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HUMAN CAPITAL AND PRODUCTIVITY GROWTH IN THE ITALIAN REGIONAL ECONOMIES: A SECTORAL ANALYSIS

Sergio Lodde

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CRENoS – CAGLIARI
VIA SAN GIORGIO 12, I-09100 CAGLIARI, ITALIA
TEL. +39-070-6756406; FAX +39-070- 6756402

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

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HUMAN CAPITAL AND PRODUCTIVITY GROWTH IN THE ITALIAN REGIONAL ECONOMIES: A SECTORAL ANALYSIS

Sergio Lodde
Università di Cagliari
Dipartimento di Ricerche Economiche e Sociali, CRENoS
E-mail: lodde@unica.it

Abstract

The paper examines the relationship between human capital and productivity growth with reference to the Italian regions. Two approaches can be distinguished. One belonging to the neoclassical tradition stresses the accumulation of human capital as a determinant of growth, while the other, inspired by Nelson and Phelps, emphasizes the role of the stock in developing endogenous technology and catching up with more advanced economies. These hypotheses have been tested at an aggregate level but results might be the overall outcome of different processes across sectors due to the different catching-up potential. In particular we expect the Nelson-Phelps hypothesis to be more relevant in the industrial sector where innovation is the most important growth determinant. A model is estimated which allows to test both the neoclassical and the Nelson-Phelps hypotheses breaking down the analysis by sector.

The results do not confirm our expectations. In the industrial sector the neoclassical hypothesis is clearly rejected by the data. Some evidence supporting the Schumpeterian one can be detected when the technical component of human capital is taken into account but it is not robust to changes in the model specification. In the service sector the results are inconclusive as well. A positive and significant effect of human capital accumulation has been found for the whole sector but the explanatory power of this variable decreases considerably in the marketable services branch.

JEL: J24, O40, R11
Key words: growth, human capital, regions, sectors

Introduction

The relationship between human capital and economic growth has been thoroughly analysed in the economic literature. In particular with reference to the advanced countries the empirical evidence still remains quite controversial as regards its underlining mechanisms. Two approaches can be distinguished. One inspired mainly by the neoclassical tradition stresses the importance of the accumulation of human capital as a determinant of output growth. According to the neoclassical approach human capital is a factor of production as well as physical capital, as such it produces level effects on output. This means that levels of human capital are associated to output levels, consequently the growth rates of the former are correlated with the growth rates of the latter. The second approach, initiated by Nelson and Phelps (1966) and revived by Benhabib and Spiegel (1994, 2005), emphasizes the role of the stock as a base for successfully developing endogenous technology and catching up with more advanced economies. In this interpretation the stock of human capital is regarded as a source of growth effects on output.

These hypotheses have been tested at an aggregate level but results are inconclusive. One reason might be that they reflect the overall outcome of different processes across sectors, due to the different role of innovation and catching-up potential. In particular, if innovation and technology diffusion are the main factors affecting the relationship between human capital and economic growth, we would expect a stronger relationship in the industrial sector where these factors are more important, and higher levels of education to be more influential since they incorporate most of the relevant knowledge.

The paper estimates a model which allows to test both the neoclassical and the Nelson-Phelps hypotheses for the Italian regions during the period 1971-2001, making use of a panel methodology. The model has been applied to the industrial and the service sector. The paper is organised as follows. The first section reports a brief overview of the relevant literature, the second is dedicated to a descriptive analysis of education at the sectoral level in the Italian regions, in the third the methodology for calculating total factor productivity is explained and the estimated model is described. The fourth section reports the results of the econometric analysis for the industrial and the service sectors. The paper ends with some concluding remarks.

1. Review of the literature

Despite the huge body of literature on human capital and growth no general consensus has been reached about the nature and the mechanics of this relationship. If we consider the theoretical and empirical standpoints on one side and the micro and macro ones on the other we can see different situations. Taking first the micro-empirical side, the Mincerian positive relationship between education and wages (Mincer 1974) is now widely accepted although disagreement persists about the theory behind it. Some argue that it is a matter of productivity effects of education while others point to signalling mechanisms. The macro side is characterised by a more general disagreement, both theoretical and empirical. The theoretical disagreement has to do with the mechanisms underlining the relationship, namely whether the accumulation or the stock of human capital are the relevant variables, and if the effect of education on growth is transitional or persists in the long run steady state dynamics. The neoclassical view regards human capital as a factor of production subject to diminishing returns, therefore its accumulation only can be a source of growth effects, and these effects can only be transitional as long as the economy is approaching its steady state. The endogenous growth theory (Lucas 1988) claims that, due to externalities, human capital accumulation causes long run growth effects through dynamic feedback mechanisms. Other researchers stress the role either of the share of human capital stock devoted to research activities (Romer 1990), or of the whole stock as an innovation enhancing factor and as a necessary condition for adopting existing technologies (Nelson and Phelps 1966).

On the empirical side the transitional nature of growth effects might be undetectable if the economies under analysis are far from the steady state, making the neoclassical and the endogenous growth theories observationally equivalent. Thus most economists agree that a positive correlation between human capital and growth is to be expected in empirical analysis. However the empirical results are often inconsistent with this expectation. On one side Mankiw Romer and Weill (1992) by extending Solow's model find that human capital, measured by enrolment rates to secondary school, significantly contributes to explaining growth rates differentials across a wide sample of countries. These results are confirmed by some subsequent studies (Lichtenberg 1992; Nonneman and Vanhoudt 1996), while others question their robustness (Temple 1998; Hamilton and Monteagudo 1998). On the other hand panel studies tend to reverse that evidence, finding negative and significant coefficients of the human capital variables (Islam 1995;

Caselli, Esquivel and Lefort 1996).

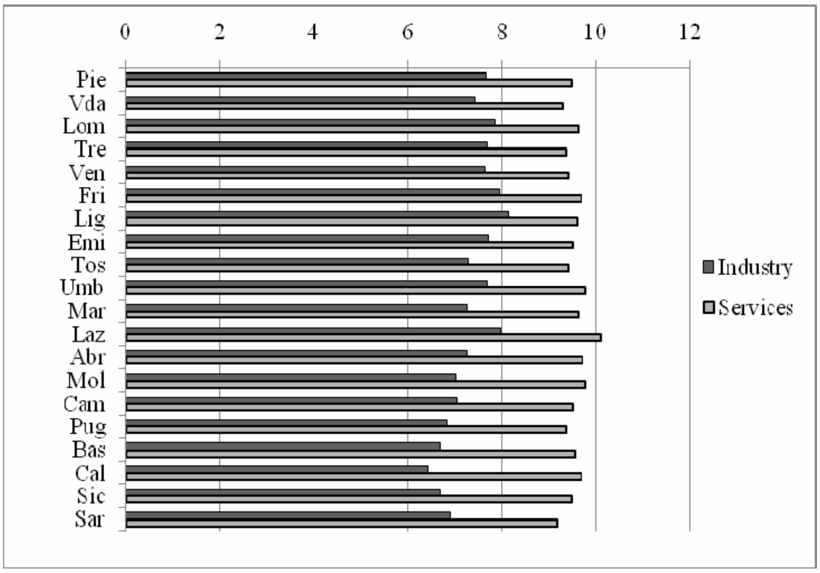
Benhabib and Spiegel's (1994, 2005) work is the empirical counterpart of the Schumpeterian approach along the lines suggested by Nelson and Phelps (1966). First they estimate a production function confirming the absence of level effects of human capital on the output per worker rate of growth, but find growth effects of the stock which corroborate the Nelson-Phelps hypothesis. The relationship between human capital and innovation is characterised more precisely in this approach. In their model Benhabib and Spiegel include three variables: the stock of human capital (measured by the average years of education) which captures its contribution to endogenous innovation, the ratio between output per worker in the leader country and country *i* as a proxy of the technological gap and catching-up opportunities and an interactive term given by the product of the two preceding variables. The latter is interpreted as an indicator of the technological absorbing capacity of the backward countries. Both the stock and the interactive term coefficients are positive and significant in their analysis, and their magnitude depends on the level of development. In the backward countries the catching-up effect is more important, while the same holds for the endogenous innovation effect in the advanced ones. Aiyar and Feyrer (2002) check the Nelson-Phelps hypothesis making use of GMM estimators and dynamic panel methodologies. They find a positive effect of human capital on total factor productivity growth in the long run.

The Nelson-Phelps-Benhabib-Spiegel hypothesis has several empirical implications. In particular, if the effect of education on output growth acts mainly through innovation, we should expect that some components of total education, such as upper secondary and higher education or those emboding technical knowledge, exert a stronger influence since they provide the most relevant R&D and technological skills. Moreover the effect of human capital on total factor productivity should be stronger in those sectors of the economy where innovation is the most important engine of growth. This is the main reason why a sectoral analysis is best suited for handling this problem and is the main motivation of this paper. To our knowledge only one study (Serrano-Martinez 1999) checks for the existence of level and growth effect of human capital at the sectoral level. Analysing Spanish regional economies he finds a positive level effect of human capital, measured by average years of education in the industrial and service sector, while there is no evidence of growth effects linked to technology.

2. Stylised facts on education at the sectoral level in the Italian regions

Although educational attainment levels have increased substantially in Italy over the last thirty years, the labour force remains one of the less educated among the advanced countries. If we consider a sample of 114 European regions belonging to fifteen countries of the Union, as recently as 2003 the best ranking Italian region was Lazio which occupied the 65th position. Some southern regions such as Sardinia, Sicily and Puglia belonged to the bottom group of fifteen regions with the lowest educational levels (below the 100th position) in the whole sample. The aggregate values disguise significant differences among the industrial and the service sector of the regional economies. Figure 1 shows the years of education of the active population averaged for the period 1971-2001. In the whole sample figures are higher in the service sector and lower in industry. In the southern regions differences are more pronounced. This is due to falling attainment levels in industry in the South, while, in the service sector, they remain very similar to the northern regions values.

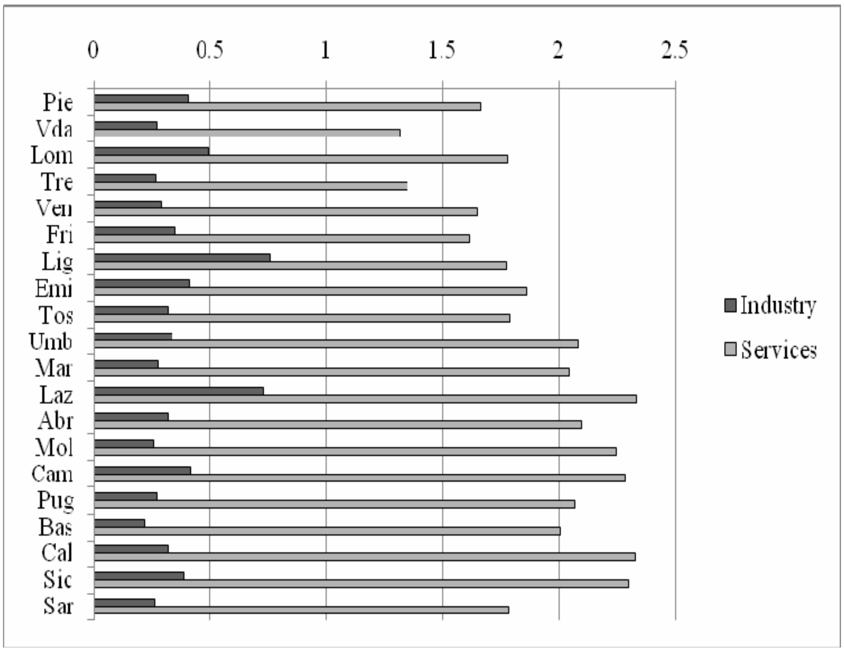
Fig. 1. Average years of education of the active population by sector and region. Average 1971-2001



Source: ISTAT, population censuses 1971-2001

Much of the difference is due to the very uneven sectoral distribution of tertiary education. Figure 2 shows quite clearly that laureates are mostly concentrated in the service sector, where their share is by far higher than in industry. It shows also that the share of tertiary education in the service sector is higher in the Southern less developed regions compared to the Northern and more developed ones.

Fig. 2. Share of tertiary education in industry and services by region. Average values 1971-2001



Source: ISTAT, population censuses 1971-2001

This anomaly can be explained if we take into account that many occupations in public subsectors such as health and education require tertiary education, and that the weight of these sectors in terms of employment is higher in the South of Italy. On the supply side the incentive for young people to take a tertiary degree is stronger in the southern regions, since it increases the probability of getting a job in a situation of general unemployment[1].

It is not easy to check whether this explanation is correct since the service sector figures for education cannot be broken down into the

[1] This can also cause some problem of over education in the public sector which absorbs most of the highly educated labour force.

marketable and non marketable components, due to problems of data comparability across the four censuses. However, according to the latest census (2001), on the average the share of the labour force with a university degree in non marketable services was more than twice as high as in marketable ones and this phenomenon was more pronounced in the southern regions[2]. This suggests that the public component may play a prominent role in the relationship between human capital and growth in the service sector. The mentioned comparability problems prevent a direct inspection of this hypothesis by running two separate equations for marketable and non marketable services. Nonetheless some indications can be obtained by comparing the behaviour of the educational variables in the whole service sector end in a subgroup of marketable services characterised by comparable figures.

3. The model

To analyse the relationship between human capital and output growth we estimate a growth equation that extends a standard CRS production function augmented with human capital. The model incorporates a catching up process which depends on differences in technological levels among regions (proxied by total factor productivity ratios), and on the capacity to exploit the technological gap thanks to the human capital endowment. To estimate the model the TFP levels for each region and sector must be previously calculated. Thus let us begin with a brief account of the applied methodology.

TFP has been obtained by calculating the Solow residual from a standard constant return to scale production function of the Cobb Douglas type:

1) $Y_i = A_i K_i^{\alpha} H_i^{1-\alpha}$

where H_i denotes human capital measured in the following way:

2) $H_i = e^{\mu(E_i)} L_i$

Human capital is an exponential function of the average years of education (E) while μ measures the returns to education. Thus $\mu(E_i)$ reflects the augmented efficiency of a labour unit endowed with E years

[2] The definition of marketable services adopted here includes public administration and defense, health, education. This is not a rigorous definition since the health and education branches include both public and private activities. However, in our opinion, it is the most reasonable approximation.

of schooling, compared to row labour with no education. This specification has been adopted in several studies (Klenow e Rodriguez Clare 1997; Hall e Jones 1999; Bils e Klenow 2000; Aiyar e Feyrer 2002) and has the advantage of being consistent with the microeconomic approach to estimating the returns to education along Mincerian lines (Mincer 1974).
Incorporating 2) in 1) and dividing both sides by L we get the per worker production function:

3) $$\frac{Y_i}{L_i} = A_i\left(\frac{K_i}{L_i}\right)^{\alpha}(e^{\mu(E_i)})^{1-\alpha}$$

Taking logs and using lower case letters to denote values per worker we have

4) $\log y_i = \log A_i + \alpha\log k_i + (1\text{-}\alpha)\mu(E_i)$

Finally from 4) we can easily get TFP as a residual:

5) $\log A_i = \log y_i - \alpha\log k_i - (1\text{-}\alpha)\mu(E_i)$

This is a Hicks neutral specification which can be converted into the correspondent Harrod neutral one by simply dividing 5) by $1\text{-}\alpha$
Some authors (Klenow and Rodriguez Clare 1997, Hall and Jones 1999, Aiyar and Feyrer 2002) suggest a different specification, replacing the capital-labour with the capital-output ratio. They argue that the former underestimates the contribution of TFP, since it does not take into account that the share of investment is endogenously determined by variations of TFP. Accordingly they suggest an alternative specification of the following form:

6) $\log A_i = \log y_i - \alpha/(1-\alpha)\log (K_i/Y_i) - \mu(E_i)$

The argument in favour of the capital-output vs. capital-labour specification is undoubtedly well grounded, however the assumption that investment decisions are entirely determined by variations of TFP is clearly implausible. As Bossworth and Collins (2003) note, both formulations give rise to some kind of distortion, the former overestimating and the latter underestimating the contribution of TFP to output growth. In this paper the capital-labour version has been adopted as the default specification, while the alternative one has been used for purposes of robustness analysis.

Another problem relates to the factor shares used in the calculation. One solution largely adopted in cross-country studies is to adopt constant shares both in the space and the time dimension with values of .3 for capital and .7 for labour. However, as Gollin (2002) clearly showed, empirical evidence does not support this assumption. Actually factor shares vary considerably both across countries and over time. Effective factor shares for the Italian regions can be easily calculated from regional accounting data provided by the National Institute of Statistics (ISTAT). To get a more correct measure of the labour share the self employed income has been added to the employee compensation share. This has been done by assigning to the self employed the same per capita income as the employees and adding up the two components. The analysis has been conducted using constant shares (the average aggregate values for the period under examination) as the default value[3], and reserving the variable shares for purposes of robustness analysis[4].

Finally as parameters for the returns to education, those estimated by Ciccone, Cingano and Cipollone (2006) have been chosen on the ground that these estimates are broken down by levels of education, allowing for decreasing returns as suggested by Psacharopoulos (1994).

Starting from equation 4) and using symbol Δ for first differences we get the following growth equation:

7) $\Delta\log y_{it} = \alpha_0 + \gamma_i + \eta_t + \alpha\Delta\log k_{it} + \beta\Delta\log h_{it} + \lambda\Delta\log A_{it} + \varepsilon_{it}$

Where $\gamma_i + \eta_t$ are fixed region and time effects. $h_{it} = H_{it}/L_{it} = e^{\mu(E_{it})}$ is the human capital variable. Setting μ equal to the Mincerian return to education, the log of human capital per worker is given by:

8) $\log h_{it} = \mu E_{it}$

Following De la Fuente (1996) let's assume that TFP growth, which is represented by the term $\Delta\log A_{it}$, depends on a catching up mechanism in which human capital is involved. In particular TFP growth is defined by the following expression:

9) $\Delta\log A_{it} = \log h_{it-1} + \log g_{it-1} + \log h_{it-1} \cdot \log g_{it-1}$

[3] The values are .31 for capital and .69 for labour. These shares are therefore constant both across regions and over time.

[4] These shares are variable across regions but constant over time. The reason behind this choice is that taking into account time variability is likely to introduce distortions in the results since it is influenced by factors which have nothing to do with the production function technology (see Torrini 2005). Moreover TFP values are rather implausible since they imply negative TFP rates of growth most of the times.

where g is the ratio between the TFP level in the leader region (in our case Lombardia) and in region i and $\log h_{it-1} \cdot \log g_{it-1}$ is an interactive term.

Therefore g is a direct measure of the technological gap, the higher g the higher the technological distance from the leader. This specification resembles very much Benhabib and Spiegel (2002) exponential model. In other terms TFP growth depends positively on the technological gap between region *i* and the leader (catching up) and on human capital which, besides its direct effect on output per worker as a factor of production (level effect in the De la Fuente terminology which is captured by the term $\Delta\log h_{it}$), affects output growth indirectly via TFP growth. In this case the stock of human capital rather than its variation is the relevant variable. First because a higher human capital stock speeds up the rate of innovation in the regional economy (endogenous innovation effect)[5], second because it fosters the adoption of imported technology (adoption effect) by improving firms absorption capacity. Following Benhabib and Spiegel (1994, 2002) we assume that the adoption effect is stronger the greater the gap between region *i* and the leader and the greater the stock of human capital in the follower region. This interaction is captured by the interactive term in equation 9), while the coefficient of the lagged human capital variable measures the endogenous innovation effect.
Substituting 9) into 7) we get the equation to be estimated for each sector:

10) $$\Delta\log y_{it} = \alpha_0 + \gamma_i + \eta_t + \alpha\Delta\log k_{it} + \beta\Delta\log h_{it} + \lambda_1\log h_{it-1} + \lambda_2\log g_{it-1} + \lambda_3\log h_{it-1}\cdot\log g_{it-1} + \varepsilon_{it}$$

The previous equation allows one to estimate both the effects of human capital on output growth as predicted by the neoclassical model and the indirect effects described by Nelson and Phelps. In the former model human capital behaves as a standard factor of production. As such it generates a level effect on output, namely more human capital is associated with more output. This in turn implies that human capital

5 Another reason suggested by Bils and Klenow (2000) is that human capital may be necessary for technology *use*. That is, human capital indexes the fraction of frontier technology which the country or region can use.

accumulation is related to output growth. The empirical corollary of this view within the framework adopted here is that a positive and significant β coefficient is expected in equation 10). The Nelson and Phelps hypothesis, on the other side, would be corroborated by positive and significant λ coefficients.

4. Estimation results

Equation 10) above has been estimated by means of a Least Square Dummy Variable model for two sectors: industry and services. The sample is a panel of twenty Italian regions each observed four times during the period 1971-2001 using census data for a total of 80 observations. Figures come from different sources. Capital is drawn from the Crenos database on capital stock in the Italian regions (see Paci and Pusceddu 1999) which provides sectoral time series from 1970 up to 1994. The series have been expanded up to 2001 by adding investment and applying a fixed rate of depreciation.

Figures on education come from the four population censuses between 1971 and 2001. Labour force is broken down by the highest educational level achieved. Unfortunately changes in the methodology over time give rise to some comparability problems. In the 2001 census figures by sector are available only for the employed workers instead of the whole labour force as in the previous ones. To overcome this problem sectoral data for the labour force have been estimated by assigning to the unemployed in each sector the same educational levels found for the aggregate unemployed in each region.

Another problem relates to changes in the sectoral break down of the data across the four censuses. Figures are comparable for the whole sectors (industry and services) but are no longer so if we split services into marketable and non marketable. This is an important limitation of the analysis given that educational levels are much higher in the public sector compared to the others, and that the weight of this sector varies considerably by region. This increases the likelihood of getting biased coefficients in the estimation results for the service sector.

4.1 Industry

The estimates for the industrial sector are reported in the first column of table 1. Neither the accumulation of human capital (Δlog *hind*) nor its initial stock (log $hind_{t-1}$) significantly affect the rate of growth of output per worker. Moreover the sign is not the expected one. The coefficient of the interaction term is not significant as well. However this does not rule out the possibility of an effect of the stock of human capital on output growth because, when the interaction term is included in the regression, the coefficient of the variable *hind* measures its effect on the dependent variable when the moderator is equal to zero. In our case this means that the estimated coefficient applies to region Lombardia. However calculating the simple slope of the human capital stock at the average value of the moderator does not increase its significance level[6]. The coefficient of the gap variable (log *gind*) is significant at 8% implying some convergence among regions.

In column two the interactive term has been dropped to reduce possible collinearity problems but while this increases the value and the significance level of the gap variable coefficient as expected, it has no appreciable effect on the human capital variables. In the third column a measure of R&D expenditure (the average R&D expenditure/GDP ratio in each decade lagged three years) is included in the regression[7]. Figures refer to total expenditure and cannot be disaggregated by sector, nevertheless the variable has been included in the analysis of industry assuming that it impacts mostly on this sector. However the coefficient is not significant and the overall picture does not show any notable change.

[6] The t test of the simple slope of log $hind_{t-1}$ is .62.

[7] To make an example the rate of growth of output per worker in the period 1991-2001 has been regressed on the average R&D/GDP ratio for the period 1989-98. Figures are available from 1978 on, thus the regression is limited to the last two decades.

Table 1. Human capital and output per worker growth in the industrial sector. LSDV estimates 1971-2001. Dependent variable average yearly growth rate of output per worker.

	1	2	3
Δlog *kind*	0.180*	0.199**	0.212**
	(0.091)	(0.091)	(0.098)
Δlog *hind*	-0.923	-0.858	-2.113
	(0.683)	(0.693)	(1.324)
Log $hind_{t-1}$	-0.134	-0.038	-0.434
	(0.185)	(0.175)	(0.294)
Log $gind_{t-1}$	0.060*	0.103***	-0.043
	(0.033)	(0.014)	(0.098)
Log $hind_{t-1} \cdot \log gind_{t-1}$	0.115		0.397*
	(0.079)		(0.211)
Log $R\&D_{t-3}$			0.028
			(0.078)
cons	0.061	0.024	0.258
	(0.075)	(0.072)	(0.161)
N	60	60	40
adj. R^2	0.67	0.66	0.62
F	5.6	5.5	5.2

*** = significant at 1% level
** = significant at 5% level
* = significant at 10% level
regional and time dummies not reported

In table 2 human capital has been broken down by schooling level. The three variables *terind, secind,* and *priind* are constructed in much the same way as the aggregate variable *hind* as the product of average years of education times their returns. The hypothesis tested here is that a more educated labour force should have a stronger impact on labour productivity growth. This is a corollary of the Nelson-Phelps approach. In particular if innovation is the main transmission channel between human capital and output growth we should expect that some components of total education, such as upper secondary and tertiary education, exert a stronger influence since they provide the most relevant skills both for boosting innovation through research and development, and for absorbing new technologies developed elsewhere. This argument applies in particular to the industrial sector where innovation is the most important engine of growth.

Table 2. Human capital disaggregated by educational level. Industrial sector. LSDV estimates 1971-2001. Dependent variable average yearly growth rate of output per worker.

	1	*2*	*3*
Δlog *kind*	0.200* (0.104)	0.163 (0.099)	0.203** (0.094)
Δlog *hind*	-0.730 (0.501)	-0.761 (0.514)	-0.752 (0.498)
Log $gind_{t-1}$	0.099*** (0.019)	0.100*** (0.016)	-0.009 (0.060)
Log $terind_{t-1}$	0.029 (0.423)		
Log $gind_{t-1} \cdot$ log $terind_{t-1}$	0.655 (1.132)		
Log $secind_{t-1}$		-0.078 (0.093)	
Log $gind_{t-1} \cdot$ log $secind_{t-1}$		0.032 (0.154)	
Log $priind_{t-1}$			-0.160 (0.108)
Log $gind_{t-1} \cdot$ log $priind_{t-1}$			0.376* (0.195)
Cons	0.008 (0.018)	0.015 (0.018)	0.057 (0.036)
N	60	60	60
Adj. R-sq	0.52	0.53	0.56
F	5.2	5.4	5.9

standard errors in parentheses
*** = significant at 1% level
** = significant at 5% level
* = significant at 10% level
regional and time dummies not reported

As before the human capital variables have no effect whatsoever on productivity growth. Neither tertiary nor secondary education coefficients are significant and the same applies to the interactive terms[8]. As regards primary education the coefficient of the interactive term is significant at 10% level, while the simple slope of the primary human capital is not at any reasonable value of the gap variable.

These results might be influenced by the methodology adopted here for calculating TFP which assigns constant shares to factors and expresses output per worker as a function of the capital-labour ratio. In table 3 we report the results obtained allowing factor shares to vary across regions and using the capital-output ratio specification.

Table 3. Human capital and output per worker growth in the industrial sector. Variable shares and K/Y specifications. Dependent variable average yearly growth rate of output per worker

	Var. shares	*K/Y*	*Var.sh. K/Y*
Δlog *kind*	0.195* (0.113)	0.205** (0.093)	0.186* (0.109)
Δlog *hind*	-1.013 (0.805)	-0.977 (0.700)	-1.073 (0.797)
Log $hind_{t-1}$	-0.062 (0.222)	-0.293 (0.185)	-0.289 (0.216)
Log $gind_{t-1}$	0.115*** (0.028)	0.027 (0.029)	0.054** (0.024)
Log $hind_{t-1} \cdot \log gind_{t-1}$	-0.064 (0.047)	0.113* (0.072)	0.013 (0.053)
cons	0.035 (0.091)	0.122 (0.075)	0.122 (0.088)
N	60	60	60
Adj. R^2	0.38	0.52	0.39
F	3.8	5.2	3.9

standard errors in parentheses
*** = significant at 1% level
** = significant at 5% level
* = significant at 10% level
regional and time dummies not reported

[8] This result does not depend on the construction procedure adopted for the human capital variables. Substituting average years of education does not change the picture significantly.

The only noticeable difference is that the coefficient of the gap term is now significant even when the interactive term is included in the regression. The human capital variables still retain no explanatory power.

The absence of any effect of human capital on output growth is a well known and puzzling result in the literature in particular in panel estimates (Islam, 1995; Caselli, Esquivel and Lefort, 1996; Krueger and Lindahl, 2001). An explanation is given by Pritchett (2000) who points out that "the lack of identification of country-specific, time-invariant variables using fixed effects in panel data is merely the limiting case of the decline in statistical power as the "between" country variance in time-persistent right side variables is swept out by the fixed effects". Thus if the dependent variable shows much volatility over time while the regressor is persistent (as is often the case for human capital variables) much of the explanatory power of the latter is captured by the fixed effects. However this explanation is hardly relevant in our case since the within component of the total variance is actually higher than the between component both for *hind* and for $\Delta hind$.

Krueger and Lindahl (2001) argue that the problem might be due to the presence of non linearities in the relationship between human capital and output growth. This possibility has been explored by adding square transformations of the human capital variables to the regressions[9]. However no significant change was detected.

Another possible explanation is that an aggregate measure of human capital is a poor proxy of what really matters for growth, namely labour force technical skills. This is particularly relevant in the industrial sector with respect to the Nelson-Phelps hypothesis, which claims that the effect of human capital on output growth is channelled through technical progress. To take this into account a measure of technical skills embodied in the labour force has been constructed from data on professions provided by the Italian censuses. In table 4 the variable *htech*[10], which measures the technicians human capital in the industrial

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[9] Results are not reported for the sake of brevity.

[10] The variable *htech* has been constructed with the same procedure applied to the other human capital variables, considering only technical occupations. The Italian censuses provide figures on educational levels by sector and profession. However raw figures are no longer available for the 1971 census and the lowest breakdown level for technical professions in the industrial sector includes the following ones: physicists, chemists, engineers, architects, surveyors, cartographers, technical designers. This is a mixture of professions requiring secondary and tertiary education and leaves out other intermediate technicians. Therefore the category of technical employees (which includes

labour force, substitutes *hind* in the four specifications of the model.

Table 4 .Technical human capital and output per worker growth in the industrial sector. Different specifications. Dependent variable average yearly growth rate of output per worker.

	Const. sh. K/L	*Var. sh. K/L*	*Const. sh. K/Y*	*Var.sh. K/Y*
Δlog *kind*	0.261*** (0.075)	0.182 (0.112)	0.284*** (0.082)	0.194* (0.104)
Δlog *hind*	-0.378 (0.417)	-0.952 (0.604)	0.012 (0.458)	-0.111 (0.596)
Log $htech_{t-1}$	0.455** (0.217)	0.525 (0.315)	0.458* (0.239)	0.429 (0.304)
Log $gind_{t-1}$	0.061*** (0.018)	0.103*** (0.024)	0.038** (0.015)	0.046** (0.018)
Log $htech_{t-1} \cdot$ log $gind_{t-1}$	1.950*** (0.521)	-0.245 (0.401)	1.507*** (0.453)	0.576 (0.438)
Cons	-0.012 (0.015)	0.020 (0.021)	-0.018 (0.017)	-0.001 (0.021)
N	60	60	60	60
Adj. R-sq	0.79	0.55	0.75	0.59
F	9.0	4.1	7.5	4.4

standard errors in parentheses
*** = significant at 1% level
** = significant at 5% level
* = significant at 10% level
regional and time dummies not reported

The picture changes somewhat. In the default specification (constant shares K/L) both the coefficients of the variable *htech* and of the interactive term are significant (5% and 1% respectively). However they

intermediate technicians with secondary education) has been added. Given the impossibility of discriminating between the two levels the average return to secondary and tertiary education has been applied to the former group.

are not robust to changes in the model specification. In particular both loose explanatory power in the variable shares scenario.

No firm conclusion can be drawn from such mixed evidence. To some extent it suggests that the stock of technical skills might matter in explaining output growth in the industrial sector, giving some support, although weak, to the Nelson-Phelps hypothesis[11]. However a more detailed investigation is needed to get more reliable results.

4.2 Services

In the service sector the role of human capital remains unclear as well. In table 5 below the results for the complete model (equation 11) in its different specifications are shown. In the default specification (constant shares and K/L) both the coefficients of the human capital variables (accumulation and stock) are significant (at 2% and 6% respectively) and have the expected sign. The coefficient of the gap variable is not significant but this does not exclude any influence of the TFP gap on the rate of growth of output per worker. Actually setting *h* to its average value and calculating the simple slope of *g*, the latter coefficient is equal to .104 and is significant at 1%.

The coefficients of the human capital variables are quite high. As regards the accumulation variable ($\Delta hser$) the coefficient value in the default specification implies that a higher rate of human capital accumulation by one percentage point nearly doubles in terms of output per worker growth percentage points. Given the returns used in calculating *h*, this means that an increase of one year in the average level of education boosts output per worker growth by roughly eleven percentage points. This effect is much bigger in magnitude compared to the 5% estimated by De la Fuente and Ciccone (2002) for the European countries. The effect of the stock (*hser*) is weaker but far from trivial if we take into account that a one year increase in the stock of education implies a 2% higher rate of growth of output per worker.

The coefficients of the human capital variables change considerably when factor shares are allowed to vary and the capital-output ratio specification is applied. In particular the coefficient of the accumulation variable is nearly halved, which implies an effect on productivity growth much closer to the De la Fuente and Ciccone (2002)

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[11] Lodde (1999) finds that the stock of technical skills, proxied by the share of technical professions in the labour force, is positively correlated with output growth in a sample of European regions.

estimates. The reduction in the stock variable coefficient is much bigger (roughly by a factor of eight) but the significance level remains low.

The strong effect of human capital accumulation might be due to the peculiar relationship between education and output in the public sector. Since in this sector profits are negligible, value added per worker is very close to the average employees compensation. This in turn tends to grow in line with average years of education in the labour force. According to this argument we should expect a stronger relationship between human capital accumulation and output per worker growth in the public sector[12]. The best way to check this hypothesis would be to run two separate equations for marketable and non marketable services. Unfortunately that is not possible because the educational levels of the labour force in the public sector cannot be compared across censuses[13].

[12] This argument holds if the returns to education remain constant when the latter increases. In our case however this constancy is imposed to the data since the human capital variable is constructed by applying aggregate and not sector specific returns to education.

[13] As regards education figures in the 1971 and 1981 population censuses the service sector is broken down into commerce, transport and communications, finance and insurance, services, public administration. The services include branches belonging either to the private sector (real estate activities, household services) and to both the private and the public sector (health, education, social and personal services).

Table 5. Human capital and output per worker growth in the service sector. Constant and variable shares, K/L and K/Y specifications. LSDV estimates 1971-2001. Dependent variable average yearly growth rate of output per worker.

	Const.sh.K/L	*Var. sh. K/L*	*Const.sh. K/Y*	*Var.sh. K/Y*
Δlog *kser*	0.258***	0.243***	0.253***	0.233***
	(0.079)	(0.081)	(0.072)	(0.082)
Δlog *hser*	1.856**	0.918**	1.182***	1.144**
	(0.738)	(0.447)	(0.387)	(0.446)
log $hser_{t-1}$	0.351*	0.041*	0.027	0.057**
	(0.177)	(0.022)	(0.023)	(0.023)
log $gser_{t-1}$	-0.015	0.161***	-0.013	0.058
	(0.047)	(0.029)	(0.032)	(0.035)
log $hser_{t-1}$ · log ... $_{t-1}$	0.213**	-0.133**	0.146**	0.009
	(0.083)	(0.054)	(0.056)	(0.070)
cons	-0.207**	-0.023	-0.039**	-0.044**
	(0.097)	(0.018)	(0.017)	(0.018)
N	60	60	60	60
adj. R^2	0.65	0.60	0.68	0.58
F	5.5	4.7	6.3	4.5

standard errors in parentheses
*** = significant at 1% level
** = significant at 5% level
* = significant at 10% level
regional and time dummies not reported

A feasible alternative is to estimate a separate regression for marketable services taking those branches for which educational figures can be measured with sufficient accuracy and compared across the censuses. Three branches satisfy these conditions: trade, transport and communications, finance and insurance. Aggregating them together and running the same equations as before we get the results reported in table 6. The explanatory power of the human capital variables decreases considerably. The accumulation variable is no longer robust to changes in the model specification. Its coefficient is significant only in the variable shares variants of the model.

It is also worth noticing that the coefficient is smaller and loses explanatory power compared to the whole service sector. Even though this result is not a rigorous test of the hypothesis formulated above, nevertheless it can be regarded as evidence compatible with it.

Table 6. Human capital and output per worker growth in marketable services.

Constant and variable shares, K/L and K/Y specifications. LSDV estimates 1971-2001. Dependent variable average yearly growth rate of output per worker.

	Const.sh.K/L	*Var. sh. K/L*	*Const.sh. K/Y*	*Var.sh. K/Y*
Δlog *kmser*	0.372***	0.399***	0.363***	0.415***
	(0.091)	(0.113)	(0.090)	(0.117)
Δlog *hmser*	1.041	1.187**	0.959	1.068**
	(0.587)	(0.503)	(0.562)	(0.476)
log $hmser_{t-1}$	0.226*	0.308**	0.010	0.189
	(0.119)	(0.147)	(0.121)	(0.139)
log $gmser_{t-1}$	0.034	0.151***	0.006	0.047
	(0.030)	(0.028)	(0.023)	(0.032)
log $hmser_{t-1}$ · log gmse	0.181***	-0.093	0.164***	0.071
	(0.063)	(0.060)	(0.051)	(0.074)
cons	-0.103*	-0.156**	-0.005	-0.103
	(0.059)	(0.072)	(0.060)	(0.067)
N	60	60	60	60
adj. R^2	0.78	0.68	0.79	0.67
F	9.2	5.8	9.4	5.6

standard errors in parentheses
*** = significant at 1% level
** = significant at 5% level
* = significant at 10% level
regional and time dummies not reported

Breaking down the human capital variables according to the schooling level we can see that aggregate results are driven mostly by the secondary component (column 2 of table 7) while the coefficient of tertiary education is not significant. Recalling that tertiary education behaves in the same way in industry this result confirms that it has no impact whatsoever on output growth, both if it is allocated to sectors which can be regarded *a priori* as more dynamic and innovative and to low productivity sectors such as public administration. The type of knowledge (whether technical or not) embodied in the labour force seems more influential than the level of education. The primary component seems uninfluential as well, however the simple slope of the variable *priser* is negative and significant at the 6% level. In the regions with a stock of primary education close to the average the latter is therefore inversely correlated to output per worker growth.

Table 7. Human capital by educational level. Service sector. LSDV estimates 1971-2001. Dependent variable average yearly growth rate of output per worker.

	1	*2*	*3*
Δlog *kser*	0.221**	0.190***	0.159*
	(0.082)	(0.066)	(0.083)
Δlog *hser*	0.513	1.084***	0.156
	(0.434)	(0.350)	(0.424)
log $terser_{t-1}$	0.130		
	(0.172)		
log $gser_{t-1}$ · log *ter*	0.563*		
	(0.293)		
log $secser_{t-1}$		0.192***	
		(0.051)	
log $gser_{t-1}$ · log *sec*		0.460***	
		(0.088)	
log $priser_{t-1}$			-0.035
			(0.059)
log $gser_{t-1}$ · log *pri*			-0.585**
			(0.249)
log $gser_{t-1}$	0.041	0.037**	0.266***
	(0.033)	(0.017)	(0.072)
Cons	-0.014	-0.036***	0.011
	(0.017)	(0.010)	(0.018)
N	60	60	60
adj. R-sq	0.63	0.78	0.65
F	4.8	8.9	5.2

standard errors in parentheses
*** = significant at 1% level
** = significant at 5% level
* = significant at 10% level
regional and time dummies not reported

Concluding remarks

The main results of the analysis presented in the preceding sections can be summarized as follows. In general the explanatory power of the human capital variables in the sectoral growth regressions of the Italian regions is very low.

In the industrial sector neither the accumulation nor the stock of human capital significantly affect the rate of growth of productivity. This result is robust with respect to different methods for calculating total factor productivity and to the inclusion of other control variables like R&D expenditure. It persists also when education is broken down by level and is common to the primary, secondary and tertiary components.

However, restricting the human capital variable to its technical component, the Nelson-Phelps hypothesis is not completely rejected by the data, although it is not robust to changes in the model specification. One possible explanation for this evidence is that the Italian regional economies are scarcely innovative because small firms specialized in the traditional sectors are largely prevalent. In this context human capital variables based on formal education such as those used in this analysis, might not capture properly the effects of other important sources of labour productivity growth like learning on the job and professional training. The evidence suggests also that the type of knowledge acquired through education might matter more than its level for productivity growth. Given also the irrelevance of formal R&D a plausible interpretation in the Italian industrial context could be that a wider diffusion of technical knowledge in the labour force acts as a learning enhancing factor which stimulates incremental innovation. However the results obtained here are mainly suggestive and further investigation is required to get more reliable conclusions on these points.

In the service sector a significant effect on productivity growth can be detected but it gets much weaker in the marketable services branch compared to the whole sector.

In the whole service sector sample the coefficient of the human capital accumulation variable is significant and very robust supporting the neoclassical hypothesis of level effects of human capital on productivity growth. The coefficient is also very high and implies a strong impact on productivity. However the impact is much lower and uncertain when the analysis is confined to marketable services. This incongruence casts some doubt on the results for the whole sector, suggesting that the relationship between human capital and productivity growth might be spurious and due to the strong correlation between educated labour force compensation and value added in the public sector.

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Appendix

Variables description

kind	capital per worker in the industrial sector
hind	returns to total education per worker in the industrial sector = $e^{\mu(E_{it})}$ where μ = Mincerian returns on total years of education (E)
htech	returns to education per worker in the technical professions
gind	ratio between the industrial sector TFP level in the leader region and in region *i*
terind	returns to tertiary education per worker in the industrial sector
secind	returns to secondary education per worker in the industrial sector
priind	returns to primary education per worker in the industrial sector
kser	capital per worker in the service sector
hser	returns to total education per worker in the service sector
gser	ratio between the service sector TFP level in the leader region and in region *i*
terser	returns to tertiary education per worker in the service sector
secser	returns to secondary education per worker in the service sector
priser	returns to primary education per worker in the service sector
kmser	capital per worker in marketable services (trade, transport and communications, finance and insurance)
hmser	total education returns per worker in the marketable services
gmser	ratio between the marketable services TFP level in the

	leader region and in region *i*
R&D	ten years average R&D expenditure/GDP ratio

Data sources

- Data on educational attainment levels come from Italian population censuses (ISTAT: Censimenti della popolazione 1971, 1981, 1991, 2001).
- Returns to education are drawn from Ciccone A., F. Cingano, P. Cipollone (2006). Since the returns to education in each sector and region are not available those estimated for the whole economy have been applied. Ciccone A., F. Cingano, P. Cipollone provide also estimates of the returns to different educational levels, they have been used to construct primary, secondary and tertiary education variables.
- Capital figures are available from the CRENoS database on capital stock in the Italian regions: Regio(cap)-IT 1970-94 (downloadable at: www.crenos.it). The database provides sectoral time series from 1970 up to 1994. The series have been expanded up to 2001 by adding investment and applying a fixed rate of depreciation.
- Labour shares have been calculated from the ISTAT publication: Conti economici regionali. Data on employees income are available since 1980. For the previous years the series have been constructed from the: Annuario di contabilità nazionale.
- Technical professions are drawn from the Italian population censuses.
- The source for R&D expenditure figures is ISTAT: Statistiche della ricerca scientifica.

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