Innovation, growth and quality of life: a theoretical model and an estimate for the Italian regions

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Innovation, Growth and Quality of Life: Evidence From the Italian Regions

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ABSTRACT. This paper carries out an explanatory investigation into the relationship between quality of life and economic growth in the Italian regions. Previous studies stress the importance of institutional quality, social capital and social conditions in determining disparities between richer and poorer regions in Italy. Building on this literature, we consider a three-sector semi-endogenous growth model with negative externalities depending on social and institutional factors that affect the innovative capacity of regional economic systems. Based on a sample of Italian regions for the period 2000-2008, the empirical investigation confirms the presence of non-linearities depending on socio-institutional conditions that constitute constraints on the translation of innovation into economic growth. Policies focused primarily on the upgrading of collective services, starting with education, social services and the safeguarding of environmental resources, have major repercussions on the economic growth of the southern regions as well as the development of the Italian economy in general. The paper suggests that generating a development strategy designed to improve quality of life in the poorer Italian regions may yield high benefits in terms of the effectiveness of public policy and economic development.

Keywords: Economic Development, Innovation, Growth, Regional Disparities, Quality of Life
JEL: O10, O30, O41, R11, R58

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1. Introduction

While economic growth is crucial in improving the quality of life, the relation between it and higher standards of living depends on many factors, including economic and social inequality and, no less importantly, specific institutional conditions. In analysing the relationship between quality of life and economic growth, this paper inverts the causal perspective with a view to providing empirical evidence in support of the thesis that the former – understood as institutional and social variables specifically linked to regional contexts – plays a key part in determining the effective ability of firms to translate the resources and technology available into increased competitiveness. According to the evolutionary approach to technological change, we argue that technological knowledge is the result of interaction between individuals, firms and organizations within a specific socio-economic and institutional context (Iammarino et al. 2009, Von Tunzelmann and Wang 2007). We thus maintain that socio-institutional conditions generate an externality affecting the capacity for the absorption of knowledge and the economic growth of regional systems.

In this line of research, Crescenzi and Rodríguez-Pose (2009) analyse the variables that act as a "social filter" and affect the territorial disparities between the European regions so as to enhance or reduce the competitiveness of regional systems of innovation. They focus on the role of human capital as a proxy for these intangible conditions. Taking their work as a starting point, our paper analyses the case of Italian regions and considers a broader set of socio-institutional dimensions related to quality of life (human capital, social inclusion and institutional efficiency)[1]. Our hypothesis is that the low quality of the human capital and collective services in the regions of the South of Italy, which provide an approximate yardstick of the weakness of the regional context as regards quality of life, acts as a negative externality that limits the dissemination of knowledge in the economic system, thus obstructing growth and innovation. It is argued that this accounts for the persistence of territorial disparities between the Italian regions despite the major efforts made since the post-war period by national policy and European regional policy.

Taking the considerations outlined above, which are drawn from the literature on regional divides in Italy and various investigations into economic growth and development, our study seeks to combine the traditional driving forces of growth and those linked to institutions and social conditions in a unified theoretical framework.

[1] Quality of life is defined here by means of objective indicators regarding socio-economic aspects that increase the satisfaction of those living in a place. See Gasper (2010) for the various definitions of quality of life.

The paper is organised as follows. The section below provides an overview of the stylized facts, which characterize North-South regional divide in Italy. We then presents a model of endogenous growth that generates the externalities linked to socio-institutional factors and shows how these hinder the transmission of knowledge and growth prospects. The fourth section describes the econometric methodology used to test our hypotheses on the Italian regions in the period 2000–2008 and section 5 discusses the results obtained. The last paragraph states the conclusions and suggests some implications for policy making.

2. Regional divides in Italy: stylized facts

As documented in numerous studies, the convergence between the regions of Southern and Central-Northern Italy developed at a steady pace in the period 1950–70 and then slowed down before coming to a halt in the 1980s (Daniele and Malanima 2007). It is our contention that the analysis of this failure to converge should be addressed in a long-term perspective and take into account the adjustments currently altering the cornerstones of the model of Italian economic development under the pressure of technical progress and the disruption of the global value chain.

The basis of our study is the work of Stefano Fenoaltea on Italy's economic development during the Liberal period. Fenoaltea identifies the forces driving the growth of the regions in the "industrial triangle" as natural resources – namely water and hydroelectric energy or "white coal" – during the first industrial revolution (*c.*1830–80) and human capital, which came to predominate during the second (1880–1915) (Fenoaltea 2007). Emanuele Felice has broadened the temporal scale of this analysis to show that human capital became still more important during the 20th century (until 1970 in overall terms), after which social capital (social networks and institutional efficiency) assumed primacy as a factor of growth in the post-Fordist phase (Felice 2010). The importance of social capital as a driving force of development lies at the root of the economic takeoff of the regions in the North, East and Centre, which owe their wealth to the success of the industrial districts. The social networks and institutions located in these districts made possible the common use of specific public assets, from infrastructures to the informal rules that cut transaction costs, thus fostering the expansion of flexible, territorially integrated firms specialising in the sectors of light industry and strongly oriented towards foreign markets.

Concisely, these analyses show that the driving forces of growth changed together with the characteristics of technology, leading in Italy first to the takeoff of the Northwest and then to the convergence of the regions in the North, East and Centre. The factors guiding the growth of the central and northern regions are a mixture of fixed resources, linked to the territory, and mobile resources, which can also come from outside. The former include natural resources (sources of energy and ease of transport), which are crucial in the initial phase, and social capital, which then becomes the main driver behind growth.

For the regions of the South, the period of intense growth has coincided, instead, with the development of the Italian economy as a whole and has been supported by the "Intervento Straordinario", a special plan to develop infrastructures and productive activities in the South.

The Intervento Straordinario channelled huge flows of resources from the North to the South so as to increase the latter's endowment of technical and financial capital. Local labour-intensive activities such as light industry and tourism were, however, neglected or crowded out, there was no improvement in technical and higher education, the supply of services fell increasingly behind the requirements of firms and citizens, and social capital was eroded due to the expansion of rent-seeking activities designed to intercept the flow of public resources (D'Antonio 1996).

Fenoaltea and Felice argue that the Intervento Straordinario failed because it focused almost exclusively on exogenous resources, namely public spending and the technology incorporated in imported machinery and the investments of firms based in the Centre and North as well as a small number of foreign firms. This model of externally "forced" development had temporary effects that gradually faded with the increasing importance of immaterial factors of growth, which are primarily local by nature but absent or very weak in Southern Italy.

While the analysis of Fenoaltea and Felice stops at the end of the 1980s, the framework of fixed and mobile resources can also be applied to the last twenty years. With the interruption of the national policy of development (the Intervento Straordinario) and the launching of a policy of European cohesion (the Nuova Programmazione), the 1990s saw the transformation of the South into a sort of laboratory for replication of the model of diffuse industrialisation of Central and Northern Italy. The decentralisation of regional policy was supposed to increase the effectiveness of spending, but this was not achieved due to the limited managerial capacity of the southern regions (D'Antonio and Scarlato 2008).

Moreover, the forms of action taken have remained unchanged with respect to the past. The area is no more than a passive receptacle for new flows of public expenditure. The participation of local actors manifests itself in the proliferation of proposals and agreements regarding the distribution of public resources for the indiscriminate support of firms and citizens' incomes (Pigliaru 2009, Scarlato 2010). The structural funds have made no impact on regional disparities in terms of labour productivity (Aiello and Pupo 2009). There has been no effect on the endowment of human and social capital and collective services and no appreciable effort to improve the efficiency of public and private institutions (Cannari 2009, De Blasio and Nuzzo 2010). On the contrary, progressive deterioration of the social and environmental indicators is taking place in the southern regions and the disparity with respect to the Centre and North in terms of collective services is now greater than the disparity in terms of per capita product (DPS 2010). It should be pointed out in this connection that the investigations into public services carried out over the last few years by the Bank of Italy (summarised in Bripi et al. 2011) show that the territorial disparities in performance are due not to lower public spending per capita but rather to differences in the efficiency of the organisational models adopted.

This brings us to our diagnosis of the halt in convergence with the Centre and North. The Intervento Straordinario, based on pumping in resources from outside, worked because it was easier in the past for technology to be incorporated in physical capital, understood as imported machinery and the monolithic plants of major corporations located in the South.

In the present-day scenario, technology is instead dematerialized and transversal, requiring local skills and excellence capable of adding specific advantages to the product, links with the advanced tertiary sector, the ability to govern the networks of knowledge scattered over the territory and outside the local system, and strong coordination of the actions of a host of small firms (Rullani 2009, Federico 2010). These are the elements emphasised in recent theoretical studies on innovation. Knowledge emerges as the result of collective activity, the production of which goes beyond the efforts of the single firm and derives rather from the interaction of economic agents through formal and informal mechanisms and a variety of flows of connections outside the firm (Quatraro 2010, Iammarino 2005). As a result, the regional capacity for innovation proves highly idiosyncratic and bound up with conditions of the economic and institutional environment that are hard to replicate in other regions. Camagni (2009) defines "territorial capital" these intangible and localised advantages.

Moreover, the last few years have seen a return to the centrality of natural resources in economic analyses. Their importance however, regards aspects that are very different with respect to the past, such as a healthy environment, amenities, collective services, affordable housing, and connections between urban centres equipped with advanced services (Glaeser and Gottlieb 2008, Glaeser and Resseger 2010). In short, these studies prove that factors linked to the quality of life are crucial in determining the potential capacity of regions to attract investment and human capital (Farole et al. 2011). On the other hand, numerous studies show that the presence of intangible disadvantages of context in the less developed Italian regions cannot be offset by a system of financial or fiscal incentives (Daniele 2007).

The weakness of territorial capital in the South of Italy means limited capacity to attract mobile resources. For example, human capital is an exclusively outwardly mobile resource in the South for reasons that go beyond the difficulties of access to the job market (few job opportunities for qualified young people without networks of family and friends, poor quality of life, and the attraction of university education in the Centre and North, which is superior and provides qualifications taken more seriously by prospective employers) (D'Antonio and Scarlato 2007, Mocetti and Porello 2010).

Finally, the primary fixed resources, namely social and institutional capital, have become increasingly important as regards response of Italian regions to external shocks because the capacity for coordination of the supply of the collective factors that determine growth (knowledge, environment and networks) depends largely on the quality of formal and informal institutions (Trigilia and Burroni 2009).

In the next section, we bring together these insights drawn from the literature on regional divides in Italy and various investigations into economic development and we provide a synthetic theoretical model that describes the effects of social externalities on economic growth.

3. A theoretical model

3.1 The assumptions of the model

We consider a representative household that maximises its intertemporal utility deriving from private consumption. The instantaneous utility function u(c) is presented as a constant elasticity of substitution (CES) function in the following form:

$$\max_{c(t)} \int \frac{c^{1-\sigma}}{1-\sigma} e^{-\rho t} dt \qquad (1)$$

where σ is the elasticity of intertemporal substitution of private consumption, ρ is the intertemporal discount rate, and $c = C / L$ is the share of private consumption per worker. The representative household is the only consumer and producer of the sole final good at the same time. The final good is produced by means of a Cobb-Douglas technology, described as follows:

$$Y = \left(AL_Y\right)^{\alpha} \int_0^A x_i^{1-\alpha} di \qquad (2)$$

where L_Y is the share of labour employed in the production of final goods and x_i is the single kind of intermediate good employed in production.

The production function thus described is characterised by the presence of technological progress, manifested as an increase in the variety of intermediate goods (Dixit and Stiglitz 1977, Ethier 1982). Invention corresponds to the discovery of a new kind of method making it possible to produce the final good described by equation (2) in an alternative (and more efficient) way. In this formulation, decreasing returns disappear due to the discovery of new kinds of intermediate goods, which then tend to increase total productivity.

As production in the sector of final goods takes place through a technology with constant returns to scale, it is possible to consider a single price-taking firm in determining the optimal quantity of the final good produced. This firm operates in the perfectly competitive sector of final output (SFO). This means that when the price of Y is normalised to 1 at every moment of time, the profit maximisation leads to the following conditional demand function:

$$w = \alpha \frac{Y}{L_Y} \qquad (3)$$

and

$$p(x)_i = (1-\alpha)\frac{Y}{x_i} \; \forall i \qquad (4)$$

where w is the unit wage paid to each worker in the sector of final output and $p(x)_i$ is the return of the kind i of intermediate good. It is important to note that equations (3) and (4) enable us to characterise the parameters α and $(1-\alpha)$ in terms of the elasticity of the factors L_Y and x_i with respect to total production[2].

The second sector, SIG, is devoted to the production of intermediate goods and is made up of an infinite number of firms in the interval between 0 and A. Through the purchasing of a project (or blueprint) from a sector of research and development SR&D, every firm in the SIG becomes the only one capable of producing that particular kind of intermediate good and

[2] This property depends on the assumption that the firms producing final goods operate in conditions of perfect competition and are characterised by constant returns to scale.

therefore operates in monopoly conditions. It is assumed for simplicity that the intermediate firm (which bought the project from the SR&D) can transform every unit of capital acquired into one unit of the intermediate good. As this transformation is assumed reversible, the intermediate good can be turned back into capital at the end of each period.

Each monopolistic firm will therefore pursue the goal of maximising its profit at every moment of time by solving the following problem:

$$\max_{x_i} p\left(x\right)_i x_i - rx_i \tag{5}$$

where $p(x)_i$ is the price of the kind *i* of intermediate good and r the return on capital per unit of time. Solving the problem of profit maximisation makes it possible to obtain the conditions of optimality expressed by the equations of the prices and the quantities supplied by the firm, described as follows:

$$\widehat{p}\left(x\right)_i = \widehat{p} = \frac{r}{(1-\alpha)} \forall i \tag{6}$$

and

$$\widehat{x}_i = \widehat{x} = \left[\frac{(1-\alpha)L_Y^{\alpha}}{\widehat{p}}\right]^{1/\alpha} \forall i \tag{7}$$

where equation (5) is inserted into (6) in order to obtain the two relations and where $\widehat{x}$ and $\widehat{p}$ are respectively the optimal price and quantity set by the monopolist in the sector of intermediate goods. The result, described in (7) and (8), represents a standard problem of profit maximisation in monopoly conditions with constant marginal costs and constant elasticity of demand. On inserting the optimal prices and quantities into the monopolist's profit function (5), its optimal profit can be derived as:

$$\widehat{\pi}_{\text{i}} = \widehat{\pi} = \alpha(1-\alpha)\frac{\text{Y}}{\text{A}} \tag{8}$$

Equations (6), (7) and (8) show that every firm operating in the SIG sets the same price and sells the same quantity of the durable good it produces. Together with the fact that the intermediate goods and capital are linked by the relation $K = \int_0^A \hat{x}\, di = A\hat{x}$, this consideration leads to the rewriting of (2) as:

$$Y = \left(L_Y A\right)^{\alpha} K^{(1-\alpha)} \tag{9}$$

Finally, it is shown through the combination of (7) and (8) that the return on the capital invested in the SIG (in monopoly conditions) is lower than it would be in a perfect competition regime, thus compensating the work carried out in the SR&D. In fact, while the value of the return on capital invested in conditions of perfect competition is given by $r = (1-\alpha)Y / K$ the return of the SR&D is described as:

$$r = (1-\alpha)^2 \frac{Y}{K} \tag{10}$$

The last sector, named research and development sector SR&D, is characterise by a large number of firms operating in a perfect competition regime. In accordance with Jones (1995), the growth rate of the stock of knowledge or technology in the economy is linked less than proportionally to the level of technological knowledge and share of labour employment in the sector. This assumption means that the function of technology accumulation is no longer linear such as in Romer 1990 but convex. Then if A is the level of acquired knowledge (i.e. technological skills) and L_A the level of employment in the sector, the technology accumulation function can be written as follows:

$$\dot{A} = \delta L_A^{\lambda} A^{\varphi} \tag{11}$$

where δ represents the externalities linked to the level of acquired knowledge and the workforce employed in the SR&D, whereas ϕ and λ respectively represent the productivity of the level of acquired knowledge in the economic system and of the workforce employed in the production of new technology.

Three distinct situations can be identified according to the assumptions adopted on the parameters ϕ and λ: i) $\phi = 1$ and $\lambda = 1$, in which case equation (12) is reduced to $\dot{A} = \delta L_A A$, the functional form described by Romer (1990)[3]; ii) $\phi = 0$ and $\lambda = 1$, or $\phi = 1$ and $\lambda = 0$ in which case, respectively, the accumulation of technology is independent either of acquired knowledge or of the workforce employed in the SR&D; iii) $\phi < 1$ and $\lambda < 1$, where the accumulation of technology is decreasing with respect to the two factors.

An alternative structure to the one described above, proposed by Steger (2005) and others, suppose a linear functional form for the technology accumulation function as in Romer (1990), which allows to interpret the parameters ϕ and λ in terms of the elasticity of factors within the technology accumulation function[4]. On this interpretation, the process of technology accumulation has constant returns to scale, so that $\phi + \lambda = 1$. However, given that the discovery of new ideas may give rise to duplications of discoveries already acquired (something known as the "fishing out" effect), there is a negative externality affecting the technological knowledge already accumulated. Under this new assumption, even if $\phi + \lambda = 1$, by taking into account the negative externality (defined as $e_\phi < 0$), we obtain that $\phi + e_\phi + \lambda < 1$.

If we adopt formulation (11), assuming that the project created in the SR&D is sold on the market of intermediate goods at a price equal to P_A and bear in mind the fact that the SR&D is a sector of perfect competition, it follows that every worker will move into this sector until the wage received is no longer as much as the wage that would be received in the SFO. This means that:

$$\mathrm{w} = \mathrm{P_A} \frac{\dot{\mathrm{A}}}{\mathrm{L_Y}} \qquad (12)$$

where w is contemporary the unit wage paid in the manufacturing sector (see equation 4) and in the SR&D. Equalisation of the two equations gives the following relationship:

$$P_A = \frac{\alpha}{\delta} A^{\alpha-\varphi} (L - L_A)^{\alpha-1} L_A^{1-\lambda} K^{1-\alpha}, \qquad (13)$$

where it is shown that the price paid for every project is an increasing function of the intensity of capital *K*. This means that if innovations are to be implemented, a quantity of capital must be invested. The greater the intensity of the capital employed in the creation both of intermediate

[3] The formulation of technology with constant returns to scale means that the production of final output takes place with increasing returns to scale, thus generating explosive growth.
[4] It is important to note that since the SR&D is perfectly competitive and the function has constant returns to scale, the parameters φ and λ can be interpreted in terms of the elasticity of factors with respect to technology.

goods and of new technology, the smaller its compensation will be and hence the higher the profit of the monopolist in the SIG.

Finally, since the decisions of firms in the SIG as regards the production of a new kind of good depend on the difference between the cost of buying the project (blueprint) from the SR&D (P_A), and the monopoly return, the firm operating in the SR&D will set the price of the blueprint so as to equalise the discounted value of profits in the SIG. Since every kind of intermediate good gives all the firms the same profit at every moment of time, this means that the equation governing arbitrage must always be satisfied:

$$r = \frac{\widehat{\pi}}{P_A} + \frac{\dot{P}_A}{P_A} \tag{14}$$

This equation can be interpreted as meaning that the firm in the SR&D will adjust the price of a project until the decision whether to purchase it and embark on the production of a new kind of intermediate good becomes a matter of indifference to the monopolist in the SIG.

3.2. The solution of the model

The main characteristic of semi-endogenous growth models is the ineffectiveness of policy actions with respect to the long-term rate of growth. As shown by Steger (2005), the solutions of the market and the social planner coincide in terms of long-term growth but tend instead to diverge as regards the rate of balanced growth, in which case the latter gives better results in terms of welfare. Given the purpose of this analysis, however, we shall present only the market solution of the model[5]

In accordance with the above observations, we shall now outline the decentralised solution of the semi-endogenous model of Jones (1995), solving the problem of consumption utility maximisation (1) under the constraint of the accumulation of capital, described as follows:

$$\dot{K} = Y - C, \tag{15}$$

where $\dot{K}$ is the growth rate of capital. It is easy to show that equation (15) can be rewritten in terms of costs of factors of production $\dot{K} = rK + wL + P_A\dot{A} + A\pi - C$.

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[5] For a detailed examination of the implications in terms of welfare, see Steger (2005), Eicher and Turnovsky (1999) and Jones (1995).

The solution of the problem of the representative consumer as regards the market of final output can be obtained through the maximisation of (1) under constraint (15) with respect to consumption per capita and capital. Following the Keynes-Ramsey rule of optimal private consumption, the growth of consumption is described as follows[6]:

$$\gamma = \frac{\dot{C}}{C} = \frac{1}{\sigma}\left[r - n - \rho\right] + n \tag{16}$$

where *r* is the return on capital, as described in equation (10), and *n* the growth rate of the workforce.

In order to obtain a system with stationary variables, we can follow Steger (2005) and rewrite equations (11), (14), (15) and (16) in terms of scaled variables defined as $y = Y / L^{\beta_K}$, $k = K / L^{\beta_K}$, $c = C / L^{\beta_K}$, $a = A / L^{\beta_A}$, $\dot{a} = \dot{A} / L^{\beta_A}$, $p_A = P_A / L^{\beta_K}$, $\zeta = L_Y / L^{\beta_A}$ and $(1-\zeta) = L_A / L^{\beta_A}$, where $\beta_k = \frac{1-\phi+e_\phi+\lambda}{1-\phi+e_\phi}$ and $\beta_A = \frac{\phi+e_\phi}{1-\lambda}$. The analytical derivation of the parameters used to construct the system with scaled variables employs the social planner's solution to the problem of the intertemporal optimisation of the representative consumer (Steger 2005).

The system of equations characterising the optimality conditions and the social planner's problem at the same time can therefore be rewritten as:

$$\gamma = \dot{c} = \frac{c}{\sigma}\left[r - (1-\sigma)n - \rho\right] - \beta_K nc \tag{17}$$

$$\dot{k} = y - c - \beta_K nc \tag{18}$$

$$\dot{a} = \delta a^{\phi}\left[\left(1-\varsigma\right)\right]^{\lambda} - \beta_A na \tag{19}$$

$$\dot{p}_A = p_A\left(r-n\right) - \pi \tag{20}$$

[6] It should be noted that using the version of the budget constraint in terms of prices of factors makes it possible to rewrite the equation as $\gamma = \frac{1}{\sigma}\left[r - \frac{\dot{L}}{L} - \rho\right] + \frac{\dot{L}}{L}$.

$$\frac{\alpha y}{\zeta} = \frac{\alpha j}{(1-\zeta)} \tag{21}$$

where $Y = (a\zeta)^{\alpha} k^{1-\alpha}$, $j = \delta(1-\zeta)^{\lambda} a^{\phi}$, $r = (1-\alpha)^2 \frac{y}{k}$ and $\pi = \alpha(1-\alpha)\frac{y}{a}$.

In particular, (17), (18) and (19) are respectively the Keynes-Ramsey rule of optimal private consumption and the equations of motion for private capital and technology, (20) is the price of the projects produced by the SR&D, and (21) describes the optimal allocation of labour between the SFO and the SR&D.

3.3 An illustrative model

To complete the theoretical analysis, we present now the results of the simulations of the system of equations (17)–(21) under the initial conditions $k(0) = k_0$ and $a(0) = a_0$.

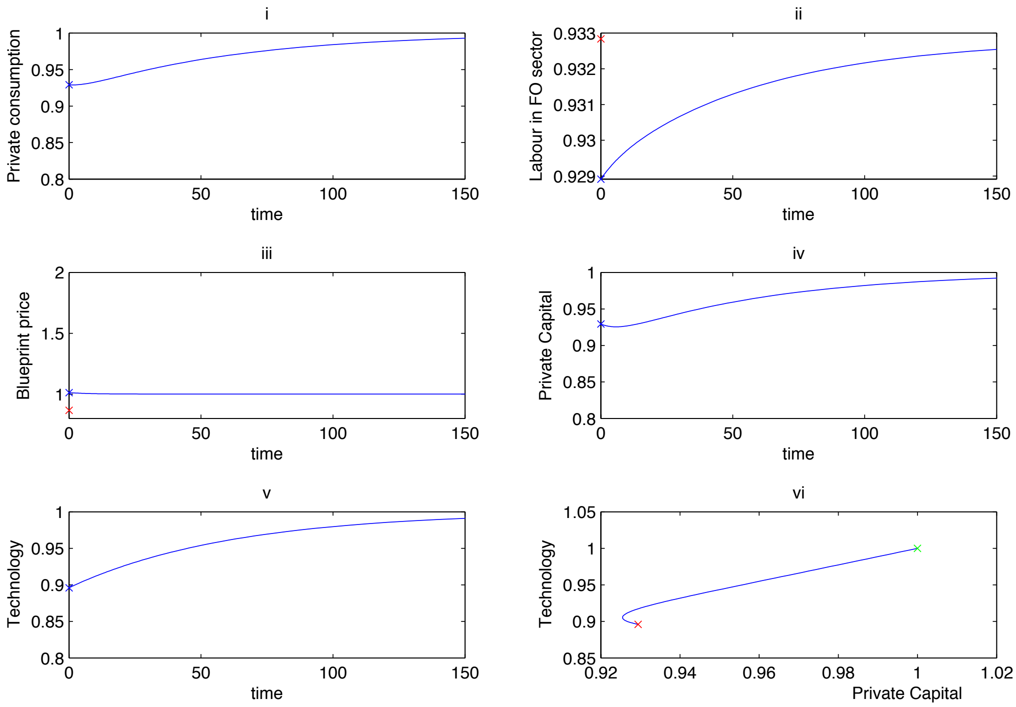
Table 1 – Key parameters of the semi-endogenous growth model

Mean labour shares	α, λ	0.62
Mean capital share	$1-\alpha$	0.38
Elasticity of technology	ϕ	0.38
Social filter	e_{φ}	0.2
Intertemporal rate of substitution	σ	1
Population growth	n	0.01
Depreciation rate	δ	0.04
Substitution rate	ρ	0.05

Note: The mean labour share is measured in terms of the contribution of the number of hours worked to surplus value. Elasticity of technology is the contribution to surplus value of ITC capital goods. All these parameters, including population growth, are extracted from the ISTAT data set and constructed as means for the period 2000-2008. The other parameters, which are standard in the growth literature, are taken from Jones and Williams (2000).

In order to obtain a more realistic outcome from the simulations, some key parameters are calibrated by means of Italian data extracted from the ISTAT (the Italian Institute of Statistics) data set, the elasticity of technology, mean labour shares and the population growth rate being measured respectively in terms of the mean value of the contribution of high-tech capital goods to surplus value, the contribution of the number of hours worked to surplus value, and the residential population growth rate. Each parameter is constructed as the mean value of each variable over the period 2000-2008. The other parameters, which are standard in the growth literature, are taken from Jones and Williams (2000).

Figure 1 – Simulations of a shock on e_φ



Note: The parameters used in the simulation are reported in Table 1. The steady state values are normalised to one for each of the key variables. The simulations use the relaxation algorithm.

Figure 1 presents the results of the simulations of a unitary percentage shock on the negative externality e_φ affecting the technological knowledge already accumulated. The impact on private consumption, the share of labour in SFO, the price of blueprints, private capital, technology, and the relationship between private capital and technology are plotted respectively from the top left. The analysis provides three major results. First of all, the shock on e_φ affects the overall economic system by reducing not only the growth rate of technology but also private consumption and private capital (the "crowding-out" effect). The most marked impact of the shock is obviously on the growth rate of technology. This is due to the need to use more technological knowledge and more human capital in order to obtain the same growth rate of technology when the negative externality of technology increases. After the shock (panel ii of the figure), a temporary decrease can also be expected therefore in the share of workers in the sector of final output as a result of moving a certain number of workers to SR&D (the crowding-out effect on human capital). Second, the simulation results do not involve the growth rate of blueprint prices (equation 20), which remain approximately constant in the event of a shock affecting the negative externality e_{φ}. Finally, even if the shock is not permanent, it is highly persistent over time. The persistency of the shock is caused by i) the continuous adjustment of the shares of workers between the sectors of final output and SR&D, and ii) by excessive investment in R&D caused by the low rate of transmission of technological skills.

3.4 Empirical specification of the growth equation

The results obtained from the simulation of the system of equations (17-21) serve to set-up an empirical formulation for the growth equation that will be used in Section 5 to estimate the relationship between technological accumulation and economic growth. The empirical formulation of the growth equation can be written as:

$$\gamma_{it} = \phi_1 p\_inv_{it-1} + \phi_2 tec_{it-1} + \phi_3 Chum_{it-1} + \phi_4 X_{it} + e_{it} \tag{22}$$

where p_inv_{it-1}, tec_{it-1} and $Chum_{it-1}$ respectively denote private capital, technological knowledge and human capital, γ_{it} is the growth rate of GDP per capita used as a proxy for the private consumption growth rate, and e_{it} is an error term. Moreover $X_{it} = [Sfilter_{it}, Sfilterxtec_{it}, SfilterxChum_{it}, Sfilterxp\_inv_{it}]$ represents the vector of exogenous variables. This includes the negative externality of technology $Sfilter_{it}$, which will be identified and estimated in Section 4, and three different interaction variables indicating the impact of this externality respectively on technological knowledge, human capital and private capital. To be more specific, $Sfilterxtec_{it}$ indicates the impact of the social filter on the accumulation of technological knowledge, $Sfilterxp\_inv_{it}$ the crowding-out of private capital, and $SfilterxChum_{it}$ the crowding-out effect of human capital. These interaction terms characterise the impact of the externality of technology on the different variables as described by panels ii, iv and v of Figure 1. We shall return to the econometric specification of the growth equation in Section 5.1.

4. An estimate of the social filter for the Italian regions

The hypotheses arising from the theoretical model can be tested for the Italian regions by estimating a composite indicator that includes yardsticks of competitiveness and environmental and social sustainability. This indicator should serve as a proxy for the negative externality affecting the knowledge already accumulated (from now on social filter), which have effects on the economic system and on territorial growth prospects, as discussed in the previous section. The identification process draws on the work of Crescenzi and Rodríguez-Pose (2009), which calculates a measurement of the social filter for the European regions based exclusively on variables regarding human resources and demographic structure.

We shall instead broaden the analysis to consider also variables reflecting other social and institutional dimensions that may affect the competitiveness of the regions. In particular, the variables that define the social filter for each Italian region can be identified primarily in the three spheres of social exclusion (Riggi and Maggioni 2009), the educational level of the population (Lundvall 1992, Bramanti and Riggi 2009, Crescenzi and Rodríguez-Pose 2009, Castellacci and Archibugi 2008) and the efficiency of local institutions in delivering essential services which affect the quality of territory (Camagni 2009, Capello et al. 2009).

The indicator is constructed based on the targets set by the Dipartimento delle Politiche di Sviluppo (DPS: Department of Development Policies) in the last cycle of regional policies (2007–13) with reference to some essential services. As regards the first sphere of interest, namely social exclusion, three variables are considered: i) long-term unemployment (ld); ii) the rate of juvenile unemployment (dg); iii) the index of regional poverty of families (pf). The first is constructed as the percentage of people seeking employment for over 12 months with respect to the total workforce, the second as the percentage of people aged 15–24 seeking employment with respect to the same age group in the total workforce, and the third as the percentage of families living beneath the poverty threshold.

The variables regarding the second sphere, which describes the quality of human resources, are as follows: i) the drop-out rate at the end of the first year of high school (ass), characterised as the number of drop-outs among pupils enrolled in the first year of high school with respect to the total; ii) the rate of secondary education (es), defined as the total number of high school pupils with respect to the 14–18 age group of the resident population; iii) the percentage of employed people taking part in courses of training and education (let), defined as the percentage of employed adults aged 25–64 involved in training and education schemes with respect to the corresponding age group of the employed population as a whole.

Finally, two variables are used to pinpoint the efficiency of local institutions: i) the presence of municipal waste-sorting services (rd); ii) the families' perception of the risk of crime in the area where they live (rc). Table 2 presents the primary results of principal component analysis (PCA) regarding the eight variables selected within the three dimensions identified. The estimate refers to the year 1998. As the Table shows, the first component accounts for a large proportion of the information contained in the set of variables, with a cumulative frequency equal to 44% of the information as a whole. When the second component is also taken into consideration, the cumulative frequency rises to approximately 80% of the total information. This result appears to confirm that the correct variables have been chosen to measure the competitiveness and socio-institutional conditions of the regions.

Table 2 – Estimate of the principal components for the Italian regions, year 1998

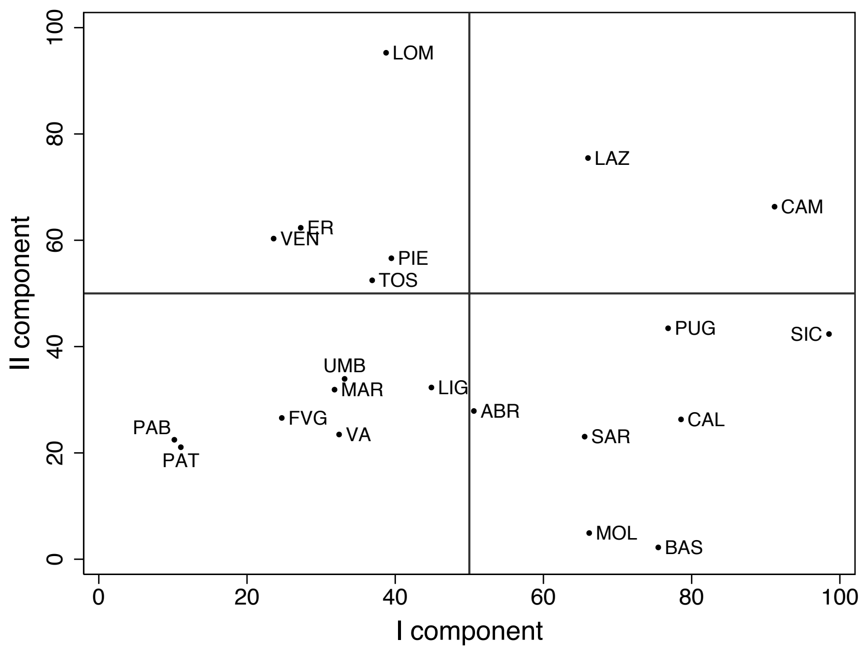
Analysis of the eigenvalues in the correlation matrix								
	Comp I	Comp II	Comp III	Comp IV	Comp V	Comp VI	Comp VII	Comp VII
Eigenvalue	3.530	2.824	0.727	0.394	0.320	0.140	0.039	0.025
Frequency	0.441	0.353	0.091	0.049	0.040	0.018	0.005	0.003
Cumulative frequency	0.441	0.794	0.885	0.934	0.974	0.992	0.997	1.000

Coefficients of the principal components								
	Comp I	Comp II	Comp III	Comp IV	Comp V	Comp VI	Comp VII	Comp VIII
es	-0.160	0.503	-0.243	0.205	-0.581	-0.407	0.031	0.340
ld	0.428	0.257	-0.321	-0.224	-0.133	0.672	-0.163	0.320
dg	0.495	0.180	-0.031	0.201	-0.009	-0.013	0.777	-0.278
let	-0.210	0.522	-0.118	0.318	0.114	0.238	-0.298	-0.641
rd	-0.484	0.096	0.201	0.397	0.244	0.429	0.357	0.433
rc	0.527	0.427	-0.013	-0.430	0.637	-0.306	0.055	0.190
pf	0.468	-0.065	-0.018	0.649	0.336	-0.212	-0.356	0.266
ass	0.220	0.292	0.884	-0.059	-0.232	0.057	-0.151	0.024

Notes: The variables used to estimate PCA are: i) the rate of secondary education (es), ii) long-term unemployment (ld), iii) juvenile unemployment (dg), iv) percentage of employed people taking part in courses of training and education (let), v) the presence of municipal waste-sorting services (rd), vi) the risk of crime (rc), vii) household poverty (pf), and viii) the drop-out rate at the end of the first year of high school (ass).

The lower section of the Table shows the contributions of each variable to the identification of all the principal components. Since the first two components prove predominant, the other six emerging from PCA are discarded. The first component is characterised by high positive coefficients with respect to long-term unemployment (ld), juvenile unemployment (dg), household poverty (pf) and the risk of crime (rc). It should be noted that the variables connected with level of education and human capital all have negative coefficients apart from the one regarding the school drop-out rate. Particularly, the positive sign of the school drop-out rate variable is in line with the expectations, since it is connected to the attractivity of the school system. These results appear to bear out the identification of the first component, measuring the competitiveness and socio-institutional conditions of the regions, as a social filter.

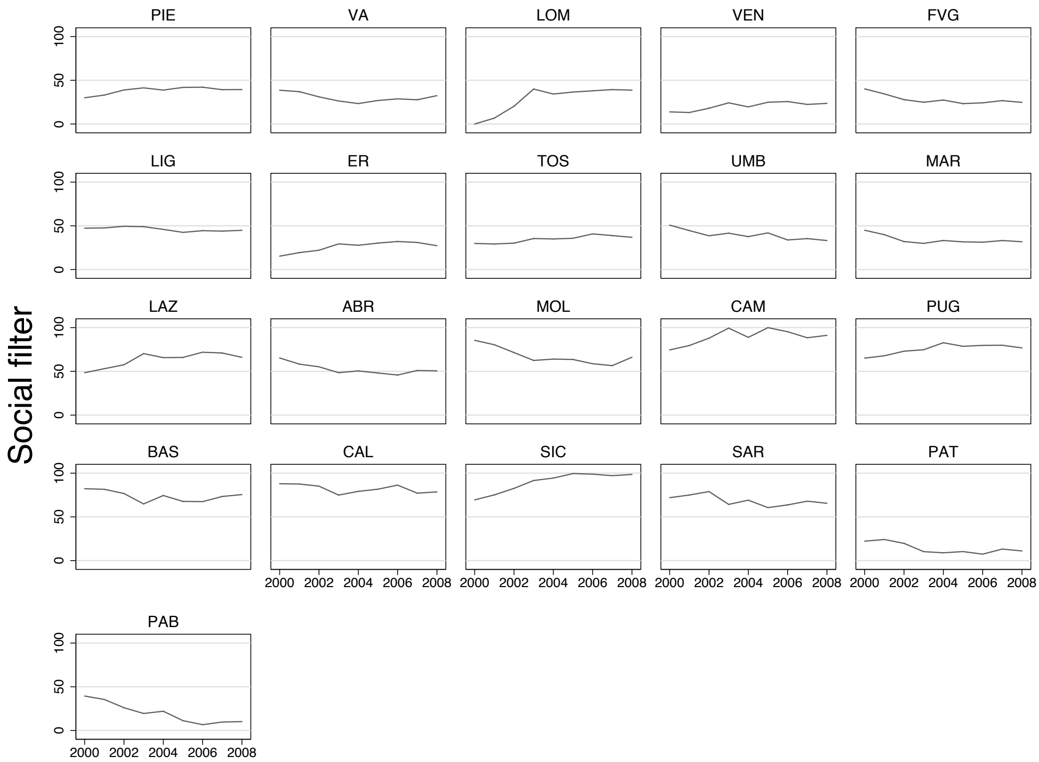
Figure 2 – Relation between the first two principal components for each region, year 1998



Notes: Both the components have been rescaled between 0 and 100. The first component, identified by the social filter, presents lower values when there is the absence of of socio-institutional problems. On the contrary, the second component, identified by an index of competitiveness of the economic system referring primarily to the endowment of human capital, presents lower values when the economic system is unattractive.

The data presented in the Table make it possible to put forward an identification also for the second principal component, which is characterised by a strongly positive incidence of the variables connected with education and human capital in general and could therefore be identified as an index of competitiveness of the economic system referring primarily to the endowment of human capital. This second identification proves less immediate, however, in view of the positive coefficients of certain variables, such as the risk of crime and juvenile unemployment.

Figure 3 – Estimate of the social filter for the Italian regions, 1998–2008



Notes: The longitudinal values of social filter are estimated by the principal component analysis maintaining the variables indentifying each component as fixed.

Figure 2 presents the ranking of the Italian regions in terms of the two principal components identified above. Some clarifications are needed before proceeding. First, Component I, which can be reasonably identified as social filter, is measured on a scale from 0 to 100, where the lower values represent the absence of socio-institutional problems. This means that the social filter has greater importance in the Italian regions on the positive side of the axis. Second, Component II is measured on a scale from 0 to 100, where the positive values correspond to a great competitive attractiveness of the economic system. Two primary results can be seen in the figure. First, the regions of the South are concentrated in the right half of the diagram and therefore are characterised by an higher incidence of the social filter. Second, among the regions of the Centre and North, which are concentrated in the left half (scarce presence of negative externalities of environmental and social character), the regions of the Northwest are distinguished by an higher degree of competitiveness of the economic system (Component II). Furthermore, except for Campania, characterized by high values of both the principal components, all the regions located in South Italy area are characterized by high values for the social filter (Component I) and low degree of competitiveness of the economic system (Component II).

Finally, Figure 3 shows the trends of the social filter over time for each of the regions considered, the results being obtained by extending the Principal Factor Analysis PFA to cover the period 1998–2008[7]. The figure shows that the social filter increased for example in Lombardy, Emilia Romagna, Campania, Puglia and Sicily, and decreased in Sardinia and Abruzzo.

5. Results of the empirical analysis

5.1. Data and variables

The data used to estimate the growth equation (22) for the Italian regions over the period 2000–2008 are extrapolated from the DPS-ISTAT territorial database on development policies. The choice of period, depending largely on the availability of data, restricts the previous analysis to the time length 2000-2008. The dependent variable γ_{it} is the yearly percentage growth rate of Gross Domestic Product per capita and p_inv_{it} is the percentage ratio of gross private investment to GDP. The percentage of patents registered at the European Office Patent per million inhabitants is the proxy variable describing the level of technological knowledge in the economic system tec_{it}, whereas $Chum_{it}$ is measured by the percentage ratio of workers employed in R&D on the total active workforce. Finally, $Sfilter_{it}$ is the score for each region with regard to the first principal component, identified and estimated in Section 4. The original measurement is scaled so as to obtain an index from 0 to 100, where 100 indicates the worst performance in terms of the impact of the social filter on the economic system.

Appendix A presents descriptive statistics for all the variables used in the panel data analysis. In order to complete the data set, different trend variables are constructed by dividing Italy into four geographical macro-regions (North, Centre, South and Islands) in accordance with the

[7] The use of PFA is suitable since allows us to fix the identification of each component over time.

classification provided by ISTAT. This classification is also contained in Appendix A. Moreover, since ISTAT also provides a more compact classification of the Italian regions into Centre-North (including the central and northern regions) and Mezzogiorno (the southern regions and islands), this is also considered in Appendix A.

5.2. Econometric methods

This subsection addresses a number of econometric issues related to the empirical growth equation (22) described in Section 3.3. Since the purpose of the empirical analysis is to investigate the transitional dynamics in the neighbour of the steady state, the error term e_{it} is reparameterised as:

$$e_{it} = \phi_0 y_{it-1} + \eta_t + v_i + \varepsilon_{it} \tag{23}$$

where y_{it-1} is the initial condition of the economic system, η_t an idiosyncratic shock, and v_i the fixed effect. The insertion of (23) into (22) then gives us:

$$\gamma_{it} = \phi_0 y_{it-1} + \phi_1 p\_inv_{it-1} + \phi_2 tec_{it-1} + \phi_3 Chum_{it} + \phi_4 X_{it} + \eta_t + v_i + \varepsilon_{it} \tag{24}$$

where p_inv_{it-1}, tec_{it-1} and $Chum_{it-1}$ respectively represent private capital, technology and human capital, γ_{it} is the growth rate of GDP per capita used as a proxy for the private consumption growth rate, and $X_{it} = [Sfilter_{it}, Sfilterxtec_{it}, SfilterxChum_{it}, Sfilterxp\_inv_{it}]$ is the vector of exogenous variables, which includes the negative externality of technology $Sfilter_{it}$, as estimated in Section 4, and three different interaction variables indicating the impact of this externality respectively on technology, human capital and private capital.

Equation (24) highlights some problems regarding the econometric estimate. First, the specific non-observable terms related to of the individual region v_i and the time period η_t must be handled in different ways due to the dynamic nature of the equation. To be more specific, the first effect is addressed using dummy variables and the second requires the use of first difference estimator. Second, in order to avoid a loss of efficiency, it is necessary to take into account the presence of endogeneity in at least two explanatory variables, namely private investment and the level of technological knowledge. The hypothesis of endogeneity in these regressors depends directly on the accumulation functions described by equations (18) and (19) respectively. Furthermore, it should be noted that since the share of the workforce in SR&D depends on the wages received by the workers in this sector compared to the wage in the sector of final output, the variable of human capital can also be treated as endogenous.

The Generalized Method of Moments (GMM) for panel data, originally presented by Arellano and Bond (1991) and Arellano and Bover (1995), is used to estimate equation (24). These estimators are based, first, on the first difference of the regressors, in order to control the non-observable effects and, second on the use of the past values of the dependent variable and the regressors as instruments to eliminate the problems due to endogeneity. Equation (24) , therefore, can be rewritten as:

$$\Delta\gamma_{it} = \varphi_1\gamma_{it-1} + \phi_2\Delta p\_inv_{it-1} + \Delta\phi_3 tec_{it-1} + \Delta\phi_4 Chum_{it}\phi_5\Delta X_{it} + \Delta\varepsilon_{it} \quad (25)$$

Thus specified, equation (25) violates the assumption of non-correlation between the term of error $\Delta\varepsilon_{it}$ and the dependent variable γ_{it-1} expressed at time $t-1$. The use of instruments becomes necessary in order to restore both the assumption of non-correlation and the assumption of exogeneity in the regressors at the same time. Moreover, it is important to note that there is a trade-off between efficiency and bias in the estimator, which derives from the excessive use of instruments, in terms of lags of the variables included in the econometric specification. As discussed by Roodman (2009), the over-use of instruments, especially when the cross-sectional component is small, can lead to a non-robust estimate of the parameters. In order to limit the presence of bias in the estimates, it is advisable to use only one lag for each explanatory variable. The moment conditions for equation (24) can therefore be written as:

$$E[\bar{X}_{it-2}(\epsilon_{it} - \epsilon_{it-1})] = 0$$

where $\bar{X}_{it+2}$ is the vector of explanatory variables that also includes the endogenous variables. Particularly, if we define $\Delta\varepsilon_i$ as the vector of transformed error terms and Z_{it} as a composite matrix of instruments, where each row contains instruments that are valid for a given period, the set of moment conditions can be written concisely as:

$$E[Z_i'\Delta\varepsilon_i] = 0$$

The use of these moment conditions makes it possible to obtain efficient and robust estimates through utilisation of the GMM estimator.

A crucial assumption for the validity of GMM is that the instruments are exogenous. If the model is exactly identified, detection of invalid instruments is impossible because even when $E[Z_i'\Delta\varepsilon_i] \neq 0$, the estimator will choose $\hat{\beta}$ so that $Z'\hat{E} = 0$ exactly. If the model is over-identified, however, a test statistic for the joint validity of the moment conditions (identifying restrictions) falls naturally out of the GMM framework. The Hansen (1982) J test statistic for over-identifying restrictions requires that, under the null of joint validity, the vector of empirical moments $\frac{1}{N}Z'\hat{E}$ should by randomly distributed around 0. A Wald test can be used verify this and has a χ^2 distribution with degrees of freedom equal to the degree of over-identification, $j-k$. When the sample size N goes to infinity, the Hansen test coincides with the Sargan (1958) statistic.

Sargan Hansen statistics can also be used to test the validity of subsets of instruments via a difference in Sargan/Hansen test statistic (DSH test), also known as a C statistic. If an estimation is performed both with and without a subset of suspect instruments, under the null of joint validity of the full instrument set, the difference in the two reported Sargan Hansen test statistics is itself asymptotically a χ^2 distribution with degrees of freedom equal to the number of suspect instruments. The regression without the suspect instruments is called the unrestricted regression, since it imposes fewer moment conditions, and is investigated by means of the unrestricted Sargan/Hansen test statistic (USH test). The difference-in-Sargan test is of course only feasible if this unrestricted regression has enough instruments to be identified.

Finally, since the estimations and the test of over-identified restrictions are valid only when there is no residual autocorrelation in the error term, the Arellano-Bond statistic is used to test for the absence of second-order autocorrelation.

Three different measures of elasticity, namely direct, indirect and total, are constructed in order to complete the empirical framework. These are obtained from the parameters estimated in equation (25). For example, the direct elasticity of technological knowledge is parameterised as:

$$dir\_e\_tec_{it} = \phi_2 \left[TEC / \Gamma \right] \tag{26}$$

where ϕ_2 is the parameter estimated in (25), and TEC and Γ are the mean values respectively of technological knowledge and the per capita GDP growth rate. Moreover, the indirect elasticity of technological knowledge with respect to the social filter is parameterised as:

$$indir\_e\_tec_{it} = \phi_{filterxtec_{it}} \left[TEC / \Gamma \right] \tag{27}$$

where $\phi_{filterxtec_{it}}$ is the parameter of the interaction variable $filterxtec_{it}$ estimated in (25). The total elasticity measure is the sum of the direct (26) and indirect (27) elasticity measures.

5.3 Results

Table 3 presents the major results obtained from equation (25) by means of the Arellano and Bond (1991) first-difference GMM estimator.

The first column, which is used as a benchmark, includes all the endogenous variables, time dummies and trend variables indicating specific temporal behaviours of the Italian macro-regions (North, South, Centre and Islands). The second shows the direct effect of the social filter and the last three indicate the indirect links between the social filter and the level of technology, private investment and human capital respectively. In accordance with Roodman (2009), the matrix of instruments used, excluding all time dummy variables and specific trend variables, includes only the first lagged value of each variable. The accuracy of the instrument matrix used is investigated for each set of variables by means of the unrestricted Sargan/Hansen test (USH test) and the first-difference Sargan/Hansen test (DSH test), and for the entire instrument set by means of the Sargan (1958) test statistic, presented at the bottom of the table along with the Arellano Bond II order serial correlation test and the number of instruments used.

Table 3 – Estimation results, full sample analysis

	II		III		IV		V		VI	
γ_{t-1}	0.194	**	0.187	**	0.068		0.112		0.196	**
	(0.083)		(0.082)		(0.146)		(0.099)		(0.097)	
$Chum_{it-1}$	0.249	**	0.322	**	0.188		0.412	***		
	(0.122)		(0.128)		(0.208)		(0.136)			
p_inv_{it-1}	0.248	*	0.246		0.305				0.513	**
	(0.172)		(0.199)		(0.286)				(0.222)	
tec_{it-1}	0.723	*	0.781	*			1.113	**	0.955	*
	(0.412)		(0.411)				(0.455)		(0.490)	
$Sfilter_{it}$			-0.045	*						
			(0.024)							
$Sfilter_{it} xtec_{it}$					-0.009	*				
					(0.005)					
$Sfilter_{it} xinv_{it}$							-0.003	***		
							(0.001)			
$Sfilter_{it} xhum_{it}$									-0.001	
									(0.002)	
$d.2001$	-9.395	***	-9.381	***	-6.796	**	-8.996	***	-8.255	***
	(1.296)		(1.277)		(3.034)		(1.385)		(1.455)	
$d.2002$	-9.363	***	-9.378	***	-7.506	***	-9.185	***	-8.474	***
	(1.075)		(1.059)		(2.409)		(1.132)		(1.172)	
$d.2003$	-7.863	***	-7.869	***	-6.516	***	-7.748	***	-7.277	***
	(0.850)		(0.837)		(1.695)		(0.886)		(0.913)	
$d.2004$	-4.847	***	-4.853	***	-3.948	***	-4.843	***	-4.477	***
	(0.638)		(0.628)		(1.156)		(0.665)		(0.673)	
$d.2005$	-3.879	***	-3.862	***	-3.278	***	-3.653	***	-3.719	***
	(0.484)		(0.477)		(0.782)		(0.506)		(0.512)	
$t.nord$	-1.664	***	-1.731	***	-1.370	***	-1.614	***	-1.564	***
	(0.241)		(0.238)		(0.522)		(0.267)		(0.289)	
$t.sud$	-1.722	***	-1.917	***	-0.277		-2.297	***	-1.387	***
	(0.268)		(0.283)		(1.747)		(0.362)		(0.304)	
$t.islands$	-2.398	***	-2.119	***	-2.326	**	-2.568	***	-2.214	***
	(0.424)		(0.437)		(1.076)		(0.568)		(0.565)	
$t.center$	-1.764	***	-1.508	***	-2.582	*	-1.049	**	-1.592	***
	(0.390)		(0.417)		(1.688)		(0.474)		(0.519)	
Sargan test	0.145	26	0.119	26	0.288	20	0.054	20	0.318	20
USH test (a)	0,585		0,539		0,421		0,151		0,430	
DSH test (a)	0,078	18	0,067	18	0,288	18	0,073	18	0,292	18
USH test (b)	0,985		0,987		0,985		0,978		0,651	
DSH test (b)	0,047	21	0,036	21	0,136	14	0,008	14	0,196	14
USH test (c)			0,105		0,245		0,046		0,263	
DSH test (c)			0,457	1	0,578	1	0,449	1	0,988	1
AB test second order	0.297		0.268		0.457		0.165		0.419	
N	147		147		147		147		147	

Note: The dependent variable is the growth rate of GDP per capita. The asterisks indicate the levels of significance of the parameters: * 0.10, ** 0.05 and *** 0.01. Two tests – the unrestricted Sargan/Hansen test (USH test) and the first-difference Sargan/Hansen test (DSH test) – are given for each set of instruments at the bottom of the table. These are applied to the set of instruments from: (a) the dependent variable, (b) the endogenous variables and (c) the exogenous variables. The Sargan (1958) test statistic is used to investigate the entire instrument set and the Arellano Bond test to investigate the presence of second-order autocorrelation into the error term.

The first column of Table 3 shows that all the key endogenous variables emerging from the semi-endogenous growth model are statistically significant in influencing the growth rate of per capita GDP in the Italian regions. In particular, the lagged value of the technological level tec_{it-1} shows a strong coefficient of 0.723, which confirms that the accumulation of technological knowledge is one of the most important factors determining the growth rate of Italian regions (see Lodde 2008, Hirsch and Sulis 2009, Marrocu and Paci 2010, Quatraro 2009). Moreover, the introduction of the direct impact of the social filter on the per capita GDP growth rate (column 2), shows that poor performance as regards factors of a social and institutional character affects regional growth with a coefficient of -0.045. The scale of this parameter is higher than that estimated by Crescenzi and Rodríguez-Pose (2009) for the European regions, where the value registered for the social filter was only of 0.010. As noted above, however, our findings differ substantially from those of Crescenzi and Rodríguez-Pose, who include only aspects connected with human capital in the estimation of the social filter.

The introduction of the first indirect effect, which regards the impact of the social filter on the accumulation of technological knowledge (column 3), shows that a further negative impact of the social filter on the per capita GDP growth performance takes place through a lower degree of accumulation of technological knowledge in line with the simulations presented in Figure 1. In detail, the negative externalities generated by adverse socio-institutional conditions reduce the possibility of using the technological knowledge already acquired in order to generate more technology.

A similar pattern is found in column IV, where the channel of private investment is taken into account. Again in line with the simulations, we find the crowding-out of private investment due to the social filter with a parameter of -0.003. In accordance with expectations, the magnitude of the impact in the latter case is weaker than the impact measured for the accumulation of technological knowledge. The last column introduces the channel of human capital, which constitutes the last link between the social filter and the per capita GDP growth rate. Unlike the two previous cases, the last column of the table presents no statistically significant relationship, thus showing either that there is no evidence of a crowding-out effect of human capital in the Italian context or, that this effect is too slow to be statistically detected.

A final result emerging from the table regards the deterministic components addressed in order to detect heterogeneous behaviours in the Italian areas during the period considered. In particular, the significance of time dummy variables shows marked variability of the per capita GPD growth performance, whereas the specific area trends show that different areas in Italy exhibit different economic performances. In order to take into account the heterogeneity emerging within the different areas in Italy, the full sample estimation is replicated for two sub-samples of Italian regions based on the values of the social filter $Sfilter_{it}$. To be more specific, an initial sub-sample is constructed including only the regions with lower than median values for the social filter together with another including all the remaining regions. The first sub-sample includes all the regions in the North and Centre of Italy, without Lazio, which is placed in the second sub-sample along with all the regions in the South and the Islands. The selected sub-samples coincide with the Centre-North/Mezzogiorno macro-regions of Italy except for Lazio.[8] The exception is due to the fact that, as shown in section 4, the position of Lazio in the Italian context, in terms of socio-institutional problems alone, is closer to the Mezzogiorno.

Table 4 presents the results for the low social filter sub-sample (the Centre-North macro-region without Lazio) using the same structure as Table 3. The first column confirms the importance of technological knowledge on per capita GDP growth performance. Since most innovation activities are concentrated in the Centre-North macro-area, the magnitude of the coefficient of tec_{it-1} near 1.8 is not surprising. The impact of the social filter on the accumulation of technological knowledge (column III) is higher than in the full sample analysis.

The estimated parameter $Sfilter_{it}xtec_{it}$ (equal to -0.012) suggests in fact that in the Centre-North sub-sample the accumulation of technological knowledge is the major channel through which the social filter affects the economy's growth rate. The rest of the table is nearly in line with the full sample analysis, with a direct impact of the social filter and a private investment crowding-out effect slightly lower than in the previous case.

[8] See Appendix A for an analytical classification of the Italian regions and macro-regions.

Table 4 – Estimation results, Centre-North macro-region without Lazio

	II		III		IV		V		VI	
γ_{t-1}	0.021		0.009		-0.270	*	0.065		0.195	
	(0.106)		(0.104)		(0.158)		(0.107)		(0.144)	
$Chum_{it-1}$	0.245	*	0.276	*	0.016		0.348	*		
	(0.146)		(0.175)		(0.201)		(0.180)			
p_inv_{it-1}	0.168		0.139		0.103				0.410	*
	(0.201)		(0.196)		(0.229)				(0.277)	
tec_{it-1}	1.782	***	1.754	***			2.066	***	2.101	***
	(0.667)		(0.646)				(0.719)		(0.753)	
$Sfilter_{it}$			-0.041	*						
			(0.022)							
$Sfilter_{it}xtec_{it}$					-0.012	*				
					(0.007)					
$Sfilter_{it}xinv_{it}$							-0.002	*		
							(0.001)			
$Sfilter_{it}xhum_{it}$									0.004	
									(0.004)	
$d.2001$	-8.049	***	-7.936	***	-3.095		-8.090	***	-8.163	***
	(1.826)		(1.787)		(2.391)		(1.808)		(2.281)	
$d.2002$	-8.370	***	-8.301	***	-4.254	**	-8.223	***	-8.104	***
	(1.459)		(1.426)		(1.984)		(1.457)		(1.758)	
$d.2003$	-7.482	***	-7.362	***	-4.601	***	-7.101	***	-7.312	***
	(1.096)		(1.075)		(1.438)		(1.087)		(1.290)	
$d.2004$	-4.579	***	-4.547	***	-3.065	***	-4.396	***	-4.316	***
	(0.779)		(0.762)		(0.932)		(0.780)		(0.902)	
$d.2005$	-3.288	***	-3.255	***	-2.455	***	-3.167	***	-3.266	***
	(0.490)		(0.480)		(0.577)		(0.490)		(0.568)	
$t.nord$	-1.339	***	-1.361	***	-0.624		-1.379	***	-1.191	***
	(0.347)		(0.336)		(0.474)		(0.358)		(0.423)	
$t.center$	-2.424	***	-2.308	***	-0.404		-2.118	***	-2.489	***
	(0.583)		(0.552)		(0.774)		(0.641)		(0.773)	
Sargan test	0.096	24	0.072	24	0.046	18	0.099	18	0.436	18
USH test (a)	0,479		0,244		0,126		0,070		0,622	
DSH test (a)	0,052	15	0,078	15	0,082	15	0,232	15	0,348	15
USH test (b)	0,114		0,073		0,152		0,046		0,613	
DSH test (b)	0,237	6	0,284	6	0,058	7	0,547	7	0,239	7
USH test (c)	0,166		0,157		0,090		0,103		0,411	
DSH test (c)	0,155	14	0,118	14	0,116	6	0,265	6	0,439	6
USH test (d)			0,057		0,150		0,076		0,501	
DSH test (d)			0,704	1	0,014	1	0,742	1	0,160	1
AB second order test	0.856		0.747		0.247		0.773		0.209	
N	87		87		87		87		87	

Note: The dependent variable is the growth rate of GDP per capita. The asterisks indicate the levels of significance of the parameters: * 0.10, ** 0.05 and *** 0.01. Two tests – the unrestricted Sargan/Hansen test (USH test) and the first-difference Sargan/Hansen test (DSH test) – are given for each set of instruments at the bottom of the table. These are applied to the set of instruments from: (a) the dependent variable, (b) the endogenous variables and (c) the exogenous variables. The Sargan (1958) test statistic is used to investigate the entire instrument set and the Arellano Bond test to investigate the presence of second-order autocorrelation into the error term.

Table 5 - Estimation results, Mezzogiorno macro-region with Lazio

	II		III		IV		V		VI	
γ_{t-1}	0.111		0.092		-0.091		-0.118		0.137	
	(0.152)		(0.146)		(0.181)		(0.177)		(0.155)	
$Chum_{it-1}$	0.986	*	0.852	*	0.002		2.123	***		
	(0.515)		(0.494)		(0.475)		(0.682)			
p_inv_{it-1}	0.518	***	0.482	**	0.179				0.345	
	(0.197)		(0.187)		(0.204)				(0.260)	
tec_{it-1}	1.081	***	1.054	***			0.768	**	0.788	**
	(0.360)		(0.345)				(0.371)		(0.335)	
$Sfilter_{it}$			-0.077	**						
			(0.031)							
$Sfilter_{it} xtec_{it}$					-0.009	**				
					(0.004)					
$Sfilter_{it} xinv_{it}$							-0.003	**		
							(0.001)			
$Sfilter_{it} xhum_{it}$									-0.005	
									(0.007)	
$d.2001$	-2.593	*	-3.061	**	0.154		-2.575	*	-3.475	**
	(1.540)		(1.478)		(3.240)		(1.722)		(1.570)	
$d.2002$	-3.837	***	-4.143	***	-1.645		-3.804	***	-4.436	***
	(1.281)		(1.226)		(2.603)		(1.428)		(1.302)	
$d.2003$	-3.054	***	-3.500	***	-2.003		-4.043	***	-3.941	***
	(1.038)		(1.004)		(1.839)		(1.130)		(1.082)	
$d.2004$	-1.483	*	-1.716	**	-0.715		-1.866	**	-2.115	**
	(0.817)		(0.782)		(1.223)		(0.900)		(0.848)	
$d.2005$	-1.914	***	-2.075	***	-1.476	*	-1.600	**	-2.484	***
	(0.712)		(0.683)		(0.958)		(0.756)		(0.694)	
$t.sud$	-0.909	***	-1.020	***	-0.291		-1.673	***	-0.879	***
	(0.258)		(0.251)		(0.747)		(0.354)		(0.320)	
$t.islands$	-1.290	***	-1.222	***	-0.223		-0.751	*	-1.198	***
	(0.379)		(0.354)		(0.491)		(0.459)		(0.400)	
Sargan test	0.11	28	0.197	28	0.108	22	0.427	22	0.023	22
USH test (a)	0.084		0.096		0.846		0.938		0.213	
DSH test (a)	0.307	18	0.455	18	0.063	18	0.242	18	0.027	18
USH test (b)	0.698		0.636		0.590		0.715		0.079	
DSH test (b)	0.053	21	0.116	21	0.054	14	0.246	14	0.061	14
USH test (c)			0.195		0.184		0.374		0.035	
USH test (c)			0.303	1	0.058	1	0.735	1	0.086	1
AB second order test	0.527		0.244		0.356		0.523		0.225	
N	60		60		60		60		60	

Note: The dependent variable is the growth rate of GDP per capita. The asterisks indicate the levels of significance of the parameters: * 0.10, ** 0.05 and *** 0.01. Two tests – the unrestricted Sargan/Hansen test (USH test) and the first-difference Sargan/Hansen test (DSH test) – are given for each set of instruments at the bottom of the table. These are applied to the set of instruments from: (a) the dependent variable, (b) the endogenous variables and (c) the exogenous variables. The Sargan (1958) test statistic is used to investigate the entire instrument set and the Arellano Bond test to investigate the presence of second-order autocorrelation into the error term.

Table 5 presents the results for the high social filter sub-sample (Mezzogiorno macro-region with Lazio). Once again, the first column shows the importance of technological knowledge as a driver of economic growth. The share of human capital with respect to active population and the share of private investment with respect to GDP also play an important role. In this context, the closeness of the parameter $Chum_{it-1}$ to 1.00 indicates that the share of skilled workers is a crucial aspect to be taken into account in order to improve the economic growth performance of the economically backward southern Italian regions. In our view, this result could be due to friction in the labour market that obstructs the hiring of skilled workers and forces them to emigrate to the central and northern regions. The rest of the table shows that the social filter has a primarily direct effect on the economic system of this area (column II) with a parameter of -0.077, whereas the indirect channels are in line with the full sample analysis.

As a final step of the empirical analysis, Table 6 presents the elasticity measures estimated for the full sample analysis and the two chosen sub-samples, along with the bootstrap standard errors (in parentheses). In greater depth, the second column of the upper part of the table presents the direct elasticity measure, estimated by means of the parameters of the first column of Tables 3-5, and the third calculates an indirect elasticity measure, estimated by means of the parameters of columns III to IV of Tables 3-5. Direct elasticity measures are given at the bottom of the table for human capital and the social filter.

The upper part of the table, which examines the accumulation of technological knowledge, confirms the previous results. While the total elasticity of technological knowledge in the full sample is equivalent to about 0.5% of the per capita GDP growth rate, the total elasticity measure proves more than three times as high in the Centre-North sub-sample. Moreover, in line with this result, the indirect elasticity of social filter on the accumulation of technological knowledge is considerably higher in the Centre-North macro-area sub-sample. In this case, a decrease of 10% in the social filter increases the impact of technological knowledge on the per capita growth rate of GDP by about 11%. On the contrary, the high social filter sub-sample shows elasticity measures in line with the full sample analysis.

Elasticity measures for private investment are presented in the second part of the table. Private investment proves to be an important driver of growth for all the samples presented, even though its greatest impact is in the Centre-North macro-area. The indirect channel, passing through the social filter, appears to be less relevant here than in the previous case.

The lower part of the table shows a different picture. The percentage of direct elasticity of human capital for the full sample analysis is more or less similar to the Mezzogiorno sub-sample and shows that a 10% increase of human capital could generate an increase of about 2% in the economy's growth rate. On the other hand, in line with the estimation results, the direct impact of the social filter in the Mezzogiorno macro-area is more than double the direct elasticity of the other samples. A 10% decrease in the social filter in the Mezzogiorno directly produces an increase in γ_{it} of about 7.5%, which confirms that the poor socio-institutional conditions of the southern Italian regions constitute their major obstacle to growth.

Table 6 – Elasticity measures

Sample	Total elasticity		Direct elasticity		Indirect elasticity	
	Technological knowledge					
Full sample analysis	0.460	*	0.465	**	-0.005	***
	(0.359)		(0.247)		(0.003)	
Centre-North macro-region without Lazio	1.496	**	1.610	***	-0.114	***
	(0.596)		(0.596)		(0.006)	
Mezzogiorno macro-region with Lazio	0.324	*	0.327	***	-0.003	***
	(0.239)		(0.108)		(0.001)	
	Private investment					
Full sample analysis	0.930	***	0.941	*	-0.011	***
	(0.247)		(0.559)		(0.000)	
Centre-North macro-region without Lazio	1.985	*	1.995	*	-0.010	***
	(1.321)		(1.321)		(0.000)	
Mezzogiorno macro-region with Lazio	1.441	***	1.449	**	-0.008	***
	(0.108)		(0.559)		(0.000)	
	Human capital Direct elasticity				Social filter Direct elasticity	
Full sample analysis	0.208	***			-0.373	**
	(0.084)				(0.198)	
Centre-North macro-region without Lazio	0.298	*			-0.263	**
	(0.188)				(0.141)	
Mezzogiorno macro-region with Lazio	0.224	**			-0.756	**
	(0.131)				(0.305)	

Note: The measurements of direct and indirect elasticity use the parameters estimated in Tables 3 to 5. Direct elasticity measures use first column estimation, whereas indirect ones use estimations from column III to IV from Tables 3 to 5. We report only direct elasticity measures for human capital and the social filter.

6. Conclusions and policy implications

Our analysis shows the importance of endogenous factors of development linked to the local territory as regards the regions' ability to absorb technical progress and increase their rate of economic growth. These findings are useful in assessing the policies to be adopted for the underdeveloped regions of the South of Italy in view of the fact that recent trends have seen the weaker areas of the country being pushed increasingly to the sidelines as regards the international distribution of wealth.

The empirical evidence obtained in this work calls for a rethinking of the basic objectives informing the development policies for Southern Italy. First and foremost, public policies should not be confined to pumping resources into the disadvantaged regions. The general aim should rather be to promote the ability of economic agents to cooperate and create networks, and to introduce models of governance capable of facilitating relations and the dissemination of knowledge, thereby generating positive externalities and boosting the productivity of local activities.

Second, policies aimed at a marked improvement of institutions, quality of life and access to collective services in the southern regions appear to be indispensable prerequisites for intensification of the dissemination of knowledge and the acceleration of economic growth. The model developed here shows that failure to meet this requirement nullifies the effects of the traditional policies aimed at material infrastructures, firms and innovation. In our view, the negative externalities encompassed in the variable of the social filter reflect the paralysis of the institutions and its consequences, namely dissatisfaction, lack of confidence, shortage of public assets and, in the final analysis, uncertainty and high transaction costs, which keep the southern regions in a state of stagnation and underdevelopment.

The implications for policy-making appear vague and ambiguous. It is difficult to define the institutions (Rodríguez-Pose 2010) and their quality is closely connected with level of income. Institutions and development are therefore phenomena that strengthen one another reciprocally (Rodrik 2004) and the same formal institutional structures can give rise to different results in terms of the accumulation of social capital (De Blasio and Nuzzo 2006).

Despite our awareness of the considerable simplification involved, we would argue, however, that the only possible starting point for policies aimed at increasing the quality of the institutions in the southern regions is a reform of local government so as to boost the efficiency of the organisation of human resources and introduce a substantial effort to monitor and assess the results pursued.

The development policies should then focus primarily on the upgrading of collective services, starting with education, social services and the safeguarding of environmental resources. There are two reasons for this. First, as these objectives represent the output of government, monitoring them makes it possible to assess the quality of the institutions indirectly and take corrective measures if necessary. Second, and more importantly, an improvement in collective services is the minimum prerequisite for elimination of the environmental obstacles acting as a negative externality on the regions' ability to absorb innovations and to attract and retain entrepreneurial projects and skills. As we have tried to show by estimating the scale and effects of the social filter, policies that reduce its impact could have major repercussions on the economic growth of the southern regions as well as the development of the Italian economy in general.

Appendix A – Mean values of each variable used in the panel data analysis

Macro area	Area	Region-id	Region	γ	p_inv	tec	Chum	Sfilter
CENTRE-NORTH	North	1	Piemonte	0.320	22.046	4.800	4.779	38.330
		2	Valle D'Aosta	0.318	24.028	3.961	4.590	30.258
		3	Lombardia	0.263	19.853	4.957	5.241	28.226
		4	Veneto	0.532	22.603	4.727	6.038	20.615
		5	Friuli Venezia Giulia	0.839	22.735	4.616	6.681	28.208
		6	Liguria	0.890	18.169	4.033	5.265	46.125
		20	Bolzano	0.690	29.195	4.059	6.565	14.135
		21	Trento	0.101	28.579	3.855	7.517	20.023
		7	Emilia Romagna	0.312	20.983	5.115	6.147	26.051
	Centre	8	Toscana	0.583	18.593	4.241	6.071	34.670
		9	Umbria	0.227	21.227	3.717	6.463	39.742
		10	Marche	0.789	21.362	4.046	5.138	34.216
		11	Lazio	0.648	18.187	3.589	6.587	63.326
MEZZOGIORNO	South	12	Abruzzo	0.432	22.898	3.675	5.839	52.607
		13	Molise	1.332	24.934	1.832	5.875	67.680
		14	Campania	0.683	21.197	2.356	4.646	89.487
		15	Puglia	0.441	21.134	2.303	4.865	75.399
		16	Basilicata	0.638	27.194	1.765	5.769	73.761
		17	Calabria	0.768	22.982	1.559	5.575	82.070
	Islands	18	Sicilia	0.866	21.206	2.509	4.401	89.710
		19	Sardegna	0.723	25.620	2.110	6.283	68.588

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