doi:10.1111/pirs.12217

Regional growth with spatial dependence: A case study on early Italian industrialization

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Received: 13 July 2015 / Accepted: 17 December 2015

Abstract. This paper estimates a conditional β-convergence model of labour productivity growth in Italy's manufacturing industry during 1871–1911, accounting for spatial dependence. The empirical evidence is based on a recent set of data at provincial (NUTS 3) level on manufacturing value added at 1911 prices, and a new set of data on human and social capital, political participation, and infrastructures. By focusing on a country and a time when the agglomeration forces and spillover effects advocated by the new economic geography were only starting to operate, we can investigate a particularly interesting case study. Our results suggest that human capital, a cooperative culture, and initial productivity in neighbouring provinces can explain much of the geographical variability of productivity growth in manufacturing in nineteenth-century Italy.

JEL classification: R11, R12, O47, N13, N93

Key words: β-convergence, manufacturing, nineteenth century Italy, spatial dependence, labor productivity, human capital

1 Introduction

Nineteenth century Italy, as many other European nations of the time, was a backward country. It was so in many dimensions. It was just moving its first steps away from agriculture to industry, and it was characterized by particularly high illiteracy rates, especially so in Southern regions. Furthermore, crucial infrastructures, such as the railroad network, were still under construction. Still, in the decades following the unification of the country in 1861 the size and composition of the Italian manufacturing system changed considerably, as production gradually moved away from traditional activities of artisanal nature to large modern industrial plants.[1] The related

[1] The Breda engineering company provides a representative example of this process of modernization. Founded in 1886 in Milan, it was able to celebrate in 1908 the production of its 1,000th locomotive, to branch out subsequently into armaments and aircraft.

mechanization of production processes fostered substantially increases in productivity, and ultimately economic growth.

In the light of the above background, this paper's aim is to shed light on the growth of labor productivity in the Italian manufacturing industry and its main determinants over the period 1871–1911. To this end, we estimate conditional β-convergence models for labor productivity using a recent dataset on manufacturing value added at 1911 prices at provincial (NUTS 3) level. The empirical analysis is enriched by a new set of control variables including human and social capital, political participation, and infrastructures. The focus on the manufacturing industry is motivated by two main reasons. The first is that despite the predominant share of agriculture on GDP in 19th century Italy, development patterns are clearly better visible in the more dynamic sectors of the economy. The second is that recent contributions (Rodrik, 2011, 2013) show that the small share of manufacturing employment in low-income countries, and the slow pace of industrialization is the main reason behind the lack of (unconditional) convergence in GDP often found in the literature. By focusing on manufacturing, instead, there is robust evidence of (unconditional) convergence.[2] In this framework, the case of Italy is of particular interest in that it represents one of the few countries for which extremely detailed historical statistical reconstruction on the manufacturing industry at the regional and provincial level (essentially NUTS 2 and NUTS 3 levels) are available (see Ciccarelli 2015, for a review). Further, by focusing on a country and a time when the agglomeration forces and spillover effects advocated by the new economic geography (NEG) literature (e.g., Fujita et al. 1999) were only starting to operate, we can investigate a particularly interesting case study.

The empirical literature on regional growth represents, to say the least, an active field of research, and provides thus a wealth of inspiring models (for a review, see, among others, Magrini 2004; Arbia et al. 2005; Arbia 2006; Rey and Le Gallo 2009). As noticed in Fingleton and López-Bazo (2006) the initial focus of many authors was on aspatial models of regional growth. Both endogenous growth theory and models inspired by the NEG suggest that interaction among agents leads to external effects tied to the size of the markets, and knowledge spillovers that ultimately push economic activities to agglomerate in a selected area (Fujita et al. 1999). Pioneering works such as Amstrong (1995) and Rey and Montouri (1999) incorporated accordingly spatial heterogeneity and dependence in regional growth analysis. Following these seminal contributions, spatial terms were often introduced in a rising number of empirical growth exercises by simply augmenting a given empirical model with a spatial lag of the dependent variable (spatial auto regressive, SAR) or of the error term (spatial error model, SEM). Works such as Anselin and Rey (1991) provided then the statistical criteria to select the more appropriate model.[3] The need for more structural or theory-driven empirical growth models with spatial effects led to important contributions such as Niebuhr (2001), Ying (2003), López-Bazo et al. (2004), Dall'erba and Le Gallo (2008), Piras et al. (2012). These studies are characterized by the inclusion of both the spatial lag of the dependent variable and control variables $\mathbf{X}$ within a conditional β-convergence framework. While these works refer to different time periods and countries, they essentially conclude, a point relevant to our study, that labor productivity growth of a given regional economy is typically influenced by the conditions of neighbouring regions. However, discriminating empirically whether spatial dependence is of 'substantive' type (Fingleton and López-Bazo 2006), i.e. involving dependent and explanatory variables, or if instead it exerts its influence through the error terms, can be extremely difficult (Gibbons and Overman, 2012). In this paper, following the approach by Fingleton (2001, 2004), López-Bazo

[2] On the distribution of manufacturing productivity in the EU regions, see in particular Fingleton and López-Bazo (2003).

[3] See Gibbons and Overman (2012) for a critical review of the literature, and Halleck Vega and Elhorst (2015) for a comprehensive overview of the strengths and weakness of different spatial econometric model specifications in terms of spillovers effect.

et al. (2004), and Egger and Pfaffermayr (2006), we do not attempt to test directly between these two alternative classes of models. Rather, we assume that externalities across Italian provinces were caused by technological diffusion and pecuniary externalities and estimate accordingly spatial lags models. Nevertheless, we test the residuals for the existence of possible spatial error dependence.

The rest of this paper is structured as follows. Section 2 describes the spatial conditional convergence model, and provides a brief review of the determinant of growth suggested in the literature. Subsections 3.1 and 3.2 describe the main quantitative features of the new dataset, and illustrates the spatial distribution of both labor productivity in the manufacturing sector and the socio-economic variables used as controls in the empirical exercise. Subsection 3.3 presents the empirical findings. Our conclusions are summarized in Section 4.

2 Modeling growth in space

The economic model here considered is the growth model with across-region externalities due to knowledge diffusion as presented in López-Bazo et al. (2004). Following the neat derivation in Fingleton and López-Bazo (2006), y_{it} represents average value added per worker, or labor productivity, in region i at time t. Then:

$$y_{it} = A_{it} k_{it}^{\tau_k} h_{it}^{\tau_h}. \tag{1}$$

In Equation (1) labor productivity is a function of the average level of physical and human capital per unit of labor k_{it}, and h_{it}, and the state of technology A_{it}; τ_k and τ_h represent internal returns to physical and human capital. Knowledge spillovers, this is an essential point, enter the model by assuming that the technological level of each region depends on that of neighbouring regions:

$$A_{it} = \Delta_t \left(k_{\rho it}^{\tau_k} h_{\rho it}^{\tau_h} \right)^{\gamma}, \tag{2}$$

where Δ_t is an exogenous component with a growth rate equal to g, $k_{\rho it}$ and $h_{\rho it}$ denote the physical and human capital-about ratios in the neighbouring regions, and γ measures the externalities across economies.

Fingleton and López-Bazo (2006) show that in case of positive spatial externalities the steady state level of output per unit of effective labor will depend positively on the stocks of physical and human capital in neighbouring regions, and then derive a growth equation representing the dynamics around the steady state. The equation, reported immediately below, represents the base of our empirical study:

$$\mathbf{g_y} = c - \left(1 - e^{-\beta t}\right) ln(\mathbf{y}_0) + \mathbf{X\delta} + \varphi ln(\mathbf{W y}_0) + \gamma \mathbf{W g_y} + \boldsymbol{\varepsilon}. \tag{3}$$

In this equation the term $\mathbf{g_y}$ represents the growth of output per unit of effective labor, β is the rate of convergence, $\mathbf{X}$ the conditioning or control variables, $\mathbf{W}$ the spatial weight matrix capturing the interactions among regions, $\mathbf{Wg_y}$ and $\mathbf{Wy}_0$ respectively growth and initial productivity level in neighbouring regions.

Before proceeding further, a remark in order is that while Equation (3) provides a fundamental theoretical basis of our analysis, using it for a time and country like nineteenth century Italy requires to keep clearly in mind that the actual relevance of the spatial components is a matter to be assessed empirically. To a large extent this also applies to the **X** control variables, which potentially determine provincial steady states. Needless to say, a large literature has been devoted to the individuation of these control variables. Economic growth theory, and in particular the branch on endogenous growth models, points to human capital as a one of the key engines of growth (for a review see, e.g., Krueger and Lindahl 2001). According to Aghion and Howitt (1998) the relation between human capital and growth can be essentially evaluated from two different perspectives. The first one (see, e.g., Lucas 1988) considers the accumulation of human capital over time as a determinant of sustained growth; the second one (see, e.g., Romer 1990) considers instead human capital as a stock generating innovations, contributing thus to a country's ability (especially so in the case of late-comers) to imitate and adapt new technology. Essentially, the first approach extends the concept of capital to embrace human capital, while in the second the link between human capital and sustained growth passes through technological progress.

A related branch of the literature, relatively less developed, links economic growth to social capital, perhaps a more slippery theme. According to Temple (2001, p. 58), much in line with Putnam et al. (1993), "social capital can be thought of as capturing such things as the extent of trustworthiness, social norms, and participation in networks and associations". Of much interest here, Temple (2001) notices that it is generally difficult to discriminate among alternative approaches using macroeconomic data at the national level and that studies at the local (regional or provincial) level can be more informative. The study by Guiso et al. (2005) provides an important example for the case of Italy.

The third branch of the literature that is relevant to our research relates economic growth to infrastructures. Already about half a century ago Eckaus (1961, p. 288) noticed that "the stock of social overhead capital available to region is regarded in current development literature as one of the most important determinants of the growth potentials of a region". Decades later, the seminal work of Aschauer (1989) provided quantitative evidence on the positive effect of public infrastructures on US total factor productivity.[4] The more recent literature however reconsiders considerably the contribution of infrastructure on regional growth. Crescenzi and Rodríguez-Pose (2012) consider European regions from 1990 to 2004 and show that infrastructures endowment (proxied by regional motorways) is a relatively poor predictor of economic growth.[5]

3 The data

The provincial (NUTS 3) value added data at 1911 prices on manufacturing industry are those reported in Ciccarelli and Fenoaltea (2013).[6] The control variables are instead entirely new. Gathering data at the provincial level for the nineteenth century is not of course an immediate task. Historical sources present their own limits, and need a careful interpretation of the figures reported. Besides that, quantitative information at the provincial level are not always available, and even studies referring to present day Italy resort in using interpolation methods to compensate for missing data on certain economic variables (see, e.g., Panzera and Postiglione 2014).[7]

4 A detailed survey on the topic is given in Romp and de Hann (2005).

5 Studies on Italian infrastructure at the regional level include, among others, Picci (1999), Cannari and Chiri (2002), and Bronzini and Piselli (2009). The latter considers the relation between R&D, human capital and public infrastructures accounting for regional spillovers in Italy's regions in 1980–2001, and is thus particularly close in spirits with the aim of our research.

6 Ciccarelli and Fenoaltea (2013) provide estimates of value added at the provincial level for the years 1871, 1881, 1901, and 1911. The estimates are largely based on population censuses. The lack of value added estimates for the year 1891, due to the fact that the population census of 1891 was not taken, is unfortunate. The twenty years gap between 1881 and 1901 essentially prevented us from using proper statistical models for longitudinal data.

7 Arbia and Basile (2005) consider spatial dependence and regional growth in Italy's provinces during 1951–2000.

It is also important to stress that in our definition of labor productivity in the manufacturing industry we only use male labor force figures in that, as it is well known, the figures from the early Italian population census tend to vastly overestimate female labor force of various southern provinces (see, e.g., Ciccarelli and Missiaia 2013).

3.1 Manufacturing value added per worker

During 1871–1911 in Italy as elsewhere in Europe, a complex interaction of many economic variables reshaped substantially the structure of the industrial system. The diffusion of railways reduced the cost of in land transports and fostered the mobility of people and circulation of ideas. The mechanization of production processes was also particularly pronounced; coal power was gradually replaced by hydroelectric power, also affecting industrial location, in a time when the transmission of electricity was still limited. Italy's international trade policy shifted from free-trade to protectionism (especially so after 1887), with uneven net protection guaranteed to the various industrial sectors, possibly inducing a reallocation of manufacturing activities (see, e.g., Ciccarelli and Proietti 2013; Basile and Ciccarelli 2015). As a result, the internal mix of manufacturing changed considerably. Traditional sectors tied to the production of consumption goods (e.g., foodstuffs) reduced their share in favor of the fast-growing 'high-tech' sector tied to the production of durable goods (e.g., engineering).

The wide changes that occurred in the provincial distribution of labor productivity in the manufacturing industry between 1871 and 1911 are summarized by Figure 1, which shows the non-parametric estimates of the density functions of labor productivity in Italy's provinces in 1871 and 1911, and Table 1, where some descriptive statistics are reported. From Figure 1 it is evident that both location and dispersion of labor productivity strongly increased, reflecting technological progress and its territorial diffusion. In fact, from Table 1, Panel A we can see that both mean and median values of labor productivity between 1871 and 1911 grew by about 80 per cent (columns 2 and 3). Growth in the lower end of the distribution was somehow slower (see column 1) so that dispersion, as measured by the interquartile range, doubled (column 5). Table 1, panel B illustrates the same descriptive statistics on labor productivity by macro-areas. The predominance of North-Western provinces (those belonging to Piedmont, Liguria, and Lombardy) over those belonging to the Centre/North East and the South is evident in both 1871 and 1911.

Figure 2 presents things from a spatial perspective.[8] The left hand side illustrates the geographical distribution of labor productivity in 1871. A North–south divide is evident, with northern provinces, especially those in the North-West, typically belonging to the upper part of the distribution. Of the ten provinces with highest labor productivity in 1871, seven belong to the North-West, and only two and one, respectively, to the Center/North-East and the South. But there is more than that. The maps also show a considerable amount of within regions heterogeneity. To exemplify, within Piedmont (Italy's most North-West region) Western provinces (Turin and Cuneo) score better than Eastern ones (Alessandria and Novara). The seven provinces of Sicily, to further exemplify, fall in five different intervals of labor productivity. The point is important and shows the clear advantage of using NUTS 3 over NUTS 2 data in this context.

The map on the right hand side of Figure 2 gives a geographical representation of labor productivity growth in manufacturing. A first glance to the map suggests that dark tints are predominant in Northern provinces. However, a closer inspection of both maps reported in Figure 2 also reveals that high growth rates (map on the right hand side) tend to be associated with low initial

[8] A detailed map of nineteenth century Italy's provinces is reported in the Appendix.

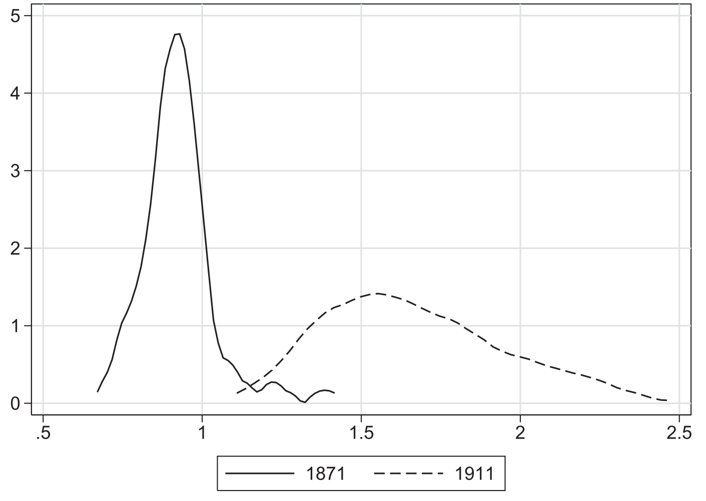

Fig. 1. Labor productivity in manufacturing industry, 1871 and 1911 (thousand lire per worker at 1911 prices)
Notes: Non parametric kernel density estimate with Silverman (1986) plug-in smoothing parameter.

Table 1 Manufacturing industry: labor productivity, descriptive statistics

A. Italy (N = 69 provinces)	(1) min	(2) median	(3) mean	(4) max	(5) IQR
1871	0.70	0.92	0.92	1.39	0.12
1911	1.21	1.66	1.67	2.37	0.25
(1911/1871)[a]	1.73	1.80	1.82	1.71	2.08
B. Macro-areas[b]					
1871					
North-West	0.84	1.00	1.05	1.39	0.18
Centre/North-East	0.70	0.91	0.91	1.04	0.09
South	0.73	0.87	0.88	1.00	0.12
1911					
North-West	1.68	2.03	2.00	2.37	0.19
Centre/North-East	1.43	1.69	1.71	2.20	0.17
South	1.21	1.43	1.43	1.73	0.13

Notes: Thousand lire per worker at 1911 prices. [a]The 1911/1871 row reports the (rounded) ratio of figures appearing in the preceding rows (so that for instance 1.73 = 1.21/0.70). [b]North-West = 14 provinces; Center/North-East = 30 provinces; South = 25 provinces.

values of labor productivity (map on the left hand side), as confirmed by a sample correlation of about −0.1.

To summarize on labor productivity, the evidence presented by Figures 1 and 2 and Table 1 is thus somewhat mixed. While both Figure 1 and Table 1 show increasing dispersion and point thus to divergence in labor productivity, Figure 2 suggests on the contrary convergence. However, a visual impression or a few descriptive statistics are of course not sufficient to get reliable conclusions. The topic need to be investigated appropriately within a proper statistical model of convergence. However, before presenting the estimation results of the conditional β-convergence model, the conditioning variables need to be introduced and discussed.

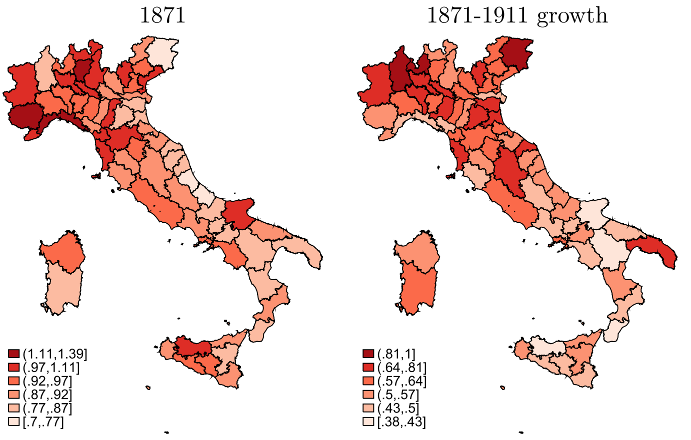

Fig. 2. Labor productivity in manufacturing

Notes: left: labor productivity in 1871 (thousand lire per worker at 1911 prices); right: 1871–1911 labor productivity growth. The maps use as class breaks the percentiles 5, 25, 50, 75, 95.

3.2 Control variables

In order to estimate the effect on manufacturing productivity growth of social participation, human and social capital, and infrastructure endowment we collected data from a wide set of historical sources ranging from population censuses, to official railways and electoral publications, to individual contributions of various scholars of the time. To increase the efficiency of our estimation procedure in some cases we resort to principal component analysis (PCA), a common way to reduce the dimensionality of the problem (examples in similar studies are, e.g., Tabellini 2010; Crescenzi and Rodríguez-Pose 2012).

The rest of this section illustrates the geographical distribution of the socioeconomic variables, mapped in Figure 3. Details on sources and methods are reported in the Appendix.

3.2.1 Human capital

We propose a broad indicator of human capital that essentially considers the three basic skills of primary education (reading, writing and arithmetic), and the size of the education sector as well. The human capital control used in the regression models is in particular the first principal component emerging from PCA on the logs of (standardized) illiteracy rates, number of pupils and number of teachers in primary school, and 'age heaping', a numeracy index constructed as an estimate of the excess frequencies of population reporting age in round numbers. This phenomenon has been shown by A'Hearn et al. (2013) to be in an inverse relationship with the numeracy of the population.

Hence, age heaping and illiteracy rates measure the education level of the population, while the number of pupils and teachers measures the size of the education sector. Figure 3, panel 1, shows that a North–south divide in term of human capital is clearly evident. Interestingly, selected provinces of Lombardy and Venetia (both part of the Austro-Hungarian Empire during the first half of the nineteenth century) score particularly well. At the opposite side of the distribution, provinces of southern Sicily performs instead poorly.[9] With few exceptions, the

[9] For reasons of space, provincial maps on elementary variables used to build the human capital index (illiteracy rates, age heaping, number of students, and number of teachers in primary school in 1871) are not reported. They are available upon request.

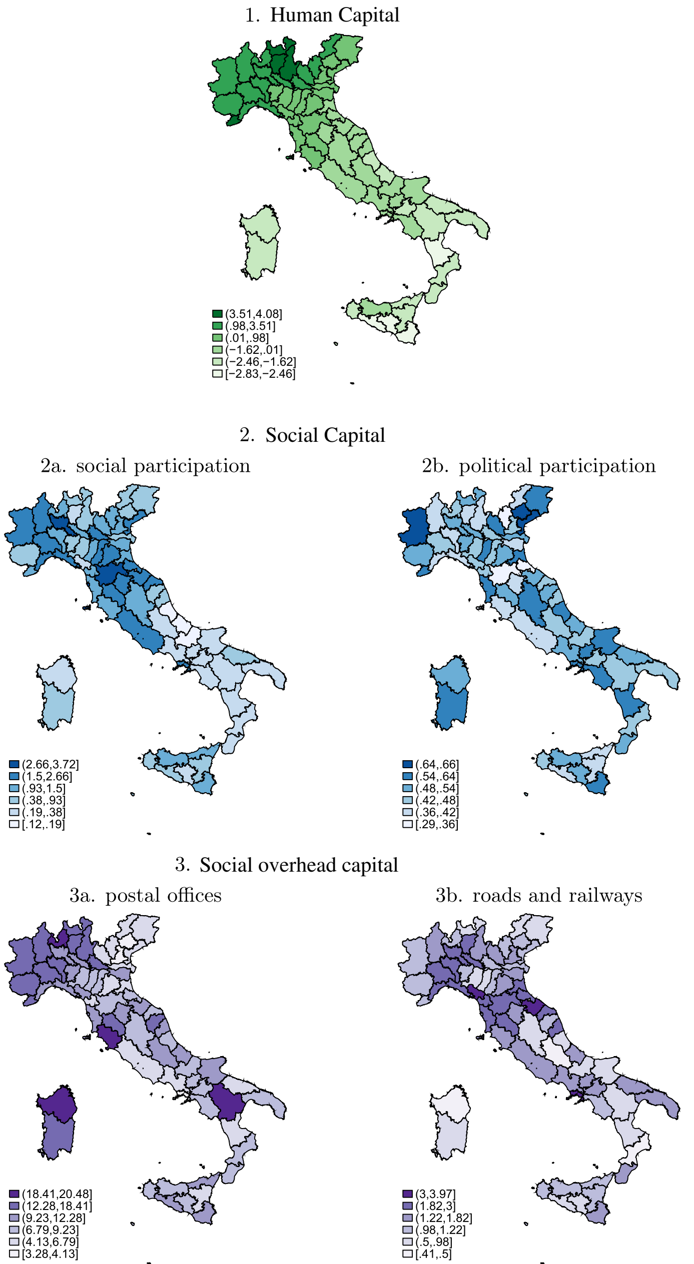

Fig. 3. Control variables used in regression models (year = 1871 ca.)
Notes: The maps use as class breaks the percentiles 5, 25, 50, 75, 95.

geographical distribution of human capital (Figure 3, panel 1) resembles closely the distribution of labor productivity growth in 1871–1911 (Figure 2). The unequal geographical distribution of human capital in 19th century Italy was well known to contemporaries at the point that Einaudi (1959, p. 198, translation by the authors), in his positive evaluation of the State education policy carried over by Italian policy makers of the time noticed that "it was more useful to spend money in the making of a secondary education system in Northern Italy [than in Southern Italy] to avoid wasting the fruits from primary education there well established".

3.2.1 Social capital

The social capital controls are here divided in two groups: (*i*) social participation; (*ii*) political participation. The first group includes the number of published newspapers and magazines (used also by Helliwell and Putnam 1995), and membership of mutual societies (both suitably standardized by the population size); the second group includes the number of voters (per 100 registered voters) in the local and national elections of mid-1860s and 1870. PCA suggests keeping these two groups separated, so we constructed a social participation variable as the simple average of the number of newspapers and magazines titles and membership of mutual societies, and a political participation variable as the simple average of the number of voters (per 100 registered voters) in the local and national elections of mid 1860s and 1870. To better frame the role of social capital in nineteenth century Italy it seems important to recall some basic facts on the matter. First, the age of mass media was only taking its first steps and the shift from elite to mass culture was far away. Our sample includes nevertheless more than a thousand titles including newspaper, magazines, and other publications. Second, in Italy as elsewhere only adult males were enfranchised to vote. Of these adult males, most were landown-owners or belonging to some other well-off category. As a result, only some two per cent of the population was involved in elections. One could further argue, perhaps legitimately, that in the lack of universal suffrage electoral participation correlates weakly with social participation. Third, the welfare state was then very limited; and in the lack of public programmes, mutual societies constituted effective tools to provide to its members insurance against various individual risks, such as those related to unemployment and health problems. We finally note that while the maps illustrated in Figure 3, panel 2a (on social capital) and Figure 2 (on industrial value added) present similar spatial patterns, with Southern provinces relatively colorless, Figure 3, panel 2b points to political participation as a variable distributed rather uniformly over the country.

3.2.3 Social overhead capital

A detailed quantitative analysis of social overhead capital in Italy's regions (NUTS 2) from 1861 to 1913, including reference to historical sources, is given in Ciccarelli and Fenoaltea (2008). Here, dealing with provinces, the quantitative information is inevitably more limited. We define infrastructure capital so to include local and national roads, railroad extension (all measured in linear kms per square km of provinces surface, as in Capello 2009b), and the number of post offices (standardized by the population size). It is here important to stress that a consistent part of the Italian railroad network was built after 1871 (the extension of the Italian network was of roughly 6,400 kms in 1870 and 15,300 in 1910; Istat 1958). Besides roads and railroads, ports were also a non-ignorable component of the national endowment of infrastructures related to costal shipping, and more generally water transport. Accordingly, we collected data[10] and used them in the early exploratory analysis. However, given that major ports were simply absent from the vast majority of Italian provinces, these controls turned out to be irrelevant and were thus dropped from the analysis. Following PCA results, the proposed regressions include the simple average of (standardized) roads and railways, and, as a separated variable, the number of post offices per 100,000 habitants. The two variables are illustrated in Figure 3, panels 3a and 3b.[11]

[10] The historical source *Statistica del Regno d'Italia. Navigazione nei porti del Regno, 1872*, reports for instance detailed information on to the economic activity of major ports (Genoa, Messina, Leghorn, Palermo, Naples, Venice, Catania, Ancona, Brindisi and Cagliari).

[11] The high number of post offices in the province of Potenza (in Southern Italy), notoriously a backward part of the country, represents an unexpected finding. In the lack of a better explanation, after judiciously double checking the sources and methods behind the result, the above finding appears classifiable within the 'data oddities' category.

Table 2 Spatial autocorrelation: Moran's *I*

	$\mathbf{g_y}$	$\mathbf{y}_{71}$	Education	Social partic.	Roads & rails	Post offices	Political particip.
Moran's *I*	0.34	0.28	0.85	0.31	0.30	0.55	−0.09
p-values	0.00	0.00	0.00	0.00	0.00	0.00	0.84

Notes: p-values, Ho: no autocorrelation (1-tail test). Moran's *I* evaluated with a spatial weights matrix *W* based on the 5 nearest neighbours. $\mathbf{g_y}$: 1871–1911 labor productivity growth; $\mathbf{y}_{71}$: labor productivity in 1871.

Table 2 complements Figure 3 by reporting Moran's *I* spatial autocorrelation coefficients applied to the same set of variables.

It emerges that the rule is constituted by (positive) spatial autocorrelation. The latter is particularly high for education, but also sizeable for manufacturing productivity growth and post offices. As expected, the exception to the rule is instead represented by the political participation variable, as we failed to reject the null of no spatial autocorrelation.

3.3 Estimation results

This section presents the results of the empirical estimation of the conditional β-convergence model for manufacturing productivity growth *à la* López-Bazo et al. (2004).[12] Our empirical model, discussed in Section 2 (see in particular Equation 3), is represented by the following equation:

$$\mathbf{g_y} = c - \left(1 - e^{-\beta t}\right) ln(\mathbf{y}_{71}) + \mathbf{X}_{71}\delta + \varphi ln(\mathbf{W}\mathbf{y}_{71}) + \gamma \mathbf{W}\mathbf{g_y} + \varepsilon, \tag{4}$$

where the 69×1 vector $\mathbf{g_y}$ denotes the 1871–1911 growth of provincial value added at 1911 prices per worker in the manufacturing industry, $\mathbf{y}_{71}$ its initial 1871 value, $\mathbf{W}$ a 69×69 spatial weights matrix, and $\mathbf{X}_{71}$ a matrix of control variables. The latter includes the 1871 values of the human capital (*Edu*), social participation (*Soc*), political participation (*Pol*), post offices (*Post*), and roads and railways (*RR*) variables.[13] Equation (4) can be formally seen as a spatial Durbin model, a very general specification allowing for both exogenous and endogenous spatial interaction effects (see e.g., Halleck Vega and Elhorst 2015). Although LeSage and Pace (2014) argue convincingly that the key point of spatial modelling is the proper interpretation of spatial effects, rather than the choice of the spatial weights matrix by itself, our data require spatial contiguity to be modelled in an especially careful way. This for two main reasons: first, the rather small average dimension of the spatial units (average population less than 400,000 in 1871); second, the complicated geographical structure of the country, with 23 per cent of the surface officially classified as plains, 42 per cent as hills and 35 per cent as mountains.[14] To take into account these issues we estimated model (4) by maximum likelihood using various spatial weights matrices. More precisely:

1. binary weights, with provinces defined as neighbours only if their administrative centres are closer than a cut-off distance. We estimated models with cut-off at 100, 150, 200 and 250 kms, but here for reasons of space we will report only the two extreme cases (100 and 250), describing briefly the intermediate ones;
2. exponentially declining weights: $w_{ij} = e^{-d_{ij}}$, with cut-off at distance $d_{ij} = 250$ kms;

[12] A related branch of the empirical literature considers the relation between productivity growth and the growth rate of output (Verdoorn's Law). Empirical tests of the Verdoorn's Law for the case of Italy's regions are discussed in Capello (2009a).

[13] The choice of using the initial (1871) level of the control variables aims at reducing the problem of endogeneity that might potentially affect estimation results.

[14] At current borders, which include territories differing by less than 5 per cent of the surface from those of the 1871–1911 borders.

3. inverse distance weights: $w_{ij} = d_{ij}^{-1}$ with cut-off at 250 and 500 kms (here reported only the former);
4. gravity weights: $w_{ij} = d_{ij}^{-2}$ with cut-off at 250 kms;
5. k-nearest neighbours (*knn*), with $k = 5, 10, 15$ (here reported only $k = 5$ and $k = 15$).

Following standard practice, binary matrices (cases 1 and 5) have been row-standardized. Distance-based weights (cases 2, 3, 4) have been instead standardized diving by the maximum eigenvalue of the matrix, so to retain their interpretation in terms of distance decay (Halleck Vega and Elhorst 2015). Finally, in the cases of binary weights with cut-off at 100, 150 and 200 kms the sample is reduced to 67 provinces, as neither of the two provinces of Sardinia has a neighbour closer than 210 kms. Remarkably, specifications search on the basis of individual significance tests led to preferred specifications essentially similar for all spatial weights matrices, which lends some support to the view by LeSage and Pace (2014) mentioned above.

The preferred specifications are reported in Table 3, and the main findings can be summarized as follows. First of all, the fit is roughly similar across models, although slightly better when the simplest weights matrix (binary weights, cut-off at 100 kms) is used. Second, the spatial autocorrelation tests against the alternative of either a spatial lag or a spatial error structure for the residuals are always largely not significant. Hence, heteroscedasticity can be tested using the standard versions of the Breusch-Pagan test and White test. For this purpose we used respectively the explanatory variables of the various models and their squares and cross-products. None of the p-values of either test is below 0.05, and all but one comfortably above 0.10. Hence, although these results are obviously conditional on the chosen set of explanatory variables, we can rather safely conclude in favour of homoscedasticity. The finding that there is no residual heteroscedasticity, a typical consequence of unmodelled spatial dependence, provides further support to the conclusion that spatial dependence of productivity growth in our dataset seems to be adequately captured by our model, independently on the definition of the spatial weights matrices.

Table 3 Estimation of the growth equation with externalities across provinces

	(1) *B*/100	(2) *B*/250	(3) *Exp*	(4) 1/*d*	(5) $1/d^2$	(6) *knn-5*	(7) *knn-15*
constant	0.58 (0.02)***	0.58 (0.02)***		0.55*** (0.01)			0.59 (0.02)***
$\mathbf{Wg_y}$	—	—		—			—
$ln(\mathbf{y}_{71})$	−0.62 (0.10)***	−0.58 (0.10)***		−0.55 (0.10)***			−0.56 (0.10)***
$ln(\mathbf{Wy}_{71})$	0.43 (0.14)***	0.41 (0.24)***		—			0.47 (0.26)*
Edu	0.34 (0.07)***	0.32 (0.07)***		0.39 (0.07)***			0.29 (0.09)***
Soc	0.54 (0.13)***	0.51 (0.14)***		0.56 (0.14)***			0.52 (0.13)***
Pol	—	—		—			—
Post	—	—		—			—
RR	—	—		—			—
R^2	0.63	0.59		0.57			0.59
LogLik	79.17	78.73		77.23			78.89
AIC	−148.35	−147.46		−146.45			−147.79
BP	6.65 (0.16)	5.28 (0.26)		4.45 (0.22)			4.86 (0.30)
LM^{lag}	0.03 (0.87)	1.04 (0.31)	0.06 (0.80)	0.18 (0.67)	1.02 (0.31)	0.09 (0.76)	0.36 (0.55)
LM^{error}	0.37 (0.54)	1.16 (0.29)	0.53 (0.47)	0.15 (0.70)	0.61 (0.43)	0.09 (0.72)	1.06 (0.30)

Notes: Coefficients: standard errors in brackets, *** and * significant at 1% and 10%. LM^{lag}, LM^{error}: spatial residual autocorrelation tests, p-values in brackets. *BP*: Breusch-Pagan heteroskedasticity test, p-values in brackets. The definition of the **W** matrix in the various columns is as follows: cols. 1–2: *B*/*d*: $w_{ij} = 1$ if distance $d_{ij} < d$, 0 else; d = 100, 250; (*B*/100: $N = 67$); col. 3: *Exp*: $w_{ij} = e^{-d_{ij}}$ if distance $d_{ij} < 250$ km, 0 else; col. 4: 1/*d*: $w_{ij} = d_{ij}^{-1}$ if distance $d_{ij} < 250$ km, 0 else; col. 5: $1/d^2$: $w_{ij} = d_{ij}^{-2}$ if distance $d_{ij} < 250$ km,0 else; cols. 6–7: $knn - N$: $w_{ij} = 1$ if *j* is one of the *N* closest provinces, 0 else. The models reported in cols. 3–6 have no spatial terms. Hence, the coefficient estimates and the non-spatial diagnostics are the same for all models.

Turning to the coefficient estimates, the first remarkable finding is that in all cases the spatial lag of the dependent variable turned out to be not significant. Accordingly, the estimates reported are computed by OLS.[15] Second, the own starting levels of productivity and of the conditioning variables (human capital, *Edu*, and social participation, *Soc*) have always significant effects, with coefficients of practically the same dimension across the various models. More precisely, the estimates of the coefficient of $ln(\mathbf{y}_{71})$, referring to the initial level of labor productivity, are between −0.62 and −0.56, implying estimates of the β parameter (see Equation 4) between 1.5 and 1.8 per cent.[16] This interval is remarkably close to the value of two per cent, often considered, after Barro and Sala-i-Martin (1991), a benchmark value in convergence studies applied to modern economies.

To appreciate the impact of the conditioning variables, which are measured on arbitrary scales, it is instructive to compute growth differentials between the best and worst endowed provinces. In the case of *Edu* these are respectively Bergamo, in Lombardy, and Syracuse, in Sicily, and we estimate the difference in 1871–1911 productivity growth due to human capital differences to be between 19.4 per cent (with spatial weights $\mathbf{W} = knn\text{-}5$) and 30.2 per cent (with gravity weights). The impact of differences in social participation is somehow smaller, but still sizeable. We estimate the implied differential in productivity growth between the top province, Leghorn in Tuscany, and the bottom one, Campobasso in Abruzzi, to be between 17.3 per cent (with binary weights and cut-off at 250 kms) and 20.1 per cent (with gravity weights). The main difference between the various models concerns the (logged) spatial lags of the 1871 productivity level. This is retained with positive effects and similar coefficients in the regressions with binary weights and in that with *knn-15* weights, but excluded with all distance-based and *knn-5* weights. In the unreported regressions this variable is weakly significant in two cases (binary weights, cut-off 200 kms, and *knn-10* weights) and not significant in another two (binary weights, cut-off at 150 kms, and inverse distance weights, cut-off at 500 kms). Summing up, the existence of a link between productivity growth and the 1871 productivity level of the neighbours cannot be excluded, but it seems to depend on the way neighbours are defined. To better asses the point, it might help to recall that the historical sources used to build up our dataset refer to administrative units (provinces). As a consequence, our analysis cannot fully distinguish between spatial spillovers operating among our cross-sectional units (provinces) from those operating in more general functional economic areas.[17] Our mixed findings about the positive effects of initial productivity levels in neighbouring provinces on productivity growth could reflect, for instance, the existence of local labour markets spreading beyond the provincial borders here considered.[18]

Overall, the estimates suggests convergence to different steady states essentially determined by the two conditioning variables always retained, human capital and social participation, and possibly by 1871 productivity level of the neighbours. Technological spillover effects, when present, seem to be captured by the initial level of labor productivity in neighbouring provinces, and not by their growth rates. This finding, when considered in the light of the spatial convergence literature, is in a sense surprising. In their study on conditional convergence of labor productivity, Fingleton and López-Bazo (2006), for instance, find that the coefficient associated with knowledge diffusion across EU regions is positive, sizeable, and significant. And it is so both in the unconditional and the conditional β-convergence model. However, knowledge diffusion and technological externalities go along with an adequate absorptive capacity of the various regions, that essentially rest on the availability of human and social capital (Cohen and Levinthal 1990; Caragliu and Nijkamp 2012; Crescenzi and Rodríguez-Pose 2012). Our finding

[15] In fact, ML coefficient estimates and standard errors based on the Hessian are equal to OLS estimates at all relevent decimal digits.

[16] With a standard error computed by the delta method approximately equal to 0.4 per cent.

[17] For an early reference on this topic see Fox and Kumar (1965).

[18] We owe this point to an anonymous referee.

about the systematic insignificance of productivity growth in neighbouring provinces might just reflect the extremely low initial level of human and social capital in a large part of nineteenth century Italy. On this point it appears appropriate to stress that our 1871 'initial values' of human and social capital are at least partly a legacy of the past, and are thus to a certain degree endogenous to economic development before our sample period. It is true that the political unification of the country occurred in the 1860s contributed to its economic integration (so that, for instance, it was adopted a single currency, trade policy was fixed at the national level, and it established a national policy on mandatory primary schools). However, Italy's unification cannot obviously be considered as an event able to entirely reset the initial conditions of the dynamic processes underlying the economic development of the various regions and, ultimately, their absorptive capacity. On the contrary, the legacies of pre-unitarian states, characterized by extremely different economic policies, produced to some degrees long-lasting socio-economic effects. So, to exemplify on literacy, in the first half of the nineteenth century primary schools were well diffused in Piedmont (then part of the Kingdom of Savoy), and in Lombardy and Venetia (then part of the Habsburg Empire). It was instead by far less diffused in the Papal States, and the Kingdom of Two Sicilies (then ruled by the House of Bourbon).[19]

To further investigate the point about knowledge diffusion and technological externalities, we also estimated in preliminary regressions *absolute β*-convergence models augmented with both the growth and the initial level of productivity in the neighbouring provinces. Although both these variables have the expected positive effects on the productivity growth of each province, model residuals always show extremely severe spatial autocorrelation.[20] Hence, these measures of technological spillovers are not sufficient to explain spatial heterogeneity in productivity growth, and a conditional convergence model need to be considered.

Our results are consistent with the view, widely shared by Italy's economists and economic historians, that the initial value of productivity (and human, and social capital as well) affected the growth potential of the local economies. For instance, Einaudi, (1959, pp. 197–198, translation by the authors) noticed in particular that for a set of historical reasons Northern regions were characterized by "better Governments, reduced distance from prosperous nations, higher self-confidence, and a geographical location prone to rapid and fruitful economic trades". And similarly, Cafagna (1989) recalled the environmental advantages of the North including more fertile land for agriculture and hydraulic resources for motive power. Ciocca (2007) summarizes the literature and concludes that during the 1860s Northern and Southern regions were different along many dimensions, including educational levels, social participation, and respect for the rule of law, all affecting the growth potential of the two macro regions, thus supporting both Einaudi's and Cafagna's view.

On the relation between social capital and industrial development our findings that active citizenship (press diffusion and social awareness, as measured by the diffusion of mutual societies) have a significant effect on labor productivity growth, is consistent with A'Hearn (1998), and De Blasio and Nuzzo (2010), also considering nineteenth century Italy. Leonardi (1995) stresses in particular that in the case of the Italian South in recent decades, social norms emphasizing collective action (i.e., social capital) as a viable means of achieving societal goods are absent. Rather, the South is permeated by a culture emphasizing individual norms oriented towards short-term individual gains (on this point see also Felice, 2012, 2014 and the literature therein).

The relation between human capital and industrial development is instead more controversial. Di Liberto (2008) shows that improvements in literacy rates had a strong impact on the growth of Southern Italian regions in the 1960s, when the income differentials with the rest of the country temporarily shrank (on this, see Paci and Saba 1998). On a much larger scale,

[19] For an accurate quantitative account of the Italian primary educational system at the regional level during the nineteenth century see Vigo (1971).

[20] The results of these preliminary regressions are not reported for reason of space, but are available on request.

Gennaioli et al. (2013) show that education is the single most determinant of the current world regional development differentials, and Tabellini (2010) that the literacy differentials can have highly persistent effects on income differentials, up to the point that regional *per capita* output in the European regions at the end of the twentieth century is significantly related to literacy rates of over a century before, which thus appear to be able to shape culture and institutions in the very long-run. However, the studies by Allen (2003) and Galor (2005) downplay considerably the role of human capital during the early phases of industrialization. Interestingly, Squicciarini and Voigtländer (2015), referring to the eighteenth and nineteenth centuries in France, shows that once upper-tail knowledge (proxied by city-level subscriptions to the *Encyclopèdie*) is distinguished from average human capital (basic literacy) the former is positively related with productivity growth of innovative industrial technology. In our case, referring to nineteenth century manufacturing in Italy, the positive and significant relation between our human capital indicator (accounting for both literacy and numeracy) and labor productivity growth constitutes one of the more robust empirical findings.

A final remark is on infrastructures. As Table 3 shows, in the various empirical specifications we find no evidence whatsoever of a significant relation between infrastructures and labor productivity growth. Interestingly, similar findings are reported by Díez-Minguela et al. (2014) who estimate a conditional convergence model for 1870–1930 Spanish provinces (NUTS 3). The lack of significance in our case might reflects the fact that postal offices (*Post* in Table 3), and road and railroads (*RR* in Table 3) are poor proxies of true infrastructure endowment. The extension of the railways network in 1871 was, for instance, still limited. But it might also well reflect the more substantial fact that “the capability of infrastructure to impact local economy is heavily influenced by the regional socioeconomic environment” (Crescenzi and Rodríguez-Pose 2012, p. 496). And as we documented, in the time and country here considered, the geographical distribution of human and social capital was largely uneven, with Southern regions lagging far behind. The point is summarized in Livi Bacci (2015, p. 269) referring to the second half of the nineteenth century, noticing that “the lack of two forms of mobility – mobility of people and circulation of ideas, via roads and schools – put the Islands and the South in a disadvantaged position that lasted well into the twentieth century.”

4 Conclusions

This paper considers the early development of provincial manufacturing in nineteenth century Italy. We contribute to the empirical growth literature by considering a conditional β-convergence model for labor productivity in the manufacturing industry, allowing for spatial effects in a time (1871–1911) and a country when the agglomeration forces and spillover effects advocated by the new economic geography literature were just starting to operate. The vast majority of the labor force was employed in agriculture, industry was only taking its first steps, literacy rates were rising but still extremely low in the South and essential infrastructures, such as the railways network, were under construction.

In this scenario, we find evidence of of conditional convergence of labor productivity growth within manufacturing, once human and social capital differentials are accounted for. Differently from the prevailing literature referring to more recent times, our estimates suggest that labor productivity benefited from the initial level of productivity in the neighbouring provinces, and not their growth rates. The absence of dynamic spillover effects, an important component of both endogenous growth and NEG models, might appear puzzling. However, as illustrated in the paper, in a backward economy like nineteenth century Italy the scope for technological and knowledge spillovers was far more limited than in contemporary economies. Furthermore, this result is consistent with A'Hearn and Venables (2013), who point to factor endowments more than market potential as the key driver of Italian regional disparities in the first decades following the unification of the country.

The paper also sheds light on the controversial role of human capital on industrial growth for past historical periods. Our results show clearly that, at least for the time period and country considered here, areas better endowed in terms of human and social capital experimented, on average, higher growth rates of labor productivity in the manufacturing industry.

Appendix: A

Sources and methods

This appendix documents the sources and the methods behind the provincial dataset (NUTS 3 units) used in this paper. Data on manufacturing value added are from previous research. Data on additional control variables are instead entirely new. To increase the efficiency of the estimation procedure we constructed synthetic indicators using principal components analysis (PCA).

A.1. Manufacturing industry: Provincial value added, 1871–1911

Manufacturing value added estimates at 1911 prices for the whole set of 69 Italian provinces, for the years 1871 and 1911, are those provided by Ciccarelli and Fenoaltea (2013). The estimates are available at http://onlinelibrary.wiley.com/doi/10.1111/j.1468-0289.2011.00643.x/suppinfo.

A.2. Human capital

The data on illiterates for 1871 are from Ministero di Agricoltura, Industria e Commercio (1874–76), vol. 2, Introduzione, pp. B-I. Data on primary education in 1871 (number of students, and number of teachers) are from Antonielli (1872), pp. 282–283. The data on age-heaping in 1871 were kindly provided by Brian A'Hearn (see A'Hearn et al. 2013).

The elementary variables used as inputs to the principal component analysis providing as output the human capital indicator used in the convergence models are:

1. illiteracy rate (*Illit*);
2. age heaping (*Age*);
3. primary school pupils divided by population in the 5–12 age bracket (*Pupils*); and
4. primary school teachers divided by population in the 5–12 age bracket (*Teach*).

The last two variables measure the size of the education sector, while the first two the quality of its output (with a negative sign). The results of PCA applied to the logs of these elementary variables are reported in Table A1.

Table A1 panel A shows in particular that the first principal component (PC1) turns out to be able to explain over 80 per cent of the total variability (inertia) of this set of variables. Table A1 panel B focuses on the first principal component (PC1) and shows that the weights are all approximately the same in absolute value, with opposite signs as to be expected for the first and the second pair. We thus decided to include the first principal component, labelled as *Edu* (Education), in the convergence regressions.

The provincial distribution of this variable is illustrated in Figure 3, panel 1.

A.3. Social capital

The data on the newspaper and magazines title are from Ottino (1875), Allegato 4, "Prospetto statistico della stampa periodica, della tipografia e della libreria in Italia". The data on the membership to mutual societies are from Ministero di Agricoltura, Industria e Commercio (1875), pp. 200–203, while those on the number of voters in local and national elections of 1865 are from Antonielli (1872), p. 146. Election data for the province of Rome, annexed to the country in 1870, refer to the national elections of 1870 and the local elections of 1872, as reported in Correnti (1873), pp. 87b and 86.

The elementary variables used in this case are the following:

1 number of journals and magazines titles per 100,000 residents (*Journals*);
2 members of mutual societies per 100,000 residents (*Mutual*);
3 number of voters at local elections per 100 registered voters (*Local_vot*); and
4 number of voters at national elections per 100 registered voters (*Nat_vot*)

The results of applying PCA on the above elementary variables are summarized in Table A2.

Table A2, panel A shows that the first principal component (PC1) turned out to be able to explain slightly less than half of the inertia of this set of variables, confirming that is rather difficult to capture the many facets of social participation. The second principal components explains less than 30 per cent of the variance. Concentrating on PC1 (Table A2, panel B), press diffusion and membership of mutual societies have positive weights, while the rate of participation to local and national elections negative ones: hence, PC1 has no obvious interpretation. On the other hand, the second principal component (PC2) has positive weights for all variables, but it explains a more limited fraction of inertia. We eventually decided to include two artificial indicators, both obtained as simple averages of the variables suitably standardized to have unit standard deviation. The first indicator is aimed at capturing social participation (*Soc*), and the second political participation (*Pol*). Formally:

$$Soc = 0.5\left(\frac{Journals}{\sigma_{Journals}} + \frac{Mutual}{\sigma_{Mutual}}\right),$$
$$Pol = 0.5\left(\frac{Local_{vot}}{\sigma_{local_{vot}}} + \frac{Nat_{vot}}{\sigma_{nat_{vot}}}\right).$$

The provincial distribution of social participation (*Soc*) and political participation (*Pol*) is illustrated in Figure 3, panel 2.

A.4. Social overhead capital

The data on the local and national roads, measured in kilometres, are from Correnti (1873), pp. 122–125. The data on the number of postal offices are from Direzione generale delle Poste (1873), p. XLIV. The extension of the railway network by province for the year 1871 is obtained adding to the figures for 1861, taken from Ferrovie dello Stato (1911), the kilometers of new lines opened in each province between 1861 and 1871, as reported in Ministero delle comunicazioni (1927).

The elementary variables used are thus the following:

1. local and national roads, km's normalized by surface of the province in km^2 (*Roads*);
2. railways, km's normalized by surface of the province in km^2 (*Rails*);

Table A1. Human capital: principal component analysis

A. Explained variance

PCs	Inertia[a]	% of total inertia[b]
PC1	3.35	83.7
PC2	0.41	10.1
PC3	0.17	4.3
PC4	0.07	1.8
TOT		100.0

B. PCI: weights of elementary variables[c]

Illit	Age	Pupils	Teach
−0.451	−0.521	0.524	0.500

[a]*inertia*: eigenvalues of correlation matrix. [b]Numbers do not add to 100 per cent, due to rounding. [c]*weights*: eigenvectors of correlation matrix.

Table A2. Social capital: principal component analysis

A. Explained variance

PCs	Inertia[a]	% of total inertia[b]
PC1	1.85	46.1
PC2	1.14	28.6
PC3	0.54	13.6
PC4	0.47	11.7
TOT		100.0

B. PCI: weights[c] of elementary variables[c]

	Journals	Mutual	Local_vot	Nat_vot
PC1:	−0.375	−0.550	0.543	0.511
PC2:	0.689	0.371	0.415	0.464

[a]*inertia*: eigenvalues of correlation matrix. [b]Numbers do not add to 100 per cent, due to rounding. [c]*weights*: eigenvectors of correlation matrix.

3. number of post offices per 100.000 residents (*Post*).

The results of applying PCA on the above elementary variables are summarized in Table A3.

Table A3 shows that the first principal component (PC1) explains about 42 per cent of the inertia of the entire set of variables, and it is positively correlated with *Roads* and *Rails* (which have almost equal weights) and negatively with *Post* (which has a smaller weight). In fact, the second principal component (PC2), which explains 32% of total inertia, is highly correlated with this latter variable. We thus decided to split this set of indicators as well, including the post offices variable (*Post*) directly, and the simple mean of the *Roads* and *Rail* variables (*RR*), duly scaled, to capture communication infrastructures:

$$RR = 0.5\left(\frac{Roads}{\sigma_{Roads}} + \frac{Rails}{\sigma_{Rails}}\right)$$

The provincial distribution of both social overhead capital indicators, *Post* and *RR*, is illustrated in Figure 3, panel 3.

Table A3. Social overhead capital: principal component analysis

A. Explained variance

PCs	Inertia[a]	% of total inertia[b]
PC1	1.27	42.2
PC2	0.97	32.2
PC3	0.77	25.6
TOT		100.0

B. PC1 and PC2: weights[c]

	Elementary variables		
Roads	Rails	Post	
PC 1	0.658	0.673	−0.339
PC 2	0.293	0.186	0.938

[a]*inertia*: eigenvalues of correlation matrix. [b]Numbers do not add to 100 per cent, due to rounding. [c]*weights*: eigenvectors of correlation matrix.

A.5. Historical sources

Antonielli, E. (1872) *Annuario statistico delle provincie italiane per l'anno 1872*. Florence.

Correnti, C. (1873) *L'Italia economica nel 1873*. Rome.

Direzione generale delle Poste (1873) *Nona relazione sul servizio postale in Italia*. Rome.

Ferrovie dello Stato (1911) Ferrovie Italiane 1861–1909, Riproduzione dei lavori grafici presentati all'esposizione internazionale di Torino del 1911.

Franchetti, L. (1875) *Condizioni economiche ed amministrative delle province napoletane*. Florence.

Istat (1958) *Sommario di statistiche storiche italiane, 1861–1955*. Rome.

Ministero di Agricoltura, Industria e Commercio (1874–76) *Popolazione. Censimento 31 dicembre 1871. 3 voll*. Rome.

Ministero di Agricoltura, Industria e Commercio (1875) *Statistica delle società di mutuo soccorso*. Rome.

Ministero delle Comunicazioni (1927) *Sviluppo delle ferrovie italiane dal 1839 al 31 dicembre 1926*. Rome.

Ottino G. (1875) *La stampa periodica, il commercio dei libri e la tipografia in Italia*. Milan.

The appendix ends by providing a map of Italy's provinces in 1911. The name of each region, in bold, is followed by the name (and tag) of its provinces. Different colors simply highlight regional borders.

PIEDMONT: Alessandria (AL), Cuneo (CN), Novara (NO), Turin (TO)
LIGURIA: Genoa (GE), Porto Maurizio (PM)
LOMBARDY: Bergamo (BG), Brescia (BS), Como (CO), Cremona (CR), Mantua (MN), Milan (MI), Pavia (PV), Sondrio (SO)
VENETIA: Belluno (BL), Padua (PD), Rovigo (RO), Treviso (TV),Udine (UD), Venice (VE), Verona (VR), Vicenza (VI)
EMILIA: Bologna (BO), Ferrara (FE), Forlì (FO), Modena (MO), Parma (PR), Piacenza (PC), Ravenna (RA), Reggio Emilia (RE)
TUSCANY: Arezzo (AR), Florence (FI), Grosseto (GR), Leghorn (LI), Lucca (LU), Massa Carrara (MS), Pisa (PI), Siena (SI)
MARCHES: Ancona (AN), Ascoli Piceno (AP), Macerata (MC), Pesaro (PE)
UMBRIA Perugia (PG)

LATIUM: Roma (RM)

ABRUZZI: Aquila (AQ), Campobasso (CB), Chieti (CH), Teramo (TE)
CAMPANIA: Avellino (AV), Benevento (BN), Caserta (CE), Naples (NA), Salerno (SA)
APULIA: Bari (BA), Foggia (FG), Lecce (LE)
BASILICATA: Potenza (PZ)
CALABRIA: Catanzaro (CZ), Cosenza (CS), Reggio Calabria (RC)
SICILY: Caltanissetta (CL), Catania (CT), Girgenti (AG), Messina (ME), Palermo (PA), Syracuse (SR), Trapani (TP)
SARDINIA: Cagliari (CA), Sassari (SS)

References

Aghion P, Howitt P (1998) *Endogenous growth theory*. MIT Press, Cambridge, MA

A'Hearn B (1998) Institutions, externalities and economic growth in southern Italy. Evidence from the cotton textile industry, 1861–1914. *Economic History Review* 51: 734–762

A'Hearn B, Delfino A, Nuvolari A (2013) 'Uniting Souls' and counting skills: Age-heaping in the first Italian national censuses, 1861–1881. Paper presented at the Valencia FRESH meeting, 13–14 June

A'Hearn B, Venables AJ (2013) Regional disparities: Internal geography and external trade. In: Toniolo G (ed) *The Oxford handbook of the Italian economy since unification*. Oxford University Press, Oxford

Allen RC (2003) Progress and poverty in early modern Europe. *Economic History Review* 56: 403–443

Amstrong HW (1995) Convergence among regions of the European Union, 1950–1990. *Papers in Regional Science* 74: 143–152

Anselin L, Rey S (1991) Properties of tests for spatial dependence in linear regression models. *Geographical Analysis* 23: 112–131

Arbia G (2006) *Spatial econometrics. Statistical foundations and applications to regional convergence*. Springer-Verlag, Berlin Heidelberg

Arbia G, Basile R (2005) Spatial dependence and non-linearities in regional growth behaviour in Italy. *Statistica* 65: 145–167

Arbia G, Basile R, Piras, G (2005) Using spatial panel data in modelling regional growth and convergence. ISAE Working Paper 55

Aschauer DA (1989) Is public expenditure productive? *Journal of Monetary Economics* 23: 177–200

Barro RJ, Sala-i-Martin X (1991) Convergence across states and regions. *Brookings Papers on Economic Activity* 22: 107–182

Basile R, Ciccarelli C (2015) The location of the Italian manufacturing industry, 1871–1911: a sectoral analysis. mimeo, University of Rome Tor Vergata.

Bronzini R, Piselli P (2009) Determinants of long-run regional productivity with geographical spillovers: The role of R&D, human capital, and public infrastructure. *Regional Studies and Urban Economics* 39: 187–199

Cafagna L (1989) *Dualismo e sviluppo nella storia d'Italia*. Marsilio, Padua

Cannari L, Chiri S (2002) Le infrastrutture economiche dall'Unità. In: Ciocca P, Toniolo G (eds) *Storia economica d'Italia. 3. Industrie, mercati, istituzioni. 1. Le strutture dell'economia*. IntesaBci and Laterza, Milan-Rome-Bari

Capello R (2009a) Macroeconomic regional growth models: Theoretical, methodological and empirical contributions. *Scienze Regionali – Italian Journal of Regional Science* 8: 59–80

Capello R (2009b) Spatial spillovers and regional growth: A cognitive approach. *European Planning Studies* 17: 639–658

Caragliu A, Nijkamp P (2012) The impact of regional absorptive capacity on spatial knowledge spillovers: The Cohen and Levinthal model revisited. *Applied Economics* 44: 1363–1374

Ciccarelli C (2015) Industry, sectors, regions: The state of play on Italy's historical statistics. *Scienze Regionali – Italian Journal of Regional Science* 14: 73–90

Ciccarelli C, Fenoaltea S (2008) Social-overhead construction in Italy's re-gions, 1861–1913. *Research in Economic History* 26: 1–80

Ciccarelli C, Fenoaltea S (2013) Through the magnifying glass: Provincial aspects of industrial growth in post-Unification Italy. *Economic History Review* 66: 57–85

Ciccarelli C, Missiaia A (2013) The industrial labor force of Italy's provinces: Estimates from the population censuses, 1871–1911. *Rivista di Storia Economica* 29: 141–192

Ciccarelli C, Proietti T (2013) Patterns of industrial specialisation in post-unification Italy. *Scandinavian Economic History Review* 61: 259–286

Ciocca P (2007) *Ricchi per sempre?* Bollati Boringhieri, Turin

Cohen W, Levinthal D (1990) Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* 35: 128–152

Crescenzi R, Rodríguez-Pose A (2012) Infrastructure and regional growth in the European Union. *Papers in Regional Science* 91: 487–513

Dall'erba S, Le Gallo J (2008) Regional convergence and the impact of European structural funds over 1989–1999: A spatial econometric analysis. *Papers in Regional Science* 87: 219–244

de Blasio G, Nuzzo G (2010) Historical traditions of civicness and local economic development. *Journal of Regional Science* 50: 833–857.

Díez-Minguela A, Martinez-Gallaraga J, Tirado-Fabregat DA (2014) Why did Spanish regions not converge before the Civil War ? Agglomeration and (regional) growth revisited: Spain, 1870–1930. Ivie WP-EC2014-05

Di Liberto A (2008) Education and Italian regional development. *Economics of Education Review* 27: 94–107

Eckaus RS (1961) The North-south differential In Italian economic development. *Journal of Economic History* 21: 285–317

Egger P, Pfaffermayr M (2006) Spatial convergence. *Papers in Regional Science* 85: 199–215

Einaudi L (1959) *Cronache economiche e politiche di un trentennio (1893–1925)* (Vol. I (1893–1902)). Einaudi, Turin

Felice E (2012) Regional convergence in Italy, 1891–2001: Testing human and social capital. *Cliometrica* 6: 267–306

Felice E (2014) *Perché il Sud è rimasto indietro*. Il Mulino, Bologna

Fingleton B (2001) Equilibrium and economic growth: Spatial econometric models and simulations. *Journal of Regional Science* 41: 117–147

Fingleton B, López-Bazo E (2003) Explaining the distribution of manufacturing productivity in the EU regions. In: Fingleton B (ed) *European regional growth*. Springer-Verlag, Berlin

Fingleton B, López-Bazo E (2004) Regional economic growth and convergence: insights from a spatial econometric perspective. In: Anselin L, Florax R, Rey S (eds) *Advances in Spatial Econometrics*. Springer-Verlag, Berlin.

Fingleton B, López-Bazo E (2006) Empirical growth models with spatial effects. *Papers in Regional Science* 85: 177–198.

Fox KA, Kumar TK (1965) The functional economic area: Delineation and implications for economic analysis. *Papers in Regional Science* 15: 57–85

Fujita M, Krugman P, Venables AJ (1999) *The spatial economy: Cities, regions, and international trade*. MIT Press, Cambridge, MA

Galor O (2005) From stagnation to growth: Unified growth theory. In: Aghion P, Durlauf S (eds) *Handbook of economic growth* (Vol. 1A). Elsevier, Amsterdam

Gennaioli N, La Porta R, Lopez-De-Silanes F (2013) Human capital and regional development. *Quarterly Journal of Economics* 128: 105–164

Gibbons S, Overman HG (2012) Mostly pointless spatial econometrics? *Journal of Regional Science* 52: 172–191
Guiso L, Sapienza P, Zingales L (2005) The role of social capital in financial development. *American Economic Review* 94: 526–556
Halleck Vega S, Elhorst JP (2015) The SLX model. *Journal of Regional Science* 55: 339–363
Helliwell JH, Putnam RD (1995) Economic growth and social capital in Italy. *Eastern Economic Journal* 21: 295–307
Krueger AB, Lindahl M (2001) Education for growth? Why and for whom? *Journal of Economic Literature* 39: 1101–1136
Leonardi R (1995) Regional development in Italy: Social capital and the Mezzogiorno. *Oxford Review of Economic Policy* 11: 165–179
LeSage JP, Pace RK (2014) The biggest myth in spatial econometrics. *Econometrics* 2: 217–249
Livi Bacci M (2015) *A history of Italian fertility during the last two centuries*. Princeton University Press, Princeton, NY
López-Bazo E, Vayá E, Artís M (2004) Regional externalities and growth: Evidence from European regions. *Journal of Regional Science* 44: 43–73
Lucas R (1988) On the mechanics of economic development. *Journal of Monetary Economics* 22: 3–42
Magrini S (2004) Regional (di)convergence. In: Henderson JV, Thisse JF (eds) *Handbook of regional and urban economics* (Vol. 4). Elsevier, Amsterdam
Niebuhr A (2001) Convergence and the effects of spatial interaction. *Jahrbuch für Regionalwissenschaft* 21: 113–133
Paci R, Saba A (1998) The empirics of regional economic growth in Italy: 1951–1993. *Rivista Internazionale di Scienze Economiche e Commerciali* 5: 513–542
Panzera D, Postiglione P (2014) Economic growth in Italian NUTS 3 provinces. *Annals of Regional Science* 53: 273–293
Picci L (1999) Productivity and infrastructure in the Italian regions. *Giornale degli Economisti e Annali d'Economia* 58: 329–353
Piras G, Postiglione P, Aroca P (2012) Specialization, R&D and productivity growth: Evidence from EU regions. *Annals of Regional Science* 49: 35–51
Putnam RD with Leonardi R, Nanetti RY (1993) *Making democracy work: Civic traditions in modern Italy*. Princeton University Press, Princeton, NJ
Rey JS, Le Gallo J (2009) Spatial analysis of economic convergence. In: Mills T, Patterson K (eds) *Palgrave handbook of econometrics* (Vol. 2Applied Econometrics). Palgrave, London
Rey JS, Montouri BD (1999) US regional income convergence: A spatial econometric perspective. *Regional Studies* 33: 143–156
Rodrik D (2011) The future of economic convergence. NBER Working Paper
Rodrik D (2013) Unconditional convergence in manufacturing. *Quarterly Journal of Economics* 128: 165–204
Romer P (1990) Endogenous technological change. *Journal of Political Economy* 89: S71–S102
Romp W, de Hann J (2005) Public capital and economic growth: A critical survey. *EIB Papers* 10: 40–70
Silverman BW (1986) *Density estimation for statistics and data analysis*. Chapman & Hall, London
Squicciarini MP, Voigtländer N (2015) Human capital and industrialization: Evidence from the Age of Enlightenment. *Quarterly Journal of Economics* 130: 1825–1883
Tabellini G (2010) Culture and institutions: Economic development in the regions of Europe. *Journal of the European Economic Association* 8: 677–716
Temple J (2001), Growth effects of education and social capital in the OECD countries. OECD economic studies, no. 33
Vigo G (1971) *Istruzione e sviluppo economico in Italia nel Secolo XIX*. Turin, ILTE
Ying LG (2003) Understanding China's recent growth experience: A spatial econometric perspective. *Annals of Regional Science* 35: 613–628