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MIND THE GAP: CONVERGENCE OF TECHNOLOGY AND TECHNOLOGY OF CONVERGENCE IN ITALIAN REGIONS, 1982-2001.

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ABSTRACT.

This paper presents a convergence analysis of labour productivity and total factor productivity across Italian regions. We check the robustness of the results by using an alternative measure of multi-factor productivity, and applying a test for the convergence hypothesis (as distinct by the mean reversion hypothesis). We interpreted the results against the backdrop of the structural change process have been occurring in the Italian economy for the late 1990s. Labour productivity doesn't show evidence of convergence, while TFP does. Technology diffusion matters more than capital accumulation, and convergence at the aggregate level is driven by convergence in service sectors. We conclude that systematic reliance on innovation, public R&D expenditure, diffusion of ICTs, together with the rise of financial and communication sectors, seem to compose the mix that is leading to the convergence of technology.

JEL Classification Codes: O41, O47

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1 Introduction

The hypothesis of economic convergence received much attention in the last decades as a consequence of the renewed interest in economic growth. The convergence hypothesis was among the main factors characterizing the traditional growth models as distinct from the so-called “new growth theory”. The evidence of a persistence of disparities in GDP per capita and income between the Western developed countries and the Southern world countries, stimulated new theorizing efforts in the late 1980s. A crucial feature of the models belonging to this new stream is the endogeneization of technological change, as an effect of investments in human capital and R&D activities. Hence countries with different levels of human capital and/or R&D investments are characterized by different growth paths (Romer 1986; Romer, 1990; Lucas, 1988).

The convergence hypothesis relies on the traditional growth models (like the one by Solow, 1957), in which diminishing returns to capital are the main responsible of catching-up from lagging behind countries (or regions). Regions with lower levels of capital per worker are likely to grow faster than regions with higher levels, converging toward the steady state level of output per capita. Within this framework cross-country (or cross-regional) disparities in GDP per capita and in income are likely to disappear in the long run.

Much empirical work has been done, to test the convergence hypothesis implicit to the traditional growth theory. The pioneering study by Baumol (1986) found the evidence of convergence of GDP per capita among 16 OECD countries. Drawing upon Maddison’s data, the regression he run yielded a negative relationship between the annual growth rate of GDP per capital and its level at the first year observed. The analysis had unfortunately a structural weakness due to a bias in the selection of the countries sample. Other analyses followed, which used larger datasets including countries from the less developed areas in the world. The distinction between absolute and conditional convergence was then introduced, to account for the different steady states which may characterize countries with different technological and political conditions (Barro, 1991; Barro and Sala-i-Martin, 1991; Barro and Sala-i-Martin, 1992; Sala-i-Martin, 1996a; Sala-i-Martin, 1996b).

The main argument convergence discontents have moved to this strand of analysis is that, focusing on the impact of capital accumulation, it says nothing about the effects of technology and policy differences even when conditional convergence is at stake. Moreover, the convergence analysis of GDP per capita (say labour productivity) and income have little or null relationships with economic growth in the observed countries. The dynamics of stratification and clustering, and hence the change in the distribution functions, should be the main object of analysis in this respect (Quah, 1996). As far as the role of technology is concerned, an alternative index of productivity has been proposed, the Total Technological Productivity (TTP), to account also for the changes in technology affecting output elasticities rather than the parameter A in the production function, which is in turn what Total Factor Productivity (TFP) account for (Bernard and Jones, 1996a; Bernard and Jones, 1996b).

In this paper we carry out an analysis of convergence in Italian regions in the period 1982-2001, comparing the evidence about labour productivity with that concerning TFP, and eventually investigating the dynamics of TTP. This analysis is relevant for at least two reasons. Firstly, it adds one more contribution to the still few analyses of convergence of technology. Secondly, to the best of our knowledge, this is the very first time such a kind of analysis is carried out focusing on Italian regions. The investigation has been conducted both at the Total Industry and at the single sector level, against the backdrop of a general process of structural change Italian economy has been facing for a decade. The emergence of two different models of capitalism after the Second World War provides an interesting conceptual framework to the understanding of productivity mobility in the-cross regional distribution. We found evidence of convergence at the national level for labour productivity and more strikingly for TFP. Disentangling the sector evidence, such a general tendency to convergence appears to be led by service sectors. We conclude that the transition towards the knowledge economy is the most likely responsible of convergence generally observed, eventually sustained by the increase in the level of educational attainment and the increasing importance of R&D activities carried out both within and outside firms' boundaries, and where the rise of Knowledge-Intensive Business Services (KIBS) represents a both an outcome and a mean.

The paper is organized as follows. In Section 2 we review the traditional approach to convergence, introducing the subsequent elaborations focusing on technology. Section 3 outlines the empirical framework, providing a picture of the characteristics of the "First" and the "Second" capitalism, as they evolved after the World War II. In Section 4 we describe the data and provide the results of convergence regressions by sector. In section 5 we check the robustness of the analysis by applying Lichtenberg's (1994a) test on convergence hypothesis and exploring the index of TTP. In Section 6 follows a discussion in the light of the background outlined in Section 3. Finally conclusions are drawn in Section 7.

2 Is That Convergence?

The traditional approach to convergence is well exposed in Barro and Sala-i-Martin (1992), and it can be summarized as follows. Let's start directly from a Cobb-Douglas production function:

$$y = f(k) = Ak^{\alpha} \tag{1}$$

Where low case letters indicate output and capital per unit of effective worker, Le^{xt}, L is labour and x is the exogenous rate of growth of labour augmenting technological change. The solution of the model, log-linearized around the steady state, yields the following result:

$$\log[y(t)] = \log[y(0)] \cdot e^{-\beta t} + \log(y^*) \cdot (1 - e^{-\beta t}) \quad (2)$$

Where the positive parameter β governs the speed of adjustment to the steady state. The average growth rate of y on the whole period observed is given by:

$$\frac{1}{T} \cdot \log\left[\frac{y(T)}{y(0)}\right] = x + \frac{1 - e^{-\beta T}}{T} \cdot \log\left[\frac{y^*}{y(0)}\right] \quad (4)$$

Where the time span ranges from *0* to *T*.

The hypothesis of β-convergence maintains that poor economies, either countries or regions, tend to grow faster than rich ones (Sala-i-Martin, 1996a). However, the seminal study carried out by Baumol (1986) already raised a bunch of problems. While the limitations due to the sample bias jeopardized the reliability of the results, they also made it clear the need for comparing a larger set of countries, in order to have a more robust test of the convergence hypothesis. However, the comparison of countries (or regions) having relevant economic differences is far from an automatic extension of the model. The traditional convergence hypothesis actually predicts that poorer and richer economics tend to converge to the same steady state, while it is likely that different economies may have different steady states due to the idiosyncratic political and technological conditions. That's why a distinction between *absolute* and *conditional* β-convergence has been eventually proposed. The former refers to the univariate case, while the latter refers to the multivariate one. In other words, in the conditional β-convergence in the right hand side of the equation a vector appears accounting for other variables affecting the convergence process. Such distinction can be understood comparing equation (5) and (6), stemming from equation (4):

$$\frac{1}{T} \cdot \log\left(\frac{y_{i,t_0+T}}{y_{i,t_0}}\right) = B - \left(\frac{1 - e^{-\beta t}}{T}\right) \cdot \log(y_{i,t_0}) + u_{i,t_0,t_0+T} \quad (5)$$

$$\frac{1}{T} \cdot \log\left(\frac{y_{i,t_0+T}}{y_{i,t_0}}\right) = B - \left(\frac{1 - e^{-\beta t}}{T}\right) \cdot \log(y_{i,t_0}) + \psi X_{i,t_0} + u_{i,t_0,t_0+T} \quad (6)$$

Where $X_{i,t}$ is the vector of variables holding constant the steady state of economy i (Sala-i-Martin 1996a). In larger samples, also comprehending third-world countries, poorer countries are likely to catch-up the richer ones *if* the former have high human capital per person, but not otherwise (Barro, 1991).

Besides the β-convergence, the concept of σ-convergence refers to the reduction over time of the cross-sectional dispersion of GDP per capita. This is to say that:

$$\sigma_{t+T} < \sigma_t \tag{7}$$

These two concepts are not independent, and Sala-i-Martin (1996) very clearly shows how β-convergence is a necessary condition for σ-convergence, even if not sufficient.

As mentioned above, the traditional convergence hypothesis received many critiques within the economic arena. On the one hand some authors argued that such an approach, focusing the interest on labour productivity, misses important aspects concerning technology and factor accumulation. The convergence analysis puts much emphasis on capital accumulation as driving force behind convergence. The analysis of labour productivity, however, doesn't allow for disentangling the separate influences of capital and technology. Moreover, if capital really is so relevant in the growth process, why the market doesn't compensate it adequately? Besides these limitations, the usefulness itself of the questions addressed by this strand of analysis is questioned, as it neglects issues like the nature of the interaction among countries, the existence of poverty traps, and so on and so forth (Quah, 1996; Bernard and Jones, 1996a and b). Finally, Friedman (1994) argues that the carrying out of convergence analysis leads to a kind of Galton's fallacy, in which the results one can get are fairly tautological.

The aim of this paper is to focus the analysis on productivity convergence, providing an account on the role of technology in the (possible) catching-up process. To this purpose, Bernard and Jones (1996b) elaborated a simple model of productivity growth, deriving testable implications for cross-sections of productivity levels and growth. Let's recall it here in a few passages. Productivity for a given sector in country *i* evolves according to the following relationship:

$$\ln P_{i,t} = \gamma_i + \lambda \ln D_{i,t} + \ln P_{i,t-1} + \ln \varepsilon_{i,t} \tag{8}$$

Where $P_{i,t}$ is the productivity, γ_{it} is the asymptotic growth rate of productivity in the country-sector, and λ parametrizes the speed of catch-up denoted by D_{it}. This latter in turn is a function of the ratio between the productivity in the country-sector and the most productive country in the sample:

$$\ln D_{i,t} = \ln\left(\frac{P_{i,t}}{P_{1,t}}\right) \tag{9}$$

The natural path for productivity turns out to be:

$$\ln\left(\frac{P_{i,t}}{P_{1,t}}\right) = (\gamma_i - \gamma_1) + (1-\lambda)\ln\left(\frac{P_{i,t-1}}{P_{1,t-1}}\right) + \ln \nu_{i,t} \tag{10}$$

This formulation implies that when $\lambda>0$ there is an impetus for catch-up: differences in productivity among the two countries increase the relative growth rate of the country with lower productivity. However, only if $\lambda>0$ and $\gamma_i=\gamma_1$ the countries' productivity will converge.

With these specifications in mind, let's turn now to drawing the background of the painting we want to realize. In the next section the main features of the Italian production system, and of its evolution, will be outlined as key to understanding the results of convergence analysis.

3 Some Stylized Facts about the Evolution of Italian Capitalism

The evolution of the Italian economy after World War II, has been represented by economic historians as one characterized by two distinct forms of capitalism, which are supposedly complementary. The expression "first capitalism" refers to a system featured by a core of large firms, both private and publicly owned, which mainly emerged in North-western Italy. These firms usually operated in highly capital-intensive sectors, like chemicals, steel and car production. Their growth was also enabled by the relying on government support, sometimes even in direct monetary terms. Some authors have argued that the Italian government in this period played the role of an entrepreneur (Amatori and Colli, 2000).

The "second capitalism" is instead the outcome of a dynamic and dispersed entrepreneurial spirit, which has venerable origins. It mainly consists of small and medium sized firms, which are settled in areas traditionally based on the work of artisans and croppers. It is the outcome of the evolution of proto-industrial systems, helped by the changes in the production technology and the conditions of the 1970s. Firms are usually linked by systemic ties, giving rise to the well known industrial districts, which are specialized in the production of consumer goods in the sectors of the so called *Made in Italy* (Antonelli and Militello, 2000).

These two capitalistic formations differ not only with respect to the organization of the production activity. They also elaborated two distinct ways of organizing the innovative activity[1]. On the one hand the large firms within the "first capitalism" are the only one able to integrate R&D activities within their boundaries (Nelson, 1959).

[1] This point has been elaborated more pervasively in Antonelli and Quatraro (2006).

In this respect they represent the very modern side of the national economic system, even if their efforts measured in terms of R&D expenditure and patents applications are weak in comparison to other large firms in OECD countries. This particular regional system of innovation basically corresponds to the North Western Italian regions. Firms carry out internal R&D activities aimed at introducing radical and generic technological innovations, able to engender a shift in the technological frontier.

On the other hand, the "second capitalism" which flourished in a macro-regional area roughly corresponding to the Adriatic coast, expanding from the original core in Veneto and Emilia towards Abruzzi and Puglie. One can find here a prevailing number of small firms, which are characterized by the mainly tacit content of technological knowledge. Learning activities are the core of knowledge accumulation, as they become a complementary factor in the innovation process. The adoption of innovations created elsewhere was followed by an intense effort aimed at adapting such technologies to the local characteristics of the economic system. Thus firms within this context carry out an innovative activity directed to the movement along the technological frontier rather than shifting it (Quatraro, 2005a).

In the late 1990s Italy started experiencing the same process of structural change which affected the United States in the 1980s and the United Kingdom in the early 1990s. The transition from the declining industrial economy towards the new digital economy in Continental Europe is slow. In many ways it follows the changes experienced by the US and UK economies, in the late 1990s. At the same time it exhibits its own path that reflects the idiosyncratic characteristics of their economic systems and their own specific momentum. The Italian case is characterized by a clear and strong divide between the path of change followed by the old industrialized regions and the late industrializing ones. While in the first firms seems exposed to raising problems, unable to cope with the decline of performances in both domestic and international markets, the second capitalism seems better able to take advantage of the new general purpose information and communication technologies by means of a process of creative adoption (Antonelli and Quatraro, 2006; Quatraro, 2006a).

4 Productivity and Technology: A Cross-Industry Comparison

In this section the results for cross-regional β- and σ-convergence in labour productivity and TFP are presented for five sectors and for the 20 Italian regions. Before proceeding to the analysis, we describe the data looking at the changing composition of output across regions.

4.1 The Data

The convergence analysis in this work is carried out by using data for five sectors and total industry for the 20 Italian regions. The five sectors are *agriculture and fisheries*, *manufacturing*, *constructions*, *monetary and financial intermediation*, *trade and hotels and communication*. The basic data source is the national accounting statistics provided by the National Bureau of Census (ISTAT), containing information about GDP, number of employees, gross fixed investments, and labour income. All the data are expressed in constant terms, on 1995 basis. We constructed labour productivity and multi-factor productivity using these variables.

Labour productivity is measured as the ratio between value added and the number of employees. The construction of multi-factor productivity is slightly more complex. We followed Solow (1957) in deriving a Hicks-neutral measure of technological change, by accounting for the shifts in the production function. Differently from that framework, we didn't apply the Divisia-Tornquist methodology. We derived the output elasticity of labour starting from the production function:

$$Y = AK^{1-\alpha}L^{\alpha} \tag{11}$$

Which implies a constant-returns-to-scale framework. Under the assumption of perfect competition, production factors are paid their marginal productivity, and hence one can write down the following relationship:

$$P'_L = w$$

Which can be written as follows:

$$\alpha\frac{Y}{L} = w \quad \rightarrow \quad \alpha_{it} = \frac{w_t L_{it}}{Y_{it}} \tag{12}$$

This expression allows us to calculate the output elasticity of labour, assuming a Cobb-Douglas production function. The multifactor productivity is then obtained through the following relation:

$$A_{it} = \frac{Y_{it}}{K_{it}^{1-\alpha}L_{it}^{\alpha}} \tag{13}$$

Where the stock of fixed capital is obtained by applying a lag operator to gross fixed investments (*GFI*) as follows:

$$K_t = GFI_t + 0.8GFI_{t-1} + 0.4GFI_{t-2} \tag{13a}$$

The index we obtained in such a way is a measure of multifactor productivity which is consistent with the Solowian TFP, as we allow output elasticities to vary over time.

Some basic questions of course remain as to what interpretations to give to differences in levels and rates of change of TFP. While Solow (1957) associated TFP growth with technological advances, Abramovitz (1956) defined the residual as some sort of measure of ignorance. Nonetheless it remains a useful signalling device, in that it provides useful hints on where the attention of the analysts should focus (Maddison, 1987).

Tables 1 and 2 summarize the average growth rates of labour productivity and TFP by region and sector, in the period 1982-2001. As far as labour productivity is concerned, the picture at the Total Industry level reveals that the four basic Italian macro-regions have similar average growth rates. It is worth stressing that regions like Molise, Marche and Friuli show up growth rates well above those of regions like Piedmont, Lombardy or Liguria (i.e. the most important North-Western regions). At the same time, Emilia Romgna's, Abruzzi's and Veneto's productivity growth rates are very close to the national value.

A deeper glance at the sectoral productivity highlights that at the national level the sector with the highest labour productivity is Agriculture and Fisheries, while the one having the worst performance is the Financial and Monetary service sector. In most of Italian regions, traditional sectors like agriculture and manufacturing, show up higher growth rates of labour productivity than service sectors. Within this framework, North-Western regions appear to have better performances than North-Eastern and Adriatic regions in the traditional sectors, while the reverse applies as far as service sectors are concerned.

INSERT TABLE 1 ABOUT HERE

For what concerns TFP, at the Total Industry level the situation is a kind of painful. It strikingly appears from table 2 that for most Italian regions, as well as for the national level, the average growth rate is negative. The same kind of evidence can be found if one looks at the Construction sector. In general the picture obtained by analyzing TFP is slightly more puzzling, above all when compared with the one concerning labour productivity. North Eastern and Adriatic regions (in particular, Emilia Romagna, Abruzzi, Molise and Puglia) show up higher TFP growth rates than in the North-West, both in the Manufacturing and in the Financial and Monetary Intermediation sector. Moreover, it is the Trade service sector that now is characterized by negative growth rates in most regions.

It is hence straightforward that whether to look at labour productivity or TFP is a crucial decision, in that the results can be very different. Even if disentangling the impact of technology from that of capital accumulation seem to us the most preferable approach, we will keep on following a comparative approach in analyzing cross-regional convergence in the next section.

INSERT TABLE 2 ABOUT HERE

4.2 Cross-Regional Convergence

In this section we use the data presented above to test the hypothesis of convergence in labour productivity and TFP, according to the models reviewed in section 2. As we are dealing with regions belonging to the same nation, it is reasonable to assume that no sensible differences in steady states should apply. The β-convergence hypothesis for labour productivity can thus be tested by deriving an econometric specification from equation (5) requiring the application of a non-linear least squares regression. Alternatively, an econometric specification implying the use of OLS can be used, like the following:

$$\frac{1}{T}\cdot\Delta\log\left(\frac{Y}{L}\right)_{t=0}^{T}=\alpha+\beta\log\left(\frac{Y}{L}\right)_{t=0}+\varepsilon \qquad (14)$$

Where the speed of convergence λ can be calculated from the following relationship:

$$\beta=\frac{1-(1-\lambda)^{T}}{T} \qquad (15)$$

INSERT TABLE 3 ABOUT HERE

The results of the econometric analysis are reported in table 3. At the Total Industry level it seems that lagging behind regions grow faster than the richer. The speed of convergence is 2,67%, which is consistent with the findings of Barro and Sala-i-Martin (1991). From the Figure 1 it is possible to have an idea of how regions are distributed around the regression line. In general it seems that it can be observed the clustering of North-Western regions in the bottom-right part of the diagram, while Adriatic regions are mostly on the top-left part. However, there are some regions, like Emilia Romagna and Umbria which lie on the centre of the diagram, making these results slightly ambivalent.

INSERT FIGURE 1 ABOUT HERE

At the sectoral level, the regression results for the Manufacturing and the Construction sectors are not good, as the t statistics are lower, and correspondingly the variance explained by the model is unimportant. The results for the Trade and the Financial and Monetary Intermediation service sectors are instead very good, and they turn out to converge at a speed of 3,03% and 3,45% respectively.

In table 4 comparable results are shown for the TFP measure of multifactor productivity. The econometric specification is the following:

$$\frac{1}{T} \cdot \Delta \log(TFP)_{t=0}^{T} = \alpha + \beta \log(TFP)_{t=0} + \varepsilon \qquad (16)$$

Where the speed of convergence is calculated the same way as before. At the Total Industry level there is evidence for convergence, and the speed of catching up is estimated about 4,2%. Surprisingly, there is no evidence of convergence in the manufacturing sector, and the hypothesis of no-mean reversion can't be rejected. This consistent both with the above findings about labour productivity, and with those in Bernard and Jones (1996b). The same applies also to the Agriculture sector. Service sectors still show up a strong evidence of convergence, as both the *t* statistics and the R^2 are fairly high. The Trade, Hotel and Communication sector turns out to converge at a speed of about 8.95%, while the Financial and Monetary service sector at a speed of 3.2%.

INSERT TABLE 4 ABOUT HERE

In the top-right side of Figure 1 we plot the result of the convergence regression for TFP at the Total Industry level. In this case the clustering of North-Eastern and Adriatic regions in the top-left side of the diagram is even more evident than for labour productivity, while North-Eastern regions still lie in the bottom-right side. Regions like Emilia, Marche, Abruzzi and Molise are characterized by higher growth rates of TFP, while the TFP in 1982 was comparatively low.

To better understand the movements and convergence of productivity, we turn now to a measure of σ-convergence, the cross-section standard deviation of log-productivity over time. This also allows for ruling out the trap of Galton's fallacy. The decline of standard deviation of log-productivity reflects the fact that regions' productivity levels are getting closer and closer. In Figure 1 we also compare σ-convergence of labour productivity and TFP at the Total Industry level. In the first case one can observe a reduction of dispersion since 1987, while in the second case is observable since 1985. However the range of variation is sensibly different. Labour productivity dispersion in the period 1987-2001 decreases of about 29%, while in the same period TFP dispersion decreases of about 48%. The magnitude of reduction is a non-trivial issue, and it will be at the core of the Lichtenberg's test of convergence we will discuss below.

In figure 2 σ-convergence both of productivity measures are compared, at the sectoral level. Agriculture and Fishery sectors don't show up any evidence for convergence neither for labour productivity nor for TFP. The same evidence can be found also looking at the manufacturing sector. The Construction sector provides ambiguous evidence, as while no clear convergence can be found for labour productivity, the dispersion of TFP appears to decrease over time, starting from 1983, even if a peak can be observed in 1999. Finally, the evidence both of service sectors considered in the analysis show evidence of convergence for both labour productivity and TFP. However, even in this case the magnitude of the reduction suggests that the convergence process is more striking when the effects of technology factors are explicitly taken into account.

INSERT FIGURE 2 ABOUT HERE

The results stemming from the analysis of β-convergence and σ-convergence carried out in this section is mostly consistent with that carried out by Bernard and Jones (1996b). The convergence hypothesis, defined as the catching-up of low-productivity regions to high-productivity regions, is occurring at the aggregate level and in some service sectors, and with respect to the TFP measure rather than labour productivity. Most surprisingly, no convergence evidence is shown by the manufacturing sector, suggesting that maybe neither capital accumulation nor cross-regional technology transfer have contributed the catching up from poorer regions.

This evidence acquires particular relevance within the context of Italian economy, as described in Section 3. Actually it provides further empirical evidence to the structural change hypothesis. Italian regions have been confronting with a substantial transition, in which traditional manufacturing sectors are slowly loosing their weight in the economic arena, giving the way to service sectors. This process is difficult to manage, and laggards are exploiting the opportunities provided by the new digital technologies to reach productivity levels of leader regions. The fact that the two service sectors show the most striking convergence evidence, suggests that some advantages of latecomers can be found in the lower levels of dynamic irreversibilities, which mostly affect leader regions. This process goes with a parallel transformation in the organization in production activities within firms' boundaries. Innovation is becoming more and more a crucial strategic factor for firms in lagging-behind regions, and the opportunities for catching-up are mainly seized through the systematic reliance upon formal R&D activities, R&D outsourcing to public labs and the increase of average firms' size (Quatraro, 2006b).

The results obtained in this section are of great importance, but they can be affected by some problems due to the way we built the index, or to the existence of just an apparent evidence of convergence. For this reason we turn now to test the robustness of the analysis conducted so far.

5 Checking the Robustness of the Analysis

The analysis carried out in the previous section provided mixed evidence about convergence. It is particularly impressing the lack of convergence which characterizes the manufacturing sector, both with respect to labour productivity and TFP. In this section we investigate whether our results are robust to problems in constructing multi-factor productivity indexes. We will hence consider the index of Total Technology Productivity (TTP), proposed by Bernard and Jones (1996b), which is intended to address some of the difficulties arising with the use of standard TFP. Moreover, we will apply the test developed by Lichtenberg (1994a) to check whether the differences between the variance at the time 0 and the one observed at the time *T*, for each sector, are statistically significant.

5.1 Total Technology Productivity

The measure of multi-factor productivity derived through the equation (13) provides an index of Hicks-neutral technological change. In other words, it accounts for parallel downwards shifts of the isoquants map. However, the introduction of technological changes may also determine changes in the shape of the isoquant, thus influencing the output elasticities of labour and capital. In Figure 3 at the time t_2 the dashed line is the outcome of neutral technological change, while the continuous line reflects the outcome of a biased technological change (capital-saving). As an extreme situation, it can also happen that the effect of technological change boils down to changes in the α, leaving the parameter *A* unchanged. Cross-sectional or temporal differences in the α are likely to cause in differences in output, as well.

INSERT FIGURE 3 ABOUT HERE

If factor share varies substantially across countries or regions, the standard measure of TFP cannot be used for comparison purposes. As we are comparing regions belonging to the same nation, we would expect no striking variance in factor shares. In Figure 4 we find the plot relative to the 20 Italian regions. It is self-evident how labour share was highly dispersed in the early years observed, the range of variation narrowing over time. Thus, variation in factor share may determine a problem of measurement, even if it proves to fall in the late 90s.

INSERT FIGURE 4 ABOUT HERE

To cope with this problem, Bernard and Jones (1996b) developed an alternative measure of multifactor productivity, Total Technology Productivity (TTP), which accounts for changes occurring both in the parameter *A* of the production function and in the output elasticities. The intuition beyond this index is very simple, in that it shows which region would produce more if all regions employed the very same quantity of labour and capital:

$$TTP_{it} = f(K_o, L_o, i, t) \qquad (17)$$

By using values of K_0 and L_0 constant over time and region-sectors, this index reflects only changes in the production function itself, and not variation in inputs utilization.

In view of this, the TTP appears to be closely related to the TFP measure of multi-productivity, as proposed by Solow (1957). Assuming a Cobb-Douglas production function, the TTP is defined as follows:

$$\ln(TTP) = \ln A_{i,t} + (1-\alpha_{it})\ln K_0 + \alpha_{it}\ln L_o \quad (18)$$[2]

Where

$$\ln(A_{it}) \equiv \ln(TFP_{it})$$

The β-convergence hypothesis is tested by using the following econometric specification:

$$\frac{1}{T}\cdot\Delta\log(TTP)_{t=0}^{T} = \alpha + \beta\log(TTP)_{t=0} + \varepsilon \quad (19)$$

The speed of convergence has been then calculated by using the relationship expressed in the equation (15).

In table 5 the results for convergence regressions on TTP are reported. We used three measures of the ratio (K_0/L_0), as the results are sensible to the value chosen. It seems that both in manufacturing and in services sectors the convergence hypothesis holds. Even more marked is the evidence about Total Industry. As far as the speed of convergence is concerned, the Trade, Hotel and Communication service sector shows up faster rates, than the manufacturing sector and the Monetary and Financial Intermediation service sector. At the aggregate level one can observe the fastest speed of convergence.

INSERT TABLE 5 ABOUT HERE

In particular, by using this index the speed of convergence for manufacturing changed from 2,6% year to 4,6% per year, and the significance of the regression is higher than in the case of TFP. For what concerns the Trade sector, the rate of convergence doesn't change so much, as it moves from 8,95% to 7,55% per year, while in the Financial and Monetary sector it is basically the same as before. At the aggregate level the convergence rate double from 4,2% to 8,4% per year.

It seems that with this alternative measure of multifactor productivity the results of convergence analysis are preserved as far as service sectors are concerned, while the manufacturing sector acquires statistical significance, doubling the catching-up

[2] It is worth noting that while this index represents a step forward in accounting for the bias effect of technological change, nonetheless it neglects an important dimension. It would be more appropriate to consider also the relationship which ties output elasticities to relatives prices, rather than merely holding constant the capital-labour ratio at an arbitrary chosen level (for more on this, see Antonelli, 2003).

speed. However β-convergence is only part of the story. Galton's fallacy is always a danger, but even when evidence of σ-convergence is found, the magnitude of the reduction in the dispersion measure matters in determining whether we can speak about convergence or not. In the following section we turn to carry out a test specifically accounting for this issue.

5.2 Testing the Convergence Hypothesis

So far, we have followed the traditional approach to the convergence analysis, departing from it by considering alternative productivity measures like TFP and TTP. We jointly considered β-convergence and σ-convergence, so as to rule out the trap of Galton's fallacy. As discussed by Sala-i-Martin (1996a), it can be the case that poorer regions grow faster than the rich ones. As an extreme case, the productivity distribution across regions can change in such a way that the measure of productivity dispersion remains unchanged. This is one the reasons why investigating the dynamics of variance over time is important.

Lichtenberg (1994a) maintains that the body of literature about convergence basically sets the hypothesis of mean-reversion equal to that of convergence. These two concepts ought to be kept well distinct. The no-mean reversion hypothesis amounts to reject the null hypothesis that β=0, while that of convergence amounts to reject the null hypothesis that $[\text{var}(\ln Y_0)]/[\text{var}(\ln Y_T)]=1$. He also shows that under the assumption that the productivity measure at t_0 and the one at T are generated by the same process, convergence cannot occur at all, or it is independent of mean reversion. We need to assume that Y_0 and Y_T stem from different processes for the mean reversion degree to affect convergence. To put it formally, let's start from the usual specification of the convergence equation:

$$\ln(Y_T) - \ln(Y_0) = \beta \ln(Y_0) + u \tag{20}$$

Which can be rewritten as follows:

$$\ln(Y_T) = \pi \ln(Y_0) + u \tag{21}$$
$$\pi \equiv (1+\beta)$$

It can be shown that the usual t-test on β is not a proper test for the convergence hypothesis, in that also the variance of the random disturbance has to be accounted for. This implies that the R^2 of the convergence regression matters. From equation (21) it can thus be derived a test which takes the following form:

$$\sigma^2_{t=0} / \sigma^2_T = R^2 / (1+\beta)^2 = R^2 / \pi^2 \tag{22}$$

Such a statistic has an F distribution with $n-2$, $n-2$ degrees of freedom.

In the last column of Tables 3, 4 and 5 we calculated the values of such a statistic, and indicated where they were statistically significant. The comparison of the results obtained with the three measures of productivity is very enlightening. First of all, as far as labour productivity is concerned, none of the sectors we considered passed this tougher test. Neither at the Total Industry level there is evidence of convergence. The situation is very different when we turn to measures of technology convergence.

The values for the TFP measure of multi-factor productivity provide support to the idea that the convergence one can observe at the aggregate level is driven by convergence in service sectors, while neither manufacturing nor agriculture sectors converge at all. Results about the construction sector are to be taken cautiously, as the data source may have some distortions. For what concerns TTP, it seems that at the aggregate level strong evidence about convergence can be found, mostly driven by convergence in the Trade, Accommodation and Communication service sectors.

We can sum up such results by arguing that in the Italian evidence, capital accumulation didn't prove to play a very crucial role in the process of catching-up. Even if we can reject the hypothesis of no-mean reversion at the aggregate level and for service sectors, the Lichtenberg's test of convergence reveal that the cross-section variance of productivity didn't fall significantly in the period considered. There is on the contrary strong evidence of convergence in technology. Both radical and incremental technological change proved to drive convergence process. In particular the macro-sector comprehending the communication service sectors showed up faster rates of convergence, and a very high influence both on the shift and on the bias effect of technological change. It seems necessary by now to frame this results within the broader context provided by the stylized facts about the evolution of the Italian capitalism.

6 Discussion

The results stemming from convergence analysis inevitably raise questions as to what lies behind the evidence of convergence (or divergence). There are at least two different and yet intertwined dimensions along which this issue can be tackled. On the one hand one can wonder what are the economic forces leading to productivity convergence across regions. On the other hand, one can be interested in the micro-dynamics generating such a macro evidence.

The traditional approach puts much emphasis on capital accumulation. Our results show that in the case of Italian regions it is not all that relevant. Disentangling technology from capital accumulation shows that the bulk of convergence drivers bears on the former rather than on the latter. Moses Abramovitz (1994) proposes to distinguish two basic elements underlying convergence: the *potential* for relatively faster growth and the existence of the classes of factors making possible the *realization* of such a potential. The potential for growth is influenced by the extent of the gap between the leader region and the laggards, the endowment level of natural resources, technological congruence and social capability. The actual realization is instead affected by the conditions of cross-borders communications, the mobility of factors and the macro economic-background.

As far as the Italian evidence is concerned, we argue that factors like technological congruence and social capability have been of paramount importance. In this framework both physical and social technologies matter. Nelson and Wright (1994) emphasized how the US leadership arose as an outcome of the emergence of a distinctly American technology and mode of business organization. Cross-borders diffusion of technology through international trade played a more important role than convergence in internal economic conditions for laggards countries to catch-up. Elsewhere (Quatraro, 2006b) we found evidence of diffusion across Italian regions of a mode of business organization characterized by the routinization of inventive activity. The rates of penetration of such an organizational innovation have been estimated through the fit of a logistic curve. We then decided to investigate whether the speeds of diffusion were somehow related to TFP growth rates. The regression yielded the following result:

$$\beta_i = \underset{(10.64)}{0.152} + \underset{(2.75)}{6.577} GR8201^{**} \tag{23}$$

$R^2 = 0.30$, *t* of Student between parentheses (coefficient significant at 5%).

This proved that cross-regional flows of technology (both physical and social) are an important factor leading to convergence. Laggards are likely to rely more systematically on imitation and diffusion because of the larger potentials for growth, while leaders are likely, other things being equal, subject to Wolff's law within the mature production paradigm (Fagerberg and Verspagen, 2002). It is fairly clear in Figure 5 that North-Eastern and Southern Italian regions (say most of "second capitalism" regions) are mainly located on the right side of the diagram, being characterized by higher rates of diffusion and higher average annual TFP growth rates.

INSERT FIGURE 5 ABOUT HERE

Such an evidence is markedly consistent with the theoretical framework elaborated by Nelson (1968), according to which differences in productivity across countries can be ascribed to differences in technology diffusion across firms, and hence to the existence of different production functions impinging upon different firms. As physical and social technologies are not adopted at the same time and at the same pace, across different regions and across different firms within a region, one can expect to find differences in productivity stemming from differences in technology diffusion.

There are plenty of factors affecting the uneven distribution of productivity and technology. The process by which firms introduce innovations within their boundaries involves a set of complex relationships going beyond the innovative entity. Such interactions can be understood as both vertical and horizontal knowledge flows, as well as university-industry relationships. The ability of combining internal and external resources so as to address rapidly changing environment has been referred to as “dynamic capabilities” (Teece et al., 1997). It can be reasonably argued that differences in such capabilities are at the heart of the variance in observed diffusion rates between firms in leading and lagging behind regions.

An implication of this view is that the availability of complementary resources to the innovation process matters. The features of the knowledge infrastructure at the local level shape the readiness and effectiveness of firms’ ability to cope with changing environments. Interactions and knowledge exchanges are indeed likely to occur within well defined geographical boundaries, as trust, the sharing of a common knowledge framework as well as of a common set of norms and rule lower transaction costs, easing technological communication (Antonelli, 2000). This is moreover well reflected in the Innovation Systems approach, which stresses the relevance of different institutional assets at the regional level, such as the presence of interface mechanisms among production, technological and scientific contexts, and the variety of interaction processes among firms (Storper, 1995a and 1995b; Storper and Scott, 1995). That’s the reason why regions like Emilia Romagna, and then those on the Adriatic coast, have been able to speed up their growth process. The positive feedbacks characterizing industrial districts made it possible to take advantage of the enhanced technological communication among agents sharing common rules and norms of reciprocity and trust. This is all the more relevant if one considers that those areas are also characterized either by high-tech industrial specialization or by virtuous innovation dynamics helped by the existence of KIBS acting as intermediaries (Patrucco, 2005; Quatraro, 2005a and b).

The institutional setting hence would appear as complementary to firms’ capabilities endowments. The extent to which institutions and technology are able to co-evolve defines the extent to which an industry is able to develop and eventually drive the catching up of productivity. The resources invested in R&D activities, both at the private and the public level, should be in particular the basic engine to productivity catching up, providing the system with the knowledge necessary to absorb the technologies created elsewhere (Mazzoleni and Nelson, 2006).

Technology has actually become more and more science based, and the ability to catch-up becomes accordingly related to the extent to which a region improves the conditions for technological understanding. The role of public support to R&D

activities has proved to be significantly influential on the rate at which the routinization of invention activity occurred across Italian regions. The change in the mode of business organization has hence gone with a stronger improvement in the conditions for absorbing technological change with high scientific underpinnings. This makes the Italian evidence similar to the story Nelson and Wright (1994) tell about the fall in American technological leadership.

The support of R&D activities represents just part of the story. The level of educational attainment is also crucial in this story. Nelson and Phelps (1966) developed a model in which investments in human capital have higher rates of return in technologically progressive economies, and foster economic growth. Mankiw et al. (1992) also proved that differences in education may explain much of the cross-country variation in income per-capita. Lichtenberg (1994b) found that both enrolment and attainment levels converge across 55 countries, even if the implications on productivity convergence are dependent on the way the production function is specified. Evidence of convergence in multi-factor productivity rather than labour productivity should hence be related also to the investments on education, and specifically to the extent to which scientific and engineering fields are boosted by policymakers (Nelson and Wright, 1994). Unfortunately the lack of data at the regional level doesn't allow us to check the magnitude of such an impact in the Italian case.

The results we presented in this paper moreover stress the driving role of trade and communication service sectors, suggesting the rise of a complementary force which is helping the coping with the process of structural change have been affecting Italian economy for the late 1990s (Quatraro, 2006a). The potential for diffusion of new technologies is favoured by the parallel penetration of ICTs within the economic system. Crespi (2006) actually analyzes Input-Output tables for four European countries, and shows that service sectors in Italy are characterized by a substantial increase in the use of ICTs in the late 1990s, and moreover they are well above the average use at the European level.

7 Conclusions

In this paper we have carried out a comparative analysis of convergence across the 20 Italian regions, along the period 1982-2001. The traditional measure of labour productivity has been compared to TFP. The results have been checked through the investigation of an alternative measure of multi-factor productivity, the TTP, and the application of a statistical test for the convergence hypothesis (as distinct from mean-reversion hypothesis).

The results of such an analysis provides support to the weakness of the convergence approach, as far as labour productivity is concerned. Capital accumulation didn't prove to be so crucial in the process of catching-up. The no mean reversion hypothesis could be rejected only at the aggregate level and for service sectors, but the no-convergence hypothesis couldn't be rejected in any sector. Disentangling the effect of capital accumulation from the effect of technology yielded important results. Still manufacturing sectors don't show any evidence of convergence, but the two service sectors and the aggregate level are characterized by a striking evidence of convergence. This is emphasized in the comparison of σ-convergence for labour productivity and TFP in Figures 1 and 2.

In the light of the specific process of evolution which characterized the Italian capitalism after the World War II, our results suggest that regions belonging to the "second capitalism" area are well exploiting the potential for growth and diffusion, catching up the more advanced regions of North-West, which in turn are experiencing a fall in growth rates due to a temporary exhaustion of technological opportunities. The rise of service sectors is the engine for convergence in technology, as proved by the results of the convergence regression on TFP. Both financial intermediation and communication service sectors show up high rates of convergence. This proves that "second capitalism" regions are coping with the ongoing process of structural change by seizing the opportunities provided by the adoption of digital technologies. Such an evidence complements the changes in the mode of business organization, characterized by the increasing routinization of innovation activity, which in turn has been favoured by the public support to R&D. Systematic reliance on innovation, public R&D expenditure, the diffusion of ICTs, together with the rise of financial and communication sectors, seem to be the mix that is leading to convergence of technology across Italian regions.

While the results stemming from the analysis picture an interesting portrait of the evolution of Italian economy at turning of the century, important questions arise as to what are the basic features of micro-level dynamics. It would be of particular relevance to check whether the Italian evidence somehow resembles what Nelson (1968) found for the Colombian one, i.e. a widening in the productivity gap between large and small firms. This would mean that productivity growth in large firms have been greater than in the small firms. Hence the aggregate results would reflect a catching up process led by top firms, in which within-region disparities got larger instead of narrowing.

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8 Appendix – Regions List

Code	Region
1	Piemonte
2	Val d'Aosta
3	Lombardia
4	Trentino Alto Adige
5	Veneto
6	Friuli Venezia Giulia
7	Liguria
8	Emilia Romagna
9	Toscana
10	Umbria
11	Marche
12	Lazio
13	Abruzzo
14	Molise
15	Campania
16	Puglia
17	Basilicata
18	Calabria
19	Sicilia
20	Sardegna

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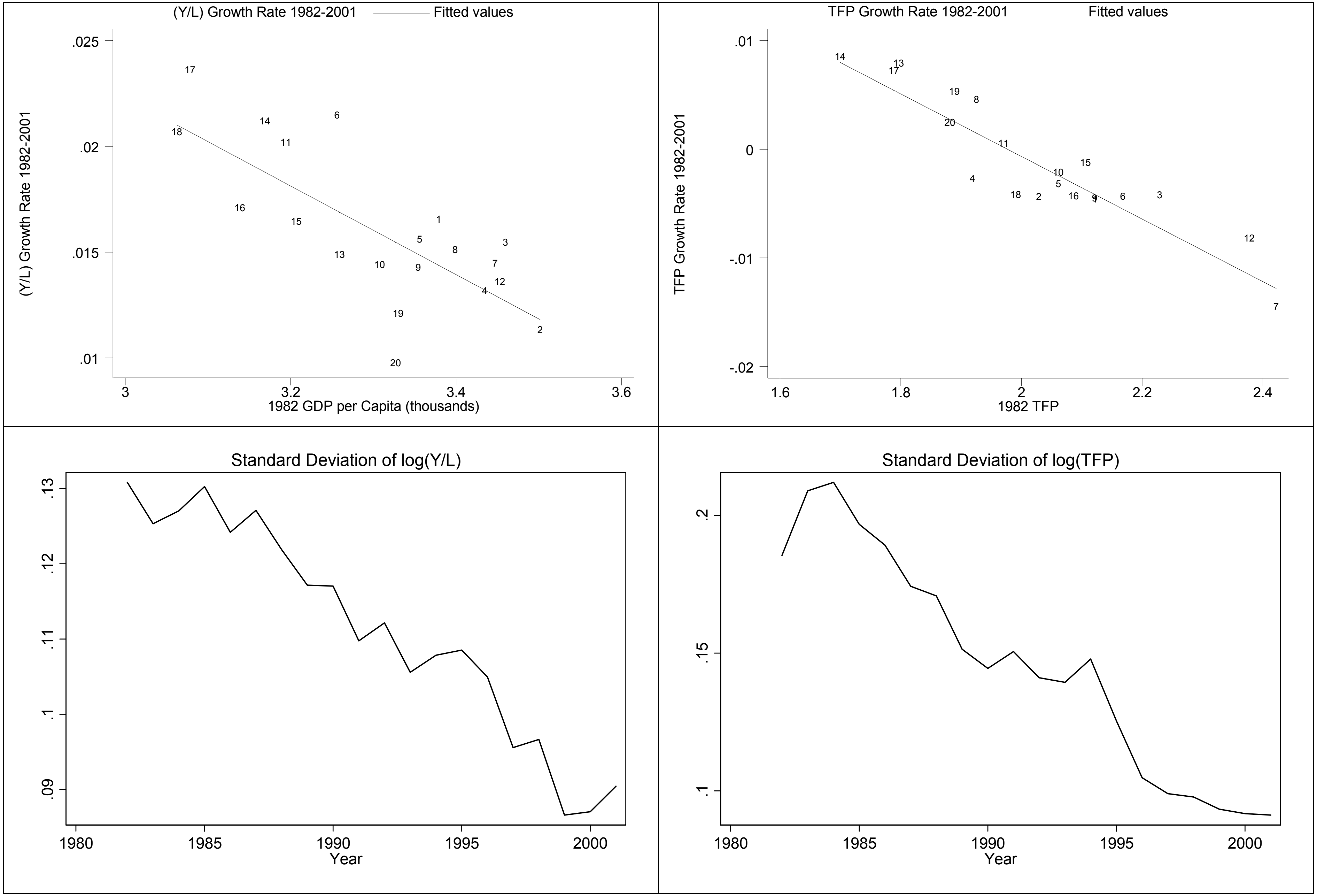

Figure 1 – Total Industry Beta and Sigma Convergence in Labour Productivity and Total Factor Productivity

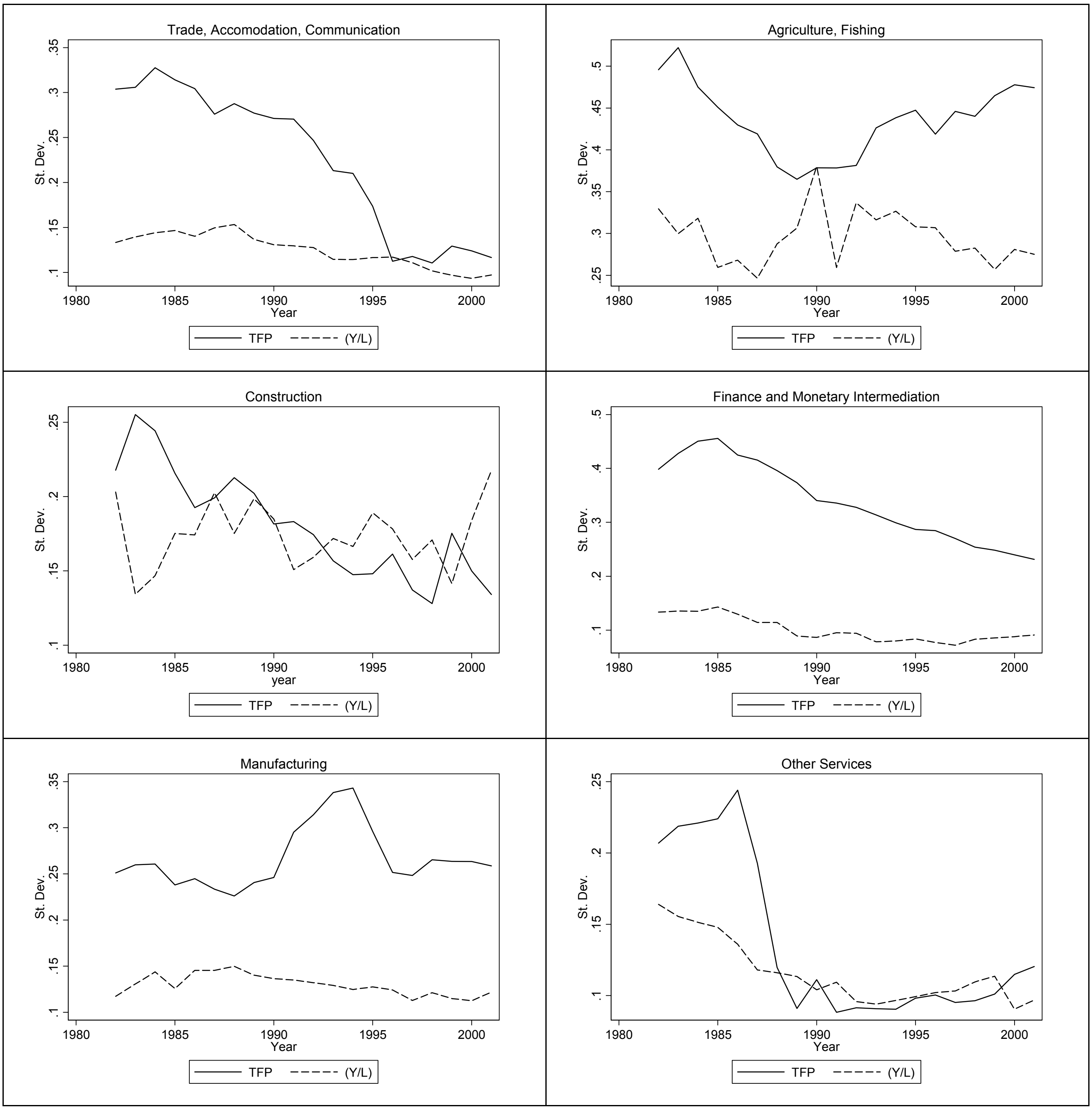

Figure 2 – Standard Deviations of (Log) Labour Productivity and Total Factor Productivity, by Sector

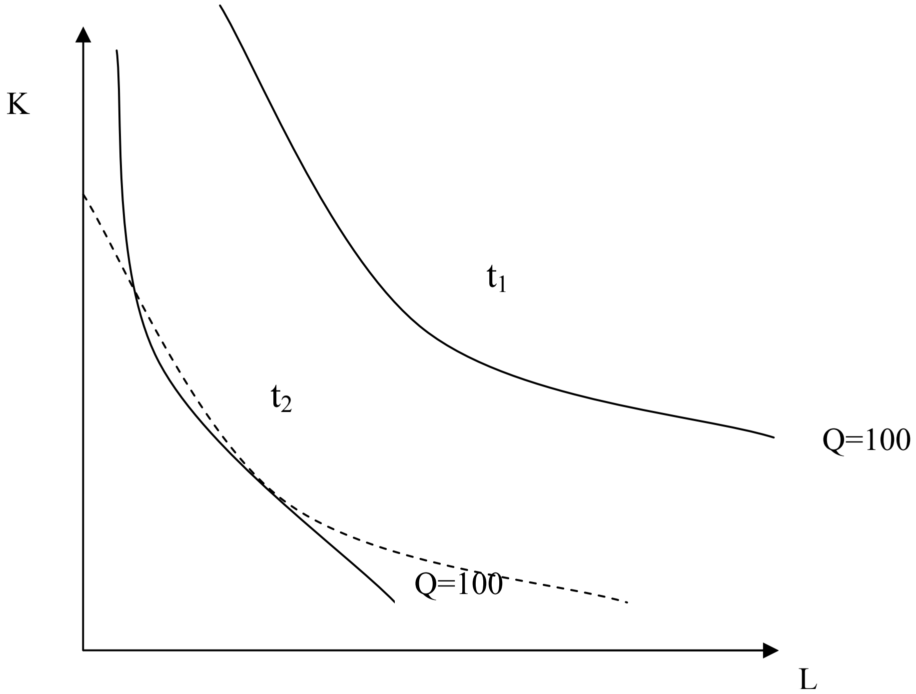

Figure 3 – Comparison between the shift and the bias effect of technological change

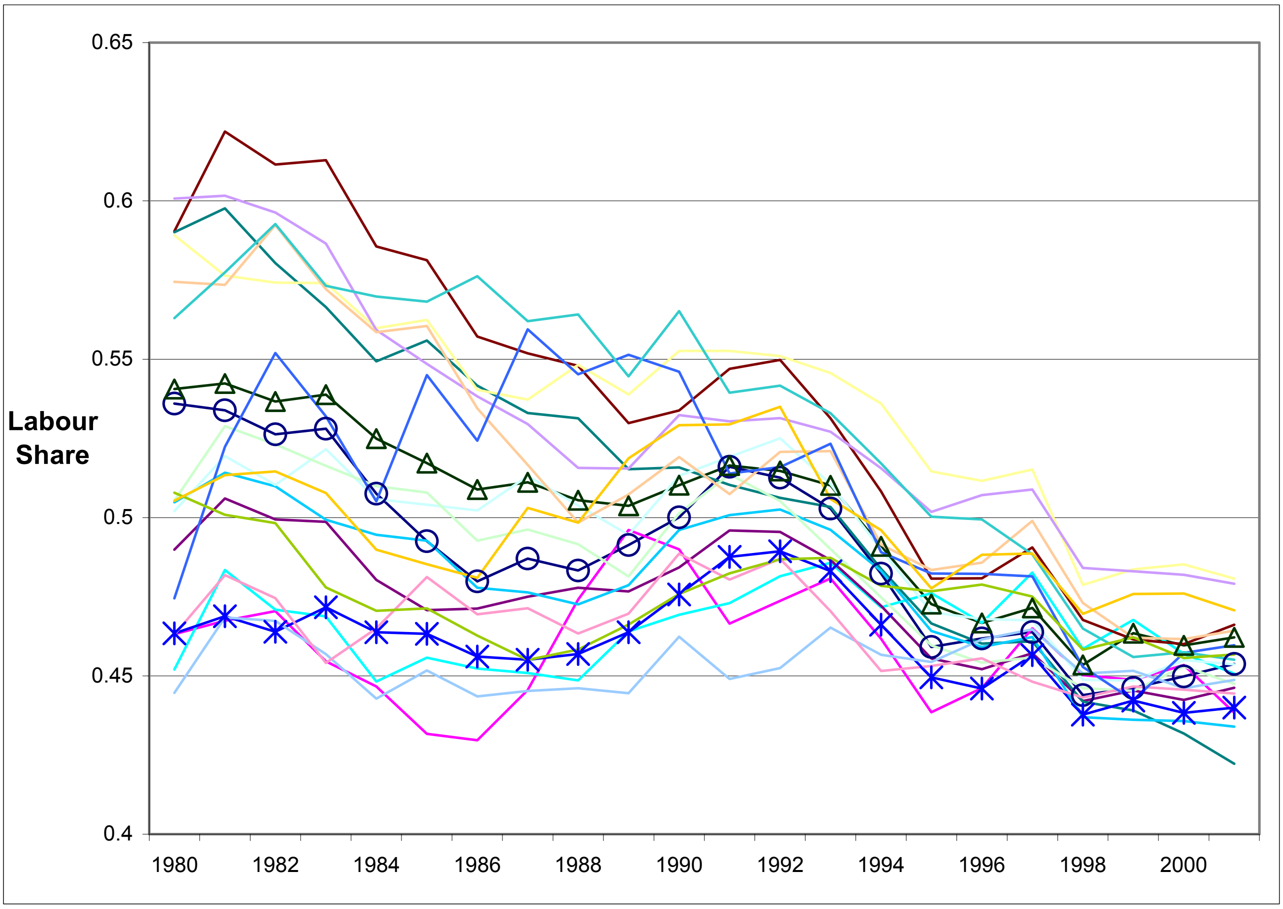

Figure 4 - Labour Share in Total Output, Total Industry

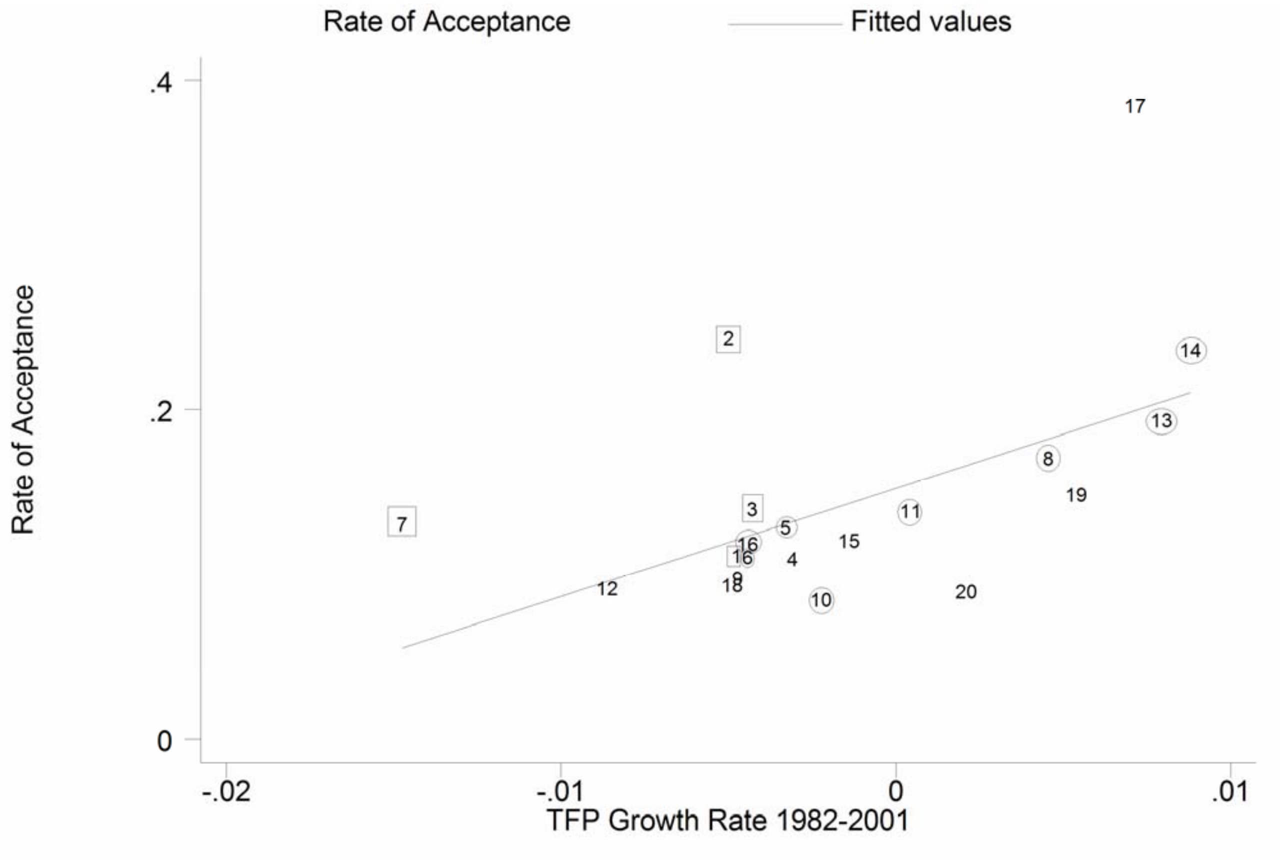

Figure 5 - Relationship between the Speed of Diffusion and the Average Annual TFP Growth Rate
Source: Quatraro (2006b).
Note: Regions in circles belong to the North-Eastern and Adriatic coast area, while regions in boxes belong to the North-Western area.

Table 1

Labour Productivity Growth Rates, 1982 – 2001

	Agriculture	Manufacturing	Commerce, Accomodation and Communications	Financial and Monetary Intermediation	Construction	Total Industry
Piemonte	0.051	0.026	0.014	-0.017	0.011	0.016
Valle d'Aosta	0.058	0.028	0.007	-0.011	-0.015	0.011
Lombardia	0.045	0.028	0.015	-0.010	-0.001	0.015
Liguria	0.064	0.029	0.017	-0.013	0.007	0.014
North-West	***0.051***	***0.028***	***0.015***	***-0.012***	***0.003***	***0.016***
Trentino-Alto Adige	0.051	0.021	0.009	-0.012	0.018	0.013
Veneto	0.044	0.024	0.015	-0.014	0.006	0.015
Friuli-Venezia Giulia	0.054	0.027	0.018	-0.001	0.008	0.021
Emilia-Romagna	0.038	0.024	0.012	-0.008	0.007	0.015
North-East	***0.042***	***0.024***	***0.013***	***-0.010***	***0.008***	***0.016***
Toscana	0.047	0.022	0.011	-0.010	0.004	0.014
Umbria	0.071	0.014	0.016	-0.005	-0.002	0.014
Marche	0.064	0.024	0.017	-0.011	0.011	0.020
Lazio	0.037	0.031	0.025	-0.012	-0.003	0.013
Abruzzo	0.055	0.022	0.012	-0.013	-0.004	0.015
Molise	0.089	0.014	0.016	-0.013	0.000	0.021
Central Italy	***0.049***	***0.024***	***0.018***	***-0.011***	***0.002***	***0.015***
Campania	0.052	0.023	0.020	-0.011	0.008	0.016
Puglia	0.023	0.025	0.018	-0.007	0.002	0.017
Basilicata	0.066	0.019	0.022	-0.010	0.004	0.023
Calabria	0.038	0.025	0.021	-0.003	0.029	0.021
Sicilia	0.027	0.014	0.019	-0.016	0.016	0.012
Sardegna	0.031	0.013	0.017	-0.021	0.000	0.010
Mezzogiorno	***0.038***	***0.020***	***0.019***	***-0.012***	***0.009***	***0.015***
Italy	**0.043**	**0.025**	**0.016**	**-0.011**	**0.007**	**0.015**

Notes: growth rates are calcualted as $\Delta \ln(Y/L)_T^{t=0} \cdot (1/T)$

Table 2

TFP Growth Rates, 1982 – 2001

	Agriculture	Manufacturing	Commerce, Accomodation and Communications	Financial and Monetary Intermediation	Construction	Total Industry
Piemonte	-0.007	0.000	0.002	0.006	-0.017	-0.005
Valle d'Aosta	0.042	-0.013	-0.021	0.004	0.002	-0.005
Lombardia	-0.003	0.006	-0.001	-0.002	-0.026	-0.005
Liguria	0.033	-0.020	-0.016	-0.012	-0.009	-0.015
North-West	***-0.001***	***0.003***	***-0.002***	***-0.001***	***-0.021***	***-0.006***
Trentino-Alto Adige	0.013	-0.007	-0.011	0.004	-0.024	-0.003
Veneto	0.005	0.008	-0.009	0.000	-0.025	-0.003
Friuli-Venezia Giulia	0.021	-0.003	-0.018	0.007	-0.022	-0.005
Emilia-Romagna	-0.006	0.008	-0.001	0.009	-0.023	0.004
North-East	***0.002***	***0.006***	***-0.007***	***0.005***	***-0.023***	***0.000***
Toscana	-0.012	0.002	0.004	-0.008	-0.014	-0.005
Umbria	0.020	-0.007	-0.012	0.002	0.003	-0.002
Marche	-0.017	0.022	-0.016	0.001	-0.024	0.000
Lazio	0.014	0.006	-0.042	-0.015	-0.009	-0.009
Abruzzo	0.021	0.009	0.014	0.009	0.001	0.008
Molise	0.036	0.006	-0.014	0.024	-0.023	0.008
Central Italy	***0.001***	***0.006***	***-0.019***	***-0.008***	***-0.012***	***-0.005***
Campania	-0.001	0.004	-0.004	0.017	0.005	-0.002
Puglia	0.000	0.005	-0.013	0.016	0.009	-0.005
Basilicata	0.014	0.007	0.024	0.013	-0.021	0.007
Calabria	0.027	-0.016	-0.005	-0.001	0.013	-0.004
Sicilia	0.019	-0.017	-0.003	0.025	-0.009	0.005
Sardegna	0.038	-0.024	-0.020	0.017	-0.020	0.002
Mezzogiorno	***0.013***	***-0.002***	***-0.003***	***0.017***	***-0.001***	***0.001***
Italy	**0.007**	**0.003**	**-0.007**	**0.004**	**-0.013**	**-0.003**

Notes: growth rates are calculated as $\Delta \ln(TFP)_T^{t=0} \cdot (1/T)$

Table 3

Convergence Regessions, Sectoral Labour Productivity

	β	SE	t	λ	R^2	R^2/π^2
Agriculture	-0.0247	0.0078	-3.16	0.0335	0.3566	1.4354
Manufacturing	-0.0183	0.0097	-1.89	0.0225	0.1649	2.0939
Trade, Accomodation and Communication	-0.0230	0.0058	-3.99	0.0303	0.4691	1.8864
Financial and Monetary Intermediation	-0.0252	0.0055	-4.55	0.0345	0.5353	2.1439
Construction	-0.0173	0.0100	-1.73	0.0209	0.1422	0.8714
Total Industry	-0.0209	0.0044	-4.75	0.0267	0.5567	2.0939

Notes: the speed of convergence, λ, has been calculated from:

$$\beta = \frac{1-(1-\lambda)^T}{T}$$

Table 4

Convergence Regessions, Sectoral TFP

	β	SE	t	λ	R^2	R^2/π^2
Agriculture	-0.0145	0.0075	-1.93	0.0170	0.1707	1.0929
Manufacturing	-0.0206	0.0100	-2.07	0.0262	0.1920	0.9422
Trade, Accomodation and Communication	-0.0423	0.0041	-10.22	0.0895	0.8531	6.8082***
Financial and Monetary Intermediation	-0.0240	0.0030	-7.92	0.0321	0.7772	2.9687**
Construction	-0.0507	0.0072	-7.00	NA	0.7312	2.5969**
Total Industry	-0.0287	0.0029	-9.82	0.0418	0.8427	4.1357***

Notes: the speed of convergence, λ, has been calculated from:

$$\beta = \frac{1-(1-\lambda)^T}{T}$$

Table 5

Convergence Regrssions, Sectoral TTP

	β	SE	t	λ	R^2	R^2/π^2
Manufacturing						
TTP Median	-0.0303	0.0085	-3.55	0.0455	0.4125	1.4737
TTP Min	-0.0270	0.0089	-3.03	0.0380	0.3380	1.2785
TTP Max	-0.0324	0.0083	-3.92	0.0509	0.4606	1.6152
Trade, Accomodation and Communication						
TTP Median	-0.0396	0.0054	-7.30	0.0755	0.7473	3.9167***
TTP Min	-0.0401	0.0047	-8.49	0.0778	0.8004	5.0095***
TTP Max	-0.0402	0.0057	-7.02	0.0783	0.7326	3.6450***
Financial and Monetary Intermediation						
TTP Median	-0.0240	0.0068	-3.56	0.0322	0.4126	1.6703
TTP Min	-0.0231	0.0063	-3.65	0.0305	0.4249	1.7291
TTP Max	-0.0247	0.0070	-3.54	0.0335	0.4103	1.6487
Total Industry						
TTP Median	-0.0413	0.0029	-14.20	0.0837	0.9180	11.0020***
TTP Min	-0.0401	0.0029	-13.99	0.0778	0.9158	10.1776***
TTP Max	-0.0421	0.0030	-14.15	0.0881	0.9175	11.2847***

Notes: the speed of convergence, λ, has been calculated from:

$$\beta = \frac{1-(1-\lambda)^T}{T}$$