DEMOGRAPHIC RESEARCH

*A peer-reviewed, open-access journal of population sciences*

*DEMOGRAPHIC RESEARCH*

**VOLUME 35, ARTICLE 28, PAGES 813–866**
**PUBLISHED 22 SEPTEMBER 2016**
http://www.demographic-research.org/Volumes/Vol35/28/
DOI: 10.4054/DemRes.2016.35.28

*Research Article*

# GDP and life expectancy in Italy and Spain over the long run: A time-series approach

**Emanuele Felice**

**Josep Pujol Andreu**

**Carlo D'Ippoliti**

# Contents

*Demographic Research*: Volume 35, Article 28
*Research Article*

# GDP and life expectancy in Italy and Spain over the long run: A time-series approach

**Emanuele Felice**[1]

**Josep Pujol Andreu**[2]

**Carlo D'Ippoliti**[3]

## Abstract

**BACKGROUND**
A growing body of literature focuses on the relationship between life expectancy and GDP per capita. However, available studies to date are overwhelmingly based on either cross-country or cross-sectional data. We address the issue from a novel, more historically grounded approach, i.e., comparing long-run consistent time series.

**OBJECTIVE**
To investigate what, if any, is the causal link between life expectancy and GDP.

**METHODS**
We provide consistent and updated long-term yearly time series of GDP and life expectancy for Italy and Spain and compare them with those available for France.

**RESULTS**
Both Italy and Spain converged towards the European core (France) earlier in life expectancy than in GDP. We find it necessary to split the series into two sub-periods, and we find that, in general, both improvements in life expectancy cause GDP growth and economic growth causes improvements in life expectancy. For the countries and the periods considered there are, however, exceptions in both cases.

**CONCLUSIONS**
Our findings confirm the hypothesis of a non-monotonic relationship between life expectancy and income, but they also emphasize the importance of empirical qualifications, imposed by the historical experience of each national case.

[1] Università "G. D'Annunzio" Chieti-Pescara, Italy. E-Mail: claudio.felice@unich.it.
[2] Universitat Autònoma de Barcelona, Spain. E-Mail: Josep.Pujol.Andreu@uab.cat.
[3] Università degli Studi di Roma, La Sapienza, Italy. E-Mail: carlo.dippoliti@uniroma1.it.

## 1. Introduction

There is a growing literature on the relation between improvements in life expectancy and the rise in gross domestic product (GDP) per capita. The subject is of the utmost interest to economists, demographers, and policymakers (at least in the developed countries, which are experiencing an ageing population and sluggish economic growth). A well-established causal link goes from income to life expectancy. According to Preston (1975), the relationship between GDP and life expectancy in the 20th century follows a logarithmic curve. The impact of GDP on life expectancy is higher when the former is low, then it decreases as GDP rises, and even disappears after GDP reaches a certain threshold. While this relationship is widely accepted in the literature[4] there is no consensus on the opposite causal link, going from life expectancy to income.

In economics, the unified growth theory holds that the demographic transition plays a crucial role in initiating the shift from stagnation to growth (Galor and Weil 2000; Galor 2012): The idea is that with the demographic transition, higher life expectancy leads to lower fertility and lower population growth, and thus to higher returns of human capital investments to those living longer. In turn, lower fertility and higher human capital both contribute to the rise of per capita GDP. A number of cross-country studies find a positive effect of life expectancy, or a negative effect of mortality, on income per capita (Bloom and Sachs 1998; Gallup, Sachs, and Mellinger 1999; Lorentzen, McMillan, and Wacziarg 2008), but the debate is still ongoing. For example, Acemoglu and Johnson (2007) find no impact of life expectancy on GDP per capita, and their explanation is that increased life expectancy actually accelerates population growth. More recent studies suggest that the causal effect of life expectancy on growth is non-monotonic, i.e., it is negative but insignificant before the onset of the demographic transition, and positive afterwards (Cervellati and Sunde 2011).

All these studies are based on cross-sectional comparisons. By contrast, here we aim to exploit new and updated time series in order to investigate the issue from a historical perspective. We use updated long-run estimates of life expectancy and GDP for Italy and Spain (1861–2008) and compare them with the available corresponding series for France. Indeed, the development and employment of these long series − an approach that can be regarded as complementary to cross-sectional comparisons − is in itself one of the main contributions of our work. In macroeconomic history, two approaches are the most popular on quantitative grounds: cross-country studies, often

[4] Of course, income is not the only factor affecting life expectancy. For a broad and updated review of the determinants of the rise in life expectancy and the reduction in mortality during the 20th century – with an empirical focus on the Spanish case – and more references to the international studies investigating the link from income to life expectancy, see Pérez Moreda, Reher and Sanz Gimeno (2015: 287–367). For a more general account of the mutual dependency between economic growth and civil development, see Zacchia (2016).

using cross-sectional data, and country-specific studies, usually employing time series. In cross-country studies the data at hand is typically limited to a few benchmark years or to short periods of time. Although a wide range of countries and indicators may be included and discussed, the lack of time series may prevent these studies from dealing efficaciously with endogeneity, even when instrumental variables are introduced, while heterogeneity or even inconsistency of the data used may be overlooked. Time-series macroeconomic analyses of specific countries or regions are of course much more complete in historical coverage and at times take advantage of refined estimates,[5] but this may be detrimental to international comparisons.[6] A combination of the two methods has also been used for international comparisons[7] and in specific country studies. For instance, limited to the Spanish case, Pérez Moreda, Reher, and Sanz Gimeno (2015: 292–299) compare GDP per capita and life expectancy/mortality in the long run by making use of both yearly series (at the national level, from 1901 to 1990) and cross-sectional data (at the regional level, in four benchmarks corresponding to the 1860s, 1900–1901, 1930–1931, and 1961), even though they only estimate simple correlations between the variables.

Here, we extend the time-series analysis to a comparison between countries, with a historical coverage spanning 148 years (1861–2008), and we also investigate the causal relationship between the two variables.[8] We consider the two largest countries of Southern Europe, Italy and Spain − which are usually regarded as similar in culture and values, as well as with respect to some key institutional features and economic patterns[9] − and compare them with France, their principal neighbour, the country that both have often looked up to as providing proper terms of evaluation. These are big countries,

---

[5] For Italy, see Fenoaltea (2003, 2005) and, more recently, Felice and Vecchi (2015a, 2015b). For Spain, see, among others, Pons and Tirado (2006), Prados de la Escosura and Rosés (2009), Prados de la Escosura (2010a), Sabaté, Fillat, and Gracia (2011) and Prados de la Escosura, Rosés, and Sanz-Villarroya (2012). For other countries, see, for instance, the remarkable study on Turkey by Altug, Filiztekin, and Pamuk (2008), or the recent reconstruction of Venezuelan GDP, 1830–2012, by De Corso (2013).

[6] Unless of course Maddison's (2010) renowned series are used. However, when it comes to a detailed scrutiny of national cases, Maddison's estimates are not always trustworthy and, above all, comparisons not always reliable (Felice 2016). For a critique of Maddison's Italian estimates, see Fenoaltea (2010, 2011). For time-series analysis using Maddison's figures, see, for instance, Ben-David and Papell (2000). Time-series analyses with alternative estimates are usually limited to industrial output: Crafts, Leybourne, and Mills (1990); see also the Williamson project (Williamson 2011).

[7] For instance, Prados de la Escosura (2007) provides long-run comparisons of European countries by combining cross-sectional and time-series data.

[8] Our analysis stops at 2008 in order to avoid the relevant impact of the recent crisis. For an analysis of the 2008 crisis impact on GDP across European countries, see e.g., Alessandrini and Fratianni (2015) or Tonveronachi (2015); for its social impact, see e.g., Botti et al. (2016). In this journal, Goldstein et al. (2013) elaborate on the impact of the crisis on fertility, a topic on which more research is certainly needed.

[9] At least in four important aspects: Both are Catholic countries, they share a Latin heritage (from neo-Latin languages to codified law), they are latecomers to European industrialization, and are medium- to large-sized countries with significant regional differences.

whose patterns can hardly be affected by geographically limited shocks, while arguably their inter-country heterogeneity is relatively low. Moreover, for these three countries it is now possible to keep at a minimum the heterogeneity coming from different estimates and procedures, at least to a reasonable degree, and this is what we strive to do in this paper.

For our analysis, we benefit from recent advances in historical research, thanks to which it is now possible to compare relatively consistent series of GDP for Italy and Spain and to produce consistent long-run series of life expectancy. In the case of GDP, we make use of the new series at constant prices for Italy (Baffigi 2011; Felice and Vecchi 2015a),[10] which is by many standards more reliable than the previous one included in Maddison (1991, 2010), and compare it with the one available for Spain produced by Prados de la Escosura (2003), which is incorporated into Maddison's (2010) work.[11] We obtain per capita series using the total population present in the country, rather than the resident population,[12] since the former is the most appropriate when dealing with gross domestic product.[13] In the case of life expectancy, we link the most updated estimates – for Italy in benchmark years (Felice and Vasta 2015) and for Spain in yearly series (Blanes Llorens 2007) – with previously available series on life expectancy or mortality, in order to produce long-run comparable series running from 1861 to 2008.

To sum up, we use updated series of life expectancy (either partly new yearly series, or new benchmarks which we interpolate with series of mortality or with previous series of life expectancy), in order to make the two countries more properly comparable, and refinements of the available GDP figures (limitedly to the use of the present population instead of the resident population). All these series are then compared with those available for France, which are taken from established databases (Maddison 2010; HMD, Human Mortality Database, 2011a). All series used were built following well-established procedures and are based on the most updated and reliable sources. However, it should be noted that the series for the second half of the 19$^{th}$ century are less reliable, as is frequently the case with this kind of data, and this is particularly true in our case for the estimates of life expectancy in Spain (Cabré,

[10] Felice and Vecchi slightly updates Baffigi by incorporating the last stretch of the new Italian national accounts, i.e., the new estimates of industrial GDP running from 1938 to 1951 (from Felice and Carreras 2012).
[11] Unlike others (Maluquer de Motes 2009a), the series by Prados de la Escosura look similar to the new Italian series in both method and level of accuracy.
[12] For Spain, we take population data from Maluquer de Motes (2008); for Italy, see the online statistical appendix.
[13] Gross domestic product (GDP) includes all income earned by the individuals and entities not officially living in a country. Gross national production (GNP) instead subtracts foreigners' incomes from GDP, and includes the foreign income of the citizens of a country. To be consistent with their definitions, GDP should be divided by the present (de facto) population, and GNP by the resident (de jure) population.

Domingo, and Menacho 2002; Cabré 1999). For this reason they should be interpreted with caution. An extended online statistical appendix provides full details and an in-depth discussion of the series we use and their underlying sources and methods, as well as additional econometric results.

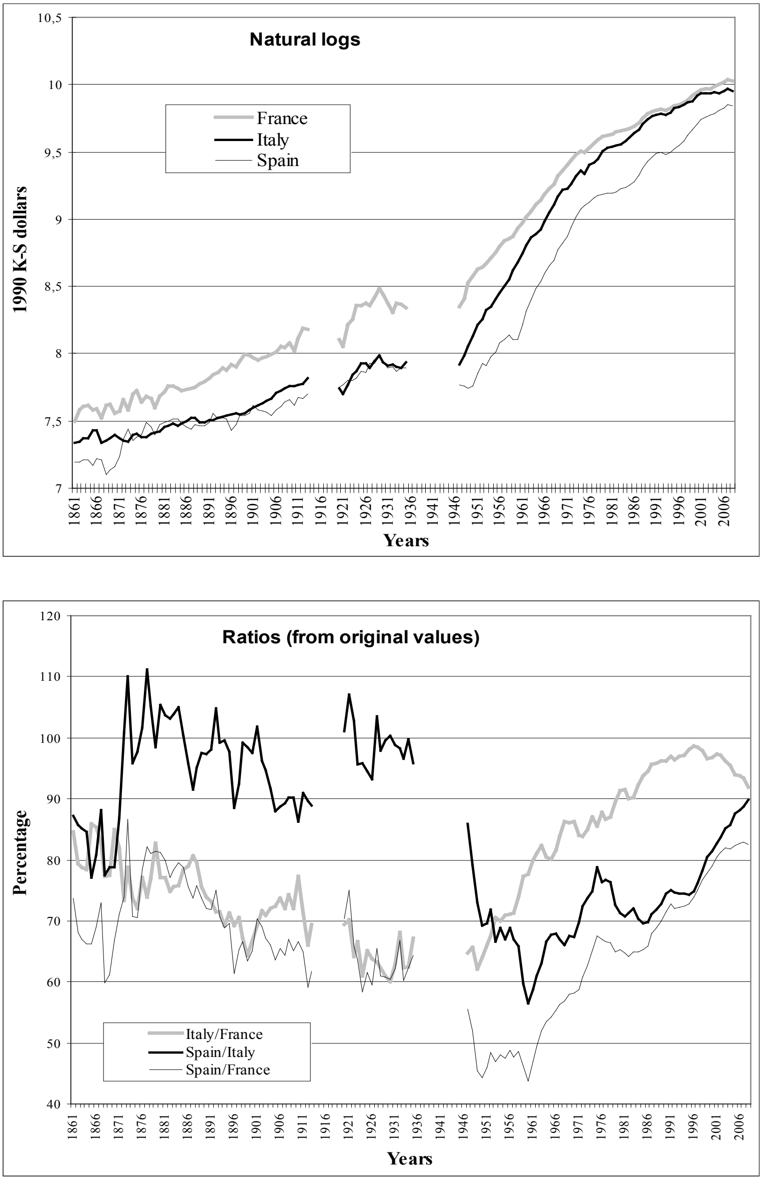
With the advantage of updated and often more reliable series, in what follows we consider the broad convergence patterns of Italy and Spain towards France in both GDP and life expectancy (Section 2), and compare the long-term movements of the two variables (Section 3). Through time-series analysis we then search for structural breaks and discuss the long-run contribution of life expectancy to GDP and of GDP to life expectancy (Section 4). We find evidence of a non-monotonic relationship between these two variables, and provide results or insights that, in our view, contribute in a number of ways to enriching extant literature.

## 2. How close, how far? A comparison by pairs of indicators (1861–2008)

The series of GDP per capita at constant prices – expressed in 1990 international purchasing power parity (PPP) dollars – of Italy, Spain, and France are displayed in Figure 1.[14] The series are expressed in natural logarithms in the upper part and in inter-country ratios in the lower part. To visually highlight the long-run trends in the series, the years around the wars (1914–1919 and 1936–1946), characterized by very high short-run variance, are not shown. These years are, however, considered in the following analyses.

[14] In order to ensure full comparability, all series consider the three countries as defined by their present geographical borders.

## Figure 1: Per capita GDP in France, Italy, and Spain, 1861–2008




*Sources*: Table A-1.

The history of the 'race' in GDP between Italy and Spain can be summarized as follows. Italy began at a higher level, but lost some ground in the first decade after unification, and then from the end of the 19th century until the Spanish Civil War it had a slight edge, although experiencing ups and downs. For fifteen years (1946–1961) after the Second World War the Italian advantage over Spain increased dramatically, but from the early 1960s Spain and Italy began to converge. Further insight comes from a comparison with France, as shown in the bottom part of Figure 1. Until the second half of the 20th century both Italy and Spain were declining, relative to France. Italy fell behind until 1899, thereafter remaining more or less stable, whereas Spain continued to lose ground until 1960. However, in the second half of the 20th century the two countries began steadily to converge, first Italy, then Spain. By the mid-1990s Italy had almost drawn equal with France, but from 2001 onwards it fell behind again, while conversely Spain continued to converge until 2008.[15]

To sum up, until the Second World War, Italy was confined to the status of the European periphery and was much closer to Spain than to France. In the second half of the 20th century its status became that of the European core; however, this status is now in doubt (Felice and Vecchi 2015a). Spain began to converge towards the European core later, but its catching-up only came to a halt with the economic crisis.

It is interesting to compare GDP with life expectancy. The new series of this variable for Italy and Spain and that already available for France are shown in Figure 2 (the years around the wars, 1914–1919 and 1936−1946, are not shown). In contrast to GDP, at the beginning, i.e., through the first decades after Italy's unification until the end of the 19th century, in life expectancy Italy's advantage over Spain increased.

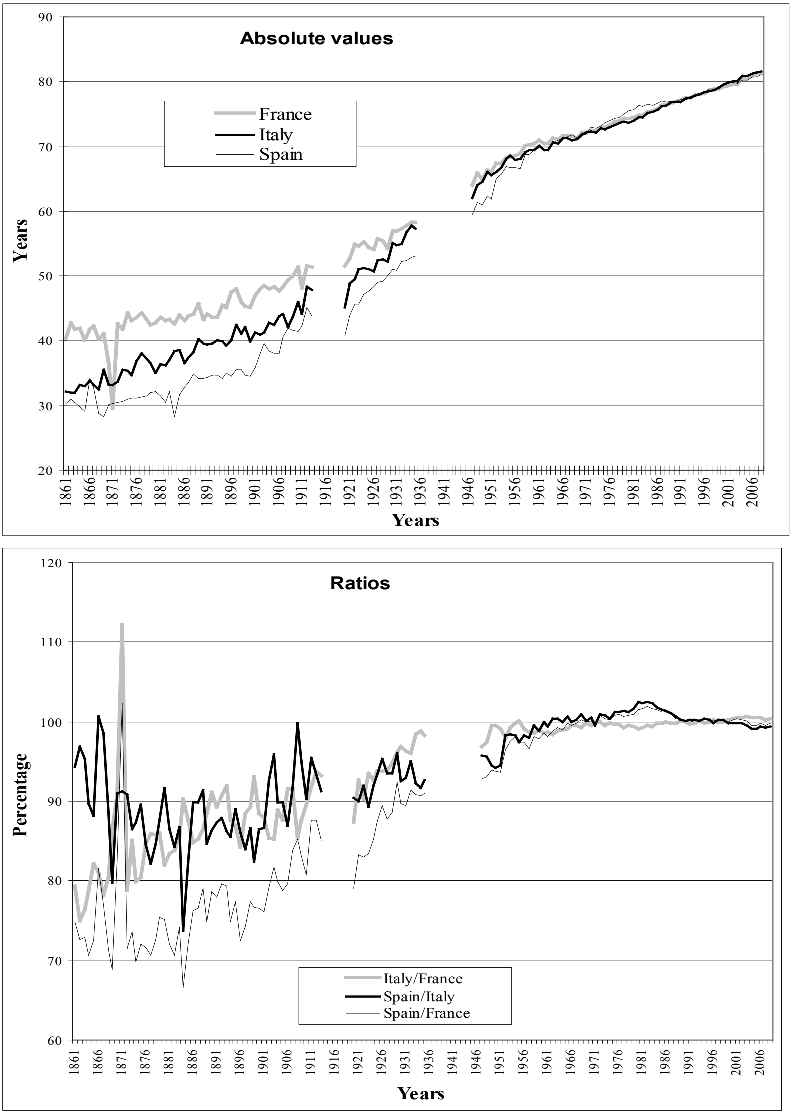
[15] This result is significantly different from that found by Molinas and Prados de la Escosura using previous series for Italy and Spain and benchmark comparisons between the two. According to them, Spain and Italy attained similar levels of per capita income at around the same historical date, but Spain converged later than Italy in structural change (Molinas and Prados de la Escosura 1989). It is probable that the discrepancy is only apparent: Spain also began to modernize later than Italy in per capita GDP. However, it is worth adding that this story would be significantly different had we used a different purchasing power parity index, closer in time to us: so different that such a PPP index would appear unreliable. When computing GDP series at 2008 PPPs (Table A-2 in the online statistical appendix) Spain appears to be significantly closer to Italy. Indeed, at 2008 PPPs it would be above Italy through most of the 1872−1935 period. Spain would also be historically much closer to France, by less than 5% in the second half of the 1870s. Italy also would rank closer to France, and it would even overtake it from 1986 to 2004. We find these results unrealistic, since they contrast with what we know about the economic histories of these countries: throughout this period Spain was most probably poorer than Italy and undoubtedly much poorer than France. Our conclusion from this exercise is that 2008 PPPs should not be used for historical comparison between these countries, probably because they reflect remarkably different trends in their respective national consumer price indexes in the first few years after the introduction of the euro. However, for the very last few years, more recent PPPs are undoubtedly more reliable and reinforce the convergence trend of Spain towards both Italy and France. This last trend is, therefore, stronger than it appears from our 1990 PPP benchmark. We also tested the 2005 and 2011 PPP benchmarks, and the results are not significantly different from those for the 2008 one. For further details on the use of different PPP benchmarks, see the online statistical appendix.

However, a second and maybe more important difference from the previous results is that Spain began to converge at the beginning of the 20th century and its life expectancy caught up with Italy's in the 1960s;[16] i.e., much earlier than its convergence in GDP. This result differs from what previous life expectancy data for Spain has suggested, that Spain began converging fifteen years earlier, around the second half of the 1880s, and stopped some years earlier, in the decade following the Second World War. This discrepancy is due to the fact that the official censuses, and even HMD data until 1930, under-reported infant mortality (for further details, see the online statistical appendix). Lastly, it should be noted that in the second half of the 1990s there was a new 'reversal of fortunes' in terms of life expectancy, with Italy once again taking the lead.

In broad terms, there are two important similarities between the patterns of GDP per capita and those of life expectancy: the initial advantage of Italy and the convergence of Spain over the long run. However, it is equally clear that the two indicators differ in at least two important respects. First, Spain began to converge sooner in life expectancy, and even overtook Italy as early as the 1960s when its convergence in per capita GDP had only just begun; second, Italy in turn again overtook Spain in life expectancy in the late 1990s, that is, at the same time as the Spanish convergence in per capita GDP accelerated remarkably.

[16] The remarkable growth of life expectancy in Spain during most of the 20th century is confirmed by other studies: see Spijker, Cámara, and Blanes (2012, p. 282) for 20-year growth rates by gender in the 1911–1991 period.

**Figure 2: Life expectancy in France, Italy, and Spain, 1861–2008**




*Sources*: Table A-4; data for France are from HMD (2011a).

When comparing Italy and Spain's life expectancy with that of France, it emerges that around 1861 France had an even greater lead over Italy in life expectancy than it did in GDP. Italy, however, began to converge soon, starting in 1863, and had caught up with France by the mid-1950s, soon after convergence in GDP had begun and well before it was completed. This is similar to what we have seen for Spain in comparison with Italy. During the last decades, Italy continued to improve its position in life expectancy with respect to France, and had surpassed France by 1999. Conversely, Spain endured more ups and downs and began to steadily converge towards France later than Italy, in the last years of the 19th century, and reached the same level as France roughly a decade after Italy did, in the middle of the 1960s. At the beginning of the 1970s, Spain also overtook France, and managed to maintain its lead throughout the 1980s. During the last two decades, Spain and France have ranked at practically the same level, although Spain has been falling slightly behind − once again, in sharp contrast with the GDP series. It may be worth adding that the convergence of Spain also took place in a wide range of other indicators of wellbeing, from height,[17] to per capita calories,[18] to composite indicators such as the Human Development Index. With respect to education, Spain has overtaken Italy in the last few years.[19]

From these comparisons, two regularities or common features emerge in the patterns of GDP and life expectancy. The first is the starting point. Differences in GDP mirror those in life expectancy at lower levels of socioeconomic development. At early stages a clear lead in GDP results in a clear lead in life expectancy, and vice versa. This finding is not new: in past historical periods when material conditions were dire and significant breakthroughs in medicine and social conditions had not yet taken place, there was a strong correlation between life expectancy and income in poor countries (e.g., Fogel 2004).[20] The second regularity concerns the trend: in both Italy and Spain, convergence in life expectancy begins earlier than in GDP. Life expectancy converges when the leading country (France in the case of Italy, and Italy in the case of Spain) is in the upward curve of its industrial transformation (which in its early stages may well have negative consequences for life expectancy). At the same time, the follower benefits from declining mortality due to breakthroughs in medicine and social conditions, but has not yet embarked on industrial transformation. This finding is in line

---

[17] For Italy, see A'Hearn, Peracchi, and Vecchi (2009: 12−13); for Spain, see María-Dolores and Martínez-Carrión (2011: 35) and Martínez-Carrión and Puche-Gil (2011: 444 and 447).
[18] For Italy, see Sorrentino and Vecchi (2011: 12); for Spain, see Cussó Segura (2005).
[19] For Italy, see Felice and Vasta (2015); for Spain, see Prados de la Escosura (2010b).
[20] It is worth noting that such a correlation holds for modern times as well, as shown most noticeably by the well-known Preston (1975) curve, but is now probably less strong, allowing for important exceptions such as the 'Jamaica paradox', i.e., countries with low GDP and high life expectancy (Riley 2005). Furthermore, as we are going to see, this correlation is no longer valid once we transform the longevity function in order to properly account for improvements among the elderly. The analysis by Pérez Moreda, Reher, and Sanz Gimeno (2015: 296–299) also confirms the existence of the Preston curve in 20th century Spain.

with literature showing that − in modern times − it is possible to reach high levels of life expectancy even at relatively low levels of GDP (Caldwell 1986; Riley 2005).[21]

Of course, life expectancy is a highly synthetic indicator, whose evolution can be better understood by looking at its specific components. A primary issue is sex difference, where the three countries show remarkable similarities. They all record higher longevity for women, and with a similar advantage over men, growing from about one year at the beginning of the period to around six years at the end (HMD 2011a, 2011b, 2011c; Cabré, Domingo, and Menacho 2002; Blanes Llorens 2007). By contrast, age differences in mortality confirm the major backwardness of Italy and above all of Spain with respect to France, especially concerning mortality between the first and the third years of life (Ramiro Fariñas and Sanz Gimeno 2000a). As is well known, until the 20th century much of the increase in life expectancy at birth nearly everywhere was a consequence of falling infant and child mortality rates. In absolute terms, this is true also for Italy and Spain. In addition, there are some broad features common to all continental Europe, despite the differences in level. Around the 1870s childhood mortality began to decline. In the interwar years, thanks to public health measures and the construction of urban infrastructure, the ratio of urban/rural mortality also started to fall. Then, after the Second World War, the spread of modern medicine and the advent of antibiotics further contributed to this process (e.g., Cutler, Deaton, and Lleras-Muney 2006; Livi-Bacci 2012).[22] However, in terms of convergence, Spain, and to a lesser degree Italy, began to catch up later. In terms of infant mortality, Spain started to converge only after 1960 (Nicolau 1989: 57 and 70–72). In Italy, convergence in infant mortality had begun in the second half of the 19th century and accelerated in the second half of the 20th century (Felice 2007: 115). These different paces seem to be at least partly related to the relative economic backwardness of the two countries. In Spain, for instance, the agrarian regions were, in demographic terms, more important than in Italy.[23] Apart from lower average incomes, agrarian regions endured lower hygienic and nutritional standards than the industrial areas, with consequences for

[21] Not only for the reasons sketched above, but also thanks to other advances in social conditions such as improvements in literacy and education, especially among women (Riley 2001: 200−219). Literacy and education are omitted variables in our study, worthy of more investigation in the future (as far as we can tell at the present stage, their inclusion will further corroborate our findings).

[22] For a recent and highly detailed analysis of these dynamics for the Spanish case, see Pérez Moreda, Reher, and Sanz Gimeno (2015: 79–248).

[23] In Spain the population of Catalonia, Madrid, and the Basque Country, the three most industrialized regions, went from 16% of the total in 1857 to 22% in 1950. At the same time, in Italy the population in the regions of the industrial triangle − Piedmont, Liguria, and Lombardy − was always above 25% (and if we include the region of Rome, the strength of which was services rather than industry, the population was around 30%–32%). For Spain, see the estimates by Rosés, Martínez-Galarraga, and Tirado (2010) and the population figures by Nicolau (2005); for Italy, see the estimates by Felice (2010, 2011) and the population figures by Felice (2007: 16).

mortality levels.[24] A similar case can be made for the convergence of Southern Italy, whose mortality trends, when compared to the Centre-North of the peninsula (Felice and Vasta 2015), display features similar to those of Spain.

But the timing of the decline in infant mortality is also linked to a broader issue, a crucial one in the theoretical literature on the relation between life expectancy and GDP: the first demographic transition. France was the first country to undergo a demographic transition. There, the demographic transition began in the 19th century and was completed in the first half of the 20th. In Italy, it lasted approximately from 1876 to 1965, as it did in other European countries such as Germany (Chesnay 1986: 294 and 301; Livi-Bacci 2012: 118). Conversely, in Spain the demographic transition was completed only during the 1980s (Carreras and Tafunell 2004: 38). A slower demographic transition means higher fertility rates and thus higher infant mortality. It may also have an impact on the relationship between life expectancy and GDP, as argued by the unified growth literature.

## 3. Trends in GDP and life expectancy

Thus far, we have considered GDP and life expectancy separately. However, in order to properly relate GDP and life expectancy, some transformations of the original values are required.

Life expectancy is a bounded variable: It has asymptotic limits that result from biological features (which may only be modified, and probably only to a certain extent, much more slowly than the time frame considered here). As a consequence, when its original values are employed, as life expectancy increases identical absolute changes result in lower increases. Specifically, when its starting level is lower, life expectancy mainly rises because of reductions in infant mortality; when its level is higher, it mainly falls among the elderly, but this has a minor impact on its rate of change. In short, the use of the original values implicitly assigns a higher weight to mortality reductions early in life (Deaton 2006); that is to say, it gives "more weight to saving the life of the younger over older people" (Prados de la Escosura 2014, p. 4). A solution was proposed by Kakwani (1993) and was adopted by Prados de la Escosura (2014), among others, via an achievement function that ensures that – so to speak – returns to increases in life expectancy do not decrease at higher levels. Accordingly, we compute Kakwani-transformed life expectancy ($LE^k$) following the formula:

[24] This is supported by what we know about the slow modernization of Spain in the production and consumption of some key foods, like milk (Hernández Adell, Muñoz Pradas, and Pujol Andreu 2013). In terms of convergence this had a higher impact, especially after the urban/rural ratio in infant mortality started to fall.

$$LE^k = \frac{[log(M-M_0)-log(M-x)]}{log(M-M_0)} \quad (1)$$

where $M$ is a maximum goalpost (83.2), $M_0$ is a minimum goalpost (20), $x$ is the value of life expectancy, and *log* stands for the natural logarithm.[25]

By contrast, the GDP is an explosive rather than a bounded variable (at least in the period considered here). Thus, for time series analyses it is usually convenient to adopt a log transformation on its original values (Sen and Anand 2000), as we did in Figure 1.[26] In the economic literature a common justification for this practice is that in the case of GDP, as opposed to life expectancy, returns to well-being, or to the quality of life, are most likely to decline as the variable grows (Palazzi and Lauri 1998; Casadio Tarabusi, and Palazzi 2004; and, for the case of Italy, Sylos Labini 2014).

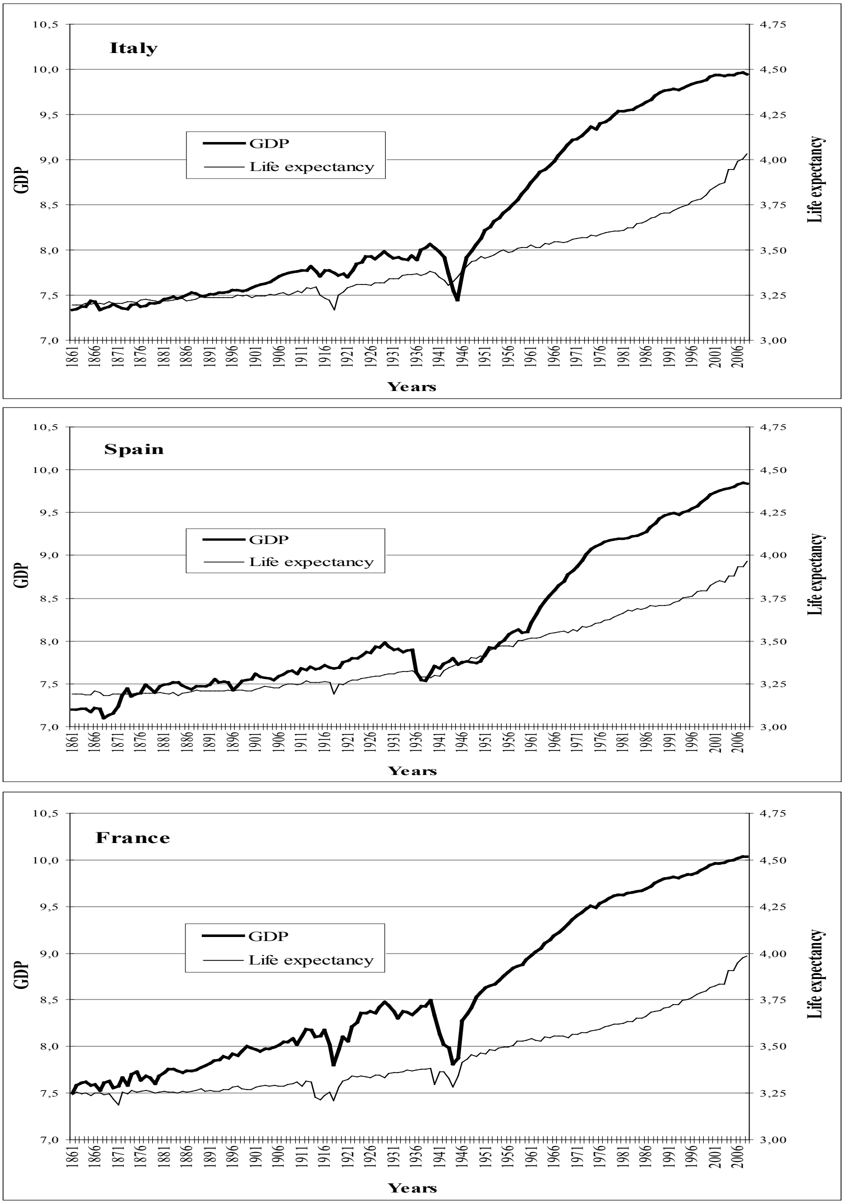
Figure 3 compares income and life expectancy for Italy, Spain, and France, making use of a natural log transformation for income and of a Kakwani transformation for life expectancy. Transformed GDP grew more than transformed life expectancy over the 1861–2008 period, even though our transformation increases the growth rate of life expectancy and decreases that of GDP. However, life expectancy accelerated its growth in the last decades, when, conversely, GDP began slowing down. Unlike the previous result, this would not have emerged had we kept the original figures for income and life expectancy.

Beside these two common broad trends, there are significant cyclical differences between the three countries, which appear to be somehow related to their different levels of socioeconomic development. In Italy, GDP grew more than life expectancy from the end of the 19th century until the 1970s; later on, it was life expectancy (or, better, achievements in longevity) that grew faster. For France we observe the same relationship, but significantly reinforced. In Spain, which was more backward, GDP grew more than life expectancy from the second half of the 19th century until the Civil War. Then, in the first two decades of Franco's regime, life expectancy grew at a faster rate than income. From the 1960s, GDP again grew faster than life expectancy, and this has only begun to change in the last few decades.

[25] For the Kakwani transformation, we thus use the same thresholds as in Prados de la Escosura (2014, 2013), which are in turn obtained from the United Nations Development Programme (UNDP) (2010). In the UNDP reports from 1995 to 2009 the maximum and minimum values for life expectancy at birth were respectively established at 85 and 25 years. In the UNDP (2011) the maximum has been updated to 83.4 years (the new highest observed value). We tested the use of 85 years as a maximum and, as expected, results do not change significantly (they are available from the authors upon request).

[26] For a test of different transformations of GDP and different assumptions of returns to scale, which support the use of a natural log function, see Cahill (2002).

**Figure 3: Income and life expectancy in Italy, Spain, and France, 1861–2008**



# 4. Time series analysis

## 4.1 Granger causality

In order to formally analyse the correlation between life expectancy and GDP, it is first necessary to investigate their order of integration. As shown in Table A-5 in the online statistical appendix, augmented Dickey-Fuller tests show that it is necessary to produce first-differences of all series in order to make them stationary, i.e., all series exhibit a unit root. As a consequence, descriptive statistics of the simple correlation between GDP and life expectancy (as shown in the correlograms in Figure 4)[27] necessarily highlight a strong comovement of the series, with marked cross-correlation in all countries even extending over a 20-year interval.

However, such correlation does not imply that the series are indeed related, since integration of the first order implies that all series grow in time, possibly within an overall process of socioeconomic development. By contrast, consideration of the first differences of the series produces much less obvious results (as shown in Figure 4c). Thus, in the rest of the analysis, both series will always be considered in their first differences (denoted by Δ).

In order to investigate the relation between GDP and life expectancy we make recourse to the concept of Granger-causality, well known to economists. As shown below, Granger causality tests allow us to check for systematic short-run correlations between life expectancy and GDP. However, it should preliminarily be noted that the two series may well exhibit longer-term relations, for instance, via health investments made much earlier in life. A time-series analysis can hardly capture this effect: To this end a cross-sectional analysis based on a larger sample of countries (even though necessarily with less measurement accuracy than is possible here) would probably be more informative. Thus, our approach should be regarded as complementary to the more diffused approaches reviewed in Section 1, rather than as an alternative.

[27] Given two series *xi and yi,* with *i* = 1, 2, … N-1, the cross-correlation *r* at delay *d* is defined as:

$$r = \frac{\sum_{i=1}^{N-1} [(x_i - \bar{x}) \times (y_{i-d} - \bar{y})]}{\sqrt{(x_i - \bar{x})^2} \times \sqrt{(y_{i-d} - \bar{y})^2}}$$

where $\bar{x}$ and $\bar{y}$ are the means of the corresponding series. The cross-correlogram in Figure 4 shows the resulting values for *d* up to 20. For an introduction to this method, see Chatfield (1980: 169–174).

## Figure 4: Cross-correlations of GDP and life expectancy

Figure 4a) – GDP and modified LE

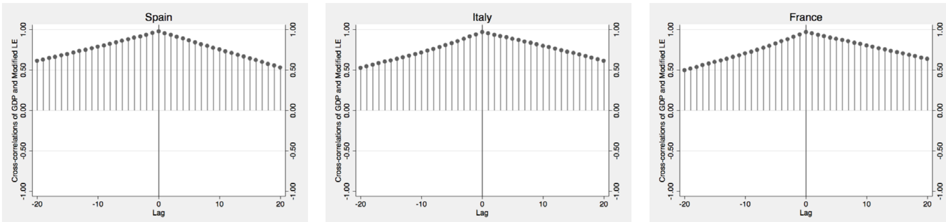



Figure 4b) – GDP and ln (LE)

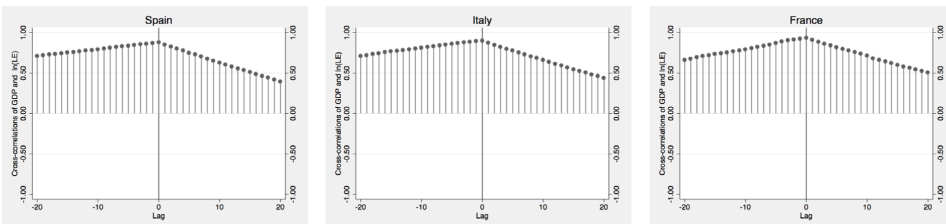
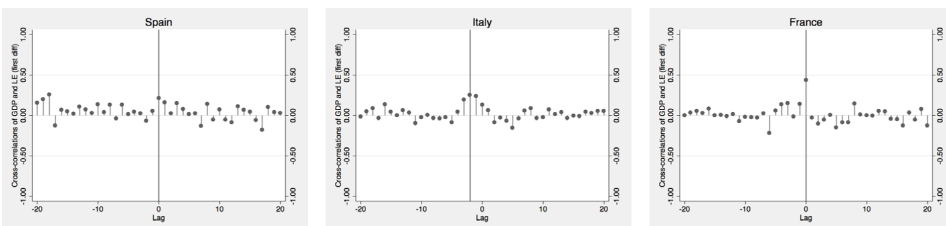



Figure 4c) – GDP and modified LE: first differences




Intuitively, a variable *x* is said to Granger-cause another variable, *y*, if *x* systematically anticipates *y* in time. That is to say, *x* is considered to be the cause of *y* if the values of *y* can be better predicted by using past values of *x* (and possibly *y* too) than by using past values of *y* alone.[28] It is customary to test for the presence of Granger

[28] Granger-causality only implies a systematic temporal relation between two variables (i.e., *x* contains useful information to foresee changes in *y*: Granger 1969). This does not necessarily entail a cause-effect relation. For example, whenever *y* depends on deliberate human action, it may be the case that people systematically anticipate their decision(s) on the basis of their expectations regarding the future (i.e., the future values of *x*).

causality by regressing $y$ on lagged values of $y$ and $x$ (Stock and Watson 2007). Wald statistics are then obtained, under the hypothesis that all coefficients on the lags of variable $x$ are jointly zero in the equation for variable $y$.

However, since we are interested in both directions of causality, we run a vector regression (VR), allowing for up to four time lags (denoted here by $j$) for both variables. As already mentioned, we consider both LE and GDP (denoted by $Y$) in first differences, in order to investigate stationary series:

$$\begin{cases} \Delta LE_t = \alpha + \sum_j^4 \beta_j \cdot \Delta LE_{t-j} + \sum_j^4 \gamma_j \cdot \Delta Y_{t-j} + \varepsilon_t \\ \Delta Y_t = \delta + \sum_j^4 \vartheta_j \cdot \Delta LE_{t-j} + \sum_j^4 \varphi_j \cdot \Delta Y_{t-j} + u_t \end{cases} \tag{2}$$

where the use of vector regression allows for the possible correlation between $\varepsilon_t$ and $u_t$. We separately test the two null hypotheses that all the coefficients that express the impact of one variable on the other (the four $\gamma_j$s and the four $\phi_j$s) are not significantly different from zero, i.e., there is no Granger causality. The alternative hypothesis is that at least one coefficient is statistically different from zero (thus Granger causality cannot be excluded at the conventional thresholds of confidence). Accordingly, the test statistics is a Wald $\chi^2$ with 4 degrees of freedom. Results are shown in the two left-hand columns of Table 1.

Overall, Granger causality tests of the relation between GDP growth and life expectancy are inconclusive. In most cases it emerges that no series has a statistically significant impact on the other at any time lag (up to four). The exceptions are Italy when using the natural logarithm of life expectancy rather than our modified index (this is done as a robustness check: see above, Section 3), and Spain, in the direction from GDP to life expectancy.

---

If that were the case, realisations of the dependent variable $y$ could actually be observed before the appearance of its real cause, $x$. Economic textbooks joke that people may send Christmas Greetings cards days before Christmas, even though the latter causes the former. Thus, in general the interpretation of Granger-causality as an actual relation of cause and effect between two variables requires reference to an underlying theoretical model (in our case, the unified growth theory). However, here we consider aggregate variables that do not depend on a single individual's decision(s), and thus here the concept of Granger-causality may be regarded as empirically meaningful, even though more research (and theoretical models) on the causal link(s) between GDP growth and life expectancy are necessary.

**Table 1: Tests for Granger causality**

| | | VAR estimation | | Acemoglu-Johnson | |
|---|---|---|---|---|---|
| | | Wald $\chi^2(4)$ | p-value | IV coeff. | Std. Err. |
| Italy | *GDP Granger-causes Modified LE* | 2.4412 | *0.655* | 0.032 | *0.034* |
| | *Modified LE Granger-causes GDP* | **14.45** | *0.006* | **0.571** | *0.267* |
| Spain | *GDP Granger-causes Modified LE* | **11.89** | *0.018* | **0.045** | *0.026* |
| | *Modified LE Granger-causes GDP* | 2.0774 | *0.722* | 0.013 | *0.331* |
| France | *GDP Granger-causes Modified LE* | 4.2224 | *0.377* | 0.047 | *0.036* |
| | *Modified LE Granger-causes GDP* | 5.6425 | *0.227* | -0.084 | *0.304* |

*Note*: bold values denote statistically significant coefficients, i.e., Granger causality cannot be refuted. For the second-step regressions in Acemoglu-Johnson estimates, see Table A-6 in the online statistical appendix.

Traditionally, economists think that such mixed results may arise due to possible endogeneity of the independent variables. Even though there is hardly reason to believe that GDP changes may be a consequence of LE developments – which they nonetheless anticipate in time – or vice versa, this has been claimed (e.g., Acemoglu and Johnson 2007). They thus propose coping with this possible endogeneity using an instrumental variables approach (IV), adopting as instruments the second differences of LE and GDP, the third differences, and so on (respectively denoted by $\Delta^2$ and $\Delta^3$, etc.).

Thus, as a robustness check we run such models, but due to computational and data limitations we limit the analysis to causality with one time lag, as shown below (variables with a hat denote predicted values):

$$\begin{cases} \Delta LE_t = \mu + \sum_j^4 \beta_j \cdot \Delta LE_{t-j} + \zeta \cdot \widehat{\Delta Y_{t-1}} + \varepsilon_t \\ \Delta Y_t = \eta + \lambda \cdot \widehat{\Delta LE_{t-1}} + \sum_j^4 \varphi_j \cdot \Delta Y_{t-j} + u_t \end{cases} \quad (3)$$

Thus the first stage regressions are:

$$\begin{cases} \Delta LE_{t-1} = a + \sum_j^4 \psi_j \cdot \Delta Y_{t-j} + b \cdot \Delta^2 LE_{t-1} + c \cdot \Delta^3 LE_{t-1} + d \cdot \Delta^4 LE_{t-1} + e \cdot \Delta^5 LE_{t-1} + \varepsilon_t \\ \Delta Y_{t-1} = f + \sum_j^4 \tau_j \cdot \Delta LE_{t-j} + g \cdot \Delta^2 Y_{t-1} + h \cdot \Delta^3 Y_{t-1} + k \cdot \Delta^4 Y_{t-1} + l \cdot \Delta^5 Y_{t-1} + u_t \end{cases} \quad (4)$$

Accordingly, the two right hand columns in Table 1 report the coefficients and standard errors of the instrumented variable in the second-step regressions of the IV estimates (the terms $\zeta$ and $\lambda$ in [3]). As shown, the results also remain mixed in this case (full results are reported in Table A-6 in the online statistical annex). Indeed, the IV procedure returns similar results to the VR estimation in terms of the statistical significance of the coefficients of interest (i.e., we cannot reject Granger causality only of LE on GDP for Italy, and of GDP on LE for Spain). Thus, in both models (VR and IV estimations) the lack of consistent results prevents us from identifying a stable and consistent causality relation between life expectancy and GDP, which is problematic from the point of view of the unified growth theory.

One possible explanation for this lack of consistency is that the relation between the two variables is non-monotonic but rather changes over time. In order to investigate this possibility, we investigate the series for possible structural breaks, i.e., points beyond which it may be said that a series exhibits a significantly different pattern (e.g., a different long-run trend) and which therefore define periods that – at least for some empirical applications – should be considered separately.

### 4.2 Structural breaks and sub-period Granger causality

In order to detect whether there are any breaks in the series, in this section we adopt an ex-post periodization. We use the well-known test developed by Bai and Perron (1998, 2003). As shown in Table A-7 in the online statistical appendix, frequently, though not consistently, the identification of several breaks fits the data better in terms of the sum of squared residuals. In the extreme, treating each year as unique would produce the best historical explanation. However, reasons of parsimony in choosing the explicative model induce us to weigh the information that additional variables provide against the complexity that they introduce into our model.

To this end, a common approach is to select the number of breaks that maximizes the Bayesian Information Criterion (BIC). Excluding the cases of four or more breaks, for all series the local maximum of the BIC corresponds to zero structural breaks. This does not imply that the series necessarily exhibit no structural breaks, but rather that, taken in isolation, the information that can be obtained from considering these breaks would not compensate for the complexity that they introduce into the model. However, since the aim of this section is to prudentially investigate whether structural breaks may induce the mixed results concerning Granger causality that we discussed above, for all series we consider at least one break.[29] This can therefore be considered as a robustness check of the previous analysis.

[29] An anonymous referee noted that from a historical point of view it can be objected that such breaks are hardly 'turning points', in the sense that no distinctly different behaviour of the variable emerges (e.g., a switch from stagnation to growth). For example, in relation to mortality, World War II merely "accelerated the process of decline already going on from 1870s". This is more or less what the BIC tests tell us. However,

As shown in Figure 5, according to the Bai-Perron tests the breaks that best describe the series (peak values of the *F* statistics) are: 1946 for both modified LE and GDP in France, respectively 1944 and 1947 for Italy, and respectively 1941 and 1937 for Spain. As shown in Table A-8 in the online statistical appendix, further tests for exogenous breaks, following Prados de la Escosura (2003), confirm the same breaks for the three countries.

Thus, we identify structural breaks in both life expectancy and GDP roughly corresponding to the Second World War for Italy and France and to the Civil War for Spain. For Italy, as is well known, the end of the Second World War marked the beginning of a period of unprecedented growth – the "economic miracle" − which brought the country back "from the periphery to the centre" (Zamagni 1993) as the sixth world economic power, and which saw remarkable improvements in social indicators and well-being (Felice and Vecchi 2015b). The misalignment of breaks in the Spanish series may arise from the peculiarity of the country's socioeconomic development, and may be interpreted as a manifestation of its underdevelopment in the early and mid-20th century, until well into the 1960s.[30]

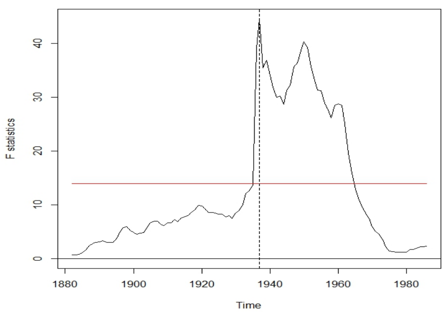
---

here we are interested in prudentially investigating – as a robustness check of the previous analysis – whether such acceleration(s), beyond a certain threshold, should be regarded as defining two periods that should be kept separate in empirical applications, and specifically whether they could induce us to falsely reject causality between LE and GDP.

[30] For Spain, this finding is partly in accordance with the results of Pons and Tirado (2006), who, through a variant of Andrews's (1993) methodology, also found no breaks in the Spanish (Prados's) GDP series before the Civil War, though they also find a break as late as 1960. A break around 1960 (in 1959) also appears in our Bai-Perron tests, but only from the model with three breaks onwards and along with another break in 1915 (see Table A-7 in the online statistical appendix). There is a vast literature stressing the missed opportunities of the Spanish economy from the last decades of the 19th century until Franco's 1959 stabilization and liberalization plan: Essentially, there was a continuity, characterized by sluggish economic growth and international isolation, from the Bourbon Restoration (1874–1923) to the dictatorship of Primo De Rivera and the short-lived Second Republic (1923–1939), to the first phase of Franchism (1939–1959) (Carreras 1990, 1997; Fraile 1991; Nadal and Sudrià 1993; Velarde 1999). Here it is worth stressing that a model with a 1959 break would not fit well in this literature, not so much concerning the first phase of Franchism, negative as it was (Carreras 1989; Comín 1995; Prados de la Escosura 1997), but rather due to the early break in 1915.

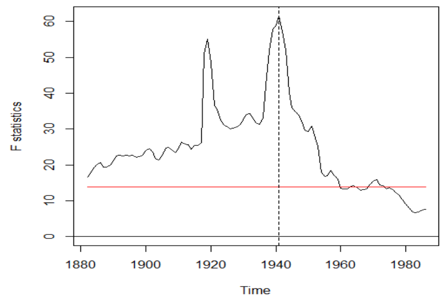
## Figure 5: Bai-Perron tests for structural breaks in GDP and LE series

Figure 5a: GDP Spain



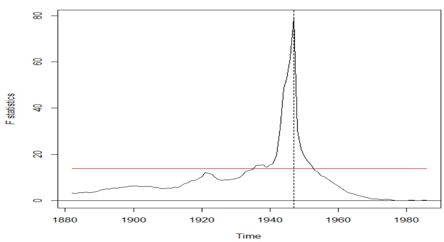

*Note*: estimated breakpoint at 1937

Figure 5b: Modified LE Spain



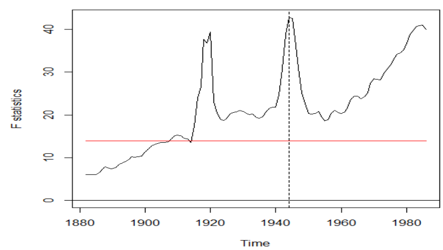

*Note*: estimated breakpoint at 1941

Figure 5c: GDP Italy



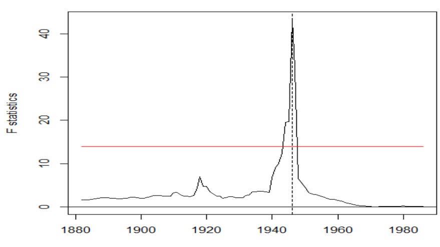

*Note*: estimated breakpoint at 1947

Figure 5d: Modified LE Italy



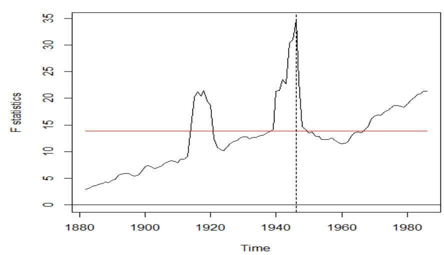

*Note*: estimated breakpoint at 1944

Figure 5e: GDP France




*Note*: estimated breakpoint at 1946

Figure 5f: Modified LE France




*Note*: estimated breakpoint at 1946

Repeating the tests of Granger causality for the sub-periods identified by these breaks, as shown in Table 2, helps us clarifying a number of crucial issues. In the first period, which can be identified with economic backwardness, economic growth consistently Granger-causes improvements in life expectancy in Spain and Italy, but not in France, the country with the highest levels of GDP and LE and the lowest LE growth. The reverse, i.e., that improvements in life expectancy Granger-cause GDP growth, seems to be true in Italy and in France for this period, but not in Spain, i.e., in the country with the lowest level of GDP and LE. In the second period, i.e., after the Second World War for Italy and France and after the Civil War for Spain, the bidirectional Granger-causality is confirmed for Italy and partially for Spain (although for Spain such a result crucially depends on the specific periodization used – i.e., if the 1941 break is included or not in this second period – and therefore the result cannot be considered as very robust). By contrast, for France we observe an inversion of statistical significance, with GDP growth now predicting LE improvements, while improvements in LE no longer predict GDP growth.

### Table 2: Tests for Granger causality in the sub-periods

| | | Wald $\chi^2(4)$ | p-value |
|---|---|---|---|
| **Italy: first GDP period (1861–1947)** | *GDP Granger-causes Modified LE* | **9.4584** | *0.051* |
| | *Mod. LE Granger-causes GDP* | **13.627** | *0.009* |
| **Italy: second GDP period (1947–2008)** | *GDP Granger-causes Modified LE* | **8.0416** | *0.09* |
| | *Mod. LE Granger-causes GDP* | **11.725** | *0.02* |
| **Italy: first LE period (1861–1944)** | *GDP Granger-causes Modified LE* | **8.168** | *0.086* |
| | *Mod. LE Granger-causes GDP* | **16.842** | *0.002* |
| **Italy: second LE period (1944–2008)** | *GDP Granger-causes Modified LE* | **18.45** | *0.001* |
| | *Mod. LE Granger-causes GDP* | **10.32** | *0.035* |
| **Spain: first GDP period (1861–1937)** | *GDP Granger-causes Modified LE* | **8.2949** | 0.081 |
| | *Mod. LE Granger-causes GDP* | 5.2346 | 0.264 |
| **Spain: second GDP period (1937–2008)** | *GDP Granger-causes Modified LE* | **8.3729** | 0.079 |
| | *Mod. LE Granger-causes GDP* | **10.58** | 0.032 |
| **Spain: first LE period (1861–1941)** | *GDP Granger-causes Modified LE* | **8.2773** | 0.082 |
| | *Mod. LE Granger-causes GDP* | 5.1629 | 0.271 |
| **Spain: second LE period (1941–2008)** | *GDP Granger-causes Modified LE* | 1.0321 | 0.905 |
| | *Mod. LE Granger-causes GDP* | **12.06** | 0.017 |
| **France: first GDP/LE period (1861–1946)** | *GDP Granger-causes Modified LE* | 2.0717 | 0.723 |
| | *Mod. LE Granger-causes GDP* | **15.886** | 0.003 |
| **France: second GDP/LE period (1946–2008)** | *GDP Granger-causes Modified LE* | **18.627** | 0.001 |
| | *Mod. LE Granger-causes GDP* | 4.7677 | 0.312 |

*Note:* bold values denote statistically significant coefficients, i.e., Granger causality cannot be refuted.

We may sum up the results as follows. Improvements in life expectancy seem to predict GDP growth, but with two exceptions: Spain in the first period, i.e., the country with lower levels of GDP and life expectancy and a delayed demographic transition; and France in the second period, i.e., the country with higher GDP and life expectancy (and slower growth). Economic growth consistently Granger-causes improvements in modified life expectancy, with one important exception: France in the first period, i.e., the country with the earliest demographic transition, where improvements in life expectancy appear to be slower and independent of economic growth.

By combining these results with the analysis in the previous Section (see Figure 3), some important points arise regarding the correlation between GDP and life expectancy. One issue is the causality going from life expectancy to income, concerning which we can detect three phases. In the first, there does not seem to be a significant contribution of life expectancy to income: The initial rise in income is independent of improvements in life expectancy. In the second phase, improvements in life expectancy do seem to lead to further advances in GDP. The movements in these first two phases are compatible with the unified growth theory, which stresses a positive impact of improvements in life expectancy upon economic growth only after the onset of the demographic transition (Galor and Weil 2000; Cervellati and Sunde 2011). In a third phase, when a negative link (or at least a non-positive one) from life expectancy to GDP seems to emerge: Very high life expectancy may result in a disproportionately old population, which may hamper economic growth. Such an outcome, in line with what has been found for other countries such as the United States (Eggleston and Fuchs 2012), was not predicted by the unified growth theory.

Concerning the impact of income on life expectancy, it is commonly held that at the early stages GDP significantly impacts upon life expectancy. By analysing the historical data for 16 Western countries in benchmark years from 1870 to 2000, Livi-Bacci (2012, p. 125) has simplified the rationale as follows: "more food, better clothing, better houses, and more medical care have a notable effect on those who are malnourished, badly clothed, poorly housed, and forced to trust fate in case of sickness". Regarding later phases, it has been argued that when a rise in per capita GDP benefits an already prosperous population the effects on life expectancy are minimal, and may even be negative if GDP growth comes at the detriment of environmental conditions.[31] Once a Kakwani transformation is employed in order to properly account for achievements in longevity − that is, once we eliminate the bias in favour of infant mortality and treat more fairly the improvements in longevity of the elderly

[31] It may even result in an increase of obesity (Egger, Swinburn, and Islam 2012). This latter, however, is also strongly influenced by other factors, such as GDP inequality (Costa-Font, Hernández-Quevedo, and Jiménez-Rubio 2014) and education. For an empirical investigation of the role of education in determining the regional differences in overweight rates observed in the Italian regions (with higher overweight rates in the South, despite lower GDP per capita), see Brunello and Labartino (2014).

population – only the first of these assumptions is supported by our findings, and even with the important exception of France (possibly because it already enjoyed a relatively high life expectancy which tended to grow less, as a consequence of an early demographic transition). A positive impact of GDP on life expectancy is also found for the following period, when GDP significantly increased.

On the whole, these results show that the heterogeneity in the relation between life expectancy and GDP growth that was found for the entire series may indeed depend on the existence of structural breaks. However, the specific historical experience of each country is important too: Within a general framework, country-specific historical idiosyncrasies should not be overlooked.

## 5. Conclusions

After reviewing and updating the available estimates, we presented and discussed long-run (1861–2008) series of per capita GDP and life expectancy for Italy and Spain and compared them with those available for France, their common and most important neighbouring country. Our goal was not only to briefly reconsider the economic history of the two countries in the light of the new time series evidence, but also to investigate the long-run evolution of per capita GDP and life expectancy and their mutual relationship, by way of country case studies and a time-series approach.

We find evidence, or confirmation, of three common features in the patterns of per capita GDP and life expectancy. First, at early stages of socioeconomic development, when both GDP and life expectancy are low, the differences in GDP mirror those in life expectancy: A clear lead in GDP results in a clear lead in life expectancy. Second, in the long run, convergence is confirmed for both indicators (significant cyclical differences notwithstanding): At the beginning of the period, Spain is the most backward country in both life expectancy and GDP, but over the entire period it is also the country converging at the highest average rate, while Italy ranks in the middle between Spain and France. Third, convergence in life expectancy tends to begin earlier than convergence in GDP: Spain caught up with Italy earlier in life expectancy than in GDP, and both countries caught up with France earlier in life expectancy than in GDP.

When looking at the correlation between the two variables through time series analysis, after dividing the series into two sub-periods we find that improvements in life expectancy may be said to cause GDP growth, with two exceptions: Spain in the first period and France in the second period. We find that economic growth causes improvements in life expectancy (in a Granger-causality sense) in all cases except for France in the first period.

Concerning the causal link from life expectancy to income, our findings may be explained by the existence of a non-monotonic relationship between the two variables. In line with recent results from unified growth theory, before the onset of the demographic transition it seems that there is no significant impact of life expectancy on income, whereas after the demographic transition improvements in life expectancy lead to further advances in GDP. More recently, however, a third phase appears to emerge, characterized by a negative link from (very high) life expectancy to GDP. Such a finding cannot be explained in terms of the unified growth theory and deserves further study.

Finally, concerning the link from income to life expectancy, once the latter is transformed in order to properly account for achievements in longevity, we find evidence of a positive and consistent impact of GDP on life expectancy. However, an exception must be made for France, which experienced an early demographic transition.

In conclusion, our findings confirm the importance of a general theoretical framework in order to address the correlation between life expectancy and GDP, such as that proposed by the unified growth theory. However, they also suggest that the peculiarity of each historical case should not be ignored.

## 6. Acknowledgments

Emanuele Felice and Josep Pujol Andreu gratefully acknowledge financial support from the Spanish Ministry of Economy and Competitiveness, project HAR2013-47182-C2-1-P, and from the Generalitat de Catalunya, project 2013 SGR 591. Carlo D’Ippoliti would like to thank Valeria Cirillo for helpful research assistance.

## References

A'Hearn, B., Peracchi, F., and Vecchi, G. (2009). Height and the normal distribution: Evidence from Italian military data. *Demography* 46(1): 1–25. doi:10.1353/dem.0.0049.

Acemoglu, D. and Johnson, S. (2007). Disease and development: The effect of life expectancy on economic growth. *Journal of Political Economy* 115(6): 925–985. doi:10.1086/529000.

Alessandrini, P. and Fratianni, M. (2015). In the absence of fiscal union, the Eurozone needs a more flexible monetary policy. *PSL Quarterly Review* 68(275): 279–296.

Altug, S., Filiztekin, A., and Pamuk, S. (2008). Sources of long-term economic growth for Turkey, 1880–2005. *European Review of Economic History* 12(3): 393–430. doi:10.1017/S1361491608002293.

Andrews, D.W.K. (1993). Tests of parameter instability and structural change with unknown change point. *Econometrica* 59(3): 821–856. doi:10.2307/2951764.

Arbelo Curbelo, A. (1951). Necesidad demográfico-sanitaria de rectificar el concepto legal de nacido vivo. *Revista Internacional de Sociología* 9(36): 393–405.

Baffigi, A. (2011). Italian national accounts, 1861–2011. Rome: Banca d'Italia (Quaderni di Storia Economica; no. 18).

Bai, J., and Perron, P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica* 66(1): 47–78. doi:10.2307/2998540.

Bai, J., and Perron, P. (2003). Computation and analysis of multiple structural change model. *Journal of Applied Econometrics* 18(1): 1–22. doi:10.1002/jae.659.

Battilani, P., Felice, E., and Zamagni, V. (2014). Il valore aggiunto dei servizi a prezzi correnti (1861–1951). Rome: Banca d'Italia (Quaderni di Storia Economica, no. 33).

Ben-David, D. and Papell, D.H. (2000). Some evidence on the continuity of the growth process among the G7 countries. *Economic Inquiry* 38(2): 320–330. doi:10.1111/j.1465-7295.2000.tb00020.x.

Blanes Llorens, A. (2007). La mortalidad en la España del siglo XX. Análisis demográfico y territorial [Ph.D. thesis]. Barcelona: Universitat Autònoma de Barcelona, Department de Geografia, Facultat de Filosofia i Lletres.

Bloom, D.E. and Sachs, J.D. (1998). Geography, demography, and economic growth in Africa. *Brookings Papers on Economic Activity* 2: 207–273. doi:10.2307/2534695.

Botti, F., Corsi, M., and D'Ippoliti, C. (2016). The gendered nature of poverty in the EU: Individualized versus collective poverty measures. *Feminist Economics* 22(4): 82–110. doi:10.1080/13545701.2016.1146408.

Brandolini, A. and Vecchi, G. (2011). The well-being of Italians: A comparative historical approach. Rome: Banca d'Italia (Quaderni di Storia Economica; no. 19).

Brunello, G. and Labartino, G. (2014). Regional differences in overweight rates: The case of Italian regions. *Economics and Human Biology* 12(1): 20–29. doi:10.1016/j.ehb.2012.10.001.

Brunetti, A., Felice, E., and Vecchi, G. (2011). Reddito. In: Vecchi, G. (ed.). *In ricchezza e in povertà: Il benessere degli italiani dall'Unità a oggi*. Bologna: Il Mulino: 209–234 and 427–429.

Cabré, A. (1999). *El sistema català de reproducció.* Barcelona: Proa, Institut Català de la Mediterrània d'Estudis i Cooperació.

Cabré, A., Domingo, A., and Menacho, T. (2002). Demografía y crecimiento de la población española durante el siglo XX. In: Pimentel Siles, M. (ed.). *Mediterráneo económico, 1. monogràfic: Procesos migratorios, economía y personas*. Almeria: Caja Rural Intermediterránea Cajamar: 121–138.

Cahill, M.B. (2002). Diminishing returns to GDP and the Human Development Index. *Applied Economic Letters* 9(13): 885–897. doi:10.1080/13504850210158999.

Caldwell, J.C. (1986). Routes to low mortality in poor countries. *Population and Development Review* 12(2): 171–220. doi:10.2307/1973108.

Carreras, A. (1989). La industrialización española en el marco de la historia económica europea: Ritmos y caracteres comparados. In: García Delgado, J.L. (ed.). *España, economía*. Madrid: Espasa Calpe: 79–115.

Carreras, A. (1990). *Industrialización española: Estudios de historia cuantitativa*. Madrid: Espasa Calpe.

Carreras, A. (1997). La industrialización: Una perspectiva de largo plazo. *Papeles de Economía Española* 73: 35–60.

Carreras, A. and Felice, E. (2010). L'industria italiana dal 1911 al 1938: Ricostruzione della serie del valore aggiunto e interpretazioni. *Rivista di Storia Economica* 26(3): 285–333.

Carreras, A. and Tafunell, X. (2004). *Historia económica de la España contemporánea*. Barcelona: Crítica.

Casadio Tarabusi, E. and Palazzi, P. (2004). An index for sustainable development. *Banca Nazionale del Lavoro Quarterly Review* 57(229): 185–206.

Cervellati, M. and Sunde, U. (2011). Life expectancy and economic growth: The role of the demographic transition. *Journal of Economic Growth* 16(2): 99–133. doi:10.1007/s10887-011-9065-2.

Chatfield, C. (1980). *The analysis of time series: An introduction.* 2nd edition. London: Chapman and Hall. doi:10.1007/978-1-4899-2923-5.

Chesnay, J.-C. (1986). *La transition démographique: Étapes, formes, implications économiques: Etude de séries temporelles (1720–1984) relatives à 67 pays*. Paris: PUF.

Comín, F. (1995). La difícil convergencia de la economía española: Un problema histórico. *Papeles de Economía Española* 63: 78–92.

Costa-Font, J., Hernández-Quevedo, C., and Jiménez-Rubio, D. (2014). Income inequalities in unhealthy life styles in England and Spain. *Economics and Human Biology* 13(2): 66–75. doi:10.1016/j.ehb.2013.03.003.

Crafts, N.F.R. (1997). The human development index and changes in standards of living: Some historical comparisons. *European Review of Economic History* 1(3): 299–322. doi:10.1017/S1361491697000142.

Crafts, N.F.R. (2002). The human development index, 1870–1999: Some revised estimates. *European Review of Economic History* 6(3): 395–405. doi:10.1017/S1361491602000187.

Crafts, N.F.R., Leybourne, S.J., and Mills, T.C. (1990). Measurement of trend growth in European industrial output before 1914: Methodological issues and new estimates. *Explorations in Economic History* 27(4): 442–467. doi:10.1016/0014-4983(90)90024-S.

Cussó Segura, X. (2005). El estado nutritivo de la población española 1900–1970. Análisis de las necesidades y disponibilidades de nutrientes. *Historia Agraria* 36: 329–358.

Cutler, D., Deaton, A., and Lleras-Muney, A. (2006). The determinants of mortality. *Journal of Economic Perspectives* 20(3): 97–120. doi:10.3386/w11963.

De Corso, G. (2013). El crecimiento económico de Venezuela, desde la oligarquía conservadora hasta la revolución bolivariana: 1830–2012. Una visión cuantitativa. *Revista de Historia Económica / Journal of Iberian and Latin American Economic History* 31(3): 321–357.

Deaton, A. (2006). Global patterns of income and health: Facts, interpretations, and policies. Cambridge (MA): NBER (Working Papers; 12735). doi:10.3386/w12735.

Dopico, F. (1987). Regional mortality tables for Spain in the 1860. *Historical Methods* 20(4): 173–179. doi:10.1080/01615440.1987.9955273.

Dopico, F. and Reher, D.-S. (1999). *El declive de la mortalidad en España, 1860–1930*. Zaragoza: Asociación de Demografía Histórica (Monografías ADEH 1).

Egger, G., Swinburn, B., and Islam, A.F.M. (2012). Economic growth and obesity: An interesting relationship with world-wide implications. *Economics and Human Biology* 10(2): 147–153. doi:10.1016/j.ehb.2012.01.002.

Eggleston, K.N. and Fuchs, V.R. (2012). The new demographic transition: Most gains in life expectancy now realized late in life. *Journal of Economic Perspectives* 26(3): 137–156. doi:10.1257/jep.26.3.137.

Escudero, A. and Simón, H. (2010). Nuevos datos sobre el bienestar en España (1850–1993). In: Chastagnaret, G., Daumas, J.C., Escudero, A., and Raveux, O. (eds.). *Los niveles de vida en España y Francia (siglos XVIII–XX)*. San Vicente del Raspeig: Publicaciones de la Universidad de Alicante: 213–252.

Felice, E. (2007). *Divari regionali e intervento pubblico: Per una rilettura dello sviluppo in Italia*. Bologna: Il Mulino.

Felice, E. (2010). Regional development: Reviewing the Italian mosaic. *Journal of Modern Italian Studies* 15(1): 64–80. doi:10.1080/13545710903465556.

Felice, E. (2011). Regional value added in Italy, 1891–2001, and the foundation of a long-term picture. *Economic History Review* 64(3): 929–950. doi:10.1111/j.1468-0289.2010.00568.x.

Felice, E. (2016). GDP and convergence in modern times. In: Diebolt, C. and Haupert, M. (eds.). *Handbook of Cliometrics*. Berlin: Springer: 263–293. doi:10.1007/978-3-642-40458-0_5-2.

Felice, E. and Carreras, A. (2012). When did modernization begin? Italy's industrial growth reconsidered in light of new value-added series, 1911−1951. *Explorations in Economic History* 49(4): 443–460. doi:10.1016/j.eeh.2012.07.004.

Felice, E. and Pujol Andreu, J. (2013). GDP and life expectancy in Italy and Spain over the long-run (1861–2008): Insights from a time-series approach. Barcelona: Universitat Autònoma de Barcelona (UHE Working Paper 2013_06). http://www.h-economica.uab.es/wps/2013_06.pdf.

Felice, E. and Vasta, M. (2015). Passive modernization? The new human development index and its components in Italy's regions (1871–2007). *European Review of Economic History* 19(1): 44–66. doi:10.1093/ereh/heu018.

Felice, E. and Vecchi, G. (2015a). Italy's growth and decline, 1861–2011. *Journal of Interdisciplinary History* 45(4): 507–548. doi:10.1162/JINH_a_00757.

Felice, E. and Vecchi, G. (2015b). Italy's modern economic growth, 1861–2011. *Enterprise and Society* 16(2): 225–248. doi:10.1017/eso.2014.23.

Fenoaltea, S. (1969). Public policy and Italian industrial development, 1861–1913. *Journal of Economic History* 29(1): 176–179. doi:10.1017/S0022050700097898.

Fenoaltea, S. (2003). Notes on the rate of industrial growth in Italy, 1861–1913. *Journal of Economic History* 63(3): 695–735. doi:10.1017/S0022050703541961.

Fenoaltea, S. (2005). The growth of the Italian economy, 1861–1913: Preliminary second-generation estimates. *European Review of Economic History* 9(3): 273–312. doi:10.1017/S136149160500153X.

Fenoaltea, S. (2010). The reconstruction of historical national accounts: The case of Italy. *PSL Quarterly Review* 63(252): 77–96.

Fenoaltea, S. (2011). *The reinterpretation of Italian economic history: From unification to the Great War*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511730351.

Fogel, R.W. (2004). *The escape from hunger and premature death, 1700–2100: Europe, America and the Third World*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511817649.

Fraile, P. (1991). *Industrialización y grupos de presión: La economía política de la protección en España*. Madrid: Alianza.

Gallup, J.L., Sachs, J.D., and Mellinger, A.D. (1999). Geography and economic development. *International Regional Science Review* 22(2): 179–232. doi:10.1177/016001799761012334.

Galor, O. (2012). The demographic transition: Causes and consequences. *Cliometrica* 6(1): 1–28. doi:10.1007/s11698-011-0062-7.

Galor, O. and Weil, D.N. (2000). Population, technology, and growth: From Malthusian stagnation to the demographic transition and beyond. *American Economic Review* 90(4): 806–828. doi:10.1257/aer.90.4.806.

Gerschenkron, A. (1947). The Soviet indices of industrial production. *Review of Economics and Statistics* 29(4): 217–226. doi:10.2307/1927819.

Gerschenkron, A. (1955). Notes on the rate of industrial growth in Italy, 1881–1913. *Journal of Economic History* 15(4): 360–375. doi:10.1017/S0022050700056539.

Glei, D.A. (2011). About mortality data for Italy [electronic resource]. Human Mortality Database. Rostock: Max Planck Institute for Demographic Research, and Berkeley: University of California. http://www.mortality.org/.

Glei, D.A., Gómez Redondo, R., Argüeso, A., and Canudas-Romo, V. (2012). About mortality data for Spain. Human Mortality Database. Rostock: Max Planck Institute for Demographic Research, and Berkeley: University of California. http://www.mortality.org/.

Goldstein, J.R., Kreyenfeld, M., Jasilioniene, A., and Örsal, D.K. (2013). Fertility reactions to the 'Great Recession' in Europe: Recent evidence from order-specific data. *Demographic Research* 29(4): 85–104. doi:10.4054/DemRes.2013.29.4.

Gómez Redondo, R. (1992). *La mortalidad infantil española en el siglo XX*. Madrid: CIS-Siglo XXI.

Granger, C.W.J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica* 37(3): 424–438. doi:10.2307/1912791.

Hernández Adell, I., Muñoz Pradas, F., and Pujol Andreu, J. (2013). Difusión del consumo de leche en España (1865–1981). Barcelona: Universitat Autònoma de Barcelona, Departament d'Economia i d'Història Econòmica (UHE Working Paper; 2013_03).

HMD (Human Mortality Database) (2011a). France, Total Population, Life expectancy at birth (period, 1x1). Human Mortality Database. Rostock: Max Planck Institute for Demographic Research, and Berkeley: University of California. http://www.mortality.org/.

HMD (Human Mortality Database) (2011b). Italy, Life expectancy at birth (period, 1x1). Human Mortality Database. Rostock: Max Planck Institute for Demographic Research, and Berkeley: University of California. http://www.mortality.org/.

HMD (Human Mortality Database) (2011c). Spain, Life expectancy at birth (period, 1x1). Human Mortality Database. Rostock: Max Planck Institute for Demographic Research, and Berkeley: University of California. http://www.mortality.org/.

Ine (Institudo Nacional de Estadística) (2012). Estimaciones de Población Actual de España. Resultados Nacionales. Madrid.

Istat (Istituto Centrale di Statistica) (1957). Indagine statistica sullo sviluppo del reddito nazionale dell'Italia dal 1861 al 1956. Rome: Istat (Annali di Statistica 8[9]).

Istat (Istituto Centrale di Statistica) (2012a). Ricostruzione della popolazione residente e del bilancio demografico. Rome: Istat.

Istat (Istituto Centrale di Statistica) (2012b). Morti ed età mediana alla morte, per sesso: Anni 1862–2009. Rome: Istat.

Kakwani, N. (1993). Performance in living standards: An international comparison. *Journal of Development Economics* 41(2): 307–336. doi:10.1016/0304-3878(93)90061-Q.

Livi-Bacci, M. (2012). *A concise history of world population.* 5th edition. Oxford: Blackwell.

Lorentzen, P., McMillan, J., and Wacziarg, R. (2008). Death and development. *Journal of Economic Growth* 13(2): 81–124. doi:10.1007/s10887-008-9029-3.

Maddison, A. (1991). A revised estimate of Italian economic growth, 1861–1989. *BNL Quarterly Review* 177: 225–241.

Maddison, A. (2006). *The world economy: A millennial perspective*. Paris: OECD. doi:10.1787/9789264022621-en.

Maddison, A. (2010). *Historical statistics of the world economy: 1–2008 AD*. Paris: OECD. www.ggdc.net/maddison/content/shtml.

Maluquer de Motes, J. (2008). El crecimiento moderno de la población de España de 1850 a 2001: Una serie homogénea anual. *Investigaciones de Historia Económica* (4)10: 129–162. doi:10.1016/S1698-6989(08)70139-5.

Maluquer de Motes, J. (2009a). Del caos al cosmos: Una nueva serie enlazada del producto interior bruto de España entre 1850 y 2000. *Revista de Economía Aplicada* 17(49): 5–45.

Maluquer de Motes, J. (2009b). Viajar a través del cosmos: La medida de la creación de la riqueza y la serie histórica del producto interior bruto de España (1850–2008). *Revista de Economía Aplicada* 17(51): 25–54.

María-Dolores, R. and Martínez-Carrión, J.M. (2011). The relationship between height and economic development in Spain, 1850–1958. *Economics and Human Biology*, 9(1): 30–44. doi:10.1016/j.ehb.2010.07.001.

Martínez-Carrión, J.M. and Puche-Gil, J. (2011). La evolución de la estatura en Francia y en España, 1770–2000: Balance historiográfico y nuevas evidencias. *Dynamis* 31(2): 429–452.

Molinas, C. and Prados de la Escosura, L. (1989). Was Spain different? Spanish historical backwardness revisited. *Explorations in Economic History* 26(4): 385–402. doi:10.1016/0014-4983(89)90015-6.

Nadal, J. and Sudrià, C. (1993). La controversia en torno al atraso económico español en la segunda mitad del siglo XIX (1860–1913). *Revista de Historia Industrial* 3: 199–227.

Nicolau, R. (1989). La población. In: Carreras, A. (ed.). *Estadísticas históricas de España: Siglos XIX–XX*. Madrid: Fundación Banco Exterior: 49–90.

Nicolau, R. (2005). Población, salud y actividad. In: Carreras, A. and Tafunell, X. (eds.). *Estadísticas históricas de España: Siglos XIX–XX*. Madrid: Fundación BBVA: 77–154.

OECD (Organisation for Economic Co-operation and Development) (2014). OECD.Stat. http://stats.oecd.org.

Palazzi, P. and Lauri, A. (1998). The Human Development Index: Suggested corrections. *Banca Nazionale del Lavoro Quarterly Review* 51(205): 193–221.

Pascua Martínes, M. (1934). *Mortalidad específica en España: I. Cálculo de poblaciones. II. Mortalidad por sexos, grupos de edad y causas en el período 1911–1930*. Madrid: Publicaciones oficiales de la CPIS.

Pérez Moreda, V., Reher, D.S., and Sanz Gimeno, A. (2015). *La conquista de la salud: Mortalidad y modernización en la España contemporánea*. Madrid: Marcial Pons Historia.

Pons, J. and Tirado, D. (2006). Discontinuidades en el crecimiento económico en el período 1870–1994: España en perspectiva comparada. *Revista de Economía Aplicada* 40: 137–156.

Prados de la Escosura, L. (1997). Política económica liberal y crecimiento en la España contemporánea: Un argumento contrafactual. *Papeles de Economía Española* 73: 83–98.

Prados de la Escosura, L. (2000). International comparisons of real product, 1820−1990: An alternative data set. *Explorations in Economic History* 37(1): 1–41. doi:10.1006/exeh.1999.0731.

Prados de la Escosura, L. (2003). *El progreso económico de España (1850–2000)*. Bilbao: Fundación BBVA.

Prados de la Escosura, L. (2007). European patterns of development in historical perspective. *Scandinavian Economic History Review* 55(3): 187–221. doi:10.1080/03585520701751640.

Prados de la Escosura, L. (2009). Del cosmos al caos: La serie del PIB de Maluquer de Motes. *Revista de Economía Aplicada* 17(51): 5–23.

Prados de la Escosura, L. (2010a). Spain's international position, 1850–1913. *Revista de Historia Económica / Journal of Iberian and Latin American Economic History* 28(1): 173–215.

Prados de la Escosura, L. (2010b). Improving human development: A long-run view. *Journal of Economic Surveys* 24(5): 841–894. doi:10.1111/j.1467-6419.2010.00639.x.

Prados de la Escosura, L. (2013). World human development: 1870−2007. Madrid: Universidad Carlos III (Working Papers in Economic History; 13–01).

Prados de la Escosura, L. (2014). World human development: 1870−2007. *Review of Income and Wealth* 61(2): 220–247. doi:10.1111/roiw.12104.

Prados de la Escosura, L. and Rosés, J.R. (2009). The sources of long-run growth in Spain, 1850–2000. *Journal of Economic History* 69(4): 1063–1091. doi:10.1017/S0022050709001387.

Prados de la Escosura, L., Rosés, J.R., and Sanz-Villarroya, I. (2012). Economic reforms and growth in Franco's Spain. *Revista de Historia Económica / Journal of Iberian and Latin American Economic History* 30(1): 45–89.

Preston, S.H. (1975). The changing relation between mortality and level of economic development. *Population Studies* 29(2): 231–248. doi:10.1080/00324728.1975.10410201.

Ramiro Fariñas, D. and Sanz Gimeno, A. (2000a). Childhood mortality in Central Spain, 1790–1960: Changes in the course of demographic modernization. *Continuity and Change* 15(2): 235–267. doi:10.1017/S0268416099003537.

Ramiro Fariñas, D. and Sanz Gimeno, A. (2000b). Il declino della mortalità nei primi anni di vita nella Spagna Interiore, 1790–1960. In: Pozzi, L. and Tognotti, E. (eds.). *Salute e malattia fra '800 e '900 in Sardegna e nei paesi dell'Europa mediterranea*. Sassari: Edes: 121–152.

Ravallion, M. (2012). Mashup indices of development. *The World Bank Research Observer* 27(1): 1–32. doi:10.1093/wbro/lkr009.

Riley, J.C. (2001). *Rising life expectancy: A global history*. Cambridge: Cambridge University Press. doi:10.1017/CBO9781316036495.

Riley, J.C. (2005). *Poverty and life expectancy: The Jamaica paradox*. Cambridge: Cambridge University Press.

Rosés, J.R., Martínez-Galarraga, J., and Tirado, D. (2010). The upswing of regional income inequality in Spain (1860–1930). *Explorations in Economic History* 47(2): 244–257. doi:10.1016/j.eeh.2010.01.002.

Sabaté, M., Fillat, C., and Belén Gracia, A. (2011). The peripheral protectionist backlash in the *First Globalization*: Spain (1870–1913). *Revista de Historia Económica / Journal of Iberian and Latin American Economic History* 29(1): 95–121. doi:10.1017/S0212610911000024.

Sen, A. and Anand, S. (2000). The income component of the Human Development Index. *Journal of Human Development* 1(1): 83–106. doi:10.1080/14649880050008782.

Sorrentino, M. and Vecchi, G. (2011). Nutrizione. In: Vecchi, G. (ed.). *In ricchezza e in povertà: Il benessere degli italiani dall'Unità a oggi*. Bologna: Il Mulino: 3–36.

Spijker, J.J.A., Cámara, A.D., and Blanes, A. (2012). The health transition and biological living standards: Adult height and mortality in 20th-century Spain. *Economics and Human Biology* 10(3): 276–288. doi:10.1016/j.ehb.2011.08.001.

Steckel, R.H. (2009). Heights and human welfare: Recent developments and new directions. *Explorations in Economic History* 46(1): 1–23. doi:10.1016/j.eeh.2008.12.001.

Stock, J. and Watson, M. (2007). *Introduction to econometrics.* 2nd edition. Boston: Pearson Addison Wesley.

Sylos Labini, P. (2014). Sviluppo economico e classi sociali in Italia. *Moneta e Credito* 67(265): 103–124.

Tonveronachi, M. (2015). Making the ECB the central bank of a non-federal coalition of states. *PSL Quarterly Review* 68(273): 91–114.

UNDP (United Nations Development Programme) (2010). *Human Development Report 2010, 20th anniversary edition: The real wealth of nations: Pathways to human development*. New York: Palgrave Macmillan for the UNDP. doi:10.18356/e5a0500a-en.

UNDP (United Nations Development Programme) (2011). *Human Development Report 2011: Sustainability and equity: A better future for all*. New York: Palgrave Macmillan for the UNDP. doi:10.18356/fdcff8d6-en.

Uriel, E., Moltó, M.L., and Cucarella, V. (2000). *Contabilidad nacional de España: Series enlazadas 1954–1967 (CNEe-86)*. Bilbao: Fundación BBV.

Vecchi, G. (ed.) (2011). *In ricchezza e in povertà: Il benessere degli italiani dall'Unità a oggi*. Bologna: Il Mulino.

Velarde, J. (1999). La economía española de 1914 a 1931. In: Anes, G. (ed.). *Historia económica de España: Siglos XIX–XX.* Barcelona: Galaxia Gutemberg-Círculo de Lectores: 470–524.

Williamson, J.G. (2011). *Industrial catching up in the poor periphery 1870–1975*. London: CEPR (Discussion Paper; DP8335). doi:10.3386/w16809.

Zacchia, G. (2016). Paolo Sylos Labini: Reflections on a classical economist. *PSL Quarterly Review* 69(277): 191–201.

Zamagni, V. (1993). *The economic history of Italy, 1860–1990: Recovery after decline*. Oxford: Oxford University Press.

# Appendices

# Online statistical appendix

## Part I: A discussion of data and sources

### A-1 Gross domestic product (GDP)

The statistical apparatus behind GDP was developed in the USA in the 1930s, and was progressively adopted by other countries only after the Second World War, beginning with Great Britain and Western Europe. This is why GDP figures for periods before the Second World War are always the product of reconstruction by economic historians or applied statisticians. The Italian *Istituto Nazionale di Statistica*, Istat, was one of the first institutions to take on the daunting task of providing a long-run series of GDP for Italy, spanning from unification (1861) until the 1950s (Istat 1957). On the whole, however, the results were disappointing, not least due to the opacity of sources and methods (e.g., Fenoaltea 2010). From the 1950s (Gerschenkron 1955; Fenoaltea 1969) until the present day (Fenoealtea 2003, 2005; Carreras and Felice 2010; Battilani, Felice, and Zamagni 2014), economic historians have tried to address the main flaws by reconstructing their own indices of national production for specific sectors and periods. Just recently, under the joint auspices of the Bank of Italy, Istat, and the University of Rome II, these efforts have been unified in a long-run series of Italy's GDP, at both current and constant prices and spanning 150 years, with fully verifiable procedures and sources (Baffigi 2011; Brunetti, Felice, and Vecchi 2011). Soon after its release the new series was further updated (Felice and Vecchi 2015) to include the last advances in the literature covering the interwar years (Felice and Carreras 2012). We make use of this latest series.

In the case of Spain, we take advantage of the estimate by Leandro Prados de la Escosura (2003), which was incorporated into Maddison's (2010) work. It was not the only available series: Recently, Jordi Maluquer de Motes (2009a) published in *Revista de Economía Aplicada* an alternative estimate of Spanish GDP at current and constant prices. The reply by Prados de la Escosura (2009) and a further clarification by Maluquer de Motes (2009b) were jointly published in the same journal. The two series are quite different. For the years 1850 to 1970 the one by Maluquer is on average 24.5% higher than the one by Prados, and thus Spain's backwardness compared with the rest of Europe is significantly reduced (Escudero and Simón 2010: 234). The main reason for this discrepancy is the way in which different series at constant prices, based on different base years, are linked in 1958, that is, in the year when the reconstruction by economic historians (1850–1958) and that by the official national accounts (1958 to date) meet. Since the value from the latter is higher,[32] a major problem is how to bridge the difference. Maluquer chooses to consider the new estimate from national accounts to be superior. Therefore, he accepts the difference, which is then rescaled to the historical series from 1958 backwards.[33] Prados's alternative strategy is to instead consider the historical estimate made at historical prices as more reliable than the new estimate made with a more recent price system and taxonomy, and thus to reject the difference for 1958 (i.e., to take as good the lower value). The difference is then distributed onwards until the next base year for the constant-price series, in this case 1995. More specifically, it is allocated from 1958 to 1995, with weights increasing with the distance from 1958 (Prados de la Escosura 2009: 12–14). As a consequence, Prados's series remains unchanged from 1958 backwards (although the growth rate from 1958 to 1995 is probably artificially increased). A second source of discrepancy is the fact that Maluquer uses one single deflator for all the series, the consumer price index, rather than implicit sectoral deflators, as Prados does. Prados's approach in this is much more data-demanding, as well as more accurate, since it considers not only consumption but also investment goods. Prados's approach pays more attention to the actual value of production in the past by assuming that the historical estimates in the base year at historical prices are more reliable than the subsequent estimates made with different price systems and taxonomy.[34] Since we are interested in a comparison with Italy we choose Prados's estimate, because both its deflation system based on implicit deflators and the redistributing rule used to link deflators with different base years are conceptually the same as the methods used for reconstructing the Italian series (and they are also in line with Maddison's approach, i.e., with the series we use for France). Indeed, the two countries now have GDP series that are very similar in methodological terms, and thus comparable, not least because the base years used to produce constant price estimates are now close, especially for the liberal age (from Italy's unification until the First World War) when Prados's estimates are made at 1913 constant prices and Italy's new series at 1911 constant prices (instead of 1870 prices, as with Maddison's previous figures for Italy).[35]

[32] As usual, and mostly due to the different price basis used. This happens because when prices and quantities are inversely correlated, late-weight indices, such as those of national accounts, tend to grow more slowly than early-weight ones (e.g., Gerschenkron 1947). See also Felice (2016).

[33] Namely, for 1958, Maluquer enlaces his series with the official accounts produced by Uriel, Moltó, and Cucarella (2000), which in 1958 have a GDP 10.7% higher than that estimated by Prados (Maluquer de Motes, 2009b: 35).

[34] Although there might be some reasons for preferring Maluquer's index, for instance, the use of some updated historical information: the new series of population estimated by Maluquer himself (Maluquer de Motes 2008). As we will explain, here this series is incorporated into Prados's index, since this can be achieved without risk of weakening the consistency of Prados's estimates.

[35] The other base years are 1929 and 1958 for Spain (Prados de la Escosura, 2003: 46–85) and 1938 and 1951 for Italy (Baffigi 2011: 56–59; Brunetti, Felice, and Vecchi 2011: 234). For the previous Italian series, see Maddison (1991).

Both series are expressed in a common unit of measure, 1990 international Geary–Khamis purchasing power parity dollars (hereafter 1990 G-K dollars). For Spain, in Maddison (2010), Prados's series of the total GDP is already expressed in 1990 G-K dollars. For Italy, we adopt the same conversion procedure used by Maddison in all of his estimates: a) the series of Italian GDP, expressed in its own national currency and at constant prices, is converted to an index; b) for the baseline year 1990, Italy's GDP, expressed in its own national currency and at current prices, is converted to 1990 international dollars using the Geary–Khamis PPP deflator;[36] c) with the index in a) and the value in b), a new national series in Geary–Khamis PPP 1990 international dollars is created.[37] In order to ensure full compatibility, we take the GDP figures for Italy, Spain, and France from the same source, the Organisation for Economic Co-operation and Development (OECD) (2014) statistics.[38] The results are displayed in Table A-1.

Maddison's method has the advantage of maintaining, for each country, the same original growth rates throughout the years of the series. However, it has the disadvantage of using only one purchasing power parity, distant in time from the early years, following the (quite unrealistic) assumption that differences in the cost of living between Italy and Spain did not alter over more than a century. Since 1997 the OECD (2014) has produced reliable PPP figures regularly. We use its 2008 benchmark, corresponding to the last year of our data, in order to re-scale our series to allow for more recent differences in the cost of living. In order to produce the series at 2008 international purchasing power parity dollars, the procedure we adopt is the same as for the series at 1990 international dollars (GDP at current prices for 2008 is taken from the same OECD source). The results are displayed in Table A-2. We find them to be unrealistic. As can be seen, Spain would rank much closer to Italy and France (and Italy, in turn, to France) than what we know from established historical literature. The reason is probably the fact that, for these countries, recent PPPs reflect remarkably different trends in the national consumer price index caused by the introduction of the

[36] The Geary–Khamis purchasing power converters for OECD countries are provided in Maddison (2006: 189). For Italy the ratio is 1384.11 liras to 1 G-K dollar.

[37] This method has the advantage of maintaining, for each country, the same original growth rates throughout the years of the series. However, it has the disadvantage of using only one purchasing power parity, distant in time from the early years, following the (quite unrealistic) assumption that the differences in the cost of living between Italy and Spain did not alter over more than a century. Prados de la Escosura (2000) estimated current-price purchasing power parities in benchmark years spanning from 1820 to 1990 for a number of advanced countries, including Italy and Spain, by retropolating the relationship between PPPs and basic economic characteristics measured in the second half of the 20th century. See forward for more details.

[38] As a result, OECD GDP in 1990 is slightly lower than for Italy (–1.8%) and a bit higher than for Spain (+5.8%) and France (+2.3%), and therefore the three series have been correspondingly rescaled. Population figures are from Table A-3 for Italy and Spain, from Maddison (2010) for France.

euro in 2002. As a consequence, we have chosen not to use the 2008 benchmark in our paper.

Backwards in time, in benchmark years spanning from 1820 to 1990, Prados de la Escosura (2000) has estimated current-price purchasing power parities for a number of advanced countries − including Italy, Spain and France − by retropolating the relationship between PPPs and basic economic characteristics measured in the second half of the 20th century. We prefer not to use Prados's converters at this stage, mainly because retropolated PPPs are inevitably less reliable and not as widely accepted as the current OECD ones. Furthermore, our goal is to compare the original series of GDP and to analyse their intrinsic cycles. In this respect, the use of too many different PPP systems would make our results less transparent, since we would not be able to differentiate between the impact of movements in the national GDP cycles and in changes in the relative cost of living between the three countries. Both these reasons are all the more valid as using PPPs distant in time significantly changes results: According to the different PPPs used, Italy and Spain overtook France early in the 20th century or even in the 19th century. But a full discussion of these results (and hypotheses) would take another paper. Therefore, we limit ourselves to the 1990 PPP benchmark popularized by Maddison, and to the final benchmark of our series from the OECD.

**Table A-1: GDP per capita in Italy, Spain, and France at current borders, 1861–2008 (1990 PPP dollars)**

| | Italy | Spain | France | | Italy | Spain | France | | Italy | Spain | France |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1861** | 1532 | 1336 | 1810 | **1911** | 2370 | 2156 | 3325 | **1961** | 6309 | 3701 | 7897 |
| **1862** | 1553 | 1333 | 1958 | **1912** | 2373 | 2127 | 3596 | **1962** | 6689 | 4079 | 8254 |
| **1863** | 1591 | 1354 | 2019 | **1913** | 2476 | 2200 | 3566 | **1963** | 7043 | 4447 | 8557 |
| **1864** | 1593 | 1349 | 2034 | **1914** | 2359 | 2148 | 3311 | **1964** | 7259 | 4828 | 9024 |
| **1865** | 1690 | 1303 | 1969 | **1915** | 2221 | 2159 | 3323 | **1965** | 7519 | 5089 | 9378 |
| **1866** | 1688 | 1365 | 1979 | **1916** | 2383 | 2236 | 3543 | **1966** | 7960 | 5407 | 9766 |
| **1867** | 1536 | 1354 | 1855 | **1917** | 2383 | 2190 | 3048 | **1967** | 8508 | 5704 | 10137 |
| **1868** | 1569 | 1215 | 2028 | **1918** | 2314 | 2156 | 2452 | **1968** | 9058 | 5982 | 10505 |
| **1869** | 1592 | 1254 | 2053 | **1919** | 2256 | 2177 | 2876 | **1969** | 9581 | 6463 | 11139 |
| **1870** | 1630 | 1284 | 1920 | **1920** | 2294 | 2321 | 3302 | **1970** | 10080 | 6784 | 11675 |
| **1871** | 1594 | 1383 | 1943 | **1921** | 2205 | 2362 | 3146 | **1971** | 10183 | 7111 | 12120 |
| **1872** | 1558 | 1571 | 2126 | **1922** | 2370 | 2436 | 3694 | **1972** | 10514 | 7621 | 12549 |
| **1873** | 1549 | 1705 | 1967 | **1923** | 2558 | 2445 | 3841 | **1973** | 11160 | 8218 | 13122 |
| **1874** | 1628 | 1559 | 2207 | **1924** | 2604 | 2494 | 4276 | **1974** | 11680 | 8743 | 13417 |
| **1875** | 1637 | 1601 | 2271 | **1925** | 2776 | 2624 | 4263 | **1975** | 11351 | 8952 | 13258 |
| **1876** | 1599 | 1626 | 2075 | **1926** | 2777 | 2588 | 4348 | **1976** | 12083 | 9222 | 13779 |
| **1877** | 1608 | 1787 | 2176 | **1927** | 2688 | 2782 | 4250 | **1977** | 12331 | 9472 | 14236 |
| **1878** | 1647 | 1733 | 2140 | **1928** | 2822 | 2764 | 4534 | **1978** | 12679 | 9679 | 14571 |
| **1879** | 1652 | 1627 | 1998 | **1929** | 2940 | 2928 | 4819 | **1979** | 13387 | 9719 | 14974 |
| **1880** | 1673 | 1761 | 2169 | **1930** | 2788 | 2798 | 4637 | **1980** | 13808 | 9853 | 15109 |
| **1881** | 1730 | 1794 | 2245 | **1931** | 2724 | 2691 | 4333 | **1981** | 13901 | 9827 | 15185 |
| **1882** | 1751 | 1805 | 2341 | **1932** | 2756 | 2706 | 4051 | **1982** | 13948 | 9937 | 15483 |
| **1883** | 1769 | 1837 | 2341 | **1933** | 2704 | 2610 | 4337 | **1983** | 14073 | 10129 | 15599 |
| **1884** | 1745 | 1832 | 2305 | **1934** | 2678 | 2670 | 4289 | **1984** | 14511 | 10222 | 15739 |

## Table A-1: (Continued)

| | Italy | Spain | France | | Italy | Spain | France | | Italy | Spain | France |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1885** | 1772 | 1777 | 2258 | **1935** | 2807 | 2688 | 4181 | **1985** | 14900 | 10381 | 15891 |
| **1886** | 1809 | 1732 | 2289 | **1936** | 2685 | 2062 | 4343 | **1986** | 15317 | 10679 | 16201 |
| **1887** | 1857 | 1698 | 2301 | **1937** | 2968 | 1884 | 4591 | **1987** | 15806 | 11243 | 16533 |
| **1888** | 1848 | 1759 | 2322 | **1938** | 3069 | 1878 | 4570 | **1988** | 16465 | 11816 | 17180 |
| **1889** | 1796 | 1751 | 2376 | **1939** | 3190 | 2045 | 4904 | **1989** | 17018 | 12401 | 17702 |
| **1890** | 1796 | 1750 | 2431 | **1940** | 3041 | 2222 | 4136 | **1990** | 17363 | 12918 | 18057 |
| **1891** | 1822 | 1786 | 2488 | **1941** | 2927 | 2172 | 3386 | **1991** | 17617 | 13207 | 18167 |
| **1892** | 1824 | 1913 | 2551 | **1942** | 2736 | 2287 | 3050 | **1992** | 17761 | 13274 | 18412 |
| **1893** | 1852 | 1837 | 2594 | **1943** | 2303 | 2354 | 2926 | **1993** | 17567 | 13085 | 18135 |
| **1894** | 1860 | 1851 | 2687 | **1944** | 1893 | 2442 | 2478 | **1994** | 17914 | 13350 | 18426 |
| **1895** | 1875 | 1831 | 2629 | **1945** | 1712 | 2256 | 2633 | **1995** | 18424 | 13675 | 18775 |
| **1896** | 1902 | 1683 | 2747 | **1946** | 2329 | 2335 | 3945 | **1996** | 18638 | 13964 | 18896 |
| **1897** | 1906 | 1764 | 2700 | **1947** | 2739 | 2353 | 4234 | **1997** | 18973 | 14462 | 19262 |
| **1898** | 1896 | 1880 | 2824 | **1948** | 2950 | 2336 | 4495 | **1998** | 19241 | 15068 | 19659 |
| **1899** | 1918 | 1888 | 2979 | **1949** | 3145 | 2297 | 5061 | **1999** | 19531 | 15716 | 20213 |
| **1900** | 1965 | 1915 | 2943 | **1950** | 3396 | 2351 | 5306 | **2000** | 20238 | 16485 | 20896 |
| **1901** | 2001 | 2036 | 2892 | **1951** | 3693 | 2569 | 5588 | **2001** | 20596 | 17026 | 21164 |
| **1902** | 2036 | 1960 | 2839 | **1952** | 3844 | 2762 | 5693 | **2002** | 20637 | 17267 | 21260 |
| **1903** | 2056 | 1948 | 2897 | **1953** | 4105 | 2730 | 5816 | **2003** | 20557 | 17510 | 21376 |
| **1904** | 2097 | 1924 | 2913 | **1954** | 4234 | 2914 | 6052 | **2004** | 20761 | 17791 | 21756 |
| **1905** | 2142 | 1885 | 2961 | **1955** | 4495 | 3007 | 6343 | **2005** | 20705 | 18130 | 22036 |
| **1906** | 2220 | 1970 | 3011 | **1956** | 4687 | 3226 | 6598 | **2006** | 21049 | 18570 | 22429 |
| **1907** | 2262 | 2021 | 3141 | **1957** | 4929 | 3302 | 6919 | **2007** | 21302 | 18893 | 22804 |
| **1908** | 2313 | 2087 | 3116 | **1958** | 5185 | 3412 | 7014 | **2008** | 20902 | 18762 | 22739 |
| **1909** | 2335 | 2109 | 3241 | **1959** | 5525 | 3300 | 7141 | | | | |
| **1910** | 2344 | 2023 | 3034 | **1960** | 5877 | 3317 | 7570 | | | | |

*Sources*: For Italy, Felice and Vecchi (2015a); for Spain, Prados de la Escosura (2003) and Maddison (2010); for France, Maddison (2010). For all the three countries, 1990 GDP at current price in the national currency is from OECD (2014). For Italy and Spain the series are based on the de facto population (see Table A.3). For further details see main text.

## Table A-2: GDP per capita in Italy, Spain, and France at current borders, 1861–2008 (2008 PPP dollars)

| | Italy | Spain | France | | Italy | Spain | France | | Italy | Spain | France |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1861** | 2440 | 2359 | 2723 | **1911** | 3774 | 3807 | 5003 | **1961** | 10048 | 6535 | 11880 |
| **1862** | 2473 | 2353 | 2946 | **1912** | 3779 | 3756 | 5409 | **1962** | 10653 | 7203 | 12417 |
| **1863** | 2534 | 2391 | 3037 | **1913** | 3943 | 3885 | 5364 | **1963** | 11217 | 7853 | 12873 |
| **1864** | 2537 | 2382 | 3060 | **1914** | 3757 | 3794 | 4981 | **1964** | 11561 | 8527 | 13575 |
| **1865** | 2692 | 2300 | 2962 | **1915** | 3536 | 3813 | 5000 | **1965** | 11974 | 8987 | 14107 |
| **1866** | 2689 | 2410 | 2977 | **1916** | 3794 | 3949 | 5330 | **1966** | 12678 | 9549 | 14691 |
| **1867** | 2447 | 2391 | 2791 | **1917** | 3794 | 3868 | 4585 | **1967** | 13550 | 10073 | 15249 |
| **1868** | 2498 | 2145 | 3051 | **1918** | 3685 | 3807 | 3688 | **1968** | 14426 | 10563 | 15804 |
| **1869** | 2536 | 2215 | 3088 | **1919** | 3593 | 3845 | 4327 | **1969** | 15259 | 11413 | 16756 |
| **1870** | 2595 | 2268 | 2888 | **1920** | 3654 | 4099 | 4967 | **1970** | 16053 | 11980 | 17563 |
| **1871** | 2539 | 2442 | 2923 | **1921** | 3511 | 4170 | 4733 | **1971** | 16217 | 12557 | 18233 |
| **1872** | 2481 | 2773 | 3199 | **1922** | 3774 | 4301 | 5557 | **1972** | 16744 | 13458 | 18878 |
| **1873** | 2467 | 3010 | 2958 | **1923** | 4074 | 4318 | 5778 | **1973** | 17773 | 14512 | 19740 |
| **1874** | 2592 | 2753 | 3320 | **1924** | 4148 | 4403 | 6433 | **1974** | 18601 | 15438 | 20184 |
| **1875** | 2608 | 2826 | 3416 | **1925** | 4421 | 4634 | 6413 | **1975** | 18078 | 15807 | 19944 |
| **1876** | 2547 | 2872 | 3122 | **1926** | 4423 | 4570 | 6540 | **1976** | 19244 | 16284 | 20728 |
| **1877** | 2561 | 3156 | 3274 | **1927** | 4281 | 4913 | 6394 | **1977** | 19638 | 16726 | 21416 |
| **1878** | 2623 | 3061 | 3219 | **1928** | 4495 | 4880 | 6820 | **1978** | 20193 | 17093 | 21919 |
| **1879** | 2631 | 2874 | 3006 | **1929** | 4682 | 5170 | 7250 | **1979** | 21320 | 17163 | 22526 |
| **1880** | 2664 | 3110 | 3263 | **1930** | 4440 | 4941 | 6976 | **1980** | 21991 | 17399 | 22729 |
| **1881** | 2755 | 3167 | 3377 | **1931** | 4338 | 4752 | 6519 | **1981** | 22139 | 17354 | 22843 |
| **1882** | 2789 | 3188 | 3522 | **1932** | 4388 | 4778 | 6094 | **1982** | 22213 | 17547 | 23292 |
| **1883** | 2817 | 3245 | 3522 | **1933** | 4307 | 4610 | 6525 | **1983** | 22413 | 17886 | 23466 |
| **1884** | 2780 | 3235 | 3468 | **1934** | 4265 | 4716 | 6453 | **1984** | 23110 | 18051 | 23677 |
| **1885** | 2822 | 3139 | 3397 | **1935** | 4470 | 4746 | 6289 | **1985** | 23729 | 18331 | 23905 |
| **1886** | 2881 | 3059 | 3443 | **1936** | 4276 | 3640 | 6533 | **1986** | 24394 | 18857 | 24371 |
| **1887** | 2958 | 2999 | 3462 | **1937** | 4726 | 3326 | 6907 | **1987** | 25173 | 19853 | 24871 |
| **1888** | 2944 | 3107 | 3493 | **1938** | 4887 | 3317 | 6874 | **1988** | 26223 | 20866 | 25844 |
| **1889** | 2861 | 3091 | 3574 | **1939** | 5081 | 3612 | 7378 | **1989** | 27103 | 21899 | 26629 |
| **1890** | 2861 | 3090 | 3657 | **1940** | 4843 | 3924 | 6222 | **1990** | 27652 | 22812 | 27163 |
| **1891** | 2902 | 3154 | 3743 | **1941** | 4662 | 3835 | 5093 | **1991** | 28057 | 23321 | 27330 |
| **1892** | 2905 | 3377 | 3837 | **1942** | 4357 | 4038 | 4589 | **1992** | 28287 | 23440 | 27698 |
| **1893** | 2950 | 3245 | 3902 | **1943** | 3668 | 4157 | 4402 | **1993** | 27977 | 23107 | 27280 |
| **1894** | 2963 | 3269 | 4042 | **1944** | 3014 | 4312 | 3728 | **1994** | 28531 | 23575 | 27719 |
| **1895** | 2986 | 3233 | 3954 | **1945** | 2727 | 3983 | 3961 | **1995** | 29342 | 24148 | 28244 |
| **1896** | 3030 | 2972 | 4133 | **1946** | 3708 | 4123 | 5934 | **1996** | 29683 | 24659 | 28426 |
| **1897** | 3036 | 3114 | 4062 | **1947** | 4362 | 4155 | 6369 | **1997** | 30216 | 25538 | 28977 |
| **1898** | 3019 | 3320 | 4248 | **1948** | 4698 | 4125 | 6762 | **1998** | 30643 | 26607 | 29574 |
| **1899** | 3055 | 3334 | 4481 | **1949** | 5009 | 4057 | 7613 | **1999** | 31106 | 27753 | 30407 |
| **1900** | 3130 | 3381 | 4427 | **1950** | 5408 | 4152 | 7983 | **2000** | 32231 | 29110 | 31435 |
| **1901** | 3186 | 3595 | 4350 | **1951** | 5882 | 4536 | 8406 | **2001** | 32802 | 30066 | 31838 |
| **1902** | 3243 | 3461 | 4271 | **1952** | 6122 | 4877 | 8564 | **2002** | 32866 | 30492 | 31983 |
| **1903** | 3274 | 3440 | 4358 | **1953** | 6538 | 4822 | 8749 | **2003** | 32739 | 30920 | 32157 |
| **1904** | 3339 | 3398 | 4382 | **1954** | 6743 | 5145 | 9105 | **2004** | 33065 | 31416 | 32728 |
| **1905** | 3411 | 3328 | 4455 | **1955** | 7159 | 5310 | 9542 | **2005** | 32975 | 32016 | 33150 |
| **1906** | 3535 | 3480 | 4530 | **1956** | 7465 | 5696 | 9925 | **2006** | 33523 | 32792 | 33741 |
| **1907** | 3602 | 3568 | 4726 | **1957** | 7850 | 5831 | 10409 | **2007** | 33926 | 33362 | 34306 |
| **1908** | 3683 | 3686 | 4687 | **1958** | 8258 | 6026 | 10552 | **2008** | 33288 | 33131 | 34207 |
| **1909** | 3719 | 3724 | 4875 | **1959** | 8799 | 5827 | 10743 | | | | |
| **1910** | 3733 | 3572 | 4564 | **1960** | 9360 | 5857 | 11387 | | | | |

*Sources*: see Table A-1.

All the series for Italy and Spain are revised to include the present population, as opposed to the resident population used in previous figures. GDP is the sum of all payments to factors of production owned by people living in a country, regardless of their nationality: Thus, it includes income earned by individuals not officially living in that country. Gross National Production (GNP) is the sum of all payments to factors of production owned by the residents in a country and thus includes income earned abroad by the citizens of that country. As a consequence, technically it is only GNP that should be divided by the resident population: GDP should be divided by the de facto population (that is, by the present or actual population). For Italy, in order to obtain the revised series, first we must estimate a series of the de facto Italian population at the present boundaries. This is achieved through a few simple steps using the data of the de facto population at historical borders from official censuses in benchmark years, and the long-run series of the resident population at historical and at present boundaries from Istat (2012a).[39] For Spain, Maluquer de Motes (2008) has recently made available a new estimate of the Spanish population, which provides a series that is for the first time geographically and methodologically consistent throughout the different periods of Spanish history and that always refers to the de facto population. Therefore, we incorporate his data in order to produce up-to-date estimates of the per capita GDP based on the de facto population,[40] comparable with those available for Italy. The difference between resident and present populations usually increases with emigration (or, for the last years, with immigration). This is why these differences are historically important for Italy (especially during the Giolitti age, but indeed throughout most of the Italian history) as well as, to a minor degree, for Spain. In this latter case, the differences between the old and the new population series are also noteworthy for the years following the 1929 crisis, for which Maluquer's new data includes emigrants returning from abroad for the first time. As a result, we have higher figures for the population and lower figures for the GDP per capita. Emigration is also why such differences are far less important for a country like France: Throughout the 19th century no more than half a million French people emigrated. It is true that France experienced more immigration, but this only affects the last decades (lowering the level of GDP per capita of the French and thus increasing Italy and Spain's rate of convergence in the last stretch, not in the whole series). The new series of the de facto population for Italy and

[39] In more detail, as the first step, the benchmarks of the de facto population at the historical borders (referring to the years 1861, 1871, 1881, 1901, 1911, 1921, 1931, 1931, 1936, 1951, 1961, 1971, 1981, 1991, 2001, and 2011) are interpolated, with the geometric average using the cycles of the resident population at the historical borders. In this way, a series of the de facto population at the historical borders is obtained. As the second step, the series of the de facto population at the historical borders is converted into the series of the de facto population at the present borders, using for each year the coefficient "population at historical borders/population at current borders" from the series of the resident population.

[40] We divide Prados's series of total GDP by Maluquer's series of de facto population (at 1 July).

Spain are presented in Table A-3. The same table also displays yearly differences with the previous series of the resident population, used in the previous figures of GDP per capita (from Istat, 2012a, for Italy; from Maddison, 2010, for Spain), so that the impact of the revision on our new figures of per capita GDP can be easily gauged.

**Table A-3: De facto population in Italy and Spain at current borders, 1861–2008 (thousands)**

| | Italy | Spain | *Pop.* de facto *minus resident population* | | | Italy | Spain | *Pop.* de facto *minus resident population* | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Italy* | *Spain* | | | | *Italy* | *Spain* |
| **1861** | 25770 | 15729 | *–558* | *30* | **1935** | 41824 | 25317 | *–768* | *738* |
| **1862** | 25935 | 15870 | *–572* | *116* | **1936** | 42169 | 25655 | *–739* | *845* |
| **1863** | 26123 | 15982 | *–589* | *173* | **1937** | 41908 | 25773 | *–1320* | *730* |
| **1864** | 26324 | 16067 | *–591* | *203* | **1938** | 41677 | 25831 | *–1933* | *552* |
| **1865** | 26528 | 16121 | *–603* | *201* | **1939** | 42221 | 25601 | *–1898* | *84* |
| **1866** | 26756 | 16188 | *–625* | *212* | **1940** | 42795 | 25846 | *–1767* | *89* |
| **1867** | 26908 | 16283 | *–532* | *251* | **1941** | 43292 | 26021 | *–1593* | *42* |
| **1868** | 26995 | 16317 | *–566* | *229* | **1942** | 43672 | 26094 | *–1447* | *–88* |
| **1869** | 27172 | 16308 | *–629* | *164* | **1943** | 43960 | 26284 | *–1275* | *–103* |
| **1870** | 27375 | 16327 | *–599* | *126* | **1944** | 44191 | 26516 | *–1153* | *–78* |
| **1871** | 27546 | 16365 | *–605* | *107* | **1945** | 44460 | 26765 | *–1080* | *–37* |
| **1872** | 27717 | 16405 | *–597* | *90* | **1946** | 44859 | 27018 | *–1051* | *6* |
| **1873** | 27872 | 16446 | *–587* | *74* | **1947** | 45292 | 27248 | *–918* | *25* |
| **1874** | 27992 | 16487 | *–559* | *58* | **1948** | 45752 | 27526 | *–800* | *89* |
| **1875** | 28119 | 16529 | *–590* | *42* | **1949** | 46225 | 27801 | *–689* | *150* |
| **1876** | 28325 | 16570 | *–639* | *25* | **1950** | 46720 | 28017 | *–575* | *–46* |
| **1877** | 28556 | 16612 | *–613* | *9* | **1951** | 47159 | 28185 | *–381* | *–113* |
| **1878** | 28742 | 16686 | *–592* | *9* | **1952** | 47373 | 28360 | *–419* | *–190* |
| **1879** | 28916 | 16790 | *–600* | *22* | **1953** | 47630 | 28588 | *–493* | *–216* |
| **1880** | 29027 | 16893 | *–525* | *34* | **1954** | 47937 | 28819 | *–540* | *–241* |
| **1881** | 29167 | 17011 | *–624* | *60* | **1955** | 48235 | 29040 | *–554* | *–279* |
| **1882** | 29365 | 17122 | *–640* | *79* | **1956** | 48487 | 29268 | *–567* | *–311* |
| **1883** | 29552 | 17202 | *–669* | *66* | **1957** | 48713 | 29509 | *–600* | *–333* |
| **1884** | 29777 | 17298 | *–734* | *68* | **1958** | 48970 | 29788 | *–670* | *–318* |
| **1885** | 30025 | 17356 | *–751* | *33* | **1959** | 49289 | 30100 | *–737* | *–273* |
| **1886** | 30209 | 17425 | *–728* | *7* | **1960** | 49617 | 30418 | *–757* | *–223* |
| **1887** | 30373 | 17532 | *–787* | *19* | **1961** | 49904 | 30764 | *–795* | *–140* |
| **1888** | 30538 | 17604 | *–787* | *4* | **1962** | 50258 | 31110 | *–802* | *–48* |
| **1889** | 30733 | 17654 | *–878* | *–24* | **1963** | 50647 | 31452 | *–797* | *22* |
| **1890** | 30936 | 17674 | *–856* | *–83* | **1964** | 51083 | 31821 | *–824* | *80* |
| **1891** | 31097 | 17709 | *–895* | *–127* | **1965** | 51504 | 32186 | *–814* | *101* |
| **1892** | 31303 | 17773 | *–886* | *–143* | **1966** | 51884 | 32550 | *–836* | *98* |
| **1893** | 31522 | 17847 | *–895* | *–149* | **1967** | 52256 | 32932 | *–825* | *82* |
| **1894** | 31740 | 17911 | *–868* | *–165* | **1968** | 52612 | 33288 | *–779* | *49* |
| **1895** | 31923 | 17956 | *–847* | *–201* | **1969** | 52980 | 33580 | *–705* | *14* |
| **1896** | 32105 | 17978 | *–850* | *–260* | **1970** | 53362 | 33832 | *–596* | *–44* |
| **1897** | 32328 | 18034 | *–872* | *–286* | **1971** | 53745 | 34118 | *–444* | *–77* |
| **1898** | 32542 | 18208 | *–827* | *–194* | **1972** | 54113 | 34468 | *–461* | *–45* |
| **1899** | 32752 | 18431 | *–853* | *–53* | **1973** | 54553 | 34818 | *–376* | *–19* |
| **1900** | 32946 | 18573 | *–793* | *7* | **1974** | 54991 | 35162 | *–302* | *–22* |
| **1901** | 33159 | 18682 | *–856* | *23* | **1975** | 55345 | 35547 | *–244* | *–17* |
| **1902** | 33391 | 18840 | *–925* | *52* | **1976** | 55622 | 35984 | *–226* | *–13* |

## Table A-3: (Continued)

| | Italy | Spain | *Pop.* de facto *minus resident population* | | | Italy | Spain | *Pop.* de facto *minus resident population* | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Italy* | *Spain* | | | | *Italy* | *Spain* |
| **1903** | 33603 | 19041 | *–952* | *122* | **1977** | 55852 | 36430 | *–211* | *–9* |
| **1904** | 33823 | 19216 | *–1052* | *166* | **1978** | 56043 | 36838 | *–204* | *–23* |
| **1905** | 34059 | 19342 | *–1088* | *209* | **1979** | 56181 | 37208 | *–207* | *8* |
| **1906** | 34284 | 19451 | *–1162* | *135* | **1980** | 56275 | 37535 | *–204* | *47* |
| **1907** | 34519 | 19564 | *–1223* | *114* | **1981** | 56336 | 37829 | *–188* | *78* |
| **1908** | 34762 | 19690 | *–1293* | *105* | **1982** | 56388 | 38081 | *–175* | *98* |
| **1909** | 35012 | 19821 | *–1358* | *100* | **1983** | 56501 | 38306 | *–64* | *122* |
| **1910** | 35305 | 19940 | *–1469* | *82* | **1984** | 56586 | 38507 | *–2* | *144* |
| **1911** | 35583 | 20054 | *–1476* | *60* | **1985** | 56638 | 38690 | *40* | *155* |
| **1912** | 35891 | 20175 | *–1350* | *47* | **1986** | 56659 | 38852 | *65* | *144* |
| **1913** | 36071 | 20299 | *–1184* | *36* | **1987** | 56674 | 39001 | *65* | *120* |
| **1914** | 36425 | 20494 | *–1372* | *96* | **1988** | 56697 | 39138 | *48* | *84* |
| **1915** | 36955 | 20733 | *–1211* | *198* | **1989** | 56719 | 39260 | *25* | *45* |
| **1916** | 37198 | 20938 | *–920* | *265* | **1990** | 56742 | 39367 | *–2* | *16* |
| **1917** | 37128 | 21124 | *–716* | *313* | **1991** | 56765 | 39487 | *–8* | *26* |
| **1918** | 36764 | 21306 | *–431* | *356* | **1992** | 56784 | 39650 | *–37* | *101* |
| **1919** | 36585 | 21226 | *–719* | *135* | **1993** | 56896 | 39807 | *54* | *179* |
| **1920** | 36817 | 21348 | *–674* | *116* | **1994** | 56973 | 39948 | *129* | *257* |
| **1921** | 37192 | 21506 | *–698* | *95* | **1995** | 56993 | 40074 | *149* | *324* |
| **1922** | 37568 | 21736 | *–713* | *108* | **1996** | 57010 | 40190 | *134* | *386* |
| **1923** | 37923 | 21933 | *–706* | *86* | **1997** | 57047 | 40307 | *143* | *452* |
| **1924** | 38253 | 22114 | *–737* | *45* | **1998** | 57043 | 40421 | *134* | *515* |
| **1925** | 38588 | 22314 | *–751* | *22* | **1999** | 57021 | 40529 | *97* | *576* |
| **1926** | 38906 | 22545 | *–759* | *27* | **2000** | 57061 | 40654 | *100* | *638* |
| **1927** | 39232 | 22787 | *–798* | *40* | **2001** | 57110 | 40797 | *116* | *710* |
| **1928** | 39550 | 23029 | *–792* | *52* | **2002** | 57551 | 41314 | *230* | *1161* |
| **1929** | 39813 | 23277 | *–782* | *67* | **2003** | 57984 | 42005 | *96* | *1788* |
| **1930** | 40114 | 23536 | *–873* | *91* | **2004** | 58408 | 42692 | *–54* | *2411* |
| **1931** | 40434 | 23856 | *–843* | *181* | **2005** | 58822 | 43398 | *70* | *3057* |
| **1932** | 40756 | 24236 | *–829* | *339* | **2006** | 59223 | 44068 | *92* | *3670* |
| **1933** | 41101 | 24625 | *–820* | *503* | **2007** | 59610 | 44874 | *–9* | *4426* |
| **1934** | 41465 | 24982 | *–800* | *633* | **2008** | 59983 | 45593 | *–62* | *5102* |

*Sources*: for Italy, see main text for de facto population and Istat (2012a) for resident population; for Spain, Maluquer de Motes (2008b) until 2001 and Ine (2012) for the years 2002 to 2008 for population de facto and Maddison (2010) for resident population.

## A-2 Life expectancy

Measures based on GDP are not the only indicators of economic growth, nor of human welfare. A wide range of social indicators, from per capita calories to average height to life expectancy, can be integrated with GDP or used to supplement it (not only because of the lack of GDP historical figures (Steckel 2009)), combined in composite indicators (of which the Human Development Index (HDI) is by far the most successful)[41] or considered individually in a 'dashboard' approach.[42] Although estimating social indicators for past periods is not, in principle, more difficult than reconstructing GDP (in fact the latter poses far greater conceptual problems),[43] international historical series of social indicators are seriously lacking. Nothing exists that is comparable with the impressive reach of the Maddison project, criticisable as it may be. Before 1950, typically only benchmark estimates are available for education, height, and nutrition. The situation is a little better for life expectancy, for which a number of consistent national series are indeed available, mostly thanks to the efforts of the Max Planck Institute for Demographic Research and the University of California (the Human Mortality Database, HMD hereafter).[44] However, this database does not always include research produced by economic historians in specific countries, which, if properly assessed and possibly incorporated, could be invaluable for enlarging both the international scope and the historical coverage of the database. For Italy, a wide range of social indicators in benchmark years has been published in a recent book by Giovanni Vecchi (2011). An alternative and more recent estimate has also been published in the case of life expectancy, in benchmark years from 1871 to the present day (Felice and Vasta 2015). For Spain, the Nisal research project has made available a wide range of social and well-being indicators, including historical estimates of life expectancy previously published by Roser Nicolau (2005).[45] Furthermore, we now have new estimates of life expectancy in benchmark years for Spain (Cabré, Domingo, and Menacho 2002) and even a yearly series from 1911 to 2004 (Blanes Llorens 2007), both of which have thus far not been considered by the HMD.

Thanks to this information, and to the available historical series published in the HMD, it is now possible to produce historical and consistent series of life expectancy for both Italy and Spain from 1861 to 2008, which are directly comparable with the GDP series in the previous section. These new series are presented and discussed here for the first time.

For Italy, the basic references are the estimates recently published by Felice and Vasta (2015), in benchmark years spanning from 1871 to 2007. From 1911 onwards these estimates are roughly the same as those published in the HMD.[46] However, in the

[41] UNDP, United Nations Development Programme (2010). For historical cross-country estimates, see Crafts (1997, 2002) and Prados de la Escosura (2010b); for Italy, see Brandolini and Vecchi (2011) and Felice and Vasta (2015); for Spain, see Escudero and Simón (2010).
[42] Ravallion (2012). For Italy, see Vecchi (2011).
[43] Cfr. Felice (2016).
[44] Freely available at: http://www.mortality.org/ (last access on November 2014).
[45] Freely available at: http://www.proyectonisal.org/ (last access on November 2014).
[46] The Human Mortality Database provides a yearly series, at historical borders, from 1871 to 2008. Both Felice-Vasta and the HMD differ from the benchmark estimates (which are also at historical borders) published by Vecchi (2011, p. 419), but the reasons for this discrepancy are unknown at present, because in

previous period, where the HMD researchers themselves consider their figures to be far less trustworthy, there are differences between the two.[47] All these estimates − those by Felice and Vasta as well as those by the HMD, and even those by Vecchi − are at historical borders. Thus, for a proper time-series analysis, they need to be converted to current borders. This is made possible by the fact that Felice and Vasta also report life expectancy data for the Italian regions at their historical borders. We make the conversion under the hypothesis that the ratio between life expectancy in Trentino-Alto Adige and part of what is now Friuli-Venezia Giulia (including Trieste) on the one hand, and the rest of Italy on the other hand, remained unchanged from the liberal age (when Trentino-Alto Adige and part of Friuli-Venezia Giulia were not part of the Italian Realm) to the interwar years (when these provinces were annexed after the First World War). Once we have estimated the new benchmarks at current borders (for 1871, 1891, 1911, 1931, 1938, 1951, 1961, 1971, 1981, 1991, 2001, and 2007), the yearly series is constructed by interpolating through the benchmarks the yearly series of the HMD (2011b), through a geometric average. From 1861 to 1870 the series is produced by projecting backwards the value of life expectancy in 1871, with the inverse of the mortality rate on the resident population for the years 1862 to 1871.[48]

If for Italy we have three sources of historical data for life expectancy, for Spain there are four sources. First, there are the benchmark figures published by Roser Nicolau (2005), mostly based on estimates by the Spanish *Instituto Nacional de Estadística* (INE), which run every ten years from 1900 to 1970 and every five years from 1970 onwards, with a last benchmark in 1998. Second, for the years 1908 to 2008, a yearly series by the HMD (2011c) is available. There are some differences between the benchmarks of Nicolau and those of the HMD series, due to different procedures for computing the population of Ceuta and Melilla and to the changes between the de facto population and the resident population. It is worth noticing, however, that the HMD researchers do not seem to be aware of the previous work by Roser Nicolau,[49] so they do not raise the issue (Glei et al. 2012). As a third source, we have the work by Fausto Dopico and David-Sven Reher referring to the second half of the 19th century and to the first half of the 20th, which consists of mortality estimates for Spain in the 1860s (Dopico 1987), and of life tables for four ten-year benchmarks from 1900 to 1930 (Dopico and Reher 1999). Their research efficaciously addresses many of the problems

---

the explanatory notes of Vecchi (2011: 128–9), reference is made to an unpublished graduate thesis; in the case of Felice and Vasta, see the discussion on p. 35.

[47] Since "deaths counts are available only by five-year age groups (i.e., 0–4, 5-9,…, 65–74, 75+)" and "the data for 1883–84 demonstrate clear patterns of age heaping" (Glei 2011: 3).

[48] The series of the mortality rate is available from Istat (2012b), for all the years 1862 to 2009; as expected, the correlation between mortality and life expectancy, for the years 1871 to 2009, is very high: a Pearson coefficient of -0.955, with $R^2$ of 0.911. The value for 1861 is interpolated linearly, through a linear regression for the years 1862–1880, in which the year is the independent variable and life expectancy the dependent one.

[49] Whose first version was published as early as 1989 (Nicolau 1989).

posed by the original sources for those years and has become a reference for historical analyses of life expectancy in Spain (e.g., Pérez Moreda, Reher, and Sanz Gimeno 2015: 292–299), as well as for further estimates concerning those periods.[50] These latter – and here we come to the fourth source – have been produced by Anna Cabré and her co-authors and more recently by Amand Blanes Llorens, who was a PhD student of Cabré. At first, Cabré, Domingo, and Menacho (2002: 127; Cabré 1999: 38–42) published five-year estimates of life expectancy in Spain, beginning as early as 1860 and running until 1995. Their reliability is more limited for the second half of the 19th century, when, due to lack of data, Cabré's figures have been constructed from Dopico (1987) and Dopico and Reher (1999) estimates for 1866 and 1990 respectively, via interpolating mortality rates by age groups – with the exception of 1885 when, due to a cholera epidemic, ad hoc mortality and life expectancy have been estimated (Cabré 1999: 243–253). In any case, for that period these are the only available series, and have been produced by making use of the most reliable sources and of widely accepted procedures. A few years afterwards, a PhD student of Cabré published a yearly series of life expectancy in Spain, from 1911 until 2004, as part of his PhD thesis (Blanes Llorens 2007)[51]. This work is truly impressive, boasting a level of accuracy and detail superior to that by the HMD (which is apparently also unaware of this work, unlike Blanes Llorens, who discusses their work);[52] moreover, the results have never been published outside the PhD thesis and are presented here to a wider public for the first time.

The higher level of accuracy of the work by Blanes Llorens can be exemplified by the way of coping with under-registration of infant mortality, an issue that indeed has an impact on the overall trend of life expectancy in Spain when compared with Italy, as we will see in the next section. According to Spanish law, until 1974 newborns that died within the first 24 hours of life were counted in the official censuses as aborted foetuses, or stillbirths, while from 1975 onwards they were included in the mortality tables. Therefore, deaths were under-registered until 1974. In order to estimate life expectancy, Blanes Llorens re-counts the number of these 'false' stillbirths from the demographic statistics (*Movimiento Natural de la Población*) of the *Instituto Nacional de Estadística* (INE) from 1911 to 1975, and with these figures he recalculates the figures from vital statistics and censuses. He then modifies his tables accordingly to make them fully comparable with the following period (Blanes Llorens 2007: 57–59).

[50] They are not, however, the only noteworthy recent research concerning the 19th century and the first half of the 20th century. Remarkable is the work by Diego Ramiro Fariñas and Alberto Sanz Gimeno on childhood mortality in central Spain, over the long-run (Ramiro Fariñas and Sanz Gimeno 2000a, 2000b), which also was considered in the work by Blanes Llorens (2007) we mostly rely upon.

[51] We are grateful to the author for having let us use the data from his PhD thesis.

[52] For a full description of sources and methods, see Blanes Llorens (2007: 43–114).

The HMD researchers also cope with this problem, but they correct infant death counts only from 1930 onwards (Glei et al. 2012: 3–5).[53]

Once we have accepted the new figures as superior, the only (minor) problem is that both the estimated series by Blanes Llorens and the benchmark data by Cabré, Domingo, and Menacho are reported by sex, with no averages for the whole population. Averages must therefore be calculated via the series of the population by sex, which is reconstructed from the data of the official censuses for benchmark years (see Nicolau 2005).[54] At this point, the different life expectancy data for the whole population is linked and unified, with the aim of producing an updated and more coherent series of life expectancy for Spain.[55] To this purpose, for the years 1911 to 2004, we use the series from Blanes Llorens (2007). The same series are linked to the five-year estimates by Cabré, Domingo, and Menacho (2002) from 1861 to 1910.[56] In order to complete the cycle, from 1861 to 1910, estimates by Cabré, Domingo, and Menacho are interpolated every five years, through a geometric average, using the series of the inverse of mortality rates until 1907[57] from Nicolau (2005), then limited to the last two years of the HMD series (2011c). For the very last stretch (2005–2008), we link the estimates by Blanes Llorens to the HMD series. Needless to say, in the overlapping years of the last period the figures are virtually identical.

It is worth stressing that, for both Italy and Spain, we never use a linear interpolation. For some years (Italy from 1861 to 1870, Spain from 1861 to 1910), we interpolate the new and more reliable benchmarks using the mortality series. In the case

[53] However, neither Blanes Llorens nor HMD researchers were the first to correct estimates of infant mortality to allow for the under-registration of deaths. Marcelino Pascua Martínes pioneered these efforts as far back as in the 1930s (Pascua Martínes 1934), followed by Antonio Arbelo Curbelo (1951). By the early 1990s, Arbelo Curbelo's procedure was the same as that adopted by Rosa Gómez Redondo, one of the main contributors to the HMD for Spain (Gómez Redondo 1992).

[54] Namely, historical data of the population by sex are available for the following benchmarks: 1860, 1877, 1887, 1897, 1900, 1910, 1920, 1930, 1940, 1950, 1960, 1970, 1981, 1991, and 2001, plus 2010. The annual series of the shares of the female (and male) population is constructed via linearly interpolating the shares of the benchmarks, through the continuous compounded annual rate.

[55] The main divergence between this new series and the previous one is in levels, concentrated in 1930 and essentially due to the under registration of births. Therefore, in terms of yearly movements there are no great differences in the long-run series; however there are in terms of structural breaks. In a previous work, an alternative series constructed by linking the Nicolau data through the HMD estimates is also tested, and the result displays some incongruities that make us doubt its reliability (see Felice and Pujol Andreu 2013: 27).

[56] It is worth noticing that for the following period, the five-year estimates by Cabré, Domingo, and Menacho are very close to the new figures by Blanes Llorens.

[57] Also in the case of Spain, for those years for which it is possible to check (i.e., from 1908 to 2001), we register a high correlation between mortality rates and life expectancy: a Pearson coefficient of –0.958 and $R^2$ of 0.918. In the series of mortality rates, the years 1871 to 1876 are missing, and from 1870 to 1877 they had to be reconstructed via linear interpolation through the continuous compounded annual rate. However, since we have an estimate of life expectancy for 1875, the years of linear interpolation are only four (1871 to 1874), plus one (1876). This is a shortcut that we make with bad conscience but good precedent (it is the usual way to cope with a few missing years in long-run series).

of Italy from 1871 onwards, we take the most reliable benchmark figures and interpolate them with the HMD yearly series. In the case of Spain from 1911 to 2004, we use the latest available yearly series (and the HMD yearly series for the last stretch).

The new series of life expectancy for Italy and Spain are displayed in table A-4.

**Table A-4: Life expectancy at birth in Italy and Spain at current borders, 1861–2008 (years)**

| | Italy | Spain | | Italy | Spain | | Italy | Spain |
|---|---|---|---|---|---|---|---|---|
| **1861** | 32.1 | 30.3 | **1911** | 44.2 | 42.2 | **1961** | 70.1 | 69.7 |
| **1862** | 32.0 | 31.0 | **1912** | 48.4 | 45.2 | **1962** | 69.4 | 69.7 |
| **1863** | 31.9 | 30.4 | **1913** | 47.9 | 43.7 | **1963** | 69.5 | 69.8 |
| **1864** | 33.1 | 29.7 | **1914** | 49.3 | 43.8 | **1964** | 70.6 | 70.6 |
| **1865** | 33.0 | 29.1 | **1915** | 41.9 | 43.6 | **1965** | 70.5 | 71.0 |
| **1866** | 33.9 | 34.1 | **1916** | 38.8 | 44.6 | **1966** | 71.2 | 71.2 |
| **1867** | 33.1 | 32.6 | **1917** | 37.3 | 43.3 | **1967** | 71.2 | 71.4 |
| **1868** | 32.4 | 28.7 | **1918** | 25.4 | 30.7 | **1968** | 71.0 | 71.7 |
| **1869** | 35.5 | 28.3 | **1919** | 41.7 | 41.9 | **1969** | 71.1 | 71.2 |
| **1870** | 33.1 | 30.1 | **1920** | 45.1 | 40.8 | **1970** | 71.8 | 72.2 |
| **1871** | 33.2 | 30.3 | **1921** | 48.8 | 43.9 | **1971** | 72.1 | 71.8 |
| **1872** | 33.6 | 30.5 | **1922** | 49.6 | 45.6 | **1972** | 72.3 | 73.0 |
| **1873** | 35.5 | 30.7 | **1923** | 51.1 | 45.6 | **1973** | 72.2 | 72.8 |
| **1874** | 35.4 | 30.9 | **1924** | 51.2 | 47.1 | **1974** | 72.8 | 73.1 |
| **1875** | 34.7 | 31.1 | **1925** | 51.0 | 47.6 | **1975** | 72.7 | 73.6 |
| **1876** | 36.9 | 31.2 | **1926** | 50.7 | 48.3 | **1976** | 73.0 | 73.9 |
| **1877** | 38.1 | 31.3 | **1927** | 52.4 | 49.0 | **1977** | 73.3 | 74.3 |
| **1878** | 37.2 | 31.5 | **1928** | 52.5 | 49.1 | **1978** | 73.6 | 74.5 |
| **1879** | 36.5 | 32.0 | **1929** | 52.2 | 50.1 | **1979** | 73.8 | 75.0 |
| **1880** | 35.0 | 32.1 | **1930** | 55.1 | 51.0 | **1980** | 73.7 | 75.5 |
| **1881** | 36.3 | 31.4 | **1931** | 54.8 | 50.9 | **1981** | 74.0 | 75.7 |
| **1882** | 36.2 | 30.5 | **1932** | 55.0 | 52.3 | **1982** | 74.5 | 76.3 |
| **1883** | 37.0 | 32.1 | **1933** | 56.8 | 52.4 | **1983** | 74.4 | 76.1 |
| **1884** | 38.4 | 28.3 | **1934** | 57.7 | 52.9 | **1984** | 75.2 | 76.5 |
| **1885** | 38.5 | 31.7 | **1935** | 57.3 | 53.1 | **1985** | 75.3 | 76.4 |
| **1886** | 36.6 | 32.9 | **1936** | 58.2 | 51.7 | **1986** | 75.7 | 76.7 |
| **1887** | 37.3 | 33.5 | **1937** | 57.2 | 48.1 | **1987** | 76.2 | 77.0 |
| **1888** | 38.2 | 34.9 | **1938** | 58.1 | 48.3 | **1988** | 76.4 | 76.9 |
| **1889** | 40.3 | 34.1 | **1939** | 59.5 | 47.9 | **1989** | 76.8 | 77.0 |
| **1890** | 39.5 | 34.1 | **1940** | 58.7 | 49.9 | **1990** | 76.9 | 77.0 |
| **1891** | 39.4 | 34.4 | **1941** | 56.1 | 48.9 | **1991** | 76.9 | 77.1 |
| **1892** | 39.5 | 34.7 | **1942** | 53.8 | 53.2 | **1992** | 77.3 | 77.5 |
| **1893** | 40.1 | 34.6 | **1943** | 50.3 | 55.2 | **1993** | 77.6 | 77.7 |
| **1894** | 39.9 | 34.1 | **1944** | 53.4 | 56.6 | **1994** | 77.8 | 78.1 |
| **1895** | 39.3 | 35.0 | **1945** | 55.8 | 58.1 | **1995** | 78.0 | 78.2 |
| **1896** | 40.1 | 34.5 | **1946** | 59.9 | 57.7 | **1996** | 78.4 | 78.3 |
| **1897** | 42.4 | 35.6 | **1947** | 62.0 | 59.4 | **1997** | 78.6 | 78.8 |
| **1898** | 41.1 | 35.6 | **1948** | 64.1 | 61.3 | **1998** | 78.7 | 78.9 |
| **1899** | 42.1 | 34.7 | **1949** | 64.6 | 61.0 | **1999** | 79.1 | 78.9 |

## Table A-4: (Continued)

| | Italy | Spain | | Italy | Spain | | Italy | Spain |
|---|---|---|---|---|---|---|---|---|
| **1900** | 39.9 | 34.5 | **1950** | 66.1 | 62.3 | **2000** | 79.5 | 79.4 |
| **1901** | 41.3 | 35.8 | **1951** | 65.5 | 61.9 | **2001** | 79.8 | 79.7 |
| **1902** | 41.0 | 38.0 | **1952** | 66.1 | 65.0 | **2002** | 80.0 | 79.8 |
| **1903** | 41.3 | 39.6 | **1953** | 66.8 | 65.7 | **2003** | 80.1 | 79.7 |
| **1904** | 42.7 | 38.4 | **1954** | 68.1 | 66.9 | **2004** | 80.9 | 80.2 |
| **1905** | 42.4 | 38.1 | **1955** | 68.5 | 66.7 | **2005** | 80.9 | 80.2 |
| **1906** | 43.7 | 38.0 | **1956** | 67.9 | 66.7 | **2006** | 81.3 | 80.8 |
| **1907** | 44.2 | 40.5 | **1957** | 68.0 | 66.6 | **2007** | 81.4 | 80.8 |
| **1908** | 42.1 | 42.0 | **1958** | 69.1 | 68.8 | **2008** | 81.6 | 81.1 |
| **1909** | 43.8 | 41.6 | **1959** | 69.5 | 68.7 | | | |
| **1910** | 46.0 | 41.5 | **1960** | 69.4 | 69.4 | | | |

# Online statistical appendix

## Part II. Additional econometric results

### Table A-5: Augmented Dickey–Fuller tests for unit roots

| | | ADF | MacKinnon *p*-value |
|---|---|---|---|
| Italy | *GDP* | -1.942 | 0.633 |
| | *ln (LE)* | -3.636 | 0.027 |
| | *Modified LE* | 1.174 | 1.000 |
| | ∆ *GDP* | -5.121 | 0.000 |
| | ∆ *ln (LE)* | -7.618 | 0.000 |
| | ∆ *Modified LE* | -6.089 | 0.000 |
| Spain | *GDP* | -0.712 | 0.972 |
| | *ln (LE)* | -1.933 | 0.637 |
| | *Modified LE* | -0.967 | 0.948 |
| | ∆ *GDP* | -4.528 | 0.001 |
| | ∆ *ln (LE)* | -6.209 | 0.000 |
| | ∆ *Modified LE* | -5.626 | 0.000 |
| France | *GDP* | -2.295 | 0.437 |
| | *ln (LE)* | -4.471 | 0.993 |
| | *Modified LE* | -0.085 | 0.993 |
| | ∆ *GDP* | -6.178 | 0.000 |
| | ∆ *ln (LE)* | -6.36 | 0.000 |
| | ∆ *Modified LE* | -5.536 | 0.000 |

*Notes*: for all series, interpolated DF critical values are: 1% significance level = -4.026; 5% = -3.444; 10% = -3.144. ∆ denotes first differences.

**Table A-6: Granger–causality tests allowing for potential endogeneity: Two-step regression results**

| | **First step regressions** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **GDP** | | | | **Modified LE** | | |
| | **Spain** | **Italy** | **France** | | **Spain** | **Italy** | **France** |
| LE (t-1) | 0.572 | -0.095 | 0.270 | GDP (t-1) | 0.007 | 0.039 | 0.041 |
| | (0.164)*** | (0.154) | (0.140)* | | (0.009) | (0.013)*** | (0.010)*** |
| LE (t-2) | 0.646 | 0.125 | 0.377 | GDP (t-2) | 0.015 | 0.033 | 0.037 |
| | (0.169)*** | (0.156) | (0.141)*** | | (0.009) | (0.014)** | (0.010)*** |
| LE (t-3) | 0.423 | 0.466 | 0.501 | GDP (t-3) | 0.013 | 0.023 | 0.030 |
| | (0.175)** | (0.161)*** | (0.139)*** | | (0.009) | (0.014) | (0.010)*** |
| LE (t-4) | 0.331 | 0.566 | 0.515 | GDP (t-4) | 0.028 | 0.018 | 0.019 |
| | (0.169)* | (0.157)*** | (0.136)*** | | (0.008)*** | (0.013) | (0.010)* |
| $\Delta$ GDP (t-1) | 2.038 | 1.834 | 1.774 | $\Delta$ LE (t-1) | 1.945 | 2.257 | 2.086 |
| | (0.131)*** | (0.142)*** | (0.137)*** | | (0.114)*** | (0.132)*** | (0.113)*** |
| $\Delta^2$ GDP (t-1) | -2.103 | -1.887 | -1.623 | $\Delta^2$ LE (t-1) | -1.825 | -2.475 | -2.002 |
| | (0.211)*** | (0.231)*** | (0.220)*** | | (0.183)*** | (0.221)*** | (0.173)*** |
| $\Delta^3$ GDP (t-1) | 1.085 | 0.984 | 0.745 | $\Delta^3$ LE (t-1) | 0.857 | 1.322 | 0.958 |
| | (0.148)*** | (0.169)*** | (0.149)*** | | (0.119)*** | (0.152)*** | (0.111)*** |
| $\Delta^4$ GDP (t-1) | -0.224 | -0.210 | -0.146 | $\Delta^4$ LE (t-1) | -0.161 | -0.277 | -0.185 |
| | (0.040)*** | (0.048)*** | (0.040)*** | | (0.029)*** | (0.039)*** | (0.027)*** |
| Constant | 0.010 | 0.013 | 0.009 | Constant | 0.003 | 0.003 | 0.003 |
| | (0.003)*** | (0.003)*** | (0.003)*** | | (0.000)*** | (0.001)*** | (0.001)*** |
| $R^2$ | 0.882 | 0.815 | 0.898 | $R^2$ | 0.761 | 0.714 | 0.797 |
| N | 142 | 142 | 142 | N | 142 | 142 | 142 |
| | **Second step regressions** | | | | | | |
| | **GDP** | | | | **Modified LE** | | |
| | **Spain** | **Italy** | **France** | | **Spain** | **Italy** | **France** |
| **LE (t-1)** | **0.013** | **0.571** | **-0.084** | **GDP (t-1)** | **0.045** | **0.032** | **0.047** |
| | **(0.331)** | **(0.267)**** | **(0.304)** | | **(0.026)*** | **(0.034)** | **(0.036)** |
| GDP (t-1) | 0.231 | 0.439 | 0.248 | LE (t-1) | -0.286 | 0.001 | -0.175 |
| | (0.085)*** | (0.083)*** | (0.095)*** | | (0.085)*** | (0.084) | (0.098)* |
| GDP (t-2) | -0.013 | -0.145 | -0.187 | LE (t-2) | 0.095 | 0.279 | -0.093 |
| | (0.086) | (0.090) | (0.084)** | | (0.084) | (0.086)*** | (0.087) |
| GDP (t-3) | 0.023 | 0.042 | 0.243 | LE (t-3) | 0.033 | 0.007 | 0.040 |
| | (0.086) | (0.090) | (0.083)*** | | (0.086) | (0.090) | (0.085) |
| GDP (t-4) | 0.027 | 0.020 | -0.111 | LE (t-4) | 0.031 | -0.154 | 0.138 |
| | (0.084) | (0.082) | (0.085) | | (0.083) | (0.087)* | (0.086) |
| Constant | 0.014 | 0.008 | 0.014 | Constant | 0.005 | 0.004 | 0.005 |
| | (0.005)*** | (0.004)* | (0.006)** | | (0.001)*** | (0.001)*** | (0.002)** |
| $R^2$ | 0.055 | 0.214 | 0.096 | $R^2$ | 0.133 | 0.081 | 0.027 |
| N | 142 | 142 | 142 | N | 142 | 142 | 142 |

## Table A-7: Bai–Perron tests for structural breaks

| | Breaks | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| GDP Spain | RSS | 0.143 | 0.109 | 0.099 | 0.093 | 0.085 | 0.085 |
| | BIC | -587.4 | -607.8 | -601.5 | -590.6 | -583.7 | -565.3 |
| | *Years* | | *1937* | *1950, 1976* | *1915, 1937, 1959* | *1915, 1937, 1959, 1981* | *1883, 1915, 1937, 1959, 1981* |
| GDP Italy | RSS | 0.338 | 0.271 | 0.239 | 0.219 | 0.216 | 0.269 |
| | BIC | -460.2 | -472.6 | -471.3 | -464.3 | -446.2 | -394.2 |
| | *Years* | | *1944* | *1945, 1970* | *1923, 1945, 1970* | *1900, 1923, 1945, 1970* | *1882, 1905, 1928, 1950, 1974* |
| GDP France | RSS | 0.241 | 0.184 | 0.166 | 0.151 | 0.149 | 0.207 |
| | BIC | -510.3 | -530.3 | -525.0 | -519.6 | -501.0 | -432.7 |
| | *Years* | | *1946* | *1924, 1946* | *1924, 1946, 1973* | *1898, 1924, 1946, 1973* | *1896, 1918, 1942, 1964, 1986* |
| LE Spain | RSS | 0.006 | 0.004 | 0.004 | 0.004 | 0.003 | 0.003 |
| | BIC | -1053.9 | -1087.0 | -1086.3 | -1076.3 | -1064.7 | -1045.5 |
| | *Years* | | *1941* | *1918, 1941* | *1891, 1918, 1941* | *1891, 1918, 1941, 1963* | *1891, 1918, 1941, 1963, 1986* |
| LE Italy | RSS | 0.014 | 0.011 | 0.009 | 0.008 | 0.008 | 0.009 |
| | BIC | -934.0 | -953.1 | -955.8 | -945.4 | -927.7 | -902.6 |
| | *Years* | | *1944* | *1920, 1986* | *1920, 1944, 1986* | *1898, 1920, 1944, 1986* | *1898, 1920, 1942, 1964, 1986* |
| LE France | RSS | 0.017 | 0.014 | 0.012 | 0.012 | 0.011 | 0.012 |
| | BIC | -899.5 | -912.0 | -908.5 | -893.3 | -882.4 | -854.0 |
| | *Years* | | *1946* | *1946, 1986* | *1916, 1946, 1986* | *1893, 1915, 1946, 1986* | *1893, 1915, 1942, 1964, 1986* |

## Table A-8: Prados de la Escosura tests for exogenous breaks

| | Spain: break 1937 | Spain: break 1941 | Italy: break 1947 | Italy: break 1944 | France: break 1946 |
|---|---|---|---|---|---|
| | **Modified LE** | | | | |
| Mod. LE (t-1) | -0.509 | -0.403 | -0.052 | -0.067 | -0.316 |
| | (0.123)*** | (0.112)*** | -0.101 | -0.106 | (0.099)*** |
| Mod. LE (t-2) | -0.256 | -0.173 | 0.126 | 0.139 | -0.217 |
| | (0.135)* | -0.119 | -0.102 | -0.109 | (0.107)** |
| Mod. LE (t-3) | -0.159 | -0.136 | -0.131 | -0.043 | 0.037 |
| | -0.134 | -0.119 | -0.103 | -0.111 | -0.11 |
| Mod. LE (t-4) | -0.139 | -0.146 | -0.368 | -0.301 | 0.218 |
| | -0.121 | -0.115 | (0.105)*** | (0.111)*** | (0.105)** |
| Break | 0.004 | 0.01 | 0.002 | 0.008 | 0.009 |
| | -0.003 | (0.003)*** | -0.004 | (0.003)** | (0.005)* |
| Break * M. LE (t-1) | 0.323 | 0.044 | -0.085 | -0.002 | 0.409 |
| | (0.171)* | -0.174 | -0.18 | -0.174 | (0.189)** |
| Break * M. LE (t-2) | 0.441 | 0.22 | 0.236 | 0.18 | 0.268 |
| | (0.180)** | -0.183 | -0.177 | -0.173 | -0.181 |
| Break * M. LE (t-3) | 0.024 | -0.069 | 0.316 | 0 | -0.172 |
| | -0.183 | -0.184 | (0.186)* | -0.176 | -0.18 |
| Break * M. LE (t-4) | 0.14 | 0.094 | 0.442 | 0.239 | -0.251 |
| | -0.174 | -0.173 | (0.178)** | -0.175 | -0.179 |
| Constant | 0.004 | 0.003 | 0.003 | 0.002 | 0.001 |
| | (0.002)*** | (0.001)** | (0.002)* | -0.002 | -0.002 |
| R2 | 0.21 | 0.23 | 0.21 | 0.19 | 0.17 |
| N | 143 | 143 | 143 | 143 | 143 |
| | **GDP** | | | | |
| GDP (t-1) | -0.067 | 0.105 | 0.395 | 0.14 | 0.095 |
| | -0.123 | -0.097 | (0.117)*** | -0.151 | -0.099 |
| GDP (t-2) | -0.169 | -0.135 | -0.332 | -0.103 | -0.127 |
| | -0.123 | -0.098 | (0.124)*** | -0.158 | -0.102 |
| GDP (t-3) | 0.035 | -0.064 | -0.197 | 0.105 | 0.209 |
| | -0.123 | -0.099 | -0.134 | -0.158 | (0.101)** |
| GDP (t-4) | -0.14 | -0.154 | -0.213 | -0.098 | -0.015 |
| | -0.124 | -0.1 | -0.149 | -0.163 | -0.104 |
| Break | 0.013 | 0.006 | 0.001 | 0.02 | 0.029 |
| | -0.009 | -0.012 | -0.011 | (0.009)** | (0.014)** |
| Break * GDP (t-1) | 0.436 | 0.181 | 0.156 | 0.405 | 0.341 |
| | (0.169)** | -0.206 | -0.178 | (0.185)** | (0.193)* |
| Break * GDP (t-2) | 0.173 | 0.21 | 0.346 | -0.11 | -0.302 |
| | -0.175 | -0.209 | (0.179)* | -0.2 | (0.180)* |
| Break * GDP (t-3) | -0.2 | 0.003 | 0.267 | -0.189 | 0.117 |
| | -0.175 | -0.209 | -0.182 | -0.201 | -0.185 |
| Break * GDP (t-4) | 0.262 | 0.397 | 0.294 | 0.167 | -0.31 |
| | -0.168 | (0.189)** | -0.183 | -0.193 | (0.173)* |
| Constant | 0.01 | 0.008 | 0.007 | 0.004 | 0.003 |
| | -0.006 | -0.005 | -0.005 | -0.006 | -0.007 |
| R2 | 0.18 | 0.15 | 0.3 | 0.27 | 0.18 |
| N | 143 | 143 | 143 | 143 | 143 |