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Stochastic Convergence or Divergence of Total Factor Productivity and GDP of Italian Regions. Re-examing the Evidence.

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Abstract

In this paper, we apply the non-parametric method proposed by Quah to examine convergence hypothesis for Italian regions using GDP and total factor productivity measured by the Malmquist index. Using the stochastic kernel approach, this study suggests that the measure of total factor productivity is a crucial precondition for the estimation of a region's growth. Our results applied to the 20 Italian regions show no convergence for both GDP and TFP variables. For the GDP case, it confirms the Italian divide but for the TFP variable, it reveals the creation of three clubs. However, looking at the long-run density, it reveals that the shape of the ergodic density distribution, for the TFP, is clearly unimodal and it could imply a long-run convergence of regional productivity in Italy.

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1. Introduction

Many empirical studies related to convergence in the recent literature on economic growth have examined GDP and per capita income as basic elements of a country's economic growth. However, in recent years a growing number of studies have suggested that total factor productivity (TFP) is a crucial precondition for the estimation of a region's economic growth and its development (Harris, 2011). Under the multiple input, multiple-output framework TFP reflects progress or regress in scale efficiency and efficiency change along with progress or regress of the frontier technology over the 1993-2013 period. The latter variable accounts for changes in the GDP produced by a given quantity of inputs (usually labor and capital) caused by organizational and institutional changes, innovation and regional technological capabilities, fluctuations in demand, the absorption level of significant spillover effects and changes in society. TFP is slightly more interesting, attempting to measure technologically-driven advancement through technical change.

Our paper complements the study of Griffith et al., (2004), Cameron (2005) and Khan (2006) by assessing the importance of TFP in analyzing the "convergence" among different economic areas trying to differentiate it from the standard literature that have been used GDP as a proxy for TFP. The latter can be considered a more articulated measure of innovations and regional technological capabilities since it captures frontier shifts (innovation component), scale efficiency subjects (scale component) and catch up (recovery component). Henceforth, our aim is to explore the differences, if any, between GDP and TFP in the convergence-divergence process of Italian regions. We empirically test the classical hypothesis that regions within a country should converge to the same long-run steady-state adding in our analysis TFP. This addition gives us the opportunity to test the convergence hypothesis (Quah, 1997) having in our mind how efficiently and intensely the inputs are utilized in output or in other word measuring the shifts in the production function. For this purpose, we estimate TFP of the twenty Italian regions for the period 1993-2013 using ISTAT database. The topic is important in Italy considering the Italian divide and because of alleviating regional disparities is regarded as a fundamental policy objective. Our results suggest no convergence for both variables but different clubs' formation. The paper has the following structure. In the next section, we present the data and the empirical analysis and explain our methodology. In the last section, we offer some concluding remarks.

2. Data and Methodology

The dataset comprises annual observations and covers all twenty Italian administrative regions (NUTS 2) and the full sample period under investigation is 1993- 2013. Most of the data were obtained from different databases published by ISTAT (National Institute of Statistics). The data used to estimate TFP consist of two inputs and one output. The output factor data (Y) used is the gross regional product (ISTAT source). As input factors, we used labor input data (L) (level of employment) drawn from the national labor force survey and the region's gross fixed capital formation in millions of euro were taken from ISTAT as a proxy for the capital formation (K). However, in order to construct the region's capital we follow the perpetual inventory method (PIM).

In this paper TFP is measured using the Malmquist index (Fare et al., 1994) as follows. Hence, we estimate the Malmquist index of TFP growth (Zrelli and Belloumi,2013) using the following formula:

$$M_o^t\left(x^t, y^t, x^{t+1}, y^{t+1}\right) = \sqrt{\frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)} \frac{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^t, y^t\right)}} \quad (1)$$

Thus we can consider GDP and TFP as continuous-time stochastic process $\{X(t), t \geq 0\}$ and assume that the each stochastic process is a continuous-time Markov chain with distribution function ϕ_t. Each $\boldsymbol{X}$ satisfies the Markovian property $Pr\left(X_{t+\tau} \in A \mid X_j, j \leq t; X_t = x\right) = P^{\tau}(x, A)$, with $A \subseteq E \subseteq \mathbb{R}$ where E is the space state of X, iP^{τ} called "stochastic kernel" and under certain condition (Quah, 1997) satisfies the following equation $\phi_{t+\tau} = \int_E (x, A)\phi_t dx$ that lead to $f_{t+\tau}(y) = \int_E f_{\tau}(y|x) f_t(x) dx$ with $f_t(x)$ and $f_{\tau}(y|x)$ which are respectively the density function of ϕ_t and P^{τ}, if they exist.

The empirical estimate of the marginal pdf of x is given by:

$$\hat{f}(x) = \int_{-\infty}^{+\infty} \hat{f}(x,y)dy = \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_x\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-x_i}{h_x}\right)^2} \int_{-\infty}^{+\infty} \frac{1}{h_y\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{y-y_i}{h_y}\right)^2} dy == \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_x\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-x_i}{h_x}\right)^2} \tag{2}$$

where the joint distribution $f(x,y)$ is obtained using a product of Gaussian kernel K (Fotopoulos, 2006):

$$\hat{f}(x,y) = \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_x\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-x_i}{h_x}\right)^2} \frac{1}{h_y\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{y-y_i}{h_y}\right)^2} = \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_x} K\left(\frac{x-x_i}{h_x}\right) \frac{1}{h_y} K\left(\frac{y-y_i}{h_y}\right) \tag{3}$$

while (h_x, h_y) are bandwidths calculated with the direct plug method applied separately in each dimension. In this way, a non parametric estimation of the stochastic kernel[1] is given by:

$$\hat{f}_\tau(y|x) = \frac{\hat{f}(y,x)}{\hat{f}(x)} \tag{4}$$

The stochastic kernel may be interpreted as a transition matrix with a continuum of rows and columns. Take a time interval of length τ, the relationship among two distribution over τ can be written as:

$$f_{t+\tau}(y) = \int_{-\infty}^{+\infty} f_\tau(y|x) f_t(x)dx \tag{5}$$

One possible way to face this problem is through a discretization of the time interval $[a,b]$ by partitioning it in n non-overlapping subintervals, then is possible to estimate $f_\tau(z_j|x_i)$ with z_j, x_i midpoints of these subintervals. If $p_{ij} = f_\tau(z_j|x_i)\frac{b-a}{n}$ (≥ 0) are defined and n is sufficiently large (which leads to $\sum_{j=1}^{n} f_\tau(z_j|x)\frac{b-a}{n} \approx 1$) then the $n \times n$ matrix $\boldsymbol{P} = \{p_{ij}\}$ has the same structure as a transition probabilities matrix and $\{p_{ij}\}_{j=1}^{n}$ may be seen as the conditional probability mass function. The ergodic density can be evaluated as $f_\infty(y) = \psi \mid \frac{b-a}{n}$, where ψ is the rescaled (unit sum) left eigenvector corresponding to the unity eigenvalue (also the largest one) of the matrix $\boldsymbol{P}$.

Following the approach developed by Johnson (2005) and Fotopoulos (2006) the long-run ergodic distribution is found as the solution to:

$$f_\infty(y) = \int_{-\infty}^{+\infty} f_\tau(y|x) f_\infty(x)dx \tag{6}$$

3. Results and Discussion

Measuring the effects of technology on productivity is a difficult pursuit. It is generally approached through metrics such as GDP and TFP. The former attempts to capture the overall output of a given economy from a macro-environmental perspective. The latter is slightly more interesting, attempting to measure technologically driven advancement through noting increases in overall output without increases in inputs.

The present concept of convergence is not identical to the classical idea of β and σ convergence encountered in the literature on economic growth across countries. The difference is that β convergence (Kodila-Tedika,2018), for example, analyzes the mobility of the various regional economies within a given distribution of national income whereas, in this study, convergence refers to the Stochastic Kernel (Quah, 1997). In addition, β and σ convergence has been criticized that completely ignores that various countries may

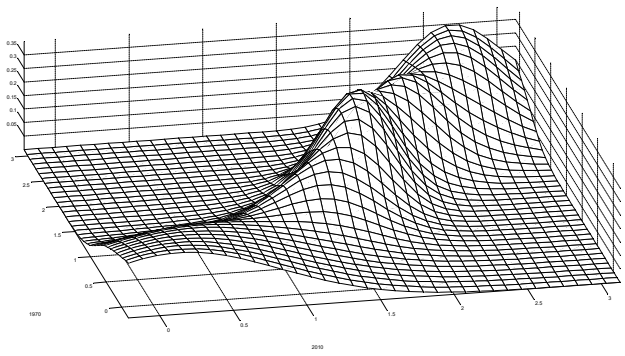
[1] In general, the characteristics of the kernel function and bandwidths influence the quality of the density estimation. Different kernel alternatives may be used (Wand and Jones 1994). Since the kernel estimator is not very sensitive to choice of K, a Gaussian kernel has been used (Magrini 2004). Moreover, the Mean Integrated Squared Error (MISE) is minimized by a multivariate standard normal density over the class of product kernels (Pagan and Ullah 1999).

modify their relative position over time (Quah, 1993a,1996a,b) and are independent from the initial conditions (Quah, 1993a,1996a). Moreover, for cases of overtaking, standard regression approaches can lead us to conclude erroneously in favor of convergence (Quah, 1993a,b;1996a,b) since these approaches focus on the average rather than the dynamics of the entire distribution (Quah, 1996a,b; 1997; Johnson 2005) while, the steady state to which countries are converging isn't the single stable steady state of neoclassical theory (Quah, 1993b).

Thus, we adopt distributional dynamics approach to examine directly the evolution of cross-sectional distribution using stochastic kernels in order to describe both the change in its external shape and the intra-distribution dynamics allowing the investigation of the formation of possible clubs concerning GDP and MPI. In addition, this approach is suitable when the analysis is limited to a "homogeneous" set of economies (Barro et al., 1991; Barro and Sala-i-Martin, 1991;1992) allowing for heterogeneity across them (Bimonte, 2009)." Also, non-parametric modeling allows us to study the dynamics of the entire distribution of the productivity index as opposed to an average behavior as is done in most time series studies. Furthermore, one of the most significant features is the fact that equilibrium is stochastic and not deterministic as in the previous approaches. Thus, state probabilities are considered fixed and countries can freely move among the states according to the transition probability matrix. Finally, the specific approach[2] embodies notions of increasing returns associated with endogenous growth theory (Quah, 1996a) while letting us consider neoclassical assumptions more liberally.

In doing so, it is necessary to replace discrete transition matrices that essentially provide a three dimensional graph, which shows how the cross-sectional distribution of TFP has developed over the past 21 years. Figure 1 presents the estimated stochastic kernel with respect to the estimated TFP values for regions of Italy.

Figure 1. Estimated stochastic Kernel for TFP over the 1993-2013 period



It is worth noting that the estimated stochastic kernel reveals the existence of three individual peaks at a lower, middle and upper level. Each specific peak reflects a
comparatively large number of observed transitions from a particular part of the distribution to another a finding that contradicts the North-South paradigm. However, while the lower peak seems to be vanishing the middle peak prevails denoting a tendency of Italian regions TFP to congregate there. The specific findings corroborate the idea of no convergence and the formation of three in our case individual clubs. It is also consistent with Calligaris et al., (2016) that show "the increase in misallocation has come mainly from higher dispersion of productivities within different firm size classes and geographical areas rather than between them". Moreover, Caselli (2005), Maffezzoli (2006), among others, have found that technological differences

[2] The difficulty with distributional dynamics analysis is that while the Markov analysis allows us to identify convergence clubs; we can't assign the countries that formed each one club. Moreover, other disadvantages associated with the Markov approach concerns the rather vague association with economic theory and the problem of spatial dependence and inference (Fingleton, 1999; 1998). Finally, significant changes from past experience in policies or technologies may not be well represented by this approach (Kounetas, 2018).

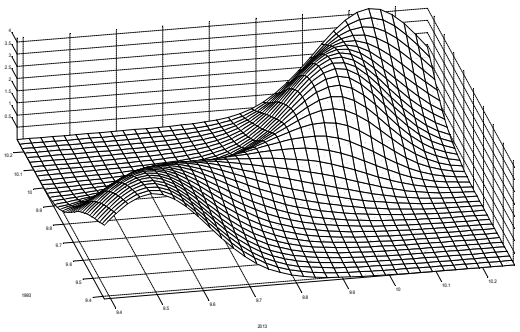
are the main causes of the uneven levels of development across countries/regions and that TFP differences are fundamental in explaining differences in output levels for recent years.

Between 2007 and 2012, Italian economy fell considerably due to the financial and economic crisis. Of course, it affected the two macro-areas of the country: North and South but with different magnitudes. This result has token the South a step back on time, up to the values recorded in the distant 1997, with dramatic effects on levels of employment. This makes it clear that, although the international economic crisis affected the entire Italian economy, the South experienced its most serious consequences. In fact, looking at the causes of this continues divergence, the problems for the South are essentially the same as those of the post-WWII period: great weight of primary activities, technological backwardness, inadequacy of tangible and intangible infrastructures, reduced entrepreneurial spirit, low productivity, low wages, and strong push for internal and international emigration. As a result, if the Center-North tends to lose touch with the growth rates of the central areas of Europe, in the South the de-industrialization process proceeds very fast. This is why Italy appears to be atypical to other countries. In short, the dualism or, according to our results using TFP, the trialism continue to characterize the Italian economy. The only real attempt to set in motion a process of convergence between the two areas of the country dates back to the extraordinary intervention operated with the *Cassa per il Mezzogiorno* between 1950 and 1975. Afterwards, the gap between the two-macro areas has returned to growth or, at best, to stabilize the gap. Yet, after the intense debate of the fifties, sixties and seventies, the analysis of Italian economic events has generally ceased to be conducted in a dualistic key, especially since the eighties. Many factors contributed to this. We mention, among others, the decline of the industrial development model based on public intervention in capital-intensive industrial sectors. It was contrasted by the establishment of a model based on the development of local entrepreneurship, based on criteria of marked specialization, in a logic of strong European and international integration.

The recent history tells us that in Europe, as in Italy, the differences between the regions seem destined to persist and, in some cases, even to strengthen. The free action of the market mechanism, both in terms of work and production capacity linked to the type of production techniques adopted, did not allow the less developed regions to link the development of the most advanced regions. The comparative advantage represented by the lower labor costs in the South did not generate the expected territorial rebalancing. Historical experience thus shows that, if left to the spontaneous action of market mechanisms, relative positions, of advantage or disadvantage, may persist over time. Once production is polarized in specific areas and in certain sectors, a spontaneous process of spreading entrepreneurial initiatives in other areas cannot be expected. Instead, in the regions where a more efficient production structure is concentrated and the so-called rich demand prevails, the investment and expansion process is encouraged; while the regions whose production activity is linked to poor demand are slowing down in investments and in the expansive process. To this, it should be added that productive specializations tend to reproduce over time and to structure themselves, showing a causal link with economic, social and institutional structures, a tendency that market forces often cannot correct. Applied to a dualistic or, even worse, a trialistic system, this tends to accentuate progressively the divergence over time.

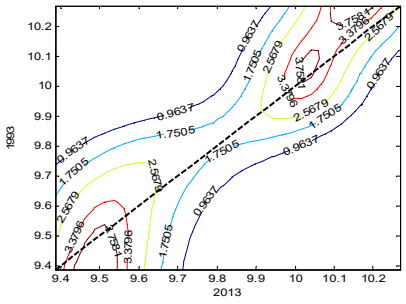
A similar analysis has been done for the GDP. A stochastic kernel of the log of the GDP per capita has been estimated. In Figure 2 the estimated stochastic kernel reveals a twin peaks situation confirming the Italian divide and corresponds to the so-called “basis of attraction”.

Figure 2. Estimated stochastic Kernel for GDP per capita over the 1993-2013 period



Turning now our attention to contour plots (figures 3a and 3b), the fact that the probability mass of the TFP and GDP per capita is concentrated to the main diagonal doesn't give us support of the idea that Italian regions situated at both ends of the relative distribution has exchange their relative position over the 1993-2013 period. In other words, the intra-distribution dynamics of the examined variables are characterized by a high level of persistence for the regions over time and low mobility. Once again the manifestation of twin-peaks for GDP per capita case and three peaks for TFP holds. These results are in line with the poor performance of the Italian economy, both at the GDP growth and productivity growth, within the last two decades.

Figure 3. Estimated contour plot for TFP and GDP over the 1993-2013 period



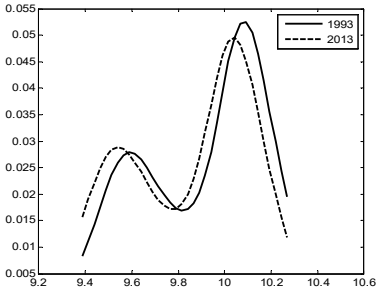
(3a)

(3b)

Moreover, our results concerning GDP per capita confirm the findings of the vast literature on the Italian north-south divide. However, by examining the total factor productivity index, an additional discretization of the regional performance emerges. There are various possible reasons that explain the existence of individual convergence clubs. The diverging pattern of Italian regions can be viewed from the perspective of localized technical change, the level of absorptive capacity, the local effect of knowledge spillovers and technological diffusion and capabilities and processes which include inadequate learning effects, specific-region market imperfections and externalities that lead to individual steady states and different paths of factor accumulation (Antonelli, 2006, Keller, 2002).

Lastly, the long-run behavior of Italian region's total factor productivity (TFP) is presented in the following Figure 4a.[3] It is clear, that the distribution is unimodal with a mean close to 1.9. Moreover, the shape of the ergodic density distribution provides a clear evidence for long-run convergence of regional productivity in Italy because there are no convergence clubs apparent.

Figure 4 Estimated ergodic density for TFP, $f_{\infty}(y)$



(4a)

(4b)

[3] It displays the corresponding ergodic density $f_{\infty}(z) = \int_{\infty} g(z|x) f_{\infty}(x) dx$ that has been estimated after 3 iterations)

In contrast with TFP variable, GDP per capita ergodic density function (4b) reveals a strongly bimodal pattern. The shape of the ergodic function provides evidence for regional disparities and the continuation of Italian split into two macro-areas.

Our results show that the gap between technologies developed in different areas of the country (seemingly the North and the South) will lead to productivity differences between Italian regions even in the absence of any barriers to technology and human capital transfer. The low productive areas must use unskilled workers in tasks performed by skilled workers in the more productive areas. This discrepancy between technologies and skills in the low productive regions will also naturally amplify the differences in per capita income. However, looking not only at GDP as a factor of convergence, we can overcome the problem of the Italian divide and see that there are at least three convergence clubs of regions in terms of productivity. Finally, considering the long-run density, it reveals that the shape of the ergodic density distribution is clearly unimodal and this could imply a long-run convergence of regional productivity in Italy

4. Conclusion

This paper contributes to the literature of economic convergence, investigating the role played by total factor productivity in Italian regions over the last two decades. We found clear evidence of a no-convergence pattern for the total factor productivity and per capita GDP of the regions of Italy over the period 1993-2013. We showed the formation of three and two individual clubs respectively, questioning the traditional view that regions in a country should converge to a steady state in the long-run. The Italian experience also raises the issue of the specific role of regions' absorptive capacity, technological capabilities, diffusion and knowledge spillovers. It also shows the role of regional policies and spatial strategies in balancing and equalizing the disparities due to private capital and public infrastructure investments from rapidly expanding developed areas to under-developed areas.

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