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## Neoclassical versus technological convergence: An empirical analysis applied to the Italian regions

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**Neoclassical versus Technological Convergence:  
An Empirical Analysis Applied to the Italian Regions**

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# Neoclassical versus Technological Convergence: An Empirical Analysis Applied to the Italian Regions

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**Abstract.** This paper tests for the existence of neoclassical and/or technological catching up between the Italian regions in the last three decades. The tests are performed by means of a modified  $\beta$ -convergence equation and of a model based on the decomposition of output growth. The results imply that while the neoclassical convergence mechanism occurred, the technological one failed. The paper also provides a possible explanation for these results and analyses their policy implications, suggesting that a complete convergence between the Italian regions may be achieved only by promoting technological transfers and by increasing research expenditure in backward regions.

**Keywords:** Convergence, catching up, TFP, Italian regions

**JEL Classification:** O41, O47, O49

## 1. Introduction

An examination of the Italian regional accounting data shows that in the last three decades the growth of GDP per worker has been on average higher in poorer than in richer regions. This phenomenon has led to a reduction in GDP per worker differences, thus causing a form of convergence between regions. The experienced convergence, however, has been only partial, since the GDP per worker of the least developed regions is still quite below that of the most developed ones.

The existence of a negative relationship between the initial GDP per worker and subsequent growth is a phenomenon largely documented in the economic literature, with reference to both cross-countries and cross-regions analyses. A large evidence on this phenomenon was firstly provided by the well-known papers by Abramovitz (1986), Baumol (1986), Barro (1991) and Mankiw, Romer and Weil (1992), and was then confirmed by a wide literature applying different techniques and examining different data sets (as, for instance, in Barro and Lee (1994), Barro and Sala-i-Martin (1995), Sala-i-Martin (1996) and Temple (1999)).<sup>1</sup>

It is interesting to notice that the theoretical foundations of the idea that poor economies should catch up the rich ones can be traced indifferently to two alternative types of approach. On the one hand, the neoclassical Solow-Swan growth model implies that least developed economies should exhibit higher rates of capital accumulation because of the assumption of a decreasing marginal productivity of capital. On the other hand, the technological catching up approach (initially developed by Abramovitz (1986), Baumol (1986) and Dowrick and Nguyen (1989), and recently introduced in an endogenous growth model by Howitt (2000)) suggests that a catching up should occur because of the capability of follower economies to easily imitate the production technology of the leader.

Unfortunately the empirical tests about the two alternative theories described above have usually been performed in the literature by means of the same econometric procedure and specification, i.e. by simply examining the

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<sup>1</sup> Recent surveys on this field have been provided by Temple (1999) and Islam (2003).

previously cited relationship between the initial level of output per worker and its subsequent growth (actually the other way round, with growth being the variable to be explained). The use of the initial output as a regressor, however, has two different interpretations according to the two alternative brands of theoretical literature. In the approach founded on the Solow-Swan model it is a proxy for the level of the initial capital per worker, while in the technological catching up approach it proxies the level of the initial technology. A negative relationship between the initial GDP per worker and its subsequent growth is thus seen in the two cases respectively as an indication that backward economies exhibit higher growth either because of their larger capital accumulation or because they can easily imitate the technology of the most developed economies.

The potential ambiguity of the convergence literature with reference to the theoretical mechanisms at its basis was primarily noted by Stokey (1994) and Temple (1999). A first attempt to solve this problem was proposed by Rogers and Dowrick (2002), who tried to distinguish and to test separately the two possible convergence mechanisms in a cross-section of countries, by introducing in the estimated equation both a measure of capital accumulation and the initial value of output per worker, as a proxy for the initial TFP level.

The aim of this paper is to try to distinguish and identify the factors underlying neoclassical and/or technological catching up in the partial convergence process occurred between the Italian regions in the last thirty years. The analysis will be based on a theoretical model and on a derived empirical specification, capable of completely separating the two possible alternative mechanisms at work. Differently from Rogers and Dowrick (2002), indeed, this study proposes to use direct measures both for the initial regional capital per worker and for the initial regional TFP. The first measure is provided by the estimates made either by Paci and Pusceddu (2000) or by Bonaglia and Picci (2000). The measure of the initial technology is instead a microeconomic proxy computed on the basis of a data sample of almost 23,000 firms surveyed by Mediocredito Centrale (1977).

The proposed analysis clearly indicates that the convergence process experienced between the Italian regions was due to the dynamics of capital accumulation, as suggested by standard neoclassical theory, while on the contrary

a technological catch up did not occur. It will be claimed that this conclusion is relevant for two different reasons. On the one hand it is important since it describes the true cause behind the experienced convergence. On the other hand it reveals which mechanism did not work, thus indicating, by consequence, what kind of policy interventions ought to be implemented in order to complete or improve the convergence process.

The paper is organized as follows. Section two shows the empirical evidence about convergence between the Italian regions in the period 1970-2002 and examines its potential sources. Section three discusses and compares the neoclassical and technological convergence mechanisms. Section four examines a possible explanation for the failure of a technological catching up between the Italian regions. Section five analyses the policy implications that can be derived from the empirical results found. Section six concludes.

## **2. The convergence process and its possible sources**

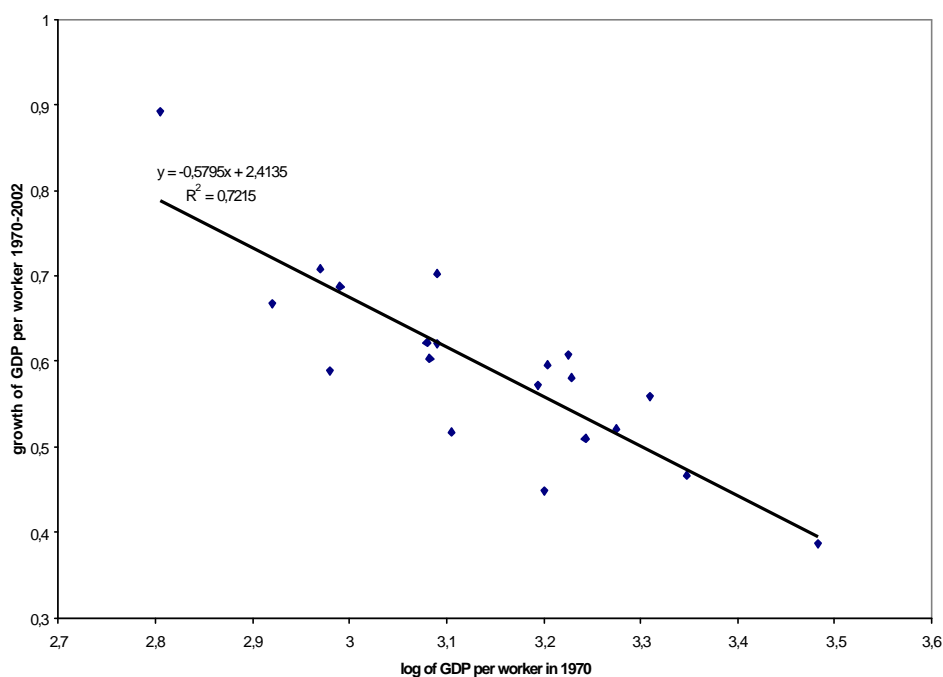
A simple test for the possible existence of a convergence process between the Italian regions can be performed by using the so-called absolute  $\beta$ -convergence equation first studied by Baumol (1986), Barro (1991) and Barro and Sala-i-Martin (1991). This equation simply studies a cross-countries (or cross-regions) relationship between the growth of GDP per worker in a given period and the initial level of GDP per worker. If the relationship is found to be negative, it is claimed that poorer economies grow faster than richer ones, thus implying that a convergence process in the level of output per worker has occurred. The *absolute  $\beta$ -convergence equation* is thus given by

$$\ln\left(\frac{y_t}{y_0}\right) = \alpha + \beta \ln(y_0) \quad [1]$$

where  $y_t$  is GDP per worker in the final year and  $y_0$  is GDP per worker in the initial year.

This equation has been estimated for the period 1970-2002 using Italian regional data.<sup>2</sup> The estimated value of coefficient  $\beta$  is  $-0.579$ , which is statically significant at the 1% level.<sup>3</sup> This result supports the claim that a convergence process between the Italian regions has taken place in the period under consideration.<sup>4</sup> A similar evidence is shown in figure 1, where a scatter plot between the two relevant variables and the derived regression line are reported. A confirmation of this result, finally, is also given by the dynamics of the regional coefficient of variation, whose value decreases from 0.15 to 0.10 in the same period 1970-2002.<sup>5</sup>

Figure 1. Convergence between the Italian regions in the period 1970-2002



Although a convergence process has occurred, it can be easily shown that the experienced catch up is far from being complete. Indeed, the average value of

<sup>2</sup> The data used in the empirical analysis are taken from the most recent Crenos database (2004), revised in order to be compatible with the new national accounting series released by Istat.

<sup>3</sup> The associated t-statistics is  $-6.83$ .

<sup>4</sup> Similar results were found in other works with reference to different time periods. In particular, Paci and Pigliaru (1997) found a negative relationship between initial GDP per worker and its subsequent growth in the period 1970-92, while Bianchi and Menegatti (1997) found some evidence of absolute  $\beta$ -convergence in the period 1970-94.

<sup>5</sup> This is the bulk of the so-called *s-convergence analysis*.

GDP per worker in the five poorest regions in 2002 is still 80% of the corresponding average value in the five richest regions.

This phenomenon of partial convergence can be theoretically justified by two different mechanisms. On one hand it is possible to assert that backward regions grew faster than more developed ones because of a decreasing rate of capital accumulation, as suggested by the Solow-Swan growth model. On the other hand, the experienced convergence could be due to technological transfers from richer to poorer economies, enabling the latter ones to improve their production techniques. These two alternative convergence mechanisms, and their actual working, can be easily illustrated by a simple theoretical framework.

Consider a closed economy where firms produce a single good  $Y$  using a Cobb-Douglas production function

$$Y_t = A_t K_t^\theta L_t^{1-\theta} \quad [2]$$

where  $Y_t$  is output,  $K_t$  capital,  $L_t$  labour, and  $A_t$  the level of technology. Assuming, as usual, constant returns to scale, this equation implies

$$y_t = A_t k_t^\theta \quad [3]$$

where  $y_t$  is output per worker and  $k_t$  capital per worker.

Let us assume furthermore that capital depreciates through time at a constant rate  $d$ , while population grows at a constant rate  $n$  and saving is a given constant fraction  $s$  of output (with  $0 < s < 1$ ). Under these assumptions, capital accumulation is described by the usual dynamic equation<sup>6</sup>

$$\dot{k}_t = sy_t - (d + n)k_t. \quad [4]$$

Finally let us assume that technology improves through time at a constant rate  $g$  so that

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<sup>6</sup>  $\dot{k}$  obviously refers to the derivative of the capital stock with respect to time.



$$A_t = A_0 e^{gt} \quad [5]$$

The rate of technical progress  $g$  is however assumed to be dissimilar in different economies.

Substituting equation [5] into [3], differentiating with respect to time and dividing by  $y_t$  we get

$$\frac{\dot{y}_t}{y_t} = \theta \frac{\dot{k}_t}{k_t} + g \quad [6]$$

The technological catching up approach suggests that there are technological transfers from the economy with superior technology to the other ones. This hypothesis can be formalised by assuming that the features of technical progress for any economy are described by the following equation:

$$g = \varphi + \psi \ln\left(\frac{A^*}{A}\right) \quad [7]$$

where  $\mathbf{j}$  and  $\mathbf{y}$  are constant terms and  $A^*$  is the higher value of  $A$  (technological leadership) in the group of economies under examination. Substituting [7] into [6] we get then:

$$\frac{\dot{y}_t}{y_t} = \theta \frac{\dot{k}_t}{k_t} + \left( \varphi + \psi \ln\left(\frac{A^*}{A}\right) \right) \quad [8]$$

The two terms in the right-hand side of [8] illustrate the two possible catching up mechanisms at work. The first term shows that the growth of output per worker depends upon capital accumulation. Since, according to equation [4] and by the assumption of decreasing returns to capital in [2], accumulation is larger in backward economies, this term implies that poorer regions will exhibit a higher growth of output per worker (*neoclassical catching up*). The second term

shows instead that a higher output growth will be generated by a greater distance from the technological leadership, so that economies with a lower initial level of technology will grow faster (*technological catching up*). Obviously the two alternative mechanisms can work either separately or together.

The analysis in the next section will test for the existence of these two mechanisms in the convergence process experienced by the Italian regions, by using an appropriate econometric specification. Before implementing this test, however, it seems useful to perform an analysis of *conditional b-convergence*, in order to compare its results with those of *absolute b-convergence*, already studied by means of equation [1]. The analysis of conditional convergence is performed, as usual, by examining the relationship between the initial level of GDP per worker and its subsequent change, after controlling for all other variables capable of characterizing the different steady states of the economies under examination or, in general, of all other variables capable of affecting economic growth.<sup>7</sup> The equation to be estimated in this case is

$$\ln\left(\frac{y_t}{y_0}\right) = \alpha + \beta \ln(y_0) + \gamma X \quad [9]$$

where  $\mathbf{g}$  is a vector of parameters and  $X$  is a vector of control regressors. Vector  $X$  usually includes several variables, such as: the investment ratio (INV), the labour force growth (N) and the stock of human capital (H) (the Appendix provides a detailed description of these variables).<sup>8</sup> Our database also includes a microeconomic measure of the initial regional TFP, which can be used to test the hypothesis of technological catching up. This measure is obtained from a data set referring to a sample of 23,000 firms surveyed by Mediocredito Centrale (1977).<sup>9</sup>

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<sup>7</sup> This kind of analysis was firstly implemented by Barro (1991) and Barro and Sala-i-Martin (1991). For more details on this approach see also Barro and Sala-i-Martin (1995).

<sup>8</sup> Because of a limited availability of comparable series, the data for human capital used are their average values in the period 1970-1994. The same data are employed in the regressions appearing in table 1.

<sup>9</sup> The data used to derive regional TFPs concern production, employees and the capital stock for each firm in 1973. Starting from this type of elementary information and summing up the data referring to every region, one can compute the value of regional TFPs by assuming that the production function is Cobb-Douglas and the factors of production elasticities are equal to their

When equation [9] is estimated, the coefficient  $\beta$  is equal to  $-0.863$  and is statistically significant in a strong way.<sup>10</sup> This result can be interpreted as a further confirmation of the existence of absolute convergence, as indicated by equation [1].<sup>11</sup> Moreover the estimate of the coefficient associated with variable  $A$  is equal to  $0.204$  and is also strongly significant from a statistical standpoint.<sup>12</sup> This further result has two implications. Firstly it shows that differences in the initial technology are relevant for growth, thus implying that technology transfers can be a potentially relevant source of convergence. Secondly it indicates that the steady states of the Italian regions are different, with the obvious implication that, even if the neoclassical convergence mechanism had worked completely, a full convergence between the Italian regions could have been achieved only if a technological catch up had occurred too.

### 3. Neoclassical versus technological convergence

On the basis of the results of previous analysis we can now compare the relevance of neoclassical and technological convergence mechanisms. For this purpose we use two different econometric specifications. First we start with estimating a simple modification of a *conditional b-convergence* equation, where the two catching up mechanisms are distinguished. Indeed, equation [9] examines the possible existence of a catching up phenomenon simply by introducing the initial output per worker among the regressors. In order to test separately the hypotheses of neoclassical and technological catch up, we introduce a different additional regressor to take into account both possible mechanisms at work. Therefore a test for assessing and comparing the validity of the two alternative explanations for convergence consists in estimating the equation

$$\ln\left(\frac{y_t}{y_0}\right) = \alpha + \beta \ln(k_0) + \gamma \ln\left(\frac{A_0^*}{A_0}\right) + \delta X \quad [10]$$

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shares in regional income. The same measure of regional TFP was used in Bianchi and Menegatti (1997).

<sup>10</sup> The associated t statistics is  $-9.16$

<sup>11</sup> The existence of *absolute b-convergence* obviously implies that of *conditional b-convergence*.

The variable  $\ln(k_0)$  is the logarithm of the initial capital per worker. A negative coefficient associated with this variable would confirm the neoclassical conjecture that capital accumulation is larger in backward regions, thus favouring their faster growth. In our analysis we make use of two alternative estimates of the initial capital stock, taken respectively from the two series computed by Paci and Pusccheddu (2000)<sup>13</sup> and by Bonaglia and Picci (2000). These two alternative estimates of the regional capital stocks are labelled INK1 and INK2 respectively.

The variable  $\ln\left(\frac{A_0^*}{A_0}\right)$ , called DIFA, is a measure of the distance between the initial TFP of any region ( $A_0$ ) and the TFP of the region being the technological leader ( $A_0^*$ ). A positive coefficient associated with this variable would confirm the conjecture that the least developed regions partially converge to the richer ones because they can easily improve their technological level by imitating the technology of the leader. The methodology used in the construction of the data set referring to this variable has been described in section two.

The most relevant coefficient estimates of the variables appearing in equation [10] are shown in table 1; in particular, the table summarises the estimates for the parameters  $\mathbf{b}$  and  $\mathbf{g}$  obtained in regressions using a different set of control variables<sup>14</sup>. The period examined goes from 1970 to 2002.

*Table 1. Neoclassical vs. technological catching up in  $\mathbf{b}$ -convergence regressions*

Regressors	Estimate for $\beta$	Estimate for $\gamma$	Adjusted $R^2$
INK1, DIFA	-0.290 (-2.45)	0.129 (1.44)	0.26
INK1, DIFA, INV, N, H	-0.411 (-3.21)	0.009 (0.09)	0.45
INK2, DIFA	-0.074 (-0.78)	0.164 (1.58)	0.04
INK2, DIFA, INV, N, H	-0.238 (-2.03)	0.007 (0.61)	0.26

Note: t-statistics in parentheses.

<sup>12</sup> The associated t-statistics is 4.42.

<sup>13</sup> The series are collected in Crenos (2000).

<sup>14</sup> The figures appearing in parentheses are the associated values of the t-statistics.

An inspection of the results of the estimates shows that the coefficient for the initial capital stock per worker is negative and strongly significant in both regressions using the capital stock data provided by Paci and Pusceddu. The estimates made by using the capital stock data supplied by Bonaglia and Picci both show a negative  $\mathbf{b}$  coefficient, which is however (slightly) significant only in the regression where control variables are introduced. The overall results, considered together, give anyway a strong indication in favour of the existence of a neoclassical convergence mechanism.

The coefficient for the differences in initial TFP, on the contrary, is never significant in all four regressions. The results obtained, therefore, clearly reject the conjecture that a technological catch up has occurred between the Italian regions.

A possible shortcoming of the previous approach is given by the fact that each of the estimated regressions is not a direct consequence of an explicit economic model, but simply consists of an equation including a group of variables affecting growth.<sup>15</sup> A possible solution to this potential problem is obtained by using a second econometric specification, provided by a modification of the solution proposed by Dowrick and Rogers (2002) and directly derived from the simple model described in section two. In fact, if one considers the logarithm of the ratio  $\frac{y_t}{y_0}$ , using the production function [3] and a modification of equation [7]

(where the proportional growth rate of  $A$  is substituted by the total growth of  $A$  in the period under consideration), one gets

$$\ln\left(\frac{y_t}{y_0}\right) = \theta \ln\left(\frac{k_t}{k_0}\right) + \varphi + \psi \ln\left(\frac{A_0^*}{A_0}\right) \quad [11]$$

Thanks to this result we can study neoclassical and/or technological convergence by estimating the equation

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<sup>15</sup> In fact these are the so-called “informal growth regressions” (Temple, 1999), which are however the most largely used techniques to study the sources of growth from an empirical point of view.

$$\ln\left(\frac{y_t}{y_0}\right) = \alpha + \beta \ln\left(\frac{k_t}{k_0}\right) + \gamma \ln\left(\frac{A_0^*}{A_0}\right) \quad [12]$$

The value of coefficient **b** can be used to test the presence of a neoclassical catching up due to diminishing returns to capital, while the value of coefficient **g** can be used to test the presence of a technological catching up due to technology transfers.

The estimates of the most relevant coefficients appearing in equation [12] are reported in the first three lines of table 2.<sup>16</sup> The table shows the results obtained by using different data for the capital stock. The first two series (called GRK1 and GRK2) are obtained from the Paci and Pusceddu (2000) and the Bonaglia and Picci (2000) estimates. Since both series are limited to the first half of the 1990s, the estimates made are related to the period 1970-94. However, Crenos has recently computed a new series for the regional capital stocks, referring to the period 1980-2002, using the new regional accounting data released by Istat. Linking these new data to those in Paci and Pusceddu (2000) for the earlier period 1970-1980, we computed a series of capital growth for the overall period 1970-2002, called GRK3.

The estimates again support the claim for the existence of a neoclassical convergence mechanism, while they reject the hypothesis of a technological catch up. These results thus confirm the previously reached conclusions: convergence between the Italian regions has depended upon capital accumulation, while technological catching up has not been a relevant phenomenon.

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<sup>16</sup> It should be noticed that equation [11] could be estimated also by introducing human capital in the production function. We would have in this case

$$\ln\left(\frac{y_t}{y_0}\right) = \alpha + \beta \ln\left(\frac{k_t}{k_0}\right) + \gamma \ln\left(\frac{A_0^*}{A_0}\right) + \delta \ln\left(\frac{h_t}{h_0}\right)$$

where *h* is human capital per worker. All estimations reported in table 2 have been repeated also by using this last equation. The results achieved are analogous to those obtained without human capital. However the estimates of the coefficient associated with human capital are in general negative and not significant.

*Table 2. Neoclassical vs. technological catching up in growth rate decomposition regressions*

Regressors	Estimate for $\beta$	Estimate for $\gamma$	Adjusted $R^2$
GRK1, DIFA	0.296 <sup>a</sup> (2.32)	0.015 (0.18)	0.16
GRK2, DIFA	0.340 <sup>a</sup> (2.26)	0.012 (0.14)	0.15
GRK3, DIFA	0.152 <sup>a</sup> (2.32)	0.124 (1.36)	0.24
GRK4, DIFA	0,306 <sup>a</sup> (2.42)	0.022 (0.27)	0.18
GRK5, DIFA	0.377 <sup>a</sup> (2.51)	0.020 (0.24)	0.20
GRK6, DIFA	0.163 <sup>a</sup> (2.44)	0.127 (1.40)	0.26

Notes: t-statistics in parentheses; <sup>a</sup> the hypothesis that the coefficient is 1 is rejected at the 1% confidence level.

A possible problem with the previous specifications is related to the possibility that technical progress is somehow embodied in the new capital goods. If, indeed, improvements in technology are introduced in the production process by substituting old equipments with new ones, then the growth rate of capital (in all our three measures GRK1, GRK2 or GRK3) can include both the sheer increase in capital due to the accumulation process and the improvements in the technology used.<sup>17</sup> For our purposes it is necessary to distinguish between the two phenomena, since only the first one is actually consistent with neoclassical convergence. In order to achieve this result, we deduct the effect of technical progress from the overall increase in the capital stock as measured by statistical data, thereby obtaining a variable which is meant to capture pure capital accumulation. This variable is obtained by computing the residuals of the regression between capital growth and a proxy for embodied technological progress at the regional level. This possible proxy for embodied technical progress is given by the number of patents registered in each region. A dataset by Crenos (1999), in particular, provides information on the number of registered patents in

<sup>17</sup> Note that this potential shortcoming is not present when using the specification shown in equation [10], where just the level of the initial capital stock is introduced.

the two periods from 1981 to 1985 and from 1990 to 1994.<sup>18</sup> The growth rates of the capital stock computed by using the residuals of the three just recalled regressions (one for each empirical measure of the capital stock) are labelled respectively GRK4, GRK5 and GRK6.

The tests about the validity of the neoclassical and technological convergence mechanisms performed using the new capital growth series excluding embodied technical progress are shown in the last three lines of table 2. These tests clearly confirm the existence of neoclassical convergence, while rejecting the hypothesis of a technological catching up.

#### **4. The failure of a technological catching up**

The analysis developed in the previous section indicates that the partial convergence process occurred between the Italian regions, described in section two, has been due to a neoclassical catching up mechanism relying on the features of capital accumulation. The effect of a technological catch up, on the contrary, was substantially not relevant for the experienced phenomenon of convergence.

The aim of this section is to deepen the analysis of this last result, by examining the relationship between the state of the initial technology and the subsequent technical progress. This analysis is important for two different reasons. Firstly it is necessary to confirm the conclusion reached above concerning the failure of a technological catching up. If, indeed, this conclusion is correct, it means that technical progress has been faster in the regions with a higher initial TFP. This conjecture is tested in this section. Secondly, when the conclusion is confirmed, the examination of the relationship between the initial technology and the subsequent technical progress is useful in order to understand the specific reasons why a technological catching up did not occur and what kind of intervention may be necessary in order to make it work in the future.

The simplest way to test whether the level of technology has grown at a faster rate in regions characterised by higher initial levels of TFPs is to compare

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<sup>18</sup> The residuals are computed using the registered patents in the two periods as separate regressors. The residuals computed using the sum of patents in the two subperiods as a single regressor generate results similar to those shown in the table.



the values of regional TFPs in different instants in time. Unfortunately we have just one observation for a microeconomic based TFP, since the surveys by Mediocredito Centrale made after 1977 do not provide the information necessary to replicate the experiment.

Even if a direct comparison of TFP in different periods is not possible, we can try to infer some information about the dynamics of technology by examining the data on some variables related to the size and intensity of regional technical progress. In particular, in order to see whether technological progress has been more rapid in the regions with a higher initial TFP, it is possible to examine the relationship between the number of registered patents and the initial TFP.<sup>19</sup> The results obtained with this enquiry are summarised in the first two lines of table 3.

The estimates performed clearly indicate the presence of a positive relationship between the initial level of regional TFP and the subsequent number of registered patents. This result confirms the conjecture that regions with a larger initial TFP have experienced a higher pace of technical progress, thus providing an explanation for the failure of a technological catching up.

*Table 3. Initial regional TFP and patents or research expenditure in subsequent years*

Regressor	Coefficient estimate	R <sup>2</sup>
PAT8185	0.007 (3.06)	0.31
PAT9094	0.002 (2.98)	0.29
RESEXP	0.502 (2.50)	0.22

Note: t-statistics in parentheses.

The phenomenon just described could finally be explained by examining the choice made in each region with reference to the amounts spent to promote technological improvements. Some information on this issue can be obtained by examining the relationship between the average share of regional GDP devoted to

<sup>19</sup> The two regressions examine the relationship between the initial TFP and the number of patents in period 1981-85 and 1990-94 respectively. A result similar to those reported in the table is obtained by using the sum of patents in the two periods.

research expenditure<sup>20</sup> and the initial TFP. The estimate obtained by following this approach is shown in the last line of table 3, which indicates the presence of a positive and strong relationship between the two variables. This result, together with the previous one, yields a possible final conclusion about the failure of technological convergence: the technological catch up did not take place since the regions with a higher initial TFP experienced a more rapid technical progress because of a larger fraction of their resources devoted to research, which also led to a higher number of innovations and patents.

## **5. Policy implications**

The analysis proposed in the previous sections examined the sources of the partial convergence phenomenon experienced by the Italian regions, comparing the two possible catching up mechanisms suggested by the relevant economic theory. The results obtained are important not only for a correct understanding of the factors behind the convergence process but also for the identification of the means that could help economic policy to promote a complete or more intense recovery of backward regions.

In order to examine these implications let us reconsider the previously reached conclusions together. Firstly, the analysis at the end of section two showed the existence of significant differences in the regional levels of technology in 1970. This result clearly indicates that a complete convergence between the Italian regions can occur only if these differences are eliminated. Secondly, the comparison between alternative catching up mechanisms suggested that a neoclassical convergence occurred in the last decades while a technological one did not. Capital accumulation was therefore capable of generating convergence while technological transfers were not.

The obvious implication of these two conclusions is that, since a process of technology homogenization is not autonomously generated by technology imitation, a complete convergence between the Italian regions will be possible only if this process is stimulated by a specific public policy. This policy should

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<sup>20</sup> The data published by Istat on this variable are available for the period 1978-2001.

act in two directions. On the one hand it should favour the transfer of technology from more developed areas to backward ones<sup>21</sup>. On the other hand it should promote an increase in the share of resources devoted to research especially in poorer regions. Policies acting on the dynamics of physical capital, on the contrary, seem less useful to increase convergence since a catching up due to capital accumulation has already taken place.

## **6. Conclusions**

The Italian regions experienced in last three decades a phenomenon of partial convergence leading to a reduction in the differences between the regional values of GDP per worker. This paper tried to show which of the possible mechanisms proposed by the relevant economic theory was responsible for generating the observed convergence results, by comparing in an empirical analysis neoclassical and technological catching up.

The test about the validity of the two alternative mechanisms was performed using two different possible econometric specifications and a few different measures of the regional capital stocks. The results indicate in all cases the presence of a neoclassical convergence mechanism, excluding, on the contrary, the existence of a technological catching up. The empirical investigation performed thus clearly indicates that the convergence phenomenon occurred between the Italian regions has been completely due to capital accumulation.

A possible explanation for this conclusion may be derived from an investigation of the relationship between the initial levels of regional TFP and subsequent technical progress, as measured by data concerning patents and research expenditure. This investigation showed, indeed, that a technological catching up did not take place because the regions initially provided with a better technology were also characterised by a greater number of innovations and a higher share of GDP in research expenditure.

The study of the sources of convergence between the Italian regions has quite relevant policy implications. The empirical analysis performed and the

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<sup>21</sup> This transfer might be stimulated, for instance, by creating conditions favourable to the localization of firms in the less developed areas.

results achieved clearly indicate, in fact, that the effort to reduce regional differences in GDP per worker in Italy should be concentrated in promoting technological transfers between regions and in increasing the amount of resources dedicated to research in backward areas, rather than insisting in stimulating capital accumulation there.

## 7. References

- Abramovitz M. (1986), "Catching up, Forging Ahead and Falling Behind", *Journal of Economic History*, 46, 385-406.
- Barro R. J. (1991), "Economic Growth in a Cross Section of Countries", *Quarterly Journal of Economics*, 106, 407-433.
- Barro R. J. and Sala-i-Martin (1991), "Convergence across States and Regions", *Brookings Papers on Economic Activity*, 1, 107-182.
- Barro R. J. and Lee J.-W. (1994), "Sources of Economic Growth", *Carnegie-Rochester Conference Series on Public Policy*, 40, 1-46.
- Barro R. J. and Sala-i-Martin X. (1995), "*Economic Growth*", McGraw-Hill, New York.
- Baumol W. J. (1986), "Productivity Growth, Convergence and Welfare: What the Long-Run Data Show", *American Economic Review*, 76 (5), 1072-1085.
- Bianchi C. and Menegatti M. (1997), "Differenziali regionali di produttività e crescita economica: un riesame della convergenza in Italia nel periodo 1970-94", *Studi Economici*, vol. 63, 15-42.
- Bonaglia F. and Picci L. (2000), "Lo stock di capitale nelle regioni italiane", Working paper n. 374, DSE, Università di Bologna.
- Crenos (1999), "Data bank on regional patents", Cagliari.
- Crenos (2000), "Regio(cap)-It 1970-1994. Data bank on the capital stock of the Italian regions", Cagliari.
- Crenos (2004), "Regio-It 1970-2002. Database on the Italian regions", Cagliari.
- Crenos (2005), "Regio(cap)-It 1980-2002. Data bank on the capital stock of the Italian regions", Cagliari.

- Dowrick S. and Rogers M. (2002), "Classical and Technological Convergence: beyond the Solow-Swan Growth Model", *Oxford Economic Papers*, 54, 369-385.
- Dowrick S. and Nguyen D. T. (1989), "OECD Comparative Economic Growth 1950-85: Catch up and Convergence", *American Economic Review*, 79, 1010-1030.
- Howitt (2000), "Endogenous Growth and Cross-Countries Income Differences", *American Economic Review*, 90, 829-846.
- Islam, N. (2003), "What Have we Learnt from the Convergence Debate?", *Journal of Economic Surveys*, 17, 309-362.
- Mankiw N. G., Romer D. and Weil D. N. (1992), "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 107, 407-437.
- Mediocredito Centrale (1977), "*Indagine sulle imprese manifatturiere - 1973*", Roma
- Paci R. and Pigliaru F. (1997), "Structural Change and Convergence: an Italian Regional Perspective", *Structural Change and Economic Dynamics*, 8, 297-318.
- Paci R. and Pusceddu N. (2000), "Stima dello stock di capitale nelle regioni italiane: 1970-1994", *Rassegna Economica, Quaderni di ricerca*, 4, 97-118.
- Sala-i-Martin (1996), "The Classical Approach to Convergence", *Economic Journal*, 106, 1019-1036.
- Solow R. M. (1956), "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, 70, 65-94.
- Stokey N. (1994), "Sources of Economic growth: Comments on Barro-Lee", *Carnegie Rochester Conference on Public Policy*, 40, 47-57
- Swan T. W. (1956), "Economic Growth and Capital Accumulation", *Economic Record*, 32, 334-361.
- Temple J. (1999), "The New Growth Evidence", *Journal of Economic Literature*, 37, 112-156.

## 8. Appendix

We summarise in this section the description and the source of the regressors used in the paper.

*Table A1. Regressors description and source*

Variable	Description	Source
INK1	Capital stock per worker in 1970	Estimates by Paci and Pusceddu (2000)
INK2	Capital stock per worker in 1970	Estimates by Bonaglia and Picci (2000)
INV	Average of the investment/GDP ratio in the period 1970-2002	Istat
N	Average growth rate of employment (in standard labour units) in the period 1970-2002	Istat
H	Participation in secondary school in the period 1970-94	Istat
A	TFP in 1973	Estimates based on data by Mediocredito Centrale (1977)
GRK1	Capital growth in the period 1970-94	Estimates by Paci and Pusceddu (2000)
GRK2	Capital growth in the period 1970-94	Estimates by Bonaglia and Picci (2000)
GRK3	Capital growth in the period 1970-2002	Our computations on estimates by Paci and Pusceddu (2000) and new data by Crenos (2005)
GRK4	Residuals of the regressions of GRK1 on PAT8185 and PAT9094	
GRK5	Residuals of the regressions of GRK2 on PAT8185 and PAT9094	
GRK6	Residuals of the regressions of GRK3 on PAT8185 and PAT9094	
DIFA	Logarithm of the ratio between the largest value of A and the value of A in each region	
PAT8185	Number of patents in the period 1980-85	Crenos (1999), data bank on regional patents
PAT9094	Number of patents in the period 1990-94	Crenos (1999), data bank on regional patents
RESEXP	Share of GDP devoted to research expenditure in the period 1978-2001	Istat