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HUMAN CAPITAL STOCKS AND THE DEVELOPMENT OF ITALIAN REGIONS: A PANEL APPROACH

Abstract: Given recent emphasis on externality to education, macroeconomic studies have a role to play in the analysis of return to schooling. In this paper we study the connection between growth and human capital for the Italian regions in a convergence regression framework. We confirm the usual result on Italian regional convergence that this process began to diminish or fail after about 1975. We include a measure of human capital in the convergence regression as a stock rather than a flows. We find this variable is significant if and only if we control for the size of the public sector. The public sector is itself strongly negative. Decomposing the human capital measure into its constituents, we find that average years of primary and secondary education act positively on growth, but that tertiary education acts negatively. When we estimate the convergence regression for the South and the North-Centre separately, we find no break in the pattern of convergence around 1975. Thus both areas seem to be converging according to a similar process, albeit to different levels of GDP per capita. The role of the human capital is strikingly similar in the two clubs. Finally, we find educating women leads to faster growth.

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1. Introduction

In this paper we ask if there is any role for human capital in Italian regional economic development. As Temple (1998) pointed out, given recent emphasis on externalities to education, macroeconomic studies have a role to play in the analysis of returns to schooling. In such models, the public returns to education will exceed private returns. In contrast, screening models of education generate the exact opposite result.. In both cases, individual-based micro analysis will be useless as a guide to public policy on education.

Differences in human capital endowments and their rates of investment have long been recognised by the theoretical growth literature as an important element in explaining observed GDP gaps. The Italian literature on the relationship between growth and human capital is surprisingly small. Despite that, Italian regional endowments of human capital are far from being perfectly homogeneous. Among the European countries, Italy has the highest dispersion of regional education structure[1]. Thus it is interesting to investigate if the observed differences in human capital can explain significant proportion of the observed regional GDP gaps.

The economic theory of growth includes many contributions emphasising the role of human capital on development. In general, human capital, whether the outcome of formal education or learning by doing, indicates the degree of productivity of the labour force. An investment in human capital arises from a deliberate investment affecting the productivity of individuals. What characterises the different models is the assumed relationship between human capital and growth. As in Aghion and Howitt (1998) we distinguish two different approaches analysing the linkage between growth and education. In the first, human capital is considered as an additional factor of production in a standard production function. Both the works of Lucas (1988) and Mankiw et al. (1992) fall into this category. Within this framework the process of accumulation of human capital is congruent to that of physical capital: it is costly, it subtracts time available to production, but it represents a remunerative investment. The difference between these two models lies in the returns to total capital, human plus physical. The presence of non-decreasing returns in this augmented form of capital

[1] See Lodde (1998). The sample includes Germany, France, UK, Belgium and Italy, 1981-1991.

leads to endogenous growth models wherein human capital accumulation affects long-run growth. On the other hand, decreasing returns implies that human capital accumulation affects growth only in the transition towards the steady state. In general all these models imply a direct role of human capital in the growth process: an increase in human capital accumulation causes an increase in the (long- or short-run) growth rate.

An alternative approach has its roots in the contribution of Nelson and Phelps (1966) and has been recently developed by the so-called Shumpeterian growth literature[2]. This literature de-emphasises the role of capital (both physical and human) accumulation as the engine of growth and highlights the importance of technological change. Within this framework, human capital is a prerequisite for economic growth where "the growth rate of output will depends on the rate of innovation and, then, on the level of human capital"[3]. That is, human capital has a fundamental but indirect role in the catch-up process, increasing the capacity to adopt and implement innovations or new technologies from abroad. These models allow " beta convergence" (catch-up among countries) but this is not caused by the existence of decreasing returns but by knowledge spillovers (or technology transfers)[4]. In this framework we expect that the higher the level of human capital and the larger the technology gap between the follower and the technology leader[5] the higher is the resulting growth rate. Empirically, the main difference with the Lucas approach is that growth rates across countries are explained by differences in human capital *stocks* rather than on their rate of accumulation. In particular, the human capital stock is a proxy for technological advancements that represent the ultimate source of growth: it is the level of human capital that affects the possibility of innovation and thus growth prospects. Moreover, the Shumpeterian approach emphasises the stock of human capital involved in innovative activities. This raises various hypothesis to be tested. Firstly, do

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[2] See Aghion P., Howitt P. (1998), "Endogenous Growth Theory, MIT Press, Cambridge Massachusetts, London England.

[3] Nelson and Phelps (1966).

[4] In this framework can be included also the literature that emphasised the "social capability" as the necessary condition for catching-up. See Abramovitz (1986).

[5] Nelson and Phelps (1966) uses the concept of gap between the theoretical level of technology and the level of technology in practice. A more explicit definition of leader and followers is found in Benhabib and Spiegel (1994).

different levels of education produce different impacts on growth? If so, we expect secondary school and higher education levels to be more important for growth then primary school levels. Secondly, for human capital to be growth enhancing, it must be employed in innovative activities. This distinction is not important in the Lucas approach where education affects individual productivity equally on all jobs.

Following these developments (and differently from other empirical studies of Italian convergence), we focus on the stock of human capital instead of its rate of accumulation. We introduce census data on educational attainment of the labour force. We investigate if differences in male and female education have different impacts on the development of the Italian regions. Finally, we use a new estimation procedure for the study of Italian regional convergence, exploiting both the time-series and the cross-sectional nature of the datasets. It is possible to show that, given the characteristics of the sample, this technique outperforms both cross-section types of analysis and the time series approach in estimating convergence.

This paper is organised into eight sections. The following section describes previous evidence on the effects of human capital on regional Italian convergence and explains the reasons we use the levels of human capital instead of the school enrolment rates as has been done so far. Section 3 introduces some stylised facts about Italian regional convergence and differences in the stock of regional human capital. Section 4, 5 and 6 discuss the major results of our empirical analysis. Section 7 discusses some subsidiary experiments while section 8 contains final observations.

2. Previous empirical evidence

Earlier work has tended to find that that human capital is insignificantly or even negatively correlated with the process of development in the Italian regions. Similar puzzling evidence on human capital is common also in international datasets[6]. Most of these studies proxied human capital by the secondary school enrolment ratio. This flow indicator was first introduced by Mankiw et al. (1992)[7] and its use

[6] See Islam (1995) among others.

[7] They estimated the cross-country growth regressions including a proxy for human capital accumulation or for the percentage of the working-age population that is in secondary school (defined by fraction of the eligible population (aged 12 to 17) enrolled

is consistent with the convergence equation derived from the augmented Solow growth model. Table 5 reproduces the main results on regional Italian convergence. These studies found results anomalous because of the obvious contradictions with theoretical models emphasising the important and positive role of human capital on the growth performance of an economy.

There are different possible explanations for these results. An additional hypothesis that we investigate here is that investments in secondary school do not represent the best proxy when the relationship between human capital and growth is investigated. In particular we investigate if the initial level of educational attainment is more strongly correlated with growth than its rate of change. Previous evidence on international datasets supports this hypothesis[8]. In general, we have seen that the use of stocks instead of flows is theoretically justified by recent models that emphasised the role of technology for growth. Two more observations justify the use of stocks instead of flows. First, it has been argued[9] that the connection across time between growth and educational enrolment is likely to be very weak. Why should a change in the regional school enrolment rates instantly produce an increase in the growth rate? Moreover, even if the use of enrolment rates were theoretically justified by the augmented Solow model, nevertheless this characterisation of the growth process is not natural within a regional framework. The closed economy assumption in these models is particularly implausible given the mobility of capital, human and physical. First, labour mobility within the Italian regions is well documented[10]. The implication is that human capital accumulation in one area does not necessarily contribute to its growth. The regional stock of human capital represents the educational attainments of the labour force effectively present in an area and able to contribute to its productivity. Second, there appears to be no correlation between per capita savings and investment across the Italian regions: see Figure 1.

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in secondary school multiplied by the fraction of the working age population that is of school age (15 to 19)).

[8] See Benhabib and Spiegel (1994).

[9] See Temple (1998).

[10] See Sestito (1992) and Attanasio and Padoa Schioppa (1989) for regional migration patterns and Goria and Ichino (1994) for a specific analysis of the relationships between migration and convergence among Italian regions.

The absence of such a connection mean that some justification for slow convergence other than the limitation of local savings must be sought. Of course, it has long been recognised that requiring investment in an economy to be financed by local savings would not generate observed long lags in convergence. Indeed, it was for this reason that the concept of a broad level of capital, human plus physical, was introduced, wherein savings now include education. This device can explain slow convergence. If, however, one controls sufficiently for human capital in a convergence regression then, in the Solow framework, savings in the narrow sense remain the only source of dynamics. We shall see below that controlling for human capital in this way hardly changes the observed dynamics which seems to imply that the Solow approach is unable to explain the data.

3. A brief descriptive analysis

We start our analysis with a brief description of the main regional differences in human capital endowments. First, we use data from the Italian census to construct four different indicators of the educational attainment of the regional labour force[11]: the illiterate proportion of the labour force and the proportions attaining primary school, secondary school and higher education as a maximum qualification[12]. Data are available for the census years: 1961, 1971, 1981, and 1991. We define the total stock of human capital of the labour force[13] as:

$$\text{Total Stock of Human Capital} = S_j \; YR_j * HK_j$$

where j is the schooling level, YR_j is the number of years of schooling represented by level j, and HK_j is the fraction of the labour force for which the *jth* level of education represents the highest level attained. Within the Italian system, primary level includes eight years of schooling, secondary level is usually attained after 5 years, and University courses include four to six years of attendance. This indicator thus represents a

[11] The exact definition is not labour force but active population.

[12] Note that, we want explicitly to focus on different levels of stock of human capital available in the workforce, without taking into account the stock of educated people in the whole population. It is possible that if one is interested in examining some social capability indicator the latter represents a better proxy while the former characterises a better proxy when the focus of the analysis is on human capital available to production.

[13] Characteristics of the dataset are described in Appendix I and II.

measure of the average years of schooling of the labour force. For descriptive purposes, we consider the usual partition of the Italian peninsula in three geographical areas, North, Centre and South[14]. This aggregation provides a good summary of the main characteristics of the more developed North and the less developed South

Table 6a provides some evidence on the main differences between educational attainment among these three areas. The southern part of the country has experienced a persistent gap in human capital: in 1961 the North had an average of 6 years of education versus 4.4 years in the South. Since 1961, the North and the Centre seem to have converged in term of human capital whereas the South has lagged behind. Gains have been made however: in 1961 the South had 25% lower average years of education than the centre versus 8% by 1991. The data on tertiary education show that this inequality has never been determined by differences in the highest level of education. Surprisingly, between 1971 and 1991 the South had a greater stock of *laureati* (people with post-secondary school education) than the North, while the Centre always had the greatest proportion of highly educated labour force. During the 60s and into the 70s, a very high proportion of the Southern labour force had no formal education. For example, 20% of the Calabria labour force had no school background in 1961 as against 0.2% in Trentino Alto Adige. However, this gap narrowed quickly. By 1981 the proportion of illiterate labour force was almost zero everywhere[15]. This explains why differences narrowed during the 60s and the 70s. The gap in education still present between the South and the rest of the country is caused by the smaller fraction of the Southern labour force with secondary school attainment. Only 25,6% of this workforce completed secondary school, against 29,2% in the North and 30,8% of the centre. This implies that a greater proportion of Southern workers decide to stop the accumulation of educational skills at the primary school level. In summary we identify persistent differences in regional

[14] These three areas correspond to the traditional division of the Italian economic environment in three geographically characterised groups: North, Centre and South. ISTAT, the National Institute of Statistics, distinguishes among, 1) North - Piemonte, Valle d'Aosta, Lombardia, Trentino Alto Adige, Veneto, Friuli Venezia Giulia, Liguria, Emilia Romagna, 2) Centre - Toscana, Umbria, Marche, Lazio, 3) South - Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia and Sardegna.

[15] Although South still shows the highest proportion of labour force without any schooling background, 1.1% in 1991.

human capital endowments. Even if the gap narrowed during the first period covered by our data, the catch-up was not complete and the South still lags behind. We analyse in the next section if these differences and their patterns over time can help to explain the observed regional pattern of growth.

4. Regressions

We investigate if, in contrast to previous results in the literature, human capital introduced as a stock instead of a flow has any effect on growth. Moreover, following the new developments in the theoretical literature discussed above, we test if different levels of educational attainment have different impacts on growth. In fact, if human capital acts on growth only through technological advances we expect to find a key role for the higher levels of education (secondary school and, in particular, tertiary education).

As we have emphasised in the previous section, the most natural way to analyse the role of human capital in a growth regression is to introduce our lagged stocks of human capital [16] in a standard beta-convergence equation: the role of the human capital endowment of an economy is then explicitly introduced into the catch-up process.

We estimate a system of 19 regional equations with an unrestricted variance-covariance matrix, thus allowing for cross-sectional correlation of the disturbances (Maximum Likelihood)[17]. The period covered by our dataset is 1963-94. The system of equations described by:

$$\Delta y_{it} = a + b y_{it-1} + g h_{it-1} + e_{it} \qquad (1)$$

Equation 1 is transformed to:

[16] We do not have data on regional aggregate capital stocks and so are unable to investigate the relationship between human capital and Total Factor Productivity, as in Benhabib and Spiegel (1994). Moreover Krueger and Lindahl (1998) find the inclusion of physical capital in this type of regressions may create problems in the estimate of the coefficient of human capital.

[17] This is obtained by iterating a Feasible Generalised Least Square procedure. ML enjoys no advantage over FGLS procedure in its asymptotic properties. However, it may be preferable in small samples.

(2) $$\Delta y^*_{it} = \beta y^*_{it-1} + \gamma h^*_{i,t-1} + \varepsilon^*_{i,t}$$

where y_{it} is the logarithm of per capita GDP and h_{it} is the logarithm of the stock of human capital in period t for region *i*, and:

(2') $$y^*_{it} = y_{it} - \bar{y}_t \qquad\qquad h^*_{it} = h_{it} - \bar{h}_t$$

where $\bar{y}_t$ and $\bar{h}_t$ are the Italian average GDP in period t[18].

The variable *h* will represent our four different school attainment indices: primary, secondary and tertiary education plus the total stock. All these indicators are estimates of the average years of schooling in the given category[19]. One problem with this formulation is that it is possible to interpret the results produced by this specification within two competing theoretical frameworks. In the Shumpeterian approach, the stock of human capital may directly increase the capacity of an economic area to innovate and, secondly, may improve the potential for adapting and/or adopting new technologies from abroad. Our indicators may capture both these elements. However the use of human capital stock instead of flows can also be justified within the framework of an augmented Solow model. In this case the relevant variable is the steady state level of human capital for which observed human capital levels may represent a good proxy[20]. Thus a positive coefficient in our human capital stock indicator in equation 2 is compatible both with an explicit process of conditional convergence (with human capital the conditioning factor) and with a process of technological catching up described by the Shumpeterian literature.

We start our regression analysis by estimating the standard convergence equation. Model (1) in Table 3 tests absolute convergence. This estimate implies absolute convergence among the Italian regions of approximately 2% a year, consistent with results found by previous

[18] We excluded one region from the sample, the Valle d'Aosta, in the estimation to avoid the multicollinearity arising from the use of data in differences from the mean.
[19] See the Appendices for more details.
[20] For proxying steady state stock human capital Islam (1995), within a panel framework, used the stock of human capital at the end points of his time span.

studies[21] on regional convergence. In model 2 we include the human capital term. The parameter is small and insignificant. A standard result in the literature on Italian convergence is that decreasing dispersion in regional per capital GDP, while strong during the 60s, all but ceased after 1975[22]. Explanations abound. There was a decrease in migration from the South to the North. There were efforts directed towards achieving a uniform wage between the northern and the less productive southern labour force[23]. There was a change in policies directed to foster the development of more backward regions. In particular, the Italian Government's efforts to boost industrial investment (especially in heavy industries like chemicals and steel) in the South during the 60s and part of the 70s is well- documented[24]. After that period, there was a shift in policy from investments to income maintenance in the form of direct transfers and through an expansion of the public sector, also associated with an acceleration in the process of administrative decentralisation. All this notwithstanding, non-homogeneity of the convergence process has been found in studies of other countries. For example, the Spanish regions seem to have experienced a similar pattern[25]. The rapid increase of oil prices in 1973-74 has presumably influenced investments, technology and other factors that may affect the convergence process internationally. Since these issues are not the focus of our study, we simply allow the beta parameter to change after 1975: see model 3. It will be seen that the convergence parameter falls from approximately 3.2% per annum before 1975 to 0.7% after that date. Thus, while beta convergence was strong in 60s and early 70s, it is currently weak and only on the border of significance. In summary, the Golden age, in which Italian GDP grew at 6% per annum, was characterised by rapid convergence in regional per capita GDP. The period starting approximately after the 1974 oil shock saw the end of this process. Note

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[21] See Barro and Sala-i-Martin (1995).

[22] See Mauro and Podrecca (1994), Boltho, Carlin and Scaramozzino (1997), Paci and Pigliaru (1995) among others.

[23] This policy started officially in 1969.

[24] From Graziani (1978), " The distribution of industrial investments has shifted mainly in favour of the Mezzogiorno, 1970 being a noticeable turning point.…. The share of the Mezzogiorno in total industrial investment reached 44% in 1973 against 15% during 1951-59……two important waves of investments have characterised the southern area: the first is in 1959-63 and coincided with a similar phase in the national economy as a whole. The second phase is during the 1969-73 that was peculiar to the south…"

[25] See de la Fuente (1998).

that the human capital term remains small and insignificant in model 2 and 3.

5. Different Levels of Educational Attainments

In Table 4 we decompose the total stock of human capital into components corresponding to the average years of schooling in primary, secondary and tertiary education attained by the Italian regional labour force[26]. This procedure is suggested by the Shumpeterian model discussed above in which the highest levels of educational attainments may act more powerfully on growth. That said, model 4 in table 3 suggests that implementing existing technology is more important than direct innovation for the Italian regions. Model 1 shows that all educational variables are significant but we find an unexpected negative sign on tertiary education. Models 3, 4 and 5 show that this finding is robust to changes in specification. We find that years in secondary school is always positive and significant while primary school shows the expected positive and (marginally) significant coefficient only when the beta shift is included. This last result seems to suggest that the positive role of primary education has been more effective during the earlier part of our sample.

The negative sign on the higher education coefficient is not new in this literature: puzzling evidence on university education has been found also with other international datasets[27]. There are a number of possible explanation for this negative sign. First, it can be argued that, unlike the lower levels of education, higher education does not increase productivity but performs a signalling function in the job market. In Italy, during the period covered by our sample, fees for higher education were almost completely subsidised, with no control on admissions[28]. As pointed out by Blaug, Layard and Woodhall (1969) "In most countries private rates of returns exceed social rates simply because (higher) education is subsidised by the State and subsidies are never recouped by subsequent income taxation of the earnings of educated people". It is possible that low costs have produced too much tertiary education. Another hypothesis is that university education, rather than encouraging

[26] For more details see Appendix I and II.

[27] For example, Wolff and Gittelman find ambiguous evidence on the role of university education as a source of growth.

[28] This is not true for the first period covered by the sample.

productive activities, simply stimulates rent- seeking activities which inhibit growth[29]. Finally it is well documented that the Italian labour market is characterised by a "bureaucratic bias" among the highly educated. Sestito (1992) finds a bias towards bureaucratic skills, mainly in the southern area of the country. Thus a possible explanation of the paradoxical result is that university educated workers have a greater tendency to be employed in the Public Sector, itself characterised by non-innovative and highly routine activities. We will examine this possibility in the next paragraph.

6. The role of the Public Sector

In general the role of the Public Sector within the growth process is controversial. Barro (1990) develops an endogenous growth model in which public consumption is detrimental for growth. In the Italian case there is a large literature on the role of the Public Sector in the development of the *Mezzogiorno*. As discussed above, one possible explanation of the observed shift in the convergence process after 1975 is a change in the nature of public intervention, from provision of physical capital to increases in local Public Administration. It has been argued that decentralisation gives rise to a new class of local bureaucrats with increasing control on local economies. This process may have "raised the scope for rent-seeking activities …usually easier to pursue at a local rather than at a national level"[30]. Mass recruitment of civil servants may have caused a distortion in the allocation of the labour force. Skilled workers may have found it more convenient to dedicate their efforts to rent-seeking rather than entrepreneurial activities. Rent-seeking aside, it is possible that the expansion of Public Administration was distortionary. The recruitment of civil servants was one of the policies adopted in Italy to reduce the very high unemployment levels in the southern area of the country. Thus overstaffing may have created "disguised unemployment"[31]. In both cases, the increase in the public

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[29] Lodde (1995) finds a positive relationship between engineers and growth but a negative one between lawyers and growth among Italian regions. See also Wolff and Gittleman (1993) and Pugno (1998).

[30] See Boltho, Carlin and Scaramozzino (1997) for brief summary of the literature on transfers and rent seeking activity in Italy.

[31] In that case workers are involved in normal working time but their capacity are not fully used. For more details on that see Blaug, Layard and Woodhall (1969). Their

sector has not been governed by efficiency criteria, and has resulted in the absorption of skilled labour force by a non innovative sector.

All of these considerations suggest introducing the relative size of the Public sector as an explanator in the convergence regression. Table 4 reports a number of experiments with this variable. It is itself always negatively signed and strongly significant. Moreover its inclusion makes significant both the total stock of human capital and the primary education variable, indicating that it is necessary to take into account how the human capital is allocated. Thus, it seems that the inclusion of the Public Sector in our model resolves a long-standing paradox in the Italian literature: without the Public Sector indicator the stock of human capital enters insignificantly in the growth equation while the inclusion of this variable shows that human capital is an important positive factor for growth. When we consider the different levels of education, we find that the inclusion of the Public Sector causes the coefficient in Primary school to increase. A slight positive effect is found also on the returns to secondary education. We find however that years of tertiary studies remains significantly negative.

7. Convergence Clubs

There is a clear duality in the Italian economy between the developed North and the less developed South: see figure 2[32]. The shift in the beta parameter after 1975 is almost certainly due to a failure of the South to continue its former rapid growth. This suggests allowing the North-Centre and South to converge separately. Other considerations suggest a separate analysis of these two non-homogenous areas. Krueger and Lindahl (1998) argue that a positive and significant coefficient on the initial level of human capital may result by incorrectly imposing a single coefficient and thus equal returns on schooling among different countries. Kiriacou (1990) explains the anomalous evidence on human capital and growth on assumption that the growth of human capital is more effective the higher is its average level[33]. These hypotheses can be

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description of the characteristics of the Indian university system presents many similarities with the current Italian situation.

[32] This duality has been analysed also in other studies on Italian convergence, usually introducing area dummies. See Table 5.

[33] For example Azariadis and Drazen (1990) describe a model in which the presence of thresholds externalities to education cause the investments in human capital to have any

tested by considering separately the North-Centre and the South, the latter having a lower average level of capital with respect to the former over the sample period[34].

In Table 5 variables are expressed as deviations from the two regional averages (North-Centre, South). In preliminary experiments we found that the beta shift variable was always insignificant and trivial in magnitude. In models 1 and 2, we restrict parameters to be equal in the two areas. It will be seen that, when one allows separate clubs, one finds uniform convergence rates across the Italian regions of about 3 to 5 percent per annum. Human capital and Public Administration perform broadly as before. In models 3 and 4 we allow parameters to differ across the two areas. The aggregate human capital variable performs well in model 3 for the South but is wrong-signed (but insignificant) for the North-Centre. In model 4, where human capital is decomposed into its constituents, we find striking agreement between the two sets of parameters except for primary education, where the South has a much larger value, opposite to Kiriacou. The size of the public sector seems to be more powerful in inhibiting growth in the South, though it is significant in the North-Centre as well. A Wald test rejects joint equality of the two sets of parameters.

7. Subsidiary experiments

One of the aims of this study was to distinguish between the effects on growth of the level of human capital and its growth rate[35]. We generally found that the level out-performed the growth rate. For example, entering the growth rate of the stock in the first model in Tables 1 and 2 we found that the growth rate was small and insignificant, while the level variable remained much as before. Since human capital is controlled for in these experiments, Solow model (with Cobb-Douglas technology) implies the beta parameter should be the product of the share of labour and the growth rate of total labour input in efficiency units (plus the rate of depreciation), say about 6% for

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significant effect on growth only within the countries that overcome a certain threshold level of human capital. See Kiriacou (1991) for an empirical analysis on that point.

[34] Thus the two areas would converge can different equilibria. The SURE estimation procedure does allow the shocks to be correlated among the two different clubs.

[35] See Barro and Lee (1993), Benhabib and Spiegel (1994), Krueger and Lindahl (1998).

Italy[36]. This is at least twice our estimate of beta which casts some doubt on the appropriateness of the Solow model for studying Italian regional growth .

We also tested a specification derived from Benhabib and Spiegel (1994) who develop a model in which the human capital plays two different roles: first, it allows a poor country to catch up with the most developed areas by copying existing technology; second, it facilitates innovation directly. They suggest that the interaction between human capital and GDP per capita should enter the convergence regression, interpreting this variable as reflecting the specific role of human capital in implementing existing technology. We found that the interaction term is positive and significant and tends to drive out the level term. It thus seems that human capital is directly important in the catch-up process and less important for the growth of technology.

Finally, Barro and Sala-i-Martin (1995) and Barro (1997) have tended to find the education of women has a negative effect on growth. This is not the case for our data. Table 2b provides some descriptive evidence. We created measures of relative female educational attainment as the average years of education of females in each category as a proportion of the corresponding male value. In Table 6 we test these variables in both the Italian regional framework (models 1 and 2) and in the convergence club specification (models 3 and 4). The total stock variable is always positive and significant. Results are less clear-cut when the stock is desegregated, but the effect is usually positive and sometimes significant. Educating women in Italy seems to be benign for growth. One plausible explanation for this is that educated women tend to have smaller families so that each child is allocated more maternal time. There is a striking correlation across time between relative female human capital and the rate of population increase. See Figure 3.

8. Summary

We have confirmed the usual result on Italian regional convergence that this process began to diminish or fail after about 1975. We include a measure of human capital in the convergence regression as a stock rather than a flow as is usually done. We find that when we

[36] We assume depreciation rate of 5%, a share of labour of 70% and a growth rate of total labour input of 4%. This last figure is computed for the aggregate Italian economy 1960-90.

control for the size of the public sector, human capital becomes positive and significant. The public sector is itself strongly negative. When we decompose the human capital measure into its constituents, we find that average years of primary and secondary education act positively on growth, but that tertiary education acts negatively. When we estimate the convergence regression for the South and the North-Centre separately, we find no break in the pattern of convergence around 1975. Thus both areas seem to be converging according to a similar process, albeit to different levels of GDP per capita. The role of the human capital is similar in the two clubs except for primary education. The rate of return to primary education is very high in the southern, more disadvantaged, area of the country. This result, together with the positive and significant coefficient on female education, seems to confirm standard results on the effects of education on earnings in the microeconometric literature which, however, have hitherto been difficult to confirm in macroeconomic data. There is no clear evidence that increased education led to an increase in the ability to innovate; rather, increased education seems to have increased the ability to implement existing technology.

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Appendix I

THE DATASET: ESTIMATION OF MISSING OBSERVATIONS

We introduce the census years as initial stock of human capital and then interpolate the remaining years exploiting the available data on school enrolment rates. More precisely, we fill the years between the census years (that is, 1962-70, 1972-80…) for the different educational attainments exploiting the annual data on the secondary school enrolment rates. In general enrolment rates at different levels of education are defined as the ratio between the total number of students enrolled at one specific schooling level and the total number of persons belonging to the relevant age group. Thus we define , the secondary school enrolment rate, as the total number of students enrolled in secondary school weighted by data on the population in the age interval 15-19. We start with the primary school level where changes in the fraction of labour force with primary school attainment (PRIM) are approximated by:

$$1)\ \Delta PRIM_{t+n} = (PRIM_{t+10} - PRIM_{t}) * \frac{(1-p_{t+n})}{\sum_{i=1}^{10}(1-p_{t+i})}$$

$n=1,...,9$

where t defines a census year and (1- p) represents the primary school enrolment rate. More precisely if p represents the secondary school enrolment rate then (1- p) is actually the flow of young people that decide not to continue studying, that is, it is approximately the actual inflow of our primary school stock. To give you an example, if we consider t=1961 then $DPRIM_{t+1}$ is the change in the fraction of labour force with primary school attainment in 1962. This change is equal to the average growth rate of *PRIM* between two subsequent years of the census available (in that case 1961-71) times what we call a proportionality factor (the last element on the right hand side) that takes into account the possible inflow of worker that attained this school level.

An analogous formula was used to interpolate the other non-census years. For secondary school we introduce a similar procedure. In this case changes in the fraction of labour force with secondary school attainment (SEC) were approximated by:

$$1)\quad \Delta SEC_{t+n} = (SEC_{t+10} - SEC_{t}) * \frac{p_{t+(n-5)}}{\sum_{i=-4}^{5} p_{t+i}}$$

$$n=1,...,9$$

where t is always equivalent to a census year and p represents the secondary school enrolment rate. Note that we introduce explicitly a three period lag in our proportionality factor because we expect a lag between an increase in secondary school enrolment rates and the effect of this process in our stock indicator. Thus the lag is necessary to take into account of the different timing between the investment in secondary education (the flow variable) and the actual inflow within the labour force. The use of lags represents a common procedure within this literature[37]. For what concern the workforce that attained post-secondary school education we exploit the same proportionality factor introduced before but using a longer lag[38]:

$$\Delta DEG_{t+n} = (DEG_{t+10} - DEG_{t}) * \frac{p_{t+(n-10)}}{\sum_{i=-9}^{0} p_{t+i}}$$

$$n=1,...,9$$

In that case, we assume the enrolment rates of tertiary education to have similar characteristics with respect to the secondary level.

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[37] Nehru, Swanson and Dubey (1995) noted that "Unlike physical capital educational investments are not placed immediately into service". On this point see also Kyriacou (1991).

[38] In fact, university enrolment ratios were not a good proportionality factor. It is not appropriate to infer from that data the regional high education enrolment ratios because of an obvious "migration effect" that is probably less present at the lower level of education. That is, it is true that a great proportion of students of a particular University are just temporary residents in the region where the University is located.

During our empirical analysis we will introduce four different indicators of human capital: a measure of the total stock of HK described earlier and an indicator of post-secondary, secondary and primary education. In particular these three different levels of educational attainment are defined as:

Average years of *ith* level of schooling in the labour force = $YR_i * HK_i$

where *i* is the schooling level, YR_i is the number of years of schooling represented by level *i*, and HK_i is the total proportion of the labour force that attained the *ith* level of education.

APPENDIX II

Source of Variables

Gross Domestic Product (1963-1994). Source: Prometeia, Bologna.

Population . Source: CRENOS, University of Cagliari, Cagliari.

Population at the age 15-19. Source: See Population.

Women at the age 15-19. Source: ISTAT, Popolazione residente per sesso, eta' e regione, Supplemento al Bollettino mensile di statistica anno 1978, n.11

Female secondary school enrolment rates. Source: ISTAT, Annuario Statistico dell'Istruzione Italiana (1958-1994), Annuario Statistico dell'Istruzione Italiana 1959 (1946-58)

DEG*-Labour force with tertiary school educational attainment (1961, 1971, 1981, 1991). Source: ISTAT, (XII-XV) Censimento della popolazione, fascicoli regionali, vol.II.

Labour force with secondary school educational attainment (1961, 1971, 1981, 1991). Source: See DEG*.

Labour force with primary school educational attainment (1961, 1971, 1981, 1991). Source: See DEG*.

Labour force that did not complete primary school (1961, 1971, 1981, 1991). Source: See DEG*.

Illiterate labour force (1961, 1971, 1981, 1991). Source: See DEG*.

Natural Rate of population Increase. Source: FEEM, Fondazione Eni Enrico Mattei, Milano.

Figure 1

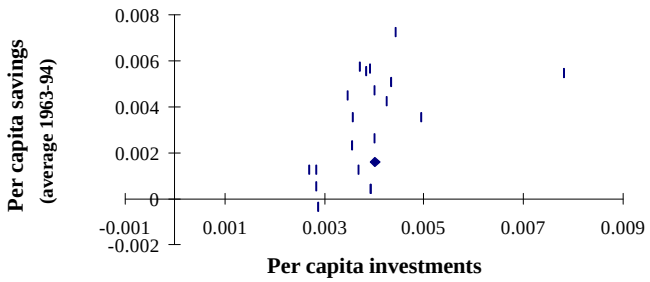

Figure 2

(North-Centre and South averages in evidence, dotted lines=North and Centre regions)

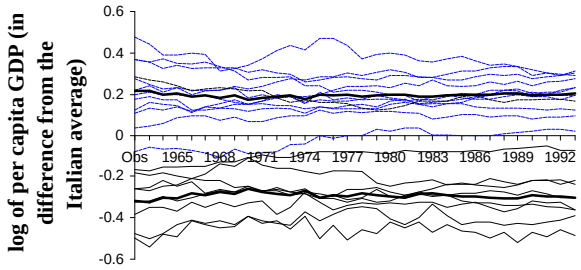

Figure 3

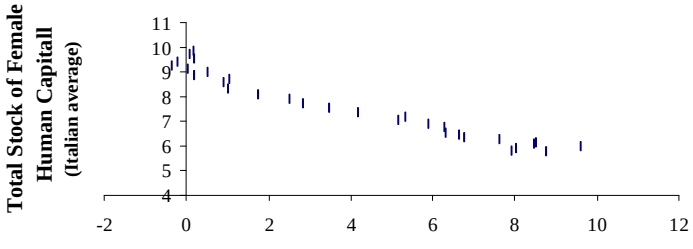

Table 1

The literature on Italian convergence

Explanatory variables		Reference	Results
Area Dummies	South	Boltho et al. (1997)	- (* only 1938-48, 1970-80)
		Cellini -Scorcu (1997)	
		Ichino-Goria(1994)	?
		Bianchi-Menegatti (1997)	-*
		Paci-Saba (1997)	-*
		Mauro-Podrecca (1994)	-
	Centre	Boltho et al.	-
	Adriatico	Paci-Saba (1997)	+*
Education	secondary school enrollment rate	Cellini -Scorcu (1997)	+ (* only 1970-80)
		Mauro-Podrecca (1994)	?
		Paci-Pigliaru (199?)	-
		Bianchi-Menegatti (1997)	+

Notes:
The fourth column gives the sign of the coefficients obtained in these papers. The star indicates that the coefficient is significant at 5% level. A question mark indicates inconclusive results.

Table 2a

Percentage of the totalabour force with different educational attainments

	Total Stock of Human Capital				**Primary School**		
	north	***centre***	***south****		***north***	***centre***	***south***
61	5.94	5.75	4.37	**61**	86.9%	83.6%	64.2%
71	6.40	6.04	4.98	**71**	78.2%	67.1%	55.7%
81	7.96	7.97	7.28	**81**	73.9%	67.4%	64.9%
91	9.39	9.49	8.82	**91**	62.4%	58.0%	61.7%

	Higher Education (degree)				**Some school**		
	north	***centre***	***south***		*north*	*centre*	*south*
61	2.2%	2.8%	2.1%	**61**	3.4%	7.1%	13.9%
71	3.2%	4.3%	3.5%	**71**	8.3%	16.1%	23.7%
81	4.8%	6.3%	5.6%	**81**	2.9%	5.7%	9.9%
91	7.3%	8.9%	7.5%	**91**	1.0%	2.0%	4.1%

	Secondary School				**No school**		
	north	*centre*	*south*		*north*	*centre*	*south*
61	6.3%	6.5%	5.0%	**61**	1.2%	4.4%	14.7%
71	9.9%	11.0%	9.5%	**71**	0.5%	1.5%	7.6%
81	18.2%	20.2%	17.4%	**81**	0.2%	0.4%	2.2%
91	29.2%	30.8%	25.6%	**91**	0.2%	0.2%	1.1%

Notes:

i) According to the ISTAT classification of regions

ii) Total stock of human capital is the average years of education in thelabour force

iii) The percentages in the table represent the percentage of people within the labour force with the corresponding maximum qualification

Table 2b

Percentage of the female labour force with different educational attainments

	Total Stock of Human Capital				**Primary school**		
	north	***centre***	***south***		***north***	***centre***	***south***
61	6.07	5.74	4.16	**61**	85.5%	74.3%	53.2%
71	6.68	6.39	4.94	**71**	76.4%	60.4%	42.7%
81	8.33	8.39	7.82	**81**	70.7%	61.3%	54.7%
91	9.88	10.02	9.58	**91**	56.6%	51.2%	52.2%
	Higher Education (degree)				**Some school**		
	north	***centre***	***south***		*north*	*centre*	*south*
61	1.6%	2.5%	2.0%	**61**	3.6%	7.5%	14.2%
71	3.0%	4.8%	4.3%	**71**	8.0%	17.6%	28.1%
81	4.8%	7.0%	7.2%	**81**	2.6%	6.2%	10.9%
91	8.5%	11.1%	10.6%	**91**	0.8%	2.1%	4.0%
	Secondary School				**No school**		
	north	*centre*	*south*		*north*	*centre*	*south*
61	8.3%	10.3%	9.1%	**61**	0.9%	5.4%	20.9%
71	12.1%	15.5%	14.5%	**71**	0.4%	1.7%	10.4%
81	21.8%	25.2%	24.5%	**81**	0.2%	0.4%	2.8%
91	34.0%	35.5%	32.2%	**91**	0.1%	0.2%	1.0%

Notes:

i) According to the ISTAT classification of regions

ii) Total stock of human capital is the average years of education in the labour force

iii) The percentages in the table represent the percentage of people within the labour force with the corresponding maximum qualification

Table 3

Human Capital in Convergence Regressions

Sample: Italy (19 regions, 1963-1994)

Dependent variable: regional growth rates yit - yit-1	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Beta-Convergence: yit-1	-0.019	-0.020	-0.007	-0.008	-0.007	-0.001	-0.019
	(-7.19)	(-6.08)	(-1.92)	(-2.03)	(-1.81)	(-0.45)	(-5.78)
Beta-Shift (before 1975)			-0.025	-0.022	0.020	-0.026	
			(-5.44)	(-4.26)	(-3.95)	(-5.70)	
Total stock of human capital		0.001	0.0008				
		(0.76)	(0.56)				
Average years of tertiary studies				-0.111	-0.125	-0.030	-0.170
				(-3.93)	(-4.78)	(-3.00)	(-6.37)
Average years of secondary studies				.023	.027		.042
				(2.98)	(3.77)		(5.51)
Average years of primary studies				.004			-0.0002
				(1.64)			(-0.09)

Notes:
i) t-stats in brackets
ii) yit is the logarithm of per capita GDP in region i in period t
iii) Beta-convergence is the beta parameter in equation 2.
iv) Total stock of human capital means the average years of schooling in the labour force
v) Average years means the average years of each level of schooling in the labour force
vi) Variables are expressed as deviations from the Italian average

Table 4

The Role of the Public Sector

Sample: Italy (19 regions, 1963-1994)

Dependent variable: regional growth rates yit - yit-1	**1**	**2**	**3**	**4**
Beta-Convergence: yit-1	-0.018 (-5.63)	-0.008 (-2.09)	-0.010 (-2.44)	-0.017 (-5.31)
Beta-Shift (before 1975)		-0.025 (-5.41)	-0.022 (-4.16)	
Total stock of human capital	0.004 (2.55)	0.003 (2.19)		
Average years of tertiary studies			-0.116 (-4.17)	-0.164 (-6.24)
Average years of secondary studies			0.028 (3.56)	0.043 (5.73)
Average years of primary studies			0.009 (3.82)	0.006 (2.45)
Proportion of the Public Sector	-0.009 (-4.82)	-0.008 (-4.29)	-0.010 (-5.53)	-0.011 (-5.93)

Notes:
i) t-stats in brackets
ii) yit is the logarithm of per capita GDP in region i in period t
iii) Beta-convergence is the beta parameter in equation 2.
iv) Total stock of human capital means the average years of schooling in the labour force
v) Average years means the average years of each level of schooling in the labour force
vi) Proportion of the Public Sector means public sector employment as a proportion of the total labour force
vii) Variables are expressed as deviations from the Italian average

Table 5

North-Centre and South as Convergence Clubs

Dependent variable: regional growth rates yit - yit-1	Restricted* Estimates		Unrestricted Estimates	
	1	2	3	4
Beta-Convergence: yit-1 (North-Centre)	-0.045	-0.032	-0.046	-0.036
	(-8.49)	(-6.10)	(-7.07)	(-5.18)
Total stock of human capital (North-Centre)	0.018		-0.022	
	(1.33)		(-1.50)	
Average years of tertiary studies (North-Centre)		-0.027		-0.025
		(-4.53)		(-2.73)
Average years of secondary studies (North-Centre)		0.032		0.024
		(3.53)		(1.87)
Average years of primary studies (North-Centre)		0.028		-0.001
		(1.64)		(-0.05)
Proportion of the Public Sector (North-Centre)	-0.012	-0.013	-0.005	-0.008
	(-5.96)	(-6.40)	(-2.16)	(-2.97)
Beta-Convergence: yit-1 (South)			-0.042	-0.031
			(-4.68)	(-3.05)
Total stock of human capital (South)			0.161	
			(5.03)	
Average years of tertiary studies (South)				-0.023
				(-2.11)
Average years of secondary studies (South)				0.028
				(1.30)
Average years of primary studies (South)				0.177
				(4.39)
Proportion of the Public Sector (South)			-0.031	-0.034
			(-4.23)	(-3.25)

Notes:
*In model 1 and 2 the parameters are restricted to be the same in the two areas
i) t-stats in brackets
ii) yit is the logarithm of per capita GDP in region i in period t
iii) Beta-convergence is the beta parameter in equation 2.
iv) Total stock of human capital means the average years of schooling in the labour force
v) Average years means the average years of each level of schooling in the labour force
vi) Proportion of the Public Sector means public sector employment as a proportion of the total labour force
vii) Variables are expressed as deviations from the regional (North-Centre or South) average
viii) The beta-shift has never been introduced in the included results

Table 6

Female labour force

Dependent variable: regional growth rates yit - yit-1	**Sample: Italy (19 regions, 1963-1994)**		**Convergence Clubs (North-Centre and South, 1963-94)**	
	1	**2**	**3**	**4**
Beta-Convergence: yit-1	-0.003 (-0.83)	-0.0007 (-0.15)	-0.036 (-6.84)	-0.030 (-5.55)
Beta-Shift (before 1975)	-0.027 (-5.95)	-0.027 (-4.59)		
Total stock of human capital	0.033 (2.74)		0.021 (1.66)	
Average years of tertiary studies		-0.026 (-4.23)		-0.023 (-3.61)
Average years of secondary studies		0.031 (3.52)		0.029 (3.32)
Average years of primary studies		0.047 (2.52)		0.011 (0.59)
Relative total stock of female human capital	0.001 (4.59)		0.0012 (5.12)	
Relative female years of tertiary studies		0.011 (1.41)		0.010 (1.30)
Relative female years of secondary studies		-0.009 (-1.06)		-0.003 (-0.38)
Relative female years of primary studies		0.0007 (1.33)		0.0015 (2.73)
Proportion of the Public Sector	-0.010 (-5.36)	-0.011 (-5.16)	-0.014 (-7.08)	-0.016 (-6.90)

Notes:
i) t-stats in brackets
ii) yit is the logarithm of per capita GDP in region i in period t
iii) Beta-convergence is the beta parameter in equation 2.
iv) Total stock of human capital means the average years of schooling in the labour force
v) Average years means the average years of each level of schooling in the labour force
vi) Proportion of the Public Sector means public sector employment as a proportion of the total labour force
vii) In models 1 and 2 variables are expressed as deviations from the Italian average; in models 3 and 4 variables are expressed as deviations from the regional (North-Centre and South) averages
viii) Relative female years means average years of female education in the labour force as a proportion of male years

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