical analysis is based on the estimation of a Cobb Douglas production function applied to a large panel of European manufacturing and services companies extracted from the Bureau van Dijk (BVD) databank over the period 2002-2006 and belonging to six countries: France, Italy, Netherlands, Spain, Sweden, United Kingdom.

The paper is organised as follows. In section 2 we present the basic model and discuss some methodological issues related to the Cobb-Douglas production function estimation. In section 3 we present a detailed description of the data. In section 4 the econometric results are presented and discussed for the entire sample as a whole and disaggregated by countries, macro-sectors and firm dimension. Section 5 offers some concluding remarks.

2. Basic model and estimation issues

The econometric analysis is based on the estimation of the following Cobb-Douglas production function[1], which includes both the internal and the external intangible capital, as well as the traditional inputs:

$$Y_{ijt} = A_{jt} TK_{ijt}^{\beta_1} IK_{ijt}^{\beta_2} L_{ijt}^{\delta} X_{jt}^{\gamma} \qquad (1)$$

where i indicates firms, j regions[2] and t the time periods. Y is value added; A is the efficiency level; TK and IK are, respectively, the tangible and intangible stock of capital for each firm; L are labour units.

X is a vector of variables specific to region j including different types of intangibles assets, which may enhance firms productivity, more specifically we consider:

$$X_{jt} = HK_{jt}^{\gamma_1} TeK_{jt}^{\gamma_2} SK_{jt}^{\gamma_3} PK_{jt}^{\gamma_4} \qquad (2)$$

where HK is human capital, TeK technological capital, SK social capital, PK public capital. A detailed description of the variables is presented in section 3 and in Table A1 in the Appendix.

Thus, the estimation of the panel model for the entire firms sample is based on the following log-linearized regression model:

$$y_{ijt} = a_{ijt} + \beta_1 tk_{ijt} + \beta_2 ik_{ijt} + \delta l_{ijt} + \gamma_1 hk_{jt} + \gamma_2 tek_{jt} + \gamma_3 sk_{jt} + \gamma_4 pk_{jt} + controls + \varepsilon_{ijt} \qquad (3)$$

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[1] Although the Cobb-Douglas (CD) specification is often deemed to be too restrictive, it is the most widely adopted in firm-level studies of productivity as the alternative more complicated specifications (such as CES and translog) did not prove outperforming in terms of parsimony and estimates improvements (Griliches and Miresse, 1984). Moreover, the adoption of the CD specification allows a more comprehensive comparison of the main findings across empirical studies.

[2] The geographical unit of analysis is defined following the Eurostat's "Nomenclature of Statistical Territorial Units". We have chosen the NUTS 2 regional level since it is characterized by a good degree of administrative and economic control. More specifically: France (22), Italy (20), Netherlands (12), Spain (17), Sweden (8), United Kingdom (37). In total we thus consider 116 regions.

where low capital letters represents the log-transformed variables described in equations (1) and (2). The controls are represented by year, country, sector and firm dimension dummies[3]. Time dummies are supposed to capture the effects of macroeconomic phenomena, which vary over time but not across firms; country dummies are included to account for differences in country-specific characteristics, such as the institutional context, the fiscal or the accounting system. Sectoral heterogeneity is accounted for by including dummy variables for 34 2-digit NACE sectors. Note that all monetary variables are in constant values at 2000 base prices; nominal values have been deflated by applying the country's consumers' price index.

Since the seminal paper by Marschak and Andrews (1944) it is well known that production function specifications such as (3) are affected by simultaneity problems given the correlation between input levels and firm-specific productivity shocks. The correlation originates from the fact that firms facing positive (negative) productivity shocks tend to respond by increasing (decreasing) the inputs use. OLS estimators are therefore biased and inconsistent. A number of alternative estimators have been proposed, the most applied ones are the parametric Instrumental Variable-GMM estimator and the GMM-SYS estimator (Blundell-Blond, 2000); the semi-parametric Olley and Pakes (OP estimator, 1996) one and its recent variant proposed by Levinsohn and Petrin (LP estimator, 2003).

The Instrumental Variable (IV) estimator guarantees consistency[4] as long as valid instruments are used, when predetermined variables are chosen the lag should be long enough to cancel the dependence between the amount of inputs selected by the firm and serially correlated productivity shock. The GMM-SYS estimator is adequate when it is reasonable to model the productivity term as a firm fixed effect with an autoregressive component and an additional term capturing measurement errors and transitory productivity shocks. The major disadvantage of this estimator is the requirement of long panels given that instruments are obtained as lagged values of the level and the

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[3] We consider 4 dimension categories: small firms with no more than 25 employees; small-medium firms with a number of employees in the range 26-100; medium-large firms with a number of employees in the range 101-250; large firms with more than 250 employees.

[4] IV are consistent estimators also when correlation between explanatory variables and the error term is induced by measurement error problems, which are quite common in the case of the capital stock.

first difference of the regressors; additional lags are supposed to improve estimate precision (Van Biesebroeck, 2007). When instruments are weak, the GMM-SYS estimator tends to underestimate the input elasticities, as is the case for the fixed effect estimator.

Olley and Pakes (1996) and Levinsohn and Petrin (2003) propose a semi-parametric estimator to deal with the production function simultaneity problem[5]. The novel idea is to find an "observable" expression for productivity, which once included in the econometric model makes the correlation between the error term and the inputs regressors disappear, thus yielding consistent estimators. For OP the productivity proxy is found by inverting non-parametrically the investment function, since they show that investment is monotonically increasing in productivity as far as it is assumed that firm's productivity is a state variable which follows a Markov process unaffected by the firm's control variables, and investment is one of the firm's control variables which increments the capital stock with a one period lag. A limit of this procedure is represented by the use of non-parametric approximation. As stressed in Van Biesebroeck (2007) "the functions that are inverted are complicated mappings from states to actions and it is required that they hold for all firms regardless of their size or competitive position". If the investment function assumes zero values or the adjustments to productivity shocks are not taking place continuously – firms might find more efficient to adjust only when shocks are above a given threshold – the mapping are weakened and this again induces correlation between the error term and the regressors resulting in biased estimates. For this reason LP propose an alternative proxy for productivity represented by intermediate inputs, such as materials or electricity. As this kind of proxy is almost always reported by firms, it allows to overcome the OP limits and allows to keep all the firms which would be otherwise truncated from the sample when reporting zero-values for investments. The use of intermediate inputs is also beneficial when firms find less costly to respond to the productivity shock by adjusting the intermediate inputs rather than revising their investment decisions.

Given the properties and the wider applicability of the LP estimator, in this paper we apply it to the entire panel sample (the "aggregate") and to sub-samples obtained by disaggregating the firms data by countries, macro-sectors and firm dimension. For comparisons purposes we have also carried out IV and OP estimations; while we did

[5] The OP method deals with the selection bias as well.

not apply the GMM-SYS estimator given the very short time dimension - just five years - of our panels.

It is worth emphasising that the aim of this study is not to assess the properties of the alternative estimators, rather to provide evidence on the effectiveness of intangible inputs employed in the production process and check the robustness of the results across different estimation approaches.

3. Data and descriptive statistics

Company-data information are taken from the database AMADEUS of BVD, which is a pan-European database providing financial and business data on public and private companies covering all economic activities for 41 European countries over the 10 most recent available years. Since it collects balance sheets throughout Europe, it has to combine data from different national providers. However, in order to overcome the comparability problem, BVD developed a uniform format that maximises the availability of financial items across the various countries, delivering a harmonized representation of European companies accounts.[6] In this paper, in order to have an adequate degree of comparability, we focus on a group of large and medium countries belonging to the European Union: France, Italy, Netherland, Spain, Sweden and United Kingdom over the period 2002-2006.[7] The selected final sample is an unbalanced panel of about 160 thousands companies over a five-year period. It is worth noting that the firms considered in the paper are highly representative of the whole economy since they account, considering the final year 2006, for about 67% of the aggregate value added and for about 41% of total employment.

As highlighted in the introductory section, the accounting literature is witnessing a vast debate on which is the most appropriate way for defining the intangible capital in order to distinguish it from other forms of investment or from current expenses. This issue goes beyond the aim of our paper and we simply use the item "intangible

[6] Firms are selected if they satisfy at least one of the following criteria: operating revenue greater than 15 million euros or total assets greater in value than 30 million euros (in the case of French, Italian, Spanish and British companies); operating revenue greater than 10 million euros or total assets greater than 20 million euros (in the case of the Netherlands and Sweden firms).

[7] Among the large European countries we have excluded Germany because of its high number of missing data on value added and employees which reduces the number of firms at the beginning of the period to only 2700.

fixed assets", extracted by BVD from the firm balance sheets, as the proxy variable for intangible production factors. They include R&D expenditures, patents, copyrights, software, employee training, trademarks and other similar costs. It is important to notice that according to the concordance tables the definition of intangibles assets for the countries considered is very homogeneous. In Table 1 we report the ratio between intangible and tangible capital at the national level for the years 2002 and 2006.

The first important point to remark is that all countries show a clear tendency to increase the share of intangibles over tangibles, confirming the growing role of knowledge capital in the competitive behaviour of the firms. On average the ratio raises from 34% in 2002 to 42% in 2006. There are also relevant differences among countries. The highest value is found for France where, at the end of the period considered, the intangible capital represents the 75% of the tangible one. The lowest, although increasing, values are reported for Sweden (30%), Italy (32%) and Spain (35%).

Let now turn our attention to the sectoral dimension making use of the taxonomy recently proposed by Castellacci (2008), which allows us to gather the individual manufacturing and service activities into 8 macro-sectors (see Table A2 in the Appendix). This new taxonomy is particularly meaningful for our purposes since it is based on an integrated framework which, at the same time, accounts for both the different characteristics that innovation takes in the manufacturing and in the service industries and for the growing interdependences between these two branches of the economy. The taxonomy is built by dividing the sectors according to the function they assume in the economic system (providers and/or recipients of advanced products, services and knowledge), this first step yields four main sectoral groups; these are then further divided into two distinct sub-groups on the basis of their technological content. For a thorough discussion on the building procedure and on the features of the resulting eight macro-sectors we refer to the quoted article by Castellacci.

In Table 2 we report the ratio of intangible over tangible capital for the eight macro-sectors. As was the case for country data, the ratio has increased strongly over the five-year period for all sectors considered. Another important finding is the high variability among sectors in terms of their knowledge capital intensity. In 2006 for the two macro-sectors of Advanced knowledge providers (S1, S2) the ratio is well above one hundred percent showing the predominant importance of intangible capital with respect to the traditional fixed one, More specifically, S2 Specialised suppliers manufacturing has the highest ratio (129%) followed by S1 Knowledge intensive business (103%). Both sectors show a very considerable increase in the intangible/tangible capital over the period 2002-2006. A high and increasing value is also presented by the macro-sector S7 Supplier dominated goods (ratio of 98% in 2006). This macro-sector includes the Publishing industry (high value of 305% in 2006) highlighting the fact that software and copyrights are nowadays more relevant than the printing machineries. Interestingly, it also contains some traditional industries where the product differentiations and thus the brand name strategy is becoming crucial requiring high and increasing investment in the intangibles assets, for instance Food and Wearing apparel in 2006 exhibit a ratio of 95% and 73%, respectively. Also the macro-sector S5 Network infrastructure shows a high ratio (65%) due to the presence of the Post and telecommunications activities (with a ratio of 135%). On the other hand, there are industries characterised by very high capital intensive technology where the value of the intangibles remains quite low, as for S6 Supporting infrastructure service and physical infrastructure (15%). As expected, a low ratio is also found in traditional industries where the knowledge capital of the firm is essentially built through a learning by doing process rather than with formalised activities (training) and assets (software, patents) as is the case for the macro-sector S8 Personal goods and services sector-supplier dominated services (26%).

To sum up, intangibles represent an important and growing component of companies fixed capital; there are significant differences among countries and industries in the way firms choose to combine intangible and tangible factors within their production process. Therefore, in the econometric analysis, aimed at assessing the role of intangible assets on firms performance, it is critical to control for both geographical and sectoral heterogeneity.

The literature has devoted a growing attention to the role played by the external factors on the firms performance. The idea is that the presence in a specific region of high endowments of intangible assets like qualified employees, technological knowledge and social cohesion enhance productivity as they generate positive externalities to the local firms. In our analysis we consider three types of intangible assets at the regional level: human, technological and social capital. We also consider the effect on firms productivity generated by the regional endowments of public capital. Table 3 reports some descriptive statistics for the regional variables disaggregated by the six countries considered.

As a proxy for human capital we consider the number of labour forces individuals with a degree (ISCED 5-6) over total population. It is worth noting that Italy stands out for showing the worst performance, with the lowest mean, a minimum of 0.05 and a maximum of 0.09; interestingly Italy shows also the lowest variability across regions (the coefficient of variation is 0.15). On the other hand, Spain shows a noticeable endowment of highly educated population accompanied by a high variation across regions.

Technological capital is measured by the number of patents applications at the Patent Cooperation Treaty (PCT) accumulated in the previous ten years per 1000 inhabitants. The lowest performance is found for Spain (the average value is 0.12), while Sweden shows, on average, the highest value (3.27), followed by Netherlands (1.12).

Some interesting considerations can also be drawn by examining the descriptive statistics for social capital, which is proxied by the percentage of people that have taken part at least once in the last 12 months in social activities such as voluntary service, unions and cultural associations meetings. The data at the regional level comes from three rounds of the European Social Survey[8]. Given the intrinsic difficulties in measuring a variable such as social capital, we are aware of the weaknesses of the proxy chosen in capturing its complex characteristics; however, it has the advantage to be so far the only homogenous indicator available at regional level in Europe.

Also for social capital the lowest performance is found for Italy; while high values are registered for Sweden and UK. It is also worth remarking that Spain shows the highest internal variability across regions (variation coefficient equals 0.41).

Finally as a proxy for public capital we have computed the length of road and rail networks in the region per square kilometre. United Kingdom shows the highest mean (3.17) for public capital, and also the highest regional variability (coefficient of variation: 0.89) within

[8] The three rounds of the European Social Survey has been conducted in 2002, 2004 and 2006. Given the very persistence of the social capital variable, we have calculated the values for 2003 and 2005 as the average between the values in the previous and following years. Notice that for Italy there are no data for 2006. For some regions in France and United Kingdom data are available at NUTS1 level so that we have assumed that level value for the included NUTS2 regions.

a range of 0.46-14.4. Not surprisingly, given the peculiar morphology of its territory, the lowest average amount of public infrastructures per square kilometre is reported for Sweden (mean 0.38); low values are also found in Spain.

4. Econometric results

In Table 4 we present the estimation results for the aggregate sample by reporting for comparison purposes the estimates obtained by applying to model (3) the IV and the OP estimator and the ones provided by the LP one, which, as argued in section 2, is our preferred estimator. For the IV method instruments are represented by one period lagged values for all firms' regressors[9]. For the OP method the variable inputs are labour and intangible capital, while physical capital and firm age are state variables. Regressors at regional level, such as human, social, technological and public capital, are "free" variables.

The LP estimator is applied to a sample which excludes United Kingdom firms due to the unavailability of data on intermediate inputs in the BVD database. In the next subsection we discuss the aggregate results in greater detail by emphasising the most relevant differences across the alternative estimation approaches. In order to save space, in sub-sections 4.2-4.4 we report only the LP results for the sub-sample analysis carried out at country, macro-sector and firm dimension level.

4.1 Aggregate results

Focusing on the aggregate production function, all the estimated models (Table 4) provide strong evidence on the relevance of all the variables included in the regressions, both at the firm level and at the local level, for all the estimation approaches considered.

The estimated elasticity of the physical capital stock is around 0.18 in the case of the IV regression, while, although remaining highly significant, it decreases sharply according to the OP (0.13) and LP (0.08) models. For the labour input a significant higher elasticity was found, it was estimated in 0.59 by IV, 0.43 by OP and 0.45 by LP. The intangible capital is significant in each regression with an elasticity estimated in around 0.06 (0.04 only for the LP method). Although the effect is not

[9] We also considered two years lagged firms' regressors as instruments; the results did not change appreciably, but for most of the countries considered the sample size was reduced considerably.

high in value, this result highlights the role played by such an input in determining firms productive performance.

As far as the regional intangible production determinants are concerned, all of them contribute positively to the production process confirming the previous evidence provided by the macro approach.[10] More specifically, human capital exhibits an estimated elasticity between 0.19-0.33 signalling that the availability in the local economy of highly educated labour forces represents an advantage for firms performance and for their innovative activities (Mankiw et al., 1992; Benhabib and Spiegel, 1994; Rauch, 1993).

The effect of regional endowments of technological capital on firms productivity is positive and significant in all estimations with an elasticity of roughly 0.07. This confirms previous results by, among many others, the recent contributions by Madsen (2008) for the OECD countries, Robbins (2006) for the US states and Fischer et al. (2009) for the European regions.

A high level of social capital in the region is supposed to grant a wider diffusion of knowledge, to reduce the transaction costs for both firms and consumers (Diani, 2004) via a widespread trust in the community (Guiso et al. 2008); all these effects are proved to enhance the economic performance of the localised enterprises (Eisingerich et al, 2010) and of the entire economy (Knack and Keefer, 1997). In our estimates social capital seems to have a lower impact, estimated in around 0.02 and it is not significant in the IV and LP estimation. These results are probably due to the weakness of our proxy for social capital, as discussed in the previous section.

The estimated models also include the variable "public capital" (measured by road and rail networks) since firms performance depends also on the level of public infrastructures present in the area in which they operate (Aschauer 1989). This variable turns out to be highly significant in all the regression models with an estimated elasticity of around 0.05[11]. This result confirms the evidence on the positive role of public infrastructure found in the previous literature; see, among others, Eberts (1990) for the Unites States; Moreno et al. (2003) for the Spanish

[10] We have also used different indicators for human capital (number of students with ISCED 5-6) and for technological capital (total R&D expenditure) and they give similar results.

[11] We have also used an alternative proxy for public capital: the capital stock in the "non market service" and "construction" sectors.

regions; Pina and St. Aubyn (2005) for Portugal; Marrocu and Paci (2009) for the Italian regions. It is interesting to notice that the impact of public capital is comparable in size to the one obtained for firms intangible capital, thus reinforcing the evidence on the increasing relevance of the intangible assets in the production process.

As far as the control variables are concerned, they are significant in most cases. More precisely firms age is always positive and significant signalling that older firms have a better performance. The dummies for the firm dimension show similar coefficients with smaller firms (less than 25 employees) revealing a higher productivity. Finally, the sectoral dummies turn out to be significant in 29 out of 34 sectors; the highest coefficient are shown by the Post and telecommunications and Financial intermediation, while the lowest are in the Hotels and restaurants and Retail trade.

4.2 Estimation results by countries

In this subsection we discuss the estimation results by comparing the estimated elasticity for each productive input across the six countries considered (Table 5). In all the regressions controls are included for time, individual sectors and firm dimension.

As mentioned in the previous section, we could not apply the LP estimation method to the sample of UK firms due to the lack of data on intermediate inputs. In order to discuss the performance of British firms in comparison with the ones located in the other European countries we chose to report the IV estimates on the basis of the larger sample selected by applying this estimation method. Note, however, that in general the IV method returns higher estimated elasticities when contrasted with the LP (and OP) one.

The first result to be remarked is that the firms intangible capital turns out to be highly significant. Moreover, it shows a low degree of variability across countries and also across estimation approaches for each estimated model. The estimated elasticity exhibits its lowest value for Spain and France (0.023 and 0.03), Sweden follows with an impact estimated in 0.04, while Italy and the Netherlands have both higher values (0.05) and UK exhibits the highest value (0.09) although it depends on the IV estimation.

Conversely, the stock of physical capital elasticity shows some variability across countries; the coefficients are significant at the 1% level for all countries, except for the Netherlands and Sweden. France and Spain exhibit an elasticity of around 0.07, while Italy shows a slightly higher value estimated in 0.10. The highest elasticity was found for UK (0.20, IV). It is worth emphasising that in most of the cases analysed in this study, the alternative estimators - IV and OP - provide higher estimated impacts, so that the LP ones can be considered as a sort of lower bound results. In the case of Sweden and the Netherlands the insignificance of the physical capital coefficient is probably due to the lack of intermediate inputs data for a considerable number of firms, which almost halves the sample size[12]. The labour input shows the highest elasticity when compared to the other productive factors; the labour coefficient ranges from 0.38 for Spain to 0.64 for UK. In Italy the labour elasticity is estimated in 0.47, followed by France (0.53) and by the Netherlands (0.57) and Sweden (0.58).

The results provided on the firms' inputs elasticities can be compared to the one presented in Hall and Mairesse (1995, 1996) for the case of France and the US and in Bontempi and Mairesse (2008) for the case of Italy. For France the quoted authors report an estimated elasticity of 0.17 for the tangible capital and 0.20 for the intangible one; both elasticities are much higher when compared to the results discussed above, which are more similar to the one the same authors provide for the US economy. For the case of Italy Bontempi and Mairesse (2008) report the following estimates: 0.13 for tangible capital, 0.04 for the intangible one and 0.83 for labour; our estimates are slightly lower for the case of the tangible capital, (around 0.10) and slightly higher for the intangible capital (around 0.05).[13] Labour, on the other hand, shows a noticeable difference in the estimated coefficient, in our case the value is reduced to 0.47; note that the alternative estimators return an elasticity not higher than 0.70.

Overall the comparisons seem encouraging and indicate the need for further investigations on the role played by the intangible factors and on how their effectiveness is affected by the other productive inputs and by environmental factors.

Turning to the regional determinants of firms' performance, we start focusing on human capital; this variable exhibits a certain degree of variability across countries but is significant for most of them. The

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[12] The estimates provided by the alternative methods are 0.24 (IV) and 0.28 (OP) for the Netherlands and 0.15 (IV) and 0.21 (OP) for Sweden.

[13] Bontempi and Mairesse (2008) include in the intangible capital stock also the expenses for advertising which represent roughly the same value of the intangible capital capitalised by the firms.

estimated elasticities depend on the model specification and on the estimation approach. In general higher values are provided by the IV estimator, while the OP and the LP estimators yield lower values. The lowest significant effect is found for Italy (0.05); higher elasticities are found for France (0.15), Spain (0.17) and the UK (0.34). The evidence provided for Italy compares favourably with that provided in Marrocu and Paci (2009) and Di Giacinto and Nuzzo (2006). As was the case for the physical capital, no significant effects are found for human capital for the Netherlands and for Sweden; again, we attribute this peculiar result to the severe reduction in the sample size induced by the construction of the proxy term for unobserved productivity on the basis of the investment function or the use of intermediate inputs[14].

The role of innovation and knowledge diffusion is assessed by including in the production function the technological capital variable. This exhibits significant positive effects in the case of France (the estimated elasticity is around 0.05), Italy (0.075), Spain (0.084), Sweden (0.14) and the UK (0.03). The results for Spain are in line with those reported in Doraszerlsky and Jaumandreu (2008). Only in the case of the Netherlands no significant impact was found for technological capital.

The social capital shows the less robust estimated elasticities across countries; this weak result is attributable almost entirely to the quality of the proxy variable included in our econometric models (see section 2). Evidence of a positive significant effect of social capital on firms' production level is found only for France (0.17) and for Spain (0.04); for the other countries social capital turns out to be not significant with the exception of Italy, where it seems to have an adverse effect on production[15].

Finally, the effect of public capital is also considered among the regional determinants of firms' performance. Significant impacts are found for France (0.06), Italy (0.09) and the UK (0.06). For Sweden the physical infrastructures measure of public capital is not significant and this not surprising given the territorial characteristics of this country; however, the alternative proxy based on capital stock in "non market services and construction" was not significant either according to the LP

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[14] The IV estimator provided a significant coefficient for human capital of 0.49 for the Netherlands and 0.22 for Sweden.

[15] We also re-specified the models by excluding the social capital variable in the cases in which it turned out to be insignificant in order to check the robustness of the other variable coefficients, which was confirmed.

estimation, a positive and significant effect of around 0.26 was found only when applying the IV method. For the Netherlands and Spain no evidence of public capital impact on production performance was provided by all the consistent estimators applied.

4.3 Estimation results by macro-sectors

The role of intangible assets in enhancing productivity is also analysed by considering the eight macro-sectors of the manufacturing and service activities discussed in section 3[16]. The estimated models are reported in Table 6; in each regression we include controls for time, country and firm dimension. For all the eight macro-sectors firms inputs exhibit positive and highly significant elasticities, the only exception are found for tangible capital in the case of the S2 and S7 macro-sector. Interestingly, these are two out of the three macro-sectors for which the ratio intangible/tangible capital is higher and increasing over time. The physical capital coefficient shows a contained variability across sectors, it ranges from 0.07 for the S8 sector (personal goods and services - supplier dominated services) to 0.14 for the S4 sector (mass production goods-scale intensive manufacturing); the labour elasticity is much higher compared to the tangible capital one; the highest value is found for the S7 sector (0.54), the S1, S2 and S8 sectors exhibit values around 0.5, while lower values (in the range 0.33-0.46) are shown by the S3-S6 sectors.

Most importantly for the purpose of this paper, the intangible capital is positive and highly significant in all macro-sectors, although the estimated elasticities show a certain degree of variability. As expected, lower elasticities are found for those sectors where the knowledge capital plays a less crucial role, as S4 Scale-intensive manufacturing (0.020), S8 Suppliers dominated services (0.019) and S6 Physical infrastructure (0.028). On the other hand, high estimates are found for those sectors where intangible assets contribute more to the production process, as it is also evident from the high values of the intangible/tangible capital, as discussed in section 3. More specifically, S5 Network infrastructure (0.099), S1 Knowledge intensive business (0.063) and S7 Supplier dominated goods (0.046). A puzzling result emerges for S2 Specialised supplier manufacturing which has a low elasticity (0.033) although the

[16] An interesting analysis of the role played by non formal R&D activities like design and training in low- and medium-technology industries is presented by Santamaria et al. (2009).

relevance of intangible capital; this unexpected outcome may depend on the very low number of observations available for this sector and the same reason might be at the base of the insignificant result obtained for human capital. In general, human capital shows positive and significant effects for all the sectors, except for S2 and S3; the highest elasticity values are found for the S5 and S7 sectors (0.35 and 0.33, respectively). The same kind of evidence also results for the technological capital - which turns out to be significant for all the eight sectors - though the estimated effects are in general much lower (the highest elasticity, 0.076, is found for the S2 sector). The public capital elasticity is significant in four cases out of eight, exhibiting the highest value for the S2 sector (0.17). On the other hand, the poor performance of social capital is confirmed also for the sectoral sub-samples, in no sector it turns out to have the expected positive and significant effect.

In general the results obtained by considering the sectoral breakdown of the firms sample provide convincing evidence on the relevance of intangible assets in fostering productivity, both in the case in which they are firm-owned and in the case in which they act as a positive externality at regional level, this was particularly the case for human and technological capital.

4.4 Estimation results by firm dimension

In Table 7 we report the results of the econometric analysis conducted with respect to the firms dimension, measured in terms of employees. We consider 4 dimension categories: small firms with no more than 25 employees; small-medium firms with 26-100 employees; medium-large firms with 101-250 employees; large firms with more than 250 employees. The picture which emerges from Table 7 confirms the main results already discussed with regard to the country and sectoral analysis. First of all, firm's intangible assets are always positive and significant, reaching the highest elasticity (0.05) for the small firms. This result is not surprising since intangible capital does not include only formal R&D, an activity mainly performed by larger firms, but it contains also other assets like employees training which are essential to absorb external knowledge, in particular for small firms (Macpherson and Holt, 2007). Note also that this estimate is quite similar to the one obtained for the S1 sector (0.06) where there is a predominance of SME firms which are likely to be engaged in knowledge-intensive business services. For the remaining dimension categories firms exhibit a lower intangible assets elasticity, ranging from 0.023 (D2) to 0.042 (D4).

Moreover, traditional inputs are positive and significant for all dimensions. Physical capital displays the highest elasticity for the large firms sub-sample (0.18), while for the other firms it exhibits an effect not lower than 0.05. The labour input is highly productive for the medium (0.52 for D2 and D3) and the large group of firms (0.53), while its impact is fairly contained for small firms (0.34).

Finally, regional intangible assets play a positive and highly significant role on firms productivity, the only exception being, once again, social capital. Human capital shows the highest elasticity for firms with more than 250 workers; the technological capital is more productive for the small-medium firms, while small firms show the highest elasticity for public infrastructures as they are probably the most dependent on the external infrastructure facilities.

5. Concluding remarks

In the last decade the empirical literature on firm's productivity has provided robust evidence on the role played by intangible assets - such as software, R&D expenditure, patents, economic competencies, employee training - in determining its level. This is true especially in the industrialised countries where competition is essentially based on ideas and innovations which represent the main ingredients of the modern knowledge society. This micro perspective is complemented at the macro level with the analysis of the regional/country economic performance, which has consistently stressed the relevance of local intangible endowments, like human capital, social capital, knowledge capital and institutional capital. These assets by generating localised externalities favour the agglomeration of economic activities and enhance the economic performances at the local level.

The study presented in this paper is an attempt to bring together the two perspectives by assessing the effects on firms' productivity of both internal and external intangible assets. Moreover, we have investigated how the effects of the intangible capital change once we divide our sample by country, macro-sector and firms dimension. This allowed us to provide a more general and consistent evidence with respect to previous studies, in which the analysis was confined to a specific country or sector.

The econometric analysis is based on the estimation of a Cobb-Douglas production function with different econometric methodologies (IV, Olley-Pakes, Levinsohn-Petrin) to face the issue of endogeneity in the production function estimation. The analysis is applied to a large panel of European companies extracted from the BVD database over the period 2002-2006 and belonging to 116 regions of six countries, France, Italy, The Netherlands, Spain, Sweden and the United Kingdom.

All countries in our sample show a clear tendency to increase the share of intangible over tangible capital, confirming the increasing role of the knowledge capital in the competitive behaviour of the firms: on average the ratio increases from 34% in 2002 to 42% in 2006. By considering the sectoral disaggregation we observe that there are some knowledge based and high tech manufacturing sectors where the value of firms intangible assets is higher than the traditional fixed capital, while almost all service sectors exhibit a significant increase in the relative amount of resources devoted to intangible assets. On the other hand, there are industries characterised by very high capital intensive technology where the value of the intangibles remains quite low.

The econometric analysis - conducted for the entire sample and for individual country, macro-sector and firm dimension - has provided novel evidence on the role played by internal and external intangible inputs on the productive performance of firms' in Europe, when such inputs are included in a production function model along with the traditional factors. Although the estimated effects show a certain degree of variability depending on the kind of disaggregation considered and on the estimation method adopted, clear indications on the effectiveness of intangible assets in enhancing firms' productivity were found. As a matter of fact the level of firms' output turns out to depend crucially on the use of the internal knowledge capital in addition to physical capital and labour. Moreover the availability in the local economy of a high endowment of intangible assets (human, technological and social capital) and of public infrastructure has proved to influence positively firms productivity.

The evidence suggests that European policy makers should pay even more attention to define wide-ranging policies aimed at favouring the increase of intangible assets at the regional level and, at the same time, at supporting the accumulation of intangible resources within the enterprises given the strong complementarities between the two channels of knowledge capital in the competition among firms and territories.

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TABLES

Table 1. Ratio of intangible and tangible capital by countries, % values

	Country	2002	2006
FR	France	43.0	75.7
IT	Italy	27.6	32.5
NL	Netherlands	46.3	46.0
ES	Spain	12.0	35.6
SE	Sweden	24.6	30.1
UK	United Kingdom	38.6	38.7
	Total	33.9	42.2

Source : own calculations on BVD

Table 2. Ratio of intangible and tangible capital by macro sectors, % values

	Sector	2002	2006
S1	Advanced knowledge providers - Knowledge-intensive business	55.6	103.0
S2	Advanced knowledge providers - Specialized suppliers manufacturing	93.0	129.3
S3	Mass production goods - Science-based manufacturing	50.8	56.4
S4	Mass production goods - Scale-intensive manufacturing	19.8	27.8
S5	Supporting infrastructure services - Network infrastructure	61.9	64.6
S6	Supporting infrastructure services - Physical infrastructure	10.5	14.9
S7	Personal goods and services - Supplier-dominated goods	77.8	98.3
S8	Personal goods and services - Supplier-dominated services	21.1	25.7

Source : own calculations on BVD

Table 3. Regional variables, summary statistics, 2006

A. Human capital (labour forces with degree over population)	Min	Max	Mean	Var. coeff.
France	0.09	0.20	0.12	0.21
Italy	0.05	0.09	0.07	0.15
Netherlands	0.12	0.21	0.15	0.20
Spain	0.11	0.25	0.16	0.22
Sweden	0.12	0.21	0.15	0.19
United Kingdom	0.11	0.24	0.15	0.21
Total	0.05	0.25	0.13	0.32
B. Technological capital (10 years patents stock over 1000 population)	Min	Max	Mean	Var. coeff.
France	0.09	1.36	0.49	0.63
Italy	0.02	0.57	0.24	0.74
Netherlands	0.31	6.07	1.12	1.41
Spain	0.03	0.33	0.12	0.77
Sweden	0.24	9.77	3.27	0.94
United Kingdom	0.22	2.13	0.76	0.63
Total	0.02	9.77	0.73	1.65
C. Social capital (people involved in social activities over population)	Min	Max	Mean	Var. coeff.
France	0.38	0.60	0.48	0.10
Italy (year 2004)	0.06	0.50	0.23	0.28
Netherlands	0.27	0.61	0.40	0.24
Spain	0.04	0.58	0.33	0.41
Sweden	0.58	0.69	0.63	0.06
United Kingdom	0.29	0.63	0.51	0.15
Total	0.04	0.69	0.47	0.25
D. Public capital (rail and road infrastructures per Km^2)	Min	Max	Mean	Var. coeff.
France	0.93	3.10	1.87	0.24
Italy	0.02	1.07	0.63	0.34
Netherlands	1.54	5.23	3.41	0.37
Spain	0.23	0.63	0.42	0.29
Sweden	0.12	0.71	0.38	0.53
United Kingdom	0.46	14.44	3.17	0.89
Total	0.02	14.44	1.90	1.08

Sources: see Appendix A1

Table 4. Production function estimation – Aggregate sample

Dependent variable: value added	**4.1**	**4.2**	**4.3**
Estimation method	*IV*	*OP*	*LP*
Firm's determinants			
Tangible capital	0.177 ***	0.130 ***	0.083 ***
	(0.002)	*(0.012)*	*(0.008)*
Intangible capital	0.063 ***	0.056 ***	0.037 ***
	(0.001)	*(0.002)*	*(0.001)*
Employment	0.590 ***	0.428 ***	0.446 ***
	(0.004)	*(0.007)*	*(0.006)*
Regional determinats			
Human capital	0.326 ***	0.253 ***	0.188 ***
	(0.011)	*(0.017)*	*(0.017)*
Technological capital	0.062 ***	0.070 ***	0.066 ***
	(0.003)	*(0.006)*	*(0.004)*
Social capital	0.012	0.019 *	-0.003
	(0.008)	*(0.011)*	*(0.007)*
Public capital	0.063 ***	0.047 ***	0.053 ***
	(0.005)	*(0.009)*	*(0.011)*
Observations	151,974	94,274	175,959

Controls: firm age and dummy variables for years, countries, individual sectors and firm dimension
All variables are log-transformed and all regressions include a constant
OP: Olley-Pakes (1996) estimation method; LP: Levinsohn and Petrin (2003) estimation method
Instruments are represented by one year lagged values of firms' regressors
The LP regression does not include UK
Standard errors in parentheses: robust for IV, bootstrapped for OP and LP regressions
Significance: * 10%; ** 5%; *** 1%

Table 5. Production function estimation by country, LP method

Dependent variable: value added	5.1		5.2		5.3		5.4		5.5		5.6	
Country	*FR*		*IT*		*NL*		*ES*		*SE*		*UK* §	
Firm's determinants												
Tangible capital	0.067	***	0.105	***	0.091		0.067	***	0.042		0.205	***
	(0.010)		*(0.016)*		*(0.065)*		*(0.009)*		*(0.031)*		*(0.005)*	
Intangible capital	0.030	***	0.051	***	0.052	***	0.023	***	0.039	***	0.088	***
	(0.002)		*(0.002)*		*(0.010)*		*(0.002)*		*(0.005)*		*(0.003)*	
Employment	0.526	***	0.471	***	0.570	***	0.381	***	0.583	***	0.641	***
	(0.013)		*(0.011)*		*(0.038)*		*(0.010)*		*(0.025)*		*(0.009)*	
Regional determinants												
Human capital	0.152	***	0.052	*	0.069		0.170	***	-0.050		0.348	***
	(0.026)		*(0.031)*		*(0.119)*		*(0.035)*		*(0.145)*		*(0.027)*	
Technological capital	0.051	***	0.075	***	0.003		0.084	***	0.139	*	0.031	***
	(0.010)		*(0.006)*		*(0.024)*		*(0.010)*		*(0.074)*		*(0.010)*	
Social capital	0.173	***	-0.037	***	0.013		0.044	***	-0.074		-0.014	
	(0.034)		*(0.009)*		*(0.127)*		*(0.011)*		*(0.121)*		*(0.035)*	
Public capital	0.053	**	0.093	***	-0.132		0.019		-0.035		0.062	***
	(0.023)		*(0.019)*		*(0.105)*		*(0.025)*		*(0.031)*		*(0.007)*	
Observations	51,248		58,582		1,353		57,631		7,145		16,686	

Controls included: firm age and dummy variables for years, individual sectors and firm dimension
All variables are log-transformed and all regressions include a constant
Bootstrapped standard errors in parentheses
§ IV estimation using one year lagged values of firms' regressors as instruments
Significance: * 10%; ** 5%; *** 1%

Table 6. Production function estimation by macro-sector, LP method

Dependent variable: value added	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8
Macro-sector	*S1*	*S2*	*S3*	*S4*	*S5*	*S6*	*S7*	*S8*
Firm's determinants								
Tangible capital	0.078 ***	0.028	0.104 ***	0.140 ***	0.087 *	0.090 ***	0.018	0.070 ***
	(0.016)	*(0.034)*	*(0.026)*	*(0.031)*	*(0.050)*	*(0.010)*	*(0.015)*	*(0.015)*
Intangible capital	0.063 ***	0.033 ***	0.040 ***	0.020 ***	0.099 ***	0.028 ***	0.046 ***	0.019 ***
	(0.005)	*(0.012)*	*(0.004)*	*(0.003)*	*(0.006)*	*(0.002)*	*(0.003)*	*(0.002)*
Employment	0.530 ***	0.533 ***	0.434 ***	0.462 ***	0.326 ***	0.424 ***	0.543 ***	0.500 ***
	(0.017)	*(0.073)*	*(0.024)*	*(0.021)*	*(0.022)*	*(0.010)*	*(0.020)*	*(0.018)*
Regional determinants								
Human capital	0.279 ***	0.191	0.076	0.066 **	0.355 ***	0.278 ***	0.331 ***	0.062 **
	(0.061)	*(0.132)*	*(0.047)*	*(0.032)*	*(0.091)*	*(0.030)*	*(0.044)*	*(0.031)*
Technological capital	0.059 ***	0.076 *	0.075 ***	0.054 ***	0.052 *	0.061 ***	0.051 ***	0.056 ***
	(0.020)	*(0.044)*	*(0.015)*	*(0.009)*	*(0.030)*	*(0.009)*	*(0.011)*	*(0.008)*
Social capital	0.039	-0.032	-0.049 **	-0.012	0.055	-0.008	-0.024	-0.006
	(0.034)	*(0.078)*	*(0.022)*	*(0.014)*	*(0.052)*	*(0.014)*	*(0.017)*	*(0.014)*
Public capital	0.104 **	0.172 *	0.072 **	0.006	0.017	0.021	0.009	0.076 ***
	(0.042)	*(0.095)*	*(0.031)*	*(0.024)*	*(0.056)*	*(0.021)*	*(0.028)*	*(0.022)*
Observations	13,843	2,102	16,001	21,996	8,623	62,199	22,993	25,829

See appendix A2 for macro-sectors description
UK firms are not included due to data unavailability on intermediate inputs
Controls included: firm age and dummy variables for years, countries and firm dimension
All variables are log-transformed and all regressions include a consta
Bootstrapped standard errors in parentheses
Significance: * 10%; ** 5%; *** 1%

Table 7. Production function estimation by firm dimension, LP method

Dependent variable: value added	**7.1**	**7.2**	**7.3**	**7.4**
Dimension	*D1*	*D2*	*D3*	*D4*
Firm's determinants				
Tangible capital	0.074 ***	0.051 ***	0.065 ***	0.182 ***
	(0.011)	*(0.008)*	*(0.014)*	*(0.024)*
Intangible capital	0.055 ***	0.023 ***	0.030 ***	0.042 ***
	(0.004)	*(0.002)*	*(0.002)*	*(0.002)*
Employment	0.338 ***	0.518 ***	0.514 ***	0.533 ***
	(0.013)	*(0.009)*	*(0.016)*	*(0.013)*
Regional determinants				
Human capital	0.152 ***	0.170 ***	0.164 ***	0.180 ***
	(0.058)	*(0.023)*	*(0.024)*	*(0.033)*
Technological capital	0.051 ***	0.080 ***	0.059 ***	0.046 ***
	(0.015)	*(0.006)*	*(0.007)*	*(0.010)*
Social capital	0.029	-0.017	-0.027 ***	-0.003
	(0.023)	*(0.010)*	*(0.010)*	*(0.016)*
Public capital	0.128 ***	0.066 ***	0.043 **	0.040
	(0.037)	*(0.014)*	*(0.017)*	*(0.026)*
Observations	25,291	68,270	45,498	36,900

Firms dimension is defined in terms of employees:
D1, at most 25 employees;*D2*, 26-100; *D3*, 101-250; *D4*, more than 250 employees
UK firms are not included due to data unavailability on intermediate inputs
Controls included: firms age and dummy variables for years, countries and individual sectc
All variables are log-transformed and all regressions include a constant
Bootstrapped standard errors in parentheses
Significance: * 10%; ** 5%; *** 1%

APPENDIX

Table A1. Data sources and definitions

Variable	Primary source	Years	Observation	Measurement unit	Indicator
Value added	BVD	2002-2006	Firm	millions euros, 2000	
Tangible capital stock	BVD	2002-2006	Firm	millions euros, 2000	
Intangible capital stock	BVD	2002-2006	Firm	millions euros, 2000	
Units of labour	BVD	2002-2006	Firm	levels	
Population	Eurostat	2002-2006	Region	levels	
Human capital	Eurostat	2002-2006	Region	levels	labour force with a degree ISCED 5-6 over total population (%)
Technological capital	OECD, REGPAT database	2002-2006	Region	levels	Patent Cooperation Treaty applications, stock for previuos 10 years per 1000 inhabitants
Social capital	European Social Survey Rounds 1-3	2002, 2004, 2006	Region	levels	population that have taken part at least once in the last 12 months in social activities such as voluntary service, unions and cultural associations meetings (%)
Public capital	Eurostat	2002-2006	Region	lenght in Km	infrastructure: road and rail networks per square km

Table A2. Macro-sectors taxonomy

S1	Advanced knowledge providers—Knowledge-intensive business services: Computer and related activities; research and development; other business activities
S2	Advanced knowledge providers—Specialized suppliers manufacturing: Machinery and equipment; medical, precision and optical instruments
S3	Mass production goods—Science-based manufacturing: Chemicals; office machinery and computers; electrical machinery and apparatus; radio, TV and communication equipmen
S4	Mass production goods—Scale-intensive manufacturing: Rubber and plastic products; other non-metallic mineral products; basic metals; fabricated metal products; motor vehicles; other transport equipment
S5	Supporting infrastructure services—Network infrastructure: Post and telecommunications; financial intermediation; insurance and pension funding; activities auxiliary to financial intermediation
S6	Supporting infrastructure services—Physical infrastructure: Wholesale trade and commission trade; land, water and air transport; supporting and auxiliary transport activities
S7	Personal goods and services—Supplier-dominated goods: Food and beverages; textiles; wearing; leather; wood and related; pulp and paper; printing and publishing; furniture; recycling
S8	Personal goods and services—Supplier-dominated services: Sales, maintenance and repair of motor vehicles; retail trade and repair of personal and household goods; hotels and restaurants

Source: Castellacci (2008)

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Finito di stampare nel mese di Novembre 2009
Presso **studiografico&stampadigitale Copy Right**
Via Torre Tonda 8 – Tel. 079.200395 – Fax 079.4360444
07100 Sassari

www.crenos.it

ISBN 978-88-84-67-556-9

9788884675569