MANKIND QUARTERLY 2018 58:4 654-665

Solar Radiation, IQ and Regional Disparities in Italy

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Contrary to Leon & Antonelli-Ponti's claim that regional socio-economic and cognitive differences between Italian provinces are best explained by differences in UV radiation, it is argued that (1) these differences are of rather recent origin, dating to the period of industrialization in the 19th and 20th centuries; and (2) regional differences in Europe today are better explained by distance from the continent's economic center of gravity in North-Western Europe. Neither UV radiation theory nor Lynn's genetic theory are required to explain economic differentials in modern Europe.
Key Words: Italy, Industrialization, Economic history, Intelligence

The causes of socioeconomic disparities between the North and South in Italy have been a matter of debate since the end of the 19th century (see, for example, Nitti, 1900; Galasso, 2005; Daniele & Malanima, 2011a; Pescosolido, 2017). In contrast to the traditional explanations, which consider institutional, economic and geographic factors as determinants, Richard Lynn (2010) has claimed that the north-south socioeconomic divide in Italy is due to regional differences in the mean IQ of their populations. By using OECD-PISA test scores as proxies for IQ, Lynn showed how, at the regional level, 'IQ scores' are significantly correlated with GDP per capita, education levels, mean height and other socioeconomic variables. Consistent with the theory of racial differences in intelligence, he argued that the comparatively lower 'IQ scores' of southern Italians are due to the genetic legacy of Phoenicians and Arabs that, in different epochs, colonized some areas of the South. As was easily predictable, Lynn's paper raised a debate, and his thesis was criticized on historical, economic and methodological grounds (Beraldo, 2010; Cornoldi et al., 2010; D'Amico et al., 2012; Daniele & Malanima, 2011b; Daniele, 2015).

In this issue, Federico R. León and Mayra Antonelli-Ponti propose the existence of a causal nexus between ultraviolet (UV) radiation (the invisible, more energy-rich part of sunlight) and Italian regional socioeconomic disparities. According to the authors, due to the latitudinal gradient of the Italian peninsula, the oxidative stress caused by UV radiation impacted negatively on the socioeconomic development of southern regions. In turn, differences in regional development accounted for those in average complex cognitive abilities, measured by school test scores. In their research, the findings on Italy were supplemented with those from two other studies, examining states/provinces of the USA and Brazil. León & A-Ponti's conclusions regarding Italy were the following:

1) North-south differences in socioeconomic development are not attributable to cognitive differences. The causal nexus seems to run in the opposite direction.

2) UV radiation is the ultimate determinant of the geographic variation in cognitive abilities and wealth.

My purpose is to discuss León & A-Ponti's findings from an economic perspective, focusing on the link between UV radiation and socioeconomic development.

The Italian North-South Divide

The works by Lynn (2010) and by León & A-Ponti both attempt to explain the significant and persistent disparities in socioeconomic development between northern and southern Italy. In 2016, GDP per capita in the South (the 'Mezzogiorno') was 56% of that of the Center-North, while poverty and unemployment rates were higher. Nowadays, north-south inequalities are apparent in dozens of socioeconomic indicators (SVIMEZ, 2017).

Did this economic divide also exist in the past or, rather, is it the result of recent historical events? This is a crucial question with regard to the theories of Lynn and those of León & A-Ponti on Italy. In fact, if the causes of the north-south divide are either genetic or related to the impact of UV radiation on human biology, the divide would have existed in the past too. But when we look back at the ancient past, we see an 'upside-down Italy' in terms of cultural and economic development. From the first half of the 8th century B.C., in southern Italy ('Magna Graecia') and on Sicily, important and populous Greek colonies flourished where the political and cultural development was comparable to that of the motherland (Astour, 1985). The South was probably more prosperous than the North in the late Middle Age too (Abulafia, 1977).

The economic differences between the two parts of the country were modest in more recent times as well, such as in 1861, when national unification was proclaimed. In 1861-78, real wages in the South and islands were equivalent to those in the Center-North (Daniele & Malanima, 2017). In the 1861-91 period, the difference in GDP per capita between the two areas has been estimated at around 7-10 percentage points (Daniele & Malanima, 2011a; Pescosolido, 2017). Infant mortality rates were very similar, and in some southern regions, such as Apulia or Sicily, lower than in some northern ones. Life expectancy did not significantly differ, either. However, literacy rates presented a clear north-south gradient. In the southern regions, 85-90% of people over 15 years of age were illiterate. Illiteracy ranged between 75% and 84% in the central regions, while it was lowest, at about 54%, in the northern ones (SVIMEZ, 1961, p. 795). Differences in education levels were mainly due to the diverse institutions and policies of the pre-unification states.

So, when did economic conditions between the North and the South diverge? The north-south divide became evident at the end of the 19th century, when the northern and western regions of Italy started the process of industrialization. Since that time, for at least 50 years the gap in levels of industrialization and GDP per capita between the two areas progressively widened. As a result, Italy became a country with a dual economy (Daniele & Malanima, 2011a, 2014). The economic structures and income levels of the northern regions became analogous to those of the most prosperous European regions; those of the South, instead, came to be very similar to those of the less developed regions of Portugal, Spain and Greece. In other words, northern Italy became part of the 'economic core' of Europe, while the South remained part of the Mediterranean periphery. Is this change in economic geography a possible explanation of the north-south Italian divide? What, then, is its role in the context of the theories proposed by Lynn (2010) and by León & A-Ponti?

The Reversal of Economic Fortune

On a global level, a significant inverse relationship exists between countries' latitudes and economic development (Nordhaus, 2006). This negative link can also be found across European countries. Figure 1 plots the relationship between latitude and logged GDP per capita in 36 European countries (R^2 = .20). Nations at higher latitudes are, on average, more developed than those at lower latitudes. Not surprisingly, as shown in Fig. 1B, UV exposure and GDP per capita are negatively related (R^2 = .21). These relationships are consistent with León & A-Ponti's hypothesis, according to which UVR influences socioeconomic activities and, possibly, complex cognitive abilities.

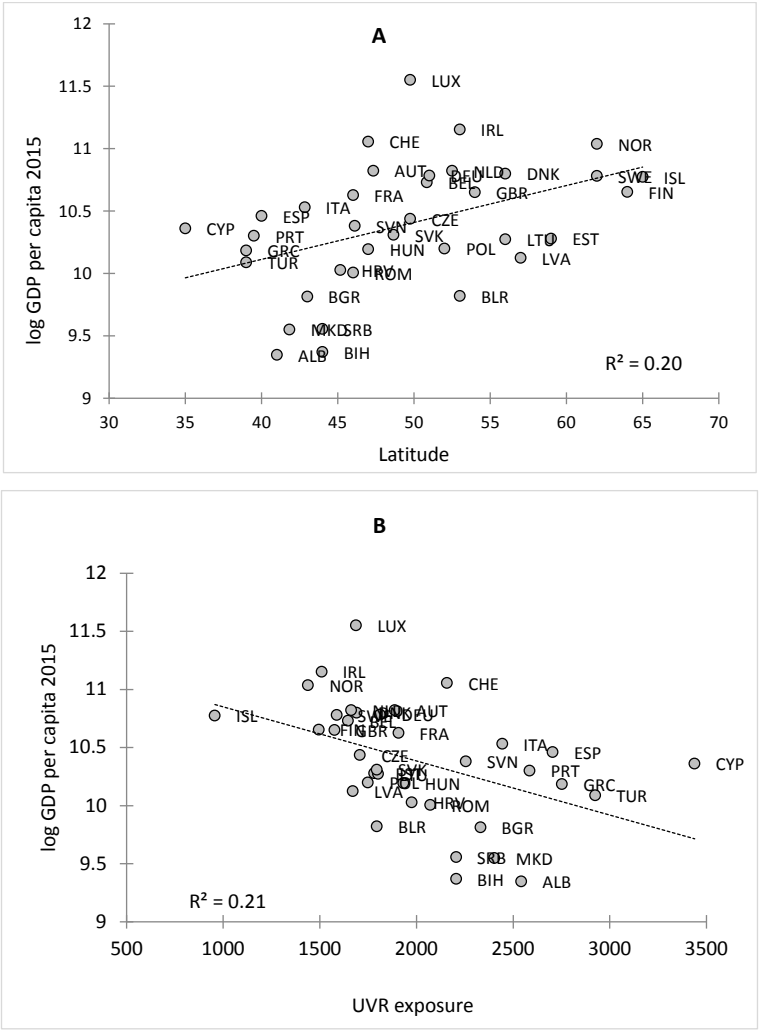

Figure 1. *Relationship between latitude and the log of GDP per capita (A) and between UV radiation (UVR) and the log of GDP per capita (B) in 2015 for 36 European countries. UVR exposure data are from the World Health Organization (WHO).*

When we look at the past, these relationships appear reversed. Figure 2 displays the link between latitude, UV radiation and the log of population density in 1500. Here, population density is used as a proxy for countries' economic

performance. In preindustrial times, technological improvements led to increased population rather than increased in per capita GDP (Clark, 2007, pp. 28-29). Figure 2 shows how in 1500, population density was higher in countries at lower latitude (R^2 = .37); consequently, UV radiation and population density were positively, although weakly, related (R^2 = .11).

These figures suggest that a 'reversal of fortune' occurred in Europe. When did it happen? It occurred in relatively recent times. Until 1600, GDP per capita was higher in Portugal and Spain than in Finland, Germany and Sweden[1]. In the subsequent century, southern countries were overtaken by northern ones. Some economists have proposed epidemiological or physiological factors as the ultimate causes of the reversal of the latitude/development relationship (Dalgaard & Strulik, 2017). For example, Andersen, Dalgaard & Selaya (2016) argued that the intensity of UV radiation influenced the comparative development of countries/regions. Schematically, their argument is that high UV radiation, being associated with eye diseases such as cataracts, reduced work-life expectancy and, therefore, the expected return to skills investment. In regions closer to the equator, this delayed the demographic transition and, thus, the take-off of modern economic growth. A study based on demographic data for Norway in the period 1676-1878 found that individuals born during a period of heightened solar activity had, on average, a lifespan 5.2 years shorter than those born in a solar minimum period (Skjærvø, Fossøy & Røskaft, 2015). For infants born in a period of solar maximum, the risk of dying before the age of 2 was higher than for those born during a period of solar minimum. The authors attributed this to a possible effect of folate degradation during pregnancy caused by UV radiation.

Did physiological or epidemiological factors really determine the economic take-off of northern European countries? There is no such evidence. History tells us that the Industrial Revolution started in England in the second half of the 18th century, and successively spread to Belgium, France, Germany, and later to other European countries (Pollard, 1981; Tilly, 2010). As industrialization spread across Europe, the Mediterranean Basin lost its centrality in the world economy and a new economic geography emerged.

[1] Historical per capita GDP estimates are available at Maddison Project Database, version 2018. See Bolt et al. (2018).

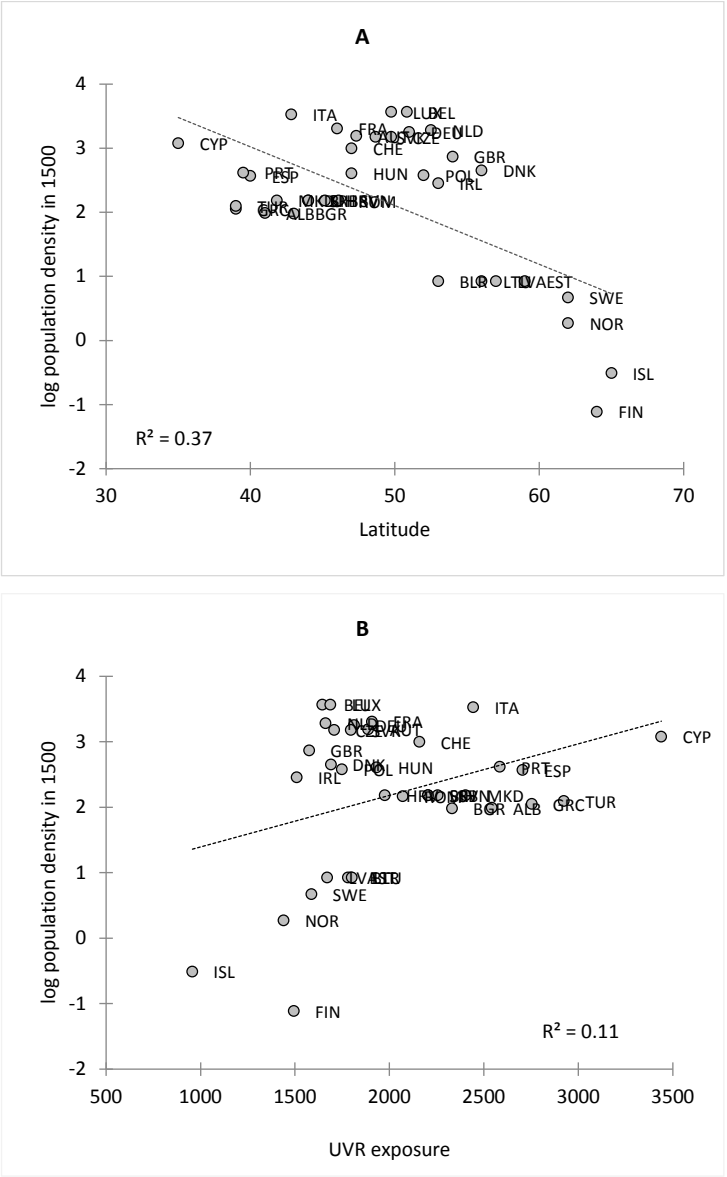

Figure 2. *Relationship between latitude and the log of population density (A) and between UV radiation (UVR) and the log of population density in 1500 (B) for 36 European countries. UVR exposure data are from the WHO.*

Economic Geography, UV Radiation and IQ

Does solar radiation influence economic activity in Italy or, instead, does it capture an economic gradient, related to the historical pattern of industrialization? To answer this question, I have considered the distance of each Italian region from Brussels, a city at the economic center of gravity in modern Europe. The distance from Brussels may be taken as a proxy of the 'peripherality' of a region with respect to the 'economic core' of Europe, an area composed of densely populated regions with high income per capita and per square kilometer. These geographically neighboring regions form a cluster that includes the South-East of the UK, the Benelux countries, West Germany, part of France and the north of Italy (the so-called 'blue banana'). The European economic periphery includes Portugal, part of Spain, southern Italy, Greece, and the Eastern European EU member states (Nordhaus, 2006; Combes, Mayer & Thisse, 2008, pp. 17-18). Economic geography theories demonstrate how, both at the international and subnational levels, economic activities tend to concentrate in geographic space because of the interplay of agglomeration economies, transportation costs and access to markets (World Bank, 2009).

Table 1. *Correlation coefficients, data for 21 Italian regions/provinces.*

	Math scores	UVR	Distance from Brussels	Temperature
GDP per capita 2015	0.80	-0.88	-0.88	-0.81
Math scores	1	-0.85	-0.85	-0.68
UVR		1	0.91	0.93
Distance from Brussels			1	0.78

Note: 5% critical value (two-tailed) = 0.43 for n = 21

Table 1 reports the correlation coefficients between GDP per capita in 2015, PISA math test scores (OECD, 2012), UV radiation, distance from Brussels, and the average annual temperatures for 19 Italian regions plus two autonomous provinces.[2] Data on UV radiation are the same as those used by León and A-Ponti, while GDP per capita is taken from the Eurostat online database. Variables are highly related to each other. GDP per capita is highly correlated with UV radiation (r = -.88), with distance from Brussels (r = -.88), with temperature (r = -

[2] Data cover 19 Italian regions plus the two autonomous provinces of Trento and Bolzano.

.81) and with test scores (r = .80). Math test scores are correlated with UV radiation (r = -.85) and, identically, with distance from Brussels. The regional distance from Brussels is, in fact, almost perfectly related to UV radiation intensity (r = .91).

Given the north-south orientation of the main geographical axis of Italy, it is possible that the regional distance from Brussels captures a possible effect of UV radiation on economic development, as hypothesized by León & A-Ponti or, as supposed by Lynn (2010), some genetic differences across Italian regions. To check if this is the case, I considered a sample composed of 21 Italian regions and 14 Spanish regions (*Comunidades autónomas*) for which PISA-math scores are available (OECD, 2012). The inclusion of Spanish regions offers some insights into the possible relationship between UV radiation and economic development, since Spain's main axis does not present the north-south gradient of Italy. Table 2 reports the correlations among variables. In this larger sample, GDP per capita is correlated -.83 with distance from Brussels and -.48 with UV radiation. Math scores are correlated -.79 with distance from Brussels and -.49 with UV radiation. In other words, the distance from Brussels is a stronger predictor than UV radiation for development levels and school test scores.

Table 2. *Correlation coefficients, 35 Italian and Spanish regions.*

	Math scores	UVR	Distance from Brussels	Temperature
GDP per capita 2015	0.77	-0.48	-0.83	-0.67
Math scores	1	-0.49	-0.79	-0.61
UVR		1	0.67	0.73
Distance from Brussels			1	0.74

Note: 5% critical value (two-tailed) = 0.34 for n = 35

These results indicate how, in the case of Italy, it is entirely possible that the link between UV radiation and economic development is spurious, capturing other effects related to the geography of the country.

Conclusion

León & Antonelli-Ponti's analysis on Italy claims a causal link between UV exposure and regional socioeconomic development. Their analysis also provides evidence that socioeconomic disparities explain north-south differences in average complex cognitive abilities. These findings contrast with Lynn's (2010) hypothesis that southern Italians have a lower average IQ than northern Italians due to the genetic legacy of Phoenicians and Arabs. León & A-Ponti's results are

consistent with studies that show how, in Italy, north-south differences in school achievement are largely explained by differences in socioeconomic conditions and in the quality and effectiveness of education (Agasisti & Vittadini, 2012; Argentin et al., 2017). It is widely recognized how, at the international level, environmental factors have powerful effects on mean IQ scores: improvements in education and, more generally, economic modernization are associated with significant IQ gains over time (Flynn, 1999; 2013, pp. 3-10). The 'Flynn effect' has also been documented at the regional level (Roivainen, 2012; Weber, Dekhtyar & Herlitz, 2017).

While the influence of temperature on economic outcomes such as labor productivity and educational attainment is documented (Dell, Jones & Olken, 2012), León & A-Ponti provide scant evidence as to the mechanisms through which UV radiation may hamper economic development, thus leaving room for doubt. Doubts arise, for example, when we look at the past. In fact, until at least the 16th century, the most prosperous regions of Europe were those of the Mediterranean Basin while northern regions were still relatively backward. For a long time, neither UV exposure nor genes seem to have had any detrimental effect on cognitive abilities or on the economic prosperity of the peoples of the Mediterranean Basin. The ancient civilizations of the Middle East and the Mediterranean bequeathed an immense cultural heritage to the West, covering philosophy, astronomy, mathematics, art. A negative relationship between the intensity of UV radiation and economic development may be found in the contemporary era, but seems to be at odds with the reality in the distant past.

Was the reversal of the latitude/development relationship due to biological or epidemiological reasons, such as the possible effects of UV radiation on fertility, cognitive abilities or economic development? On this point, we can only formulate conjectures. Documented historical facts show us how modern industrialization started in England and progressively spread across Europe, reaching countries and regions at different times and with diverse intensities. As a result, the economic geography of Europe underwent a deep change. In the case of Italy, it is entirely possible that the inverse link between UV radiation and economic development may simply capture the effect of the economic forces that progressively led to the geographical concentration of economic activities in the Center-North of Europe, leaving the Mediterranean regions at the margins.

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