Local Human Capital Externalities and Wages at Firm Level*

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Abstract

We use a unique data set providing administrative information on earnings by skill-level (blue collars, white collars), on the local stock of human capital and on several firm's characteristics, including balance sheet data, to investigate the size of localized human capital externalities in Italian manufacturing. Our estimates do not show any evidence of human capital spillovers neither at the firm nor at the local level. This finding is not really surprising and can be explained by many features of Italian manufacturing.

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1 Introduction

More than three decades after the seminal work by Mincer (Mincer, 1974), economists have reached a wide consensus on the positive relationship between an individual's education and his/her earnings. More recent research has also shown that this positive association reflects a causal relationship: education has a positive effect on incomes over and above an individual's ability. Although there is still some debate whether the positive returns to education reflect educated worker's higher productivity, as maintained by the so-called human capital theory (Becker, 1993), or simply the signaling value of education (Spence, 1973), many opt for the first explanation.

Human capital is likely to produce not only private returns but also both market and non-market social returns (Moretti, 2004b). An example of the former is the increase in the productivity of uneducated individuals due to the sharing of knowledge with the educated ones, while an example of the latter is a reduction in crime rates. Put it simply, human capital may generate positive spillovers. Despite this idea being around for awhile, the empirical evidence on positive human capital externalities is still 'mixed'.

However, fully understanding the existence and magnitude of these spillovers is very important since both secondary and tertiary education in most countries draw heavily on public resources spent by central and local governments under the form of direct and indirect subsidies (fee exemptions). One of the reasons why local governments invest in the education of the resident population is that they should enjoy most, or some, of the economic returns from such investments by making their workforce more productive. In short, human capital externalities may be localized. This is likely to be the case especially in countries characterized by low individual's and worker's mobility. Hence, in these countries policies aimed at increasing local higher education supply expansion have a strong rationale if they produce localized human capital spillovers.

In this respect, Italy represents an interest case study, since due to the low mobility of workers (Di Addario, 2006; Di Addario and Patacchini, 2008) there is potentially a wide scope for localized human capital externalities. Moreover, given the policy of huge local higher education supply expansion, which was undertaken in Italy in the 90s and financed with public resources, (cf. Bratti et al., 2008), to find out whether human capital produces localized externalities is very important for both policy makers and taxpayers.

In this paper we investigate localized human capital externalities using a unique data set obtained merging a very rich survey on Italian Manufacturing firms, administrative data on average firm's earnings by skill-level from the Italian National Institute for Social Security (INPS) and Census data on the local stock of human capital.

We make several contributions with respect to the existing literature. Firstly, unlike previous studies using individual-level data, we are able to use very reliable firm's earnings data coming from an administrative source and therefore are likely to be less affected by measurement error. Secondly, firm data includes both balance sheet and survey data. This enables us to control for many potential confounding factors at firm level such as physical capital investments or ICT and R&D expenditures. This is likely to be a problem in individual-level studies not using employer-employees data since firms located in areas where the workforce is highly educated may invest more in skill-complementary technologies or capital and local human capital could pick up these unobserved factors. Last but not least, focusing on firm data that also provide information on the skill-structure of the workforce within the firm will enable us to test whether localized human capital externalities emerge over and above spillovers potential rising within a firm.

A central finding of this paper is that human capital spillovers do not emerge when considering Italian manufacturing neither at the firm nor at the local level. This result may seem at first sight rather surprising but at a deeper look is not and it is probably related to the many peculiarities of manufacturing in Italy. Indeed, Italian manufacturing firms are small, often family owned, are mainly specialized in traditional and mature industries and in low-skilled work intensive products (Faini et al., 1999), under-invest in high-skilled work complementary technologies (Bratti and Matteucci, 2005) and express a low demand for graduates. Our results do not exclude however that substantial spillovers may instead emerge in other economic branches in which the role 'knowledge' is more important.

The structure of the paper is as follows. Section 2 introduces a brief survey of the empirical evidence, distinguishing between the international evidence and the one relating to Italy. Section 3 describes the econometric model. Section 4 summarizes the main characteristics of the data set and discusses identification issues. Section 5 reports the main empirical results and 6 concludes.

2 Previous literature

In this section we report a short survey of the empirical evidence on local human capital externalities distinguishing between the international evidence and the one related to Italy.

2.1 International evidence

There are several potential sources of localized human capital externalities. Moretti (2004b) mentions 'technological externalities' produced by technological increasing returns (Lucas, 1988). As stated by Lucas (1988) the source of this kind of externalities may be, for instance, the sharing of knowledge between workers or individuals. Externalities may also take a pecuniary form, not originating from assumptions about the production function but from market interactions like for instance in Acemoglu (1998): an increase in the supply of human capital could increase R&D investment to introduce skill-complementary technologies and raise the productivity of skilled workers in the long-run (skill-bias technological change, SBTC hereafter).

Externalities of course need not be positive. Moretti (2004b) makes the example of the signaling model of education. Education might simply be a signal of an individual's productivity (ability). If the level of workers' education increases locally, employers might simply increase their hiring standard without any positive effect on productivity. In this case, the social returns to education would be zero.

As stated by Moretti (2004b) there are different ways of testing for the presence of human capital externalities in production, by looking at wages, production or land prices. However, due to data availability researchers have often resorted to wages, on which we will focus this short survey of the empirical literature.

Acemoglu and Angrist (2000) use individual-level cross-section wage data from the US population Census and data on schooling at the state level (the average of the highest graded completed top-coded at 17 years among workers aged 16-64 taken from the Censuses). Using instrumental variables (IVs) estimation, and compulsory schooling and child-labour laws as instruments, the authors estimate a Mincer equation augmented with local human capital but do not find evidence of positive human capital externalities.

However, the 'standard Mincer approach' to estimating human capital externalities has been criticized by Moretti (2004b,a) and Ciccone and Peri (2006) as it may lead to misleading conclusions. Indeed, this approach may confound 'standard neoclassical supply effects', as defined by Ciccone and Peri (2006), with externalities. Because of the increase in the supply of skilled workers the wage of unskilled workers will increase if skilled and unskilled workers are imperfect substitutes and the average wage will increase too even in absence of positive externalities. Moretti (2004a) addresses this critic

Hence, the evidence from US studies is 'mixed'. As to the difference in results between Acemoglu and Angrist (2000) and Moretti (2004b), one possible reason put forward by Halfdanarson et al. (2008) is that the former's target are white middle-aged males only, which are likely to be better educated on average and produce rather then benefit from human capital spillovers. Another one is that Moretti (2004a) focuses on higher education rather than on secondary schooling like Acemoglu and Angrist (2000), since he suggests that the former could produce market externalities (e.g., productivity growth) while the latter is likely to produce non-market effects. One third reason, cited by Duranton (2006) is that the instruments used by Acemoglu and Angrist (2000), child-labour and compulsory-schooling laws, are likely to have an effect especially on 'marginal students' and to affect lower schooling levels rather than higher education. Last but not least, the specific choice of the spatial unit could also make a difference since, as Jaffe et al. (1993), show the geographical spread of knowledge spillovers could be limited. Hence, focusing on smaller spatial units (e.g., cities or metropolitan areas rather than states) could help to identify localized human capital externalities. The different results in Moretti (2004a) and Ciccone and Peri (2006) could be due to the different proxies for local human capital used by the two papers: the fraction of graduates among workers by the first and the average years of schooling by the second. As stated by Moretti (2004a), university educated workers may be the primary source of positive market externalities. There are papers focusing on other countries, like Muravyev (2006) that studies Russia. Russia offers to the author a nice instrument since educational levels in the communist era were largely exogenous with respect to wages. The author using IVs finds evidence of positive human capital externalities both on college graduates and on less educated workers.

Another stream of literature is mainly interested in within-firm social returns to education. The underlying idea is that educated workers in a firm makes also uneducated workers more productive in the same firm, and that should emerge within-firm in the first place. Battu et al. (2003) and Martins and Jin (2008), for instance, using different methodologies report evidence of human capital spillovers within firms.

Surprisingly enough, the two streams of literature, the one on localized human capital externalities and the one focusing on within-firm human capital spillovers, despite being very related hardly speak to each other. Indeed, papers on localized human capital spillovers using individual-level wage data generally are not able to control for the skill composition of the workforce within a firm and do not test for within-firm spillovers. Hence, what are generally interpreted as local human capital spillovers emerging in restricted spatial units like cities may in reality be produced at an even smaller level, that is within a firm or an establishment.[1] By contrast, papers in the second stream of literature generally omit controls for localized human capital and also in this case what are interpreted as within-firm spillovers may be instead localized human capital spillovers as firms where local human capital is more abundant are also more likely to hire highly educated workers.

In this paper, by using firm-level data we try to bridge the two literatures. In particular, we will analyze average firm's wages by skill-level and include among the regressors both the firm's skill-ratio, defined as the percentage of workers with tertiary education within a firm, and a proxy for the local stock of human capital.

[1] A notable exception is Moretti (2004c) that investigates human capital externalities by estimating plant-level production functions.

2.2 Evidence for Italy

Few studies have addressed the issue of localized human capital externalities in Italy.

Dalmazzo and de Blasio (2007b) use Italian individual-level data from the Survey of Household Income and Wealth (SHIW) run by the Bank of Italy to study human capital externalities at the local labour market (LLM) level. The authors use as a proxy of local human capital average years of schooling in the LLM, taken from the 1991 Census. They both apply OLS and IVs to repeated cross-sections from SHIW and find a significant positive effect of local human capital on average wages. However, as emphasized by Moretti (2004b) the evidence of a positive effect of local human capital on average wages is not necessarily an indication of human capital externalities but may be produced by imperfect substitutability between skilled and unskilled workers. Then, Dalmazzo and de Blasio proceed to estimate separate wage regressions for low-skilled and high-skilled workers. The effect of local human capital on both wages is positive, only marginally statistically significant for skilled-workers and statistically significant and larger for unskilled workers, as predicted by the theory in case of imperfect skill substitutability. The authors take this as evidence in favour of human capital externalities.

In a closely related paper using the same data, Dalmazzo and de Blasio (2007a) make an important point. If local human capital produces consumption externalities, i.e. it increases residents' utility by raising the quality of life, looking only at wages may understate the effect of human capital externalities. For instance, assuming that skilled workers derive higher utility from cities' amenities than low-skilled workers, they may accept a lower wage in exchange of a higher quality of the city environment. Hence, the average wage may remain the same or even fall also in the presence of human capital production spillovers, depending on the relative magnitude of consumption and production externalities. The authors estimate a Mincer equation for wages and a similar equation for rents using both OLS and IVs and find a positive effect of local human capital both on rents and wages. The authors conclude by saying that their results point to the existence of both production and consumption human capital externalities.[2]

3 Econometric model

We adopt the Mincer approach by estimating a firm-level (log) wage regression, by skill level augmented with an indicator of local human capital. In particular, we follow Moretti (2004b) and estimate the following model:

[2]However, it must be noted that unlike in Dalmazzo and de Blasio (2007b) the authors in this paper disregard the imperfect substitutability argument which might lead to an increase in the average wage even without productive human capital spillovers.

$$w_{ijs} = \alpha_0 + \alpha_1 KINT_i + \mathbf{TECH_i'}\boldsymbol{\alpha_2} + \alpha_3 SKILL_i + \alpha_4 LHC_j + \mathbf{X_i'}\boldsymbol{\alpha_5} + u_i + \epsilon_i \quad (1)$$

where i, j and s are firm, spatial and skill-level subscripts, respectively. In particular, we consider as the relevant spatial unit Italian provinces,[3] which are the administrative equivalent of US counties, and two levels of skills, blue collars (BC) and white collars (WC). This distinction is due to the fact that earnings data come from the Italian National Social Security Institute's archives (see section 4), which does not collect earnings by educational level but only by level of qualification. w_{ijs} is the firm-level average wage for firm i, in province j and for skill-level s in natural logarithm. $KINT_i$ is the natural logarithm of physical capital intensity, that is the ratio between the real capital stock and the total number of workers. $\mathbf{TECH_i}$ is a vector of technological indicators, $SKILL_i$ the skill-ratio, measured as the fraction of university graduate workers on total firm's employment and $\mathbf{X_i}$ a vector of other firm-level controls. LHC_j is the local measure of human capital and α_4 is the main parameter of interest. We will interpret a statistically significant $\alpha_4 > 0$ for WC as evidence consistent with positive localized human capital spillovers. Indeed, a positive α_4 for BC is not necessarily an indication of positive spillovers, since, as we already mentioned, it might be generated by supply substitution effects. Similarly, a positive and significant α_3 in the wage equation for BC will be interpreted as evidence consistent with within-firm human capital spillovers. A positive α_3 in the WC wage equations is instead expected given the widely observed individual returns to education and that graduates are likely to be in WC occupations. u_i and ϵ_i are firm unobservables, the latter is assumed to be white noise while the former may be correlated with the other regressors included in equation (1). A more detailed description of the variables used is available in Appendix I.

Moretti (2004b) carefully discusses the problem of endogeneity of local human capital. In particular, the problem is likely to be produced by the correlation between firm's unobservable characteristics u_i and local human capital. Some candidate unobservables are for instance demand shocks to specific sectors or firms which may attract skilled workers to a given area and also increase workers' productivity. Moretti (2004a) makes the example of San Jose in California following the internet boom that drove up demand for qualified workers, increased their wages and attracted highly educated workers in the area. This could also be seen as a problem of reverse causality, i.e. one could find a higher supply of human capital in areas where firms pay higher wages. As noted by Moretti (2004b) finding proxies for all possible unobservables is not a viable solution to the problem and an alternative is resorting to IVs techniques. This of course poses the uneasy task of finding a

[3] In Italy in 2001 there were 20 regions (NUTS 2) and 103 provinces (NUTS 3).

variable correlated with local supply of human capital but not with average firm's wages.

4 Data

The local stock of human capital is proxied by the percentage of workers with a university degree at province-level like in Moretti (2004a) and is computed on 2001 Italian Census data. We also make a robustness check by considering the percentage of workers with either an upper secondary school diploma or a tertiary degree.[4] This will also highlight at what level of education human capital externalities are likely to manifest themselves. We use the micro-data version of the 2001 Census released by the Italian National Statistical Institute (ISTAT) gathering information on a representative sample of 1,117,928 individuals, 2% of the total population in 2001. The percentages of highly educated workers by province are computed using sample weights which expand the sample to the whole Italian population.

'Wage' data are gathered by the National Institute of Social Security (INPS). In particular, data refer to average annual earnings by skill-level (blue collars and white collars). These data have advantages and disadvantages. The main advantage is that earnings data come from an administrative source and are likely to be less affected by measurement error compared to the survey data normally used in individual-level studies of localized human capital spillovers. The main disadvantage is that unlike those studies we are unable to compute a measure of hourly wages. Hence, despite our measure of average annual earnings being adjusted for part-time work in terms of days (see Appendix II), the variable mixes information on hourly wages with the one on hours worked. An implication is that our estimates of human capital spillovers might pick up both the effect on hourly wages and the one on working hours. Firm-level average earnings by skill-level where available to us for each year in the period 1997-2002.

Firm data come from the 'Survey of Italian Manufacturing Firms' (*Indagine sulle Imprese Manifatturiere*, SIMF hereafter) managed by the Unicredit banking group. The survey collects information on a sample of manufacturing firms with 11-500 employees and on all firms with more than 500 employees. The SIMF has been repeated over time at three-year intervals since 1991 and in each wave a part of the sample is fixed while the other part is completely renewed every time (see Capitalia, 2002, p. 39). This helps to analyse both variations over time for the firms observed in different waves (panel section) and the structural changes of the Italian economy, for the

[4] In particular, we consider as tertiary degrees university diplomas, university undergraduate and post-graduate degrees and non-university tertiary education. Upper secondary schooling includes people with 4-year or 5-year upper secondary schooling diplomas.

part of the sample varying in each wave. Like in many other surveys used in the empirical literature,[5] also SIMF is biased against micro-firms. The data set gathers a wealth of information on: balance sheet data integrated with information on the structure of the workforce and governance aspects; innovation; information on investments and R&D expenditures; information on firms' international activities (export, off-shoring and FDI flows by area); information on financial structure and strategies. Information about the educational level of the workforce, the skill-ratio that we include as a control in equation (1), is reported only for the final year in each wave. Given that we can be confident about our measure of local human capital only for 2001, the year of the Census, while we do not have good measures of local human capital for other years we limit our analysis to 2001 and focus on the 9th wave of SIMF referring to 2001-2003. In particular, we merge the 9th wave of SIMF with Census data and INPS data.[6] The 9th wave provides information on the educational level of workers only for 2003, three years after the Census and an year for which we do not have wage data, we decided to restrict the analysis to firms appearing both in the 9th and the 8th wave of SIMF, referring to 1998-2000. So doing, we use the firm's skill-ratio measured at 31 December 2000 as a proxy for the skil

4.1 Identification

Before discussing the identification strategy we would like to make a point. The problems of endogeneity and reverse causality of local human capital are likely to be less severe for Italy than for other countries such as the US and the UK where graduates are relatively mobile (Bound et al., 2004). This is the case since individual geographical mobility is extremely low in Italy. Di Addario (2006) and Di Addario and Patacchini (2008) observe that non-pecuniary benefits from residence (social networks, friendship) and substantial mobility costs related to travel or housing are likely to be responsible for the low workers' mobility in Italy. This means that the ability of firms to attract human capital from other provinces is generally limited and that human capital must be produced locally. However, local production of new human capital is a lengthy process (e.g., for the period under study it took on average 6 years to form a new university graduate in Italy) and individuals are unlikely to make correct long-term predictions on wages when enrolling in HE.[7] In this respect, Italian university students appear to be systemati-

[5] See for instance Bernard and Jensen (2004), Becker and Egger (2007).

[6] The merging procedure between SIMF and INPS data was made under a confidentiality agreement at the INPS Head Office (Rome). See Appendix II for more detailed information.

[7] Dominitz and Manski (1996) and Betts (1996), for instance, cast serious doubts on students' ability to correctly predict earnings. These studies generally show a large heterogeneity in students' expectations about actual earnings, which reflect a large variation in students' information.

cally mismatched with respect to labour demand, in particular there seems to be a systematic excess production of graduates in Arts and Humanities.[8]

However, as usual, we cannot be absolutely sure that local human capital is exogenous, and for this reason we make use of IVs estimation. We propose as an instrument the local human capital stock in the population aged more than 65 living in the same province in which the firm is located. The rationale is that given the already cited low mobility of Italians, they often study and work where they are born and live close to their parents (cf. Di Addario and Patacchini, 2008). The Mediterranean welfare model is such that parents take care of children even when they are young adults (Bentolila et al., 2005), while the latter take care of their older parents. Hence, elderly people residing in a province are likely to be the parents of the workers residing in the same province, which contribute to the stock of local human capital stock. This implies that: 1) local elderly people's education will be very correlated with local workers' education, given the high intergenerational persistence in education, especially higher education, in Italy (cf. Checchi and Flabbi, 2007; Checchi et al., 2008); 2) these individuals, given their age, are unlikely to be in the labour force and to affect wages and their level of human capital is unlikely to correlated with factors related to local firms' current productivity. Hence, the one we propose should be theoretically a strong and valid instrument.

For the moment, due to the lack of credible instruments we will not address the issue of the potential endogeneity of the firm's skill-ratio and we limit ourselves to lag it one year. It must be noted that also other regressors, such the firm's physical capital intensity, may be endogenous.

5 Results

We start by reporting OLS estimates in column I of Table 1. We already said that OLS estimates may be affected by an endogeneity bias, due to the correlation between local human capital and firms' unobserved characteristics shared by all firms located in the same province. The estimated specification includes as controls of technological capital R&D intensity in 2001 (nominal R&D expenditures on nominal production in 2001) and a dummy for having performed ICT investments in 1998-2000.[9] We also include regional (NUTS 2) and II-digit sectoral dummies (ATECO classification similar to NACE), firm size (total number of employees) in 2001, and a dummy for the firm being an exporter in 2000. In the regression for WC the stock of human

[8] OECD (2008) reports that in 2004 the percentage of graduates in Arts and Humanities was 19% compared to an OECD average of 12%.

[9] We use lagged ICT investments and lagged export status because the latter is collected only for the whole three-year period and the second for the last year in each three-year period, and we want to avoid that ICT investments and export status refer to a date following 2001.

capital in (natural logarithm) turns out to be statistically significant and positively related to the wage of WC with an estimated elasticity of 0.028. R&D and ICT investments are not statistically significant. The skill-ratio is significantly positively correlated with WC wages. A one percent point increase in the firm's skill-ratio is associated to a 0.24 per cent increase in firm's wages. For BC (column II of Table 1) the estimated elasticity of wages with respect to capital intensity is a statistically significant 0.016, about half the one for WC. For BC the firm's skill-ratio turns out to be statistically insignificant. This suggests the absence of substantial within-firm human capital externalities. Also local human capital is not statistically associated to BC wages. The insignificance of R&D and ICT is not a news for Italy. Several papers have not found any evidence of SBTC for Italy using SIMF data (see, among others, Piva and Vivarelli, 2002; Bratti and Matteucci, 2005). It is also worth noting the significant positive correlation between export status and wages for WC and the negative one for BC.

Columns III and IV of Table 1 report instrumental variables estimates, which try to address the potential endogeneity of local human capital. Results do not change substantially. For WC (column III) the local stock of human capital continues to be positive but statistically insignificant unlike the firm's skill-ratio. For BC (column IV) neither local human capital nor the skill ratio turn out to be associated with average wages. First stages statistics show that our instrument for local human capital is very strong, the F-test being 105.66 in the equation for WC and 105.21 in the equation for BC. We also included the instrument directly in the first stage and in no case it turned out to be statistically significant, which supports empirically our exclusion restriction (see Table 1).

How should these results be interpreted overall? Our estimates do not suggest the presence of positive spillovers of human capital neither at the local nor at the firm level in Italian Manufacturing. Is this really surprising? No. Italian manufacturing is specialized in traditional sectors and low-skill, high labor-intensive productions (Faini et al., 1999) and there is probably little scope for positive human capital externalities. The fact that Italian firms underinvest in R&D and in skill-intensive technologies (ICT) means that also the demand for skilled workers is relatively low (cf. Bratti and Matteucci, 2005). The low demand for graduates in Italian manufacturing, also due to its productive structure where small sized and family-owned firms prevail, suggests that manufacturing is not probably the sector in which spillovers should be looked for. Our results are consistent we those in papers investigating the dynamic of the skill-ratio in Italy, which generally do not find any evidence of SBTC in manufacturing (see, among others Piva and Vivarelli, 2002; Piva et al., 2005; Bratti and Matteucci, 2005).

Our analysis, being restricted to Manufacturing, cannot exclude however that within-firm or localized human capital externalities may nonetheless emerge and be important in other economic branches, like in the service sector. Previous work by Dalmazzo and de Blasio (2007b,a) using individual-level data suggests that this is probably the case.

These considerations on the structure of Italian manufacturing could also suggest that tertiary education is not the right educational level at which one should look at. Spillovers may emerge at lower educational levels, for instance at upper secondary schooling. In order to explore at which level of education local human capital are likely to manifest themselves we run an additional analysis using an alternative proxy of local human capital stock. In particular, we use the percentage of upper secondary and tertiary educated people in the workforce at province level. In a similar way we define the firm's skill ratio as the percentage of tertiary and upper secondary educated workers within the firm. Columns I and II of Table 2 reports OLS estimates. Results do not change, local human capital is not significant neither in the WC equation nor in the BC equation. However, in this case the skill-ratio turns out to be positively related to average BC wages. This happens since blue collars workers with upper secondary schooling are likely to be in manual skilled positions and raise average BC wages. Columns III and IV show IVs estimates using as an instrument the percentage of upper secondary and tertiary educated people in the population aged 65 or more. Local human capital is never statistically significant and the instrument appears to be valid. Hence, we conclude that positive local human capital spillovers do not emerge even at the upper secondary schooling level in Italy.[10]

6 Conclusion

The idea that localized human capital produces positive production externalities is both intuitive and compelling but the empirical evidence on human capital externalities is still 'mixed'.

However, the emergence and magnitude of human capital externalities are probably country and sector specific. In particular, positive externalities are more likely to emerge in countries and sectors specializing in complex technologies and hi-tech products ('knowledge economies' or hi-tech sectors) compared to countries and industries specialized in traditional sectors and unskilled-intensive products like Italy.

We use a unique data set combining firms' balance sheet and survey data, Census data on local human capital and administrative data on earnings to investigate the presence of human capital spillovers in Italian manufacturing. Using both OLS and instrumental variables estimates we do not find any evidence of positive local human capital spillovers.

[10] We plan to extend the analysis by focusing on the stock of local human capital operating in the firm's sector (manufacturing) or industry (2-digit groups), to test the hypothesis that spillovers may only emerge within a sector or within an industry.

This result can be easily explained by many features of Italian manufacturing, which is characterized by small-sized and family-owned firms, mostly specialized in traditional sectors and that underinvest in both R&D and ICT. With such a specialization there might be little scope for human capital externalities in Italian manufacturing. This does not exclude that human capital spillovers may be important in other sectors, like in services. We leave the investigation of human capital externalities in other sectors for future research.

Appendix

Appendix I. List of variables

Wages. Firm average wage data, our dependent variable, come from Italian National Social Security Institute's archives. They are full-time adjusted average earnings by skill-level (white collars vs blue collars). For more details see Appendix II. Data refer to 2001. The variable is included in natural logarithm.

Physical capital intensity. It is the ratio between real capital stock and real production. The nominal capital stock is derived from balance sheet data and is evaluated at the net 'historical cost' that is cost originally borne by a firm to buy the good reduced by the depreciation measured according to the fiscal law (*Fondo di ammortamento*), which accounts for obsolescence and use of the good. The real capital stock is obtained using capital stock deflators provided by the Italian National Statistical Institute (ISTAT). The nominal value of production is computed as the sum of sales, capitalized costs and the change in work-in-progress and in finished goods inventories (cf. Parisi et al., 2006). All variables are deflated with the appropriate three-digit production price index (ISTAT). Data refer to 2001 and come from the 9th wave of SIMF. The variable is included in natural logarithm.

Local human capital. According to the specification is computed either as the percentage of workers with tertiary education at province (NUTS 2) level, or as the percentage of workers with tertiary or upper secondary education at province level. Data refer to the 2001 Italian Census (ISTAT).

Firm skill-ratio. According to the specification is computed either as the percentage of workers within a firm with tertiary education or as the percentage of workers within a firm with tertiary or upper secondary education. Data refer to 2000 and come from 8th wave of SIMF (see section 4).

R&D intensity. It is computed as the ratio between nominal R&D and nominal production (see above). Data refer to 2001 and come from the 9th wave of SIMF.

ICT investment. It is a dummy that takes value one if the firm performed ICT investiments in 1998-2000 and zero otherwise (see section 4). Data come from the 8th wave of SIMF.

Export status. It is a dummy that takes value one if the firm exported in 2000 and zero otherwise. Data come from the 8th wave of SIMF.

Sector dummies. II-digit ATECO sector dummies referring to 1998-2000. ATECO stands for *Classificazione delle attività economiche*, that is an Italian classification of economic activit

Region dummies. NUTS 2 dummies referring to 1998-2000. In Italy there are 20 regions. Data come from the 8th wave of SIMF.

Local elderly's human capital. It is our instrumental variable. According to the specification is computed either as the percentage of population aged

65 or more with tertiary education at province (NUTS 2) level, or as the percentage of population aged 65 or more with tertiary or upper secondary education at province level. Data refer to the Italian 2001 Census (ISTAT).

Appendix II. Earnings data and INPS-SIMF match

i. Matching procedure

To perform the analyses in this paper we linked together two different firm-level data archives: the *Osservatorio sulle Imprese* from the Italian National Institute for Social Security administrative archives (INPS) with the Survey of Italian Manufacturing Firms (SIMF) run by Unicredit (formerly by Capitalia and Mediocredito).

The *Osservatorio* is built upon the compulsory contributions forms collected by INPS from all private Italian firms with at least one employee on a monthly basis. It includes high quality data on employment size and earnings broken down by skill level (manual and non manual workers, cadre and managers, apprentices), plus information on sector of activity, firm's birth and closure dates.

We linked the INPS wave (covering years from 1997 to 2002), to the 8th and 9th SIMF's waves (covering years from 1998 to 2003) using the fiscal ID number as a linkage key. Probably due to clerical errors in the maintenance of both archives the match was not perfect, but link failures remained below 2% of SIMF data. Since it is the first time that these data sources have been integrated, we performed some data quality checks to verify the information coherence on the following common variables: economic activity code; province where the firm is legally based; total number of employees. The check on firm size tells apart small (< 21 employees), medium (21-150 employees) and big (>150 employees) firms, considering a relative difference threshold of 30%, 20% and 10% respectively. The results were quite satisfactory, and are summarized in the table below:

Quality of INPS-SIMF match

	Year			
	1998	1999	2000	2001
% obs. with equal 3-digit activity codes	71	71	71	71
% obs. with coherent firm size	96	97	97	97
% obs. with same province	93	93	93	93

ii. Average annual earnings data

Average employees' annual earnings are computed as:

$$rma = \sum_{i=1}^{12} \frac{Mr_i}{D}$$

where:

rma: annual average earnings;

Mr_i: total wage bill in month i;

$D = \frac{1}{12}\sum_i^{12} d_i$: average number of employees (blue collars or white collars), where d_i is the average number of employees in month i.

Since the 1990-1994 edition of the *Osservatorio* the computation of average employees' earnings has been done by adjusting monthly firm's total wage bill to the maximum number of working days in a month (26), in the following way:

$$Mrm_i = \frac{Mr_i}{Gr_i} \times 26 \times d_i$$

where:

Mrm_i: total wage bill share of month i for a full-month;

Mr_i: actual monthly wage bill share for month i;

Gr_i: actual number of working days in month i;

d_i: average number of employees in month i.

For part-time white collars and blue collars the total number of working days is obtained by dividing by 6.66 the total number of hours indicated in INPS form DM10 (40 weekly hours divided in 6 days).

Further details are available (in Italian) at:

servizi.inp.it/banchedatistatistiche/menu/imprese/intro.doc

Tables

Table 1: Estimates using tertiary education

	OLS				Instrumental Variables			
	(I)		(II)		(III)		(IV)	
Variable	WC		BC		WC		BC	
log physical capital intensity	0.0276	***	0.0152	***	0.0279	***	0.0154	***
local human capital[(a)] (NUTS 3)	0.0010		0.0012		0.0031		0.0030	
firm skill-ratio[(b)]	0.0024	***	0.0010		0.0023	***	0.0009	
R&D intensity	0.2492		0.2575		0.2518		0.2589	
ICT investment (dummy)	-0.0160		-0.0021		-0.0165		-0.0026	
Export status	0.0461	***	-0.0344	***	0.0460	***	-0.0346	***
Sector dummies (2-digit)	YES		YES		YES		YES	
Region dummies (NUTS 2)	YES		YES		YES		YES	
Size	YES		YES		YES		YES	
Exclusion of instrument[(c)]								
F(test) first stage	-		-		105.66		105.21	
F(test) second stage	-		-		1.72		2.17	
R^2	0.21		0.25		0.21		0.25	
N. obs.	1,692		1,716		1,692		1,719	

* significant at 1%; ** significant at 5%; *** significant at 1%.
Notes. The dependent variable is the natural logarithm of average firm's annual earnings for white collars (WC) and blue collars (BC). Standard errors are clustered by province. [(a)]Percentage of workers with tertiary education at province level; [(b)]Percentage of workers with a university degree within the firm; [(c)]IVs use as an instrument the percentage of tertiary educated people in the population over 64 in the province.

Table 2: Estimates using upper secondary and tertiary education

	OLS				Instrumental Variables			
	(I)		(II)		(III)		(IV)	
Variable	WC		BC		WC		BC	
log physical capital intensity	0.0282	***	0.0156	***	0.0286	***	0.0157	***
local human capital[(a)] (NUTS 3)	0.0005		0.0009		0.0017		0.0011	
firm skill-ratio[(b)]	-0.0001		0.0005	***	-0.0001		0.0005	***
R&D intensity	0.3955	*	0.2378		0.3952	*	0.2376	
ICT investment (dummy)	-0.0141		-0.0027		-0.0144		-0.0028	
Export status	0.0483	***	-0.0027	***	0.0482	***	-0.0344	***
Sector dummies (2-digit)	YES		YES		YES		YES	
Region dummies (NUTS 2)	YES		YES		YES		YES	
Size	YES		YES		YES		YES	
Exclusion of instrument[(c)]								
F(test) first stage	-		-		80.63		79.75	
F(test) second stage	-		-		0.93		0.69	
R^2	0.20		0.2563		0.20		0.26	
N. obs.	1692		1716		1692		1716	

* significant at 1%; ** significant at 5%; *** significant at 1%.
Notes. The dependent variable is the natural logarithm of average firm's annual earnings for white collars (WC) and blue collars (BC). Standard errors are clustered by province. [(a)]Percentage of workers with tertiary or upper secondary education at province level; [(b)]Percentage of workers with a university degree or an upper secondary school diploma within the firm; [(c)]IVs use as an instrument the percentage of upper secondary or tertiary educated people in the population over 64 in the province.

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