

Convergence in infant mortality rates: the Spanish regions case

Convergencia en tasas de mortalidad infantil: el caso de las regiones españolas

Cristina Martínez-Asenjo and Antonio Montañés

Universidad de Zaragoza, España

Abstract

This paper studies the evolution of infant mortality rates in Spanish regions. Our results allow us to reject the null hypothesis of convergence, but we find the presence of several convergence clubs, which implies the existence of different patterns of behavior. We also find some degree of connection between the Great Recession and the evolution of infant mortality rates. The population density, the evolution of the labor market and the percentage of the female population that admits to having drunk alcoholic beverages in the previous two weeks are the factors that help us to explain the forces that drive the creation of the clubs.

Keywords: Convergence analysis, Phillips-Sul, infant mortality rate, Great Recession.

Resumen

Este trabajo estudia la evolución de las tasas de mortalidad infantil en las regiones españolas. Nuestros resultados nos permiten rechazar la hipótesis nula de convergencia, pero podemos encontrar la presencia de varios clubes de convergencia, lo que implica la existencia de varios patrones de comportamiento estadísticamente diferentes. También encontramos cierto grado de conexión entre la Gran Recesión y la evolución de las tasas de mortalidad infantil. La densidad de población, la evolución del mercado de trabajo y el porcentaje de mujeres que admiten beber alcohol son factores adicionales que nos ayudan a explicar las fuerzas que impulsan la creación de los clubes.

Palabras clave: Análisis de convergencia, Phillips-Sul, tasa de mortalidad infantil, Gran Recesión.

INTRODUCTION

The infant mortality rate (IMR hereafter) is one of the main health indicators collected by various international organizations. The importance of this indicator is demonstrated by the fact that the United Nations explicitly included the reduction of the child mortality rate as a target of the Millennium Development Goals, seeking a reduction of two thirds of the child mortality rate in 2015 (United Nations 2000). Likewise, this organization has again emphasized the role of the fight against child and maternal mortality as a very important part of its Sustainable Development Goals, with the aim of eradicating preventable deaths of newborns and children under 5 by 2030 (United Nations, 2015).

Given the relevance of the IMR as an indicator of the health status of a country, and thus its welfare, the existence of a large literature on the econometric modeling of the IMR using different time series techniques is not surprising. For example, Bishai (1995), Dreger and Reimers (2005), and Erdogan *et al.* (2013), among others, apply unit root tests obtaining different results, while Caporale and Gil-Alana (2014) use fractional integration techniques. Conley and Springer (2001), Silva (2007), and Siah and Lee (2015) also allow for structural breaks in IMR without reaching a general conclusion, although it is true that great advances have been made in reducing the IMR.

In fact, we should note that the efforts made to achieve the reduction in the IMR has been remarkable (the global under-5 mortality rate declined by more than half in 1990-2015, whilst child deaths fell from 90 to 43 deaths per 1000 live births in this same period). However, this reduction has not affected all countries in the same way. This conclusion is supported by the results of Martínez and Montañés (2017) who demonstrated that worldwide child mortality rates do not converge, but that the presence of several patterns of behavior can be observed. This is not very surprising, given that the sample included very different countries. These authors found statistical differences even among European countries, which can be grouped into different convergence clubs. This result is additionally supported by some previous analysis. For instance, Nixon (2000), found different patterns of behavior when analyzing σ and β convergence in EU countries, while Gil-Alaña *et al.* (2017) observed important differences in the time series properties of the child mortality rates of 37 OECD countries. Dreger and Reimers (2005) applied a unit root test to IMR using a sample of 21 OECD countries from 1975 to 2001, finding inconclusive

results on the stationarity of the series. None of these previous studies are compatible with the convergence of these rates.

However, the interpretation of the results achieved from an international comparison of child mortality rates is often handicapped by the noticeable differences between the health policies and health systems of these countries. For instance, it is not easy to compare the results of Spain, Italy and Portugal, whose health policies are based on National Health Care systems, with those of France, Germany and the United Kingdom, whose Health Care systems are based on a social insurance system. We can also find disparities within these two groups. Therefore, it is possible that the differences in the reduction of the IMR have been caused by the disparity of the health systems.

We would expect that the regional analysis of the IMR of a given country should offer more evidence of convergence. In this regard, Bishai (1995), who studied the IMR in Sweden, the UK and the USA, Silva (2007) in Australia, Sidebotham *et al.* (2014) in the UK and Wales or Latto (2015) in Finland, among others, cast some doubts on this expectation and offer evidence of regional differences in the IMR. Something similar occurs for the case of Spain, considered in the present study. Given that all the regions have quite similar health systems and socioeconomic conditions, the IMR of the Spanish regions should be similar. However, this does not seem to be the case. The seminal works of Regidor *et al.* (1994, 1995) and Regidor *et al.* (2002) find remarkable differences in both infant and adult mortality patterns of behavior across the Spanish regions. Moreover, these authors also offer evidence of the importance of socio-economics factors to explain these disparities.

In spite of the unquestionable interest of the above-mentioned papers, we consider that they do not totally exploit the time series properties of the variables. Consequently, their results are not time consistent. For example, the presence of trends in the IMR could lead us to observe some very interesting phenomena, such as the possible existence of stochastic convergence. This concept is commonly employed in economics to explain the growth of economies. We should note that Barro and Sala-i-Martin (1991, 1992) introduced the notion of convergence to assess whether poor regions (or countries) grow faster than rich ones, implying that they will catch up (β -convergence) in the long-run, or whether the dispersion of income diminishes over time (σ -convergence). Montero-Granados *et al.* (2007) apply this methodology to an analysis of the IMR in Spanish regions from 1975-2000, finding a significant increase in its dispersion. We propose to

adapt both concepts to the case of IMR and to determine whether the regions with the highest infant mortality rates have converged towards those with the lowest rates applying a novel methodology which admits transitional heterogeneity and, moreover, is flexible with the time series properties of the variables. Furthermore, the recent advances in this type of study allow us to determine the presence of multiple patterns of behavior. The regions can be grouped into different convergence clubs and, subsequently, we can try to explain how these clubs are created.

Against this background, our aim is to use time series tools to analyze the behavior of the Spanish regional IMRs, paying special attention to the study of the convergence hypothesis which could provide information about the existence of regional differences in this rate. To that end, the rest of the paper is organized as follows. Section 2 describes the data base. The methodology for testing for the null hypothesis of convergence is reported in section 3, along with the results of its application. Section 4 discusses the factors that can help to explain the disparities previously found. The paper ends with the main conclusions.

DATA BASE DESCRIPTION

The regional IMRs have been taken from the Spanish Institute of Statistics. This variable is defined as the ratio of the number of deaths in the first year of life over the number of live births occurring in the same population during the same period of time. The data are available for the 17 Spanish regions and cover the 1975-2017 period. Table 1 includes the acronyms of these regions and several descriptive statistics.

If we consider the evolution of the total Spanish IMR, we can observe that it declined from 18.9 in 1975 to 2.7 in 2017, following the general pattern of behavior of developed countries. However, differences can be seen if we split the sample. The growth rate is -5.6 per cent for 1975-1999, whilst it is -2.7 per cent for 2000-2017. The rate slightly reduces (in absolute terms) to -2.6 per cent for 2000-2012, when the Spanish government took drastic decisions which involved serious cuts in public expenditure, including the health services. After these economic decisions were implemented, we can observe that the average growth rate of 2013-2017 is no longer negative. Thus, the cuts in health expenditure seem to have negatively affected the evolution of the Spanish infant mortality rate, at least from an aggregate point of view.

Table 1: Descriptive analysis of the Spanish regional IMR

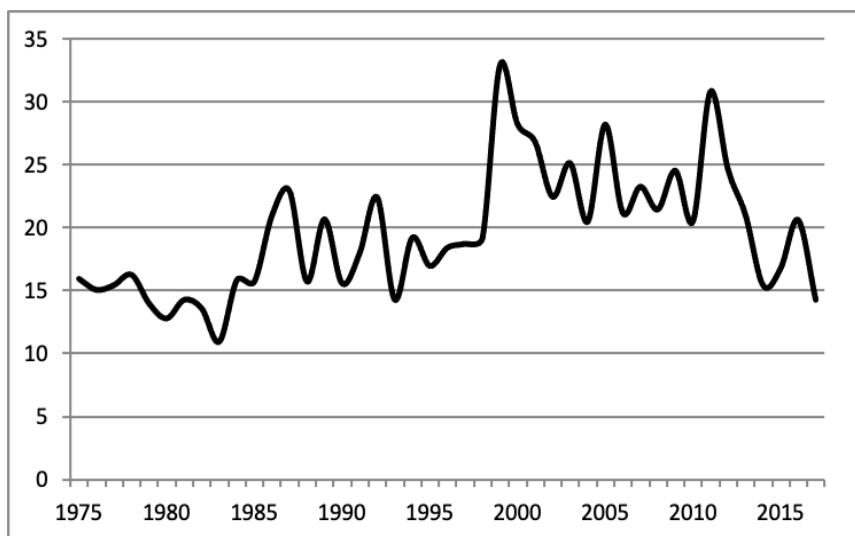
Region	Acronym	min	max	g_{7517}	g_{7599}	g_{0017}	g_{1317}
Andalucía	AND	2.7	21.7	-4.4%	-5.6%	-2.5%	0.0%
Aragón	ARA	1.8	15.8	-4.3%	-3.9%	-5.2%	5.8%
Asturias	AST	1.6	20.8	-4.2%	-6.5%	-0.5%	13.9%
I. Baleares	BAL	2.5	16.5	-3.8%	-5.2%	-2.4%	2.5%
Canarias	CAN	2.4	20.1	-4.2%	-5.5%	-4.2%	4.4%
Cantabria	CAB	1.9	20.7	-4.6%	-8.9%	1.5%	-4.2%
Castilla - La Mancha	CLM	2.2	24.0	-4.4%	-6.9%	-1.0%	1.7%
Castilla y León	CYL	2.1	21.0	-4.6%	-6.8%	-2.2%	3.0%
Cataluña	CAT	2.4	15.3	-4.2%	-4.8%	-2.1%	-0.6%
C. Valenciana	VAL	2.4	16.3	-4.1%	-5.5%	-1.6%	2.4%
Extremadura	EXT	2.0	22.9	-4.5%	-6.2%	-2.5%	9.5%
Galicia	GAL	2.0	23.6	-5.4%	-8.6%	-3.8%	0.9%
Madrid	MAD	2.4	14.8	-4.1%	-5.4%	-3.1%	-3.6%
Murcia	MUR	2.8	23.4	-4.8%	-4.5%	-5.1%	-4.6%
Navarra	NAV	1.6	18.8	-5.0%	-8.7%	-3.7%	-3.3%
País Vasco	PAC	2.2	18.6	-4.6%	-5.2%	-1.3%	1.3%
La Rioja	LAR	1.1	19.0	-4.2%	-4.0%	-2.0%	-2.5%
Total Spain	SPA	2.7	18.9	-4.4%	-5.6%	-2.7%	0.3%

This table reflects some descriptive statistics of the Spanish regional IMR. The name of the regions and their respective acronyms are shown in columns 1 and 2. Columns 3 and 4 present the minimum and maximum values across the total sample (1975-2017). Columns 5-8 reflect the values of g_{xxyy} , with g_{xxyy} being the average growth rate of the XX-YY period.

Source: own elaboration.

If we now turn to the Spanish regions, we observe that CYL presents the highest IMR in 1975 (24.0), 5 points above the Spanish rate (18.9). By contrast, MAD reflects the lowest rate at the beginning of the sample (14.8), just 4 points below the national rate. At the end of the sample, CYL again presents the highest rate (3.4), whilst NAV now exhibits the lowest rate (2.1). We can also observe that the differences between the regional IMRs reduces.

The clear reduction in the rates could be compatible with the presence of convergence in the sense that, if all the regions presented similar IMRs at the end of the sample, then the variance would be reduced, suggesting evidence of σ -convergence. To verify this, the evolution of the coefficient of variation across the sample is graphically represented in Figure 1.

Figure 1: σ -convergence analysis for infant mortality rates in Spanish regions

This table reflects the coefficient of variation of the IMR of the Spanish regions for 1975-2017.
Source: own elaboration.

It is true that we can observe an initial reduction in the coefficient of variation for 1975-1983, but it later begins to grow until 2012 when the trend changes and the coefficient of variation diminishes to the values of the 1980s. Therefore, an analysis of Figure 1 would not lead us to think that the Spanish regional IMRs have converged. Rather, this figure leads us to consider that they may have diverged. However, this previous analysis is far from conclusive and, consequently, we should employ more powerful tools in order to test for convergence, which is the aim of the next section.

TESTING FOR CONVERGENCE IN INFANT MORTALITY

The previous analysis has shown the disparities that exist between the IMRs of the Spanish regions, which casts serious doubts on the existence of convergence. However, it would be more appropriate to test for the convergence hypothesis instead of relying on a figure to determine whether this phenomenon has occurred. To do so, we have followed the recent papers of Phillips and Sul (2007, 2009) (PS hereafter) in which they develop a framework that allows us, first, to test for the convergence hypothesis and, if this hypothesis is rejected, to estimate the number of convergence clubs.

Following these authors, let us consider that X_{it} represents the log of the IMR considered in this paper, with $I = 1, 2, \dots, 17$ (the 17 Spanish regions) and $t = 1975, \dots, 2017$. This variable can be decomposed as $X_{it} = \delta_{it} \mu_t$, where μ_t and δ_{it} are the common and the idiosyncratic component, respectively. PS suggest testing for convergence by analyzing whether δ_{it} converges towards δ . To do so, they first define the relative transition component:

$$h_{it} = \frac{X_{it}}{N^{-1} \sum_{i=1}^N X_{it}} = \frac{\delta_{it}}{N^{-1} \sum_{i=1}^N \delta_{it}} \quad (1)$$

In the presence of convergence, h_{it} should converge towards unity, whilst its cross-sectional variation (H_{it}) should go to 0 when T goes toward infinity,

$$H_{it} = N^{-1} \sum_{i=1}^N (h_{it} - 1)^2 \xrightarrow{As} 0, \text{ as } T \xrightarrow{as} \infty \quad (2)$$

PS test for convergence by estimating the following equation:

$$\log \frac{H_1}{H_t} - 2 \log[\log(t)] = \alpha + \beta \log(t) + u_t, \quad t = [rT] + 1, \dots, T \quad (3)$$

with r taking values in the (0.2, 0.3) interval, as PS suggest. Equation (3) is commonly known as the log- t regression. The null of convergence is tested by way of a standard t -statistic and, according to PS, the null hypothesis is rejected whenever this t -statistic takes values lower than -1.65. If we reject convergence, we can use the PS algorithm to consider the existence of clubs.¹

The results we have obtained are presented in Panel A of Table 2. This table reflects the results for the total IMR. We have also considered the pre-Great Recession sample (1975-2007). We can first observe that the null hypothesis of convergence is rejected for both samples. This leads us to conclude that the IMRs of the Spanish regions do not follow a single pattern of behavior.

¹ See Phillips and Sul (2007, 2009) or Panopoulou and Pantelidis (2013) for a description of the use of this algorithm.

Table 2: Testing for convergence in the IMR of the Spanish regions

Panel A. Testing for convergence	
Total sample (1975-2017)	-3.80 ^a
Pre Great Recession sample (1995-2007)	-22.26 ^a
Panel B. Estimated convergence clubs. Total sample	
Club 1	
AND, ARA, AST, BAL, CAN, CAB, CYL, CAT, CVA, EXT, MAD, MUR, PAV	
Club 2	
CLM, GAL, LAR	
Divergent Region	
NAV	

This table presents the results of applying the Phillips and Sul methodology to the Spanish regional IMR. Panel A shows the results of the PS log-t ratio employed for testing the null hypothesis of convergence. Panel B displays the members of each estimated club.

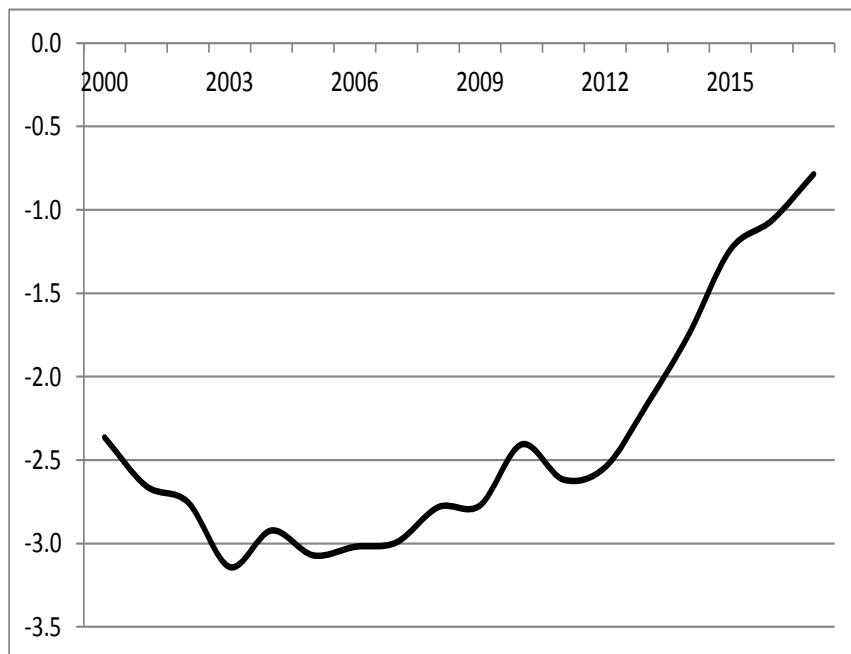
^a implies the rejection of the null hypothesis of convergence at a 5% significance level.

Source: own elaboration.

Rather, they diverge and different patterns of behavior probably co-exist. Furthermore, if we compare the estimated values of the parameter β for the two samples, we can see that they are clearly different, the estimation of β for the pre-Great Recession being approximately double the estimated value for the total sample. This would imply that the evidence against the null hypothesis was greater for 1975-2007 than for the total sample, inducing us to think that the cuts in health services since 2008, derived from the Great Recession, have affected the evolution of the IMR. In order to study this question more deeply, we have estimated the β parameter for the samples that cover the period 1975-N, with $N = 2000, 2001, \dots, 2017$. Figure 2 reflects the evolution of the estimation of the parameter β . We can observe that it was around -3.0 until 2007, whilst this value increased during 2008-2017, especially since 2012. This result implies that the evidence against the null hypothesis of convergence reduced during the Great Recession period. Therefore, the policies that aimed to reduce public expenditure, especially in the health services, affected the convergence process, diminishing the disparities in the IMR between the Spanish regions. Moreover, if we assume that the recent trend will continue, we could expect these disparities to disappear in the near future. However, the convergence direction is not clear and it is possible that the regions with the lowest IMRs become closer to those with the largest ones. If this is the

case, it could be interpreted as an adverse effect of the recent health cuts. We will come back to this point later.

Figure 2: Evolution of the estimation of the parameter β



This figure reflects the evolution of estimation of the parameter β in equation (3) when the sample covers the period from 1975 to N, with N= 2000, 2001, ..., 2017.

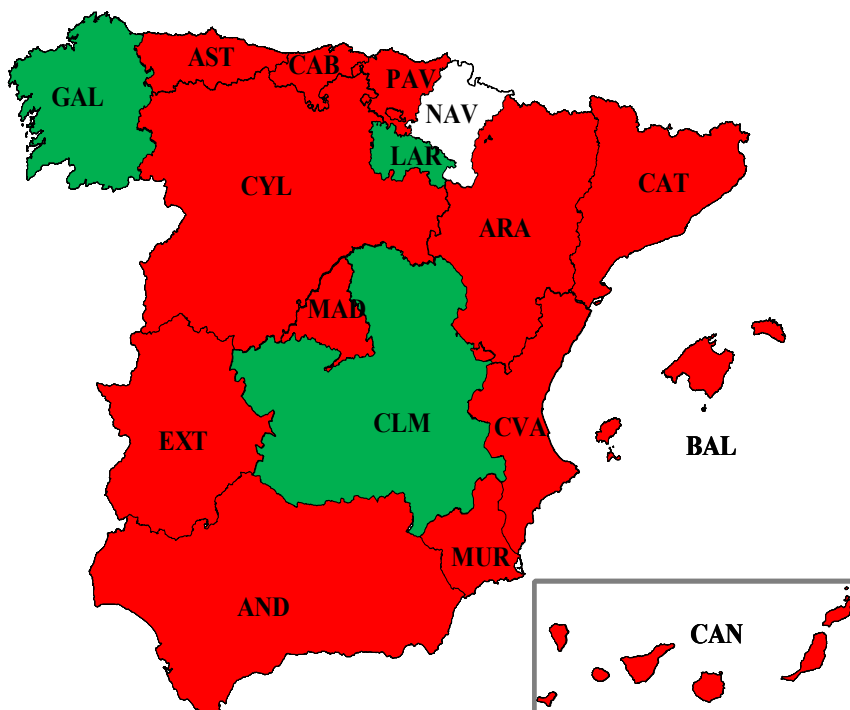
Source: own elaboration.

Once we have rejected the convergence null hypothesis, we should consider the possible presence of different convergence clubs. To that end, we can employ the PS algorithm. The results we have obtained, after testing whether the adjacent clubs can be joined, are presented in Panel B of Table 2.

The analysis of this table permits us to observe the presence of different patterns of behavior in the IMR of the Spanish regions, finding 2 different clubs. Figure 3 maps these clubs in different colors. We can see the evolution of the different clubs by generating an index that takes the average values of the IMR of the regions included in the different clubs. This is presented in Figure 4. It is clear that clubs 1 and 2 evolve in a different manner. The values of club 2 are the greatest until 1999.

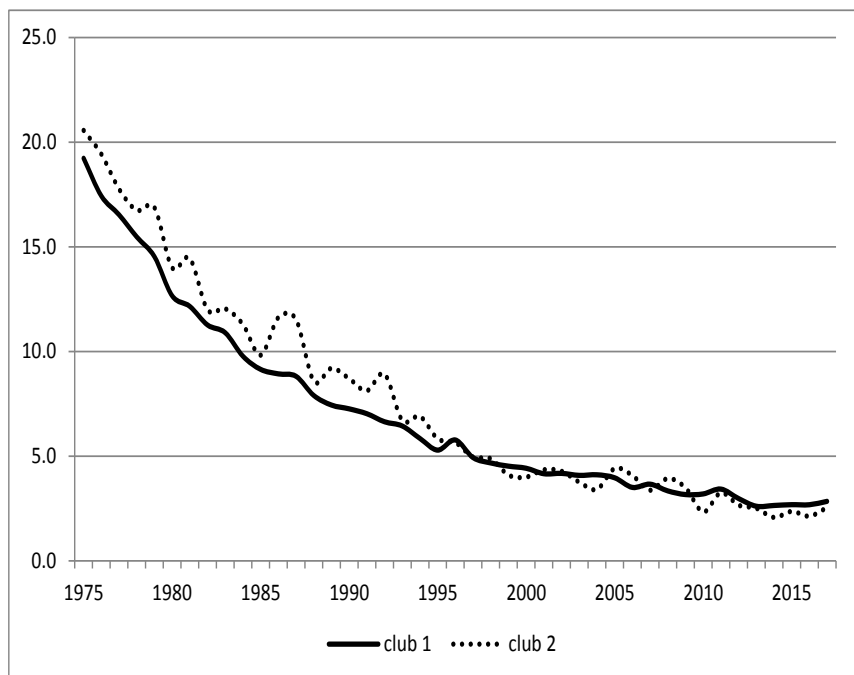
Since then, the club 1 commonly exhibits the greatest values, especially since 2010. However, the differences are significant for 2013-2017. Club 1 shows an average growth rate of 1.7 per cent, while the values of club 2 slightly vary. This result again warns us about the possible negative effect of the cuts in health expenditure on the evolution of the IMR in Spain, influencing the convergence process in the opposite direction to what would be desirable.

Figure 3: Estimated convergence clubs



This figure presents the estimated clubs.
 Club 1 in red Club 2 in green
 Source: own elaboration.

Figure 4: Average values of the total IMR in convergence clubs 1-2



This figure presents the evolution for the average total IMR of Clubs 1-2 when the 1975-2017 sample is considered.

Source: own elaboration.

WHAT ARE THE FORCES THAT DRIVE THE CREATION OF CLUBS?

The previous section has shown that the IMRs of the Spanish regions do not follow a single pattern of behaviour across the sample considered. Rather, we can observe multiple patterns. The next step is to investigate the sources of these differences. We should bear in mind that many factors have been used to try to explain such differences. For instance, some economic factors are commonly employed to justify differences in child mortality. The Gross Domestic Product (GDP hereafter) has frequently been used to explain the evolution of child mortality reaching a general consensus of the inverse relationship between the two variables. An example is the paper by Gbesemete and Jonsson (1993), who found that infant mortality has a negative and statistically significant relationship with the level of income in low-middle income African states. In the same way, Alves and Belluzzo (2004), at the municipal level in Brazil, Hakobyan *et al.* (2006) in

the Armenian case, Renton *et al.* (2012), who extend the paper by Wang *et al.* (1999) for 102 developing countries, and Subramaniam *et al.* (2016) in the case of the older ASEAN-4 economies, all allude to per capita income as an important determining factor for reducing infant mortality. Ko *et al.* (2014) also consider the labour market as a possible explanatory variable, concluding that low parental employment status is associated with higher IMR.

Some of the above-mentioned authors, among others, use educational levels as another important factor to understand the evolution of mortality, especially maternal or female education. We can cite the paper by Mondal *et al.* (2009), who pointed out that the risk of infant mortality in Bangladesh is lower among women with secondary and higher education than those having no education, Defo (1996), who found that the lack of maternal schooling explains all the excess childhood mortality in the most vulnerable groups of children in Cameroon, or Bourne and Walker (1991), whose results stress the importance of mothers' education to reduce infant mortality in India. Also, Alves and Belluzzo (2004) highlight education as the most important factor for reducing infant mortality, their results being supported by the studies of Hakobyan *et al.* (2006) and Renton *et al.* (2012).

Female fertility is another important indicator of infant mortality thoroughly examined in the literature. Most studies found a positive relationship between child mortality and female fertility. For example, Schultz (1993), among others, pointed out the positive bidirectional relationship between fertility and infant mortality. However, some recent analyses have found a negative relationship between these two variables, as is the case of Hondroyiannis and Papapetrou (2002) for Finland and Narayan and Peng (2007) for Japan.

Demographic factors should also be taken into account. There is a large body of literature which associates health with place of residence. For instance, Jankowska *et al.* (2013), Fink *et al.* (2014) and Quansah *et al.* (2016) have recently found evidence of the comparative advantages of urban over rural residence. This is mainly due to the improvement in living standards offered by urban zones, namely, access to better health care services, education and housing. However, we should note that the influence of the urban population on the IMR seems to have weakened in recent years, if we consider the results of Kimani-Murage *et al.* (2014). Root (1997), Dye (2008) or Hathi *et al.* (2017) also find a negative relationship between pop-

ulation density and infant mortality connected to better healthcare access and sanitation.

Finally, we should consider that some authors, such as Hanmer *et al.* (2003) among others, have found a strong negative relationship between child mortality and access to healthcare.

In order to reflect all these potential explanatory factors, the variables that we have selected are presented in Table 3. The socioeconomic variables selected are per capita GDP and the total unemployment rate; the health factors are the percentage of the female population that admits to smoking daily, the percentage of the female population with a body mass index greater than 30, and the percentage of the female population that recognizes having drunk alcoholic beverages in the previous two weeks; the demographic factors are the fertility rate and the population density. We have also considered the terrain roughness, the per capita public health expenditure, the private medical insurance rate and the migration rate.

Table 3: Average values of the explanatory variables

	Club 1	Club 2
Terrain Ruggedness	193.6	154.1
Population density	168.1	56.8
GDP (pc)	19,393	17,765
Unemployment rate	17.9	16.5
Migration rate	7.5	5.7
Public Health Exp. (pc)	560.7	544.1
Private medical insurance rate	0.7	0.4
Female Obesity rate	17.6	19.8
Female smoking rate	20.3	19.0
Female alcoholic beverage rate	38.8	35.5
Fertility global rate	46.9	47.7

This table presents the average values of the different explanatory variables employed in the probit estimation.

Source: own elaboration.

We have estimated an ordered probit model. The dependent variable is constructed in such a manner that it takes the value i if the region has been assigned to the i -th club, excluding the non-convergent regions. The final specification has been selected by using a general-to-particular strategy where the non-significant variables have been iteratively removed. We should also note that the final specification includes the variables that are

more helpful to explain why a region is included in either Club 1 or Club 2. As a consequence, the final specification is composed of the variables that exhibit the highest discriminatory power, as can be observed by analyzing the values shown in Table 3.

Table 4: Estimation of the ordered probit model

	IMR
Female alcoholic bev. consumption	-0.23 (-1.99)
Population density	-0.006 (-1.94)
Total Unemployment rate	-0.46 (-1.86)
Pseudo R ²	0.55
Number of cases correctly predicted	14 (82.4%)

This table reflects the estimation of an ordered probit model for the total IMR. The dependent variable is constructed by assigning the value i to the regions in club i , with $i = 1, 2$. The values in parenthesis are the robust t-ratios for testing the single significance of the parameters.

Source: own elaboration.

The estimated model is presented in Table 4. The first factor that helps us to explain the creation of the estimated clubs is alcohol consumption. The higher the percentage of female people in a region that have drunk alcoholic beverages in the previous two weeks, the higher the probability of this region being included in club 1 and, consequently, the higher the IMR, as predicted by O'Connor and Whaley (2007). The second factor is the population density. The higher the population density, the higher the probability that a region will belong to the club with the highest IMR. This result is apparently somewhat different to the those obtained by Root (1997), Dye *et al.* (2008) or Hathi *et al.* (2017), who find that the higher the population density, the lower the IMR. However, we can reconcile these results if we take into account that, as mentioned above, the estimation of the probit model merely helps us to explain the forces that may drive the creation of the clubs and should not be used to infer causality. Besides this, Carrillo and Jorge (2017) find that the three regions included in club 2 show a high degree of health efficiency, when this is measured in terms of several health outcome indicators, including the infant mortality rate. Then, we should conclude that these regions use their health resources very successfully in spite of the distortions that their low population density may generate on

the health of their populations. As a consequence, their IMRs are lower than those in the rest of the Spanish regions.

The economic variables also play an important role in the model. The total unemployment rate is included, with this variable commonly used to reflect the cyclical component of an economy. So, according to our results, the higher the total unemployment rate of a region, the more probable the region is included in club 1. These results support those reported by Ko *et al.* (2014), who found that a low parental employment status was associated with a higher IMR. This fact is important, given that it connects the economic situation to the evolution of the infant mortality rate. It seems sensible to accept that those regions more influenced by the Great Recession have exhibited a very negative evolution of the unemployment rate and, additionally, have had to adopt very serious cuts in public services in general, and in health expenditure in particular. Then, the results presented in Table 4 would again link the consequences of the Great Recession with the increase in the IMR across some of the Spanish regions. However, we also consider that more studies should be carried out in this regard, to better understand the relationship between health expenditure and the IMR. This point is left for future research.

CONCLUSIONS

This paper analyses the evolution of Spanish regional IMRs by testing for the null hypothesis of convergence. Our results lead us to reject this hypothesis, which implies that these mortality rates do not share a similar pattern of behavior. Rather, we can observe the presence of two different convergence clubs.

We have also considered the possible effect of the cuts in health services provoked by the Great Recession on the evolution of the IMR. Whilst it is true that the null hypothesis of convergence is rejected even when the sample only considers the pre-Great Recession period, we can observe that the increment of the sample reduces the evidence against this null hypothesis. Thus, there seems to be a connection between economic decisions and the evolution of the IMR. Moreover, if the present trend continues, we could expect convergence in the near future. However, this convergence process would go in the undesirable direction, given that the regions with the lowest IMR would increase their rates, catching-up the regions with the highest IMR. This can be better appreciated by observing the values shown in Figure 4, where we can see that the average values of both clubs

increase but the distance between them is considerably reduced at the end of the sample.

Finally, we have estimated a model in order to know which forces drive the creation of the convergence clubs. Using an ordered probit, we observe that the probability of a region being assigned to club 1, the one with the highest IMR, grows with the number of female people who admit to having drunk alcoholic beverages in the previous two weeks, the population density and the total unemployment rate. The inclusion of this last variable could again suggest that the evolution of the Spanish economy in general and the cuts in the health services in particular are strongly related with the IMR. However, this last result should be interpreted with some caution and additional research needs to be carried out, especially an analysis of causality between these two variables.

Acknowledges

Funding: the authors acknowledge the financial support of the MEC, project ECO2012-37194, and of the Aragonese Government, project S34_20R. Conflict of interest: The authors declare that they have no conflict of interest.

REFERENCES

- Alves, D., and Belluzzo, W., 2004, *Demand for child health in Brazil: a household decision model*. Final seminar on child health, poverty and the role of social policies. Washington, DC: IDB.
- Barro R. and X. Sala-i-Martin, 1991, "Convergence across states and regions", in *Brookings Papers on Economic Activity*, 1, 107-158.
- Barro, R. and X. Sala-i-Martin, 1992, "Convergence", in *Journal of Political Economy*, 100, 223-251.
- Bishai, D., 1995, "Infant mortality time series are random walk with drift: are they cointegrated with socio economic variables?", in *Health Economics* 4, 157-167.
- Bourne, K. L., and Walker, G. M., 1991, "The differential effect of mother's education on mortality of boys and girls in India", in *Population Studies*, 45, 203-219.
- Caporale, G. and Gil-Alana, L.A., 2014, "Infant mortality rates: time trends and fractional integration", in *Journal of Applied Statistics* 42, 589-602.
- Carrillo, M., and Jorge, J. M., 2017, "DEA-like efficiency ranking of regional health systems in Spain", in *Social Indicators Research*, 133(3), 1133-1149.
- Conley, D. and Springer, KW., 2001, "Welfare state and infant mortality", in *American Journal of Sociology* 107, 768-807.

- Defo, B. K., 1996, "Areal and socioeconomic differentials in infant and child mortality in Cameroon", in *Social Science and Medicine*, 42(3), 399–420.
- Dreger, C. and Reimers, H., 2005, *Health care expenditures in OECD countries: A panel unit root and cointegration analysis*. IZA Discussion Paper Series 1469.
- Dye, C., 2008, "Health and urban living", in *Science*, 318, 766–769.
- Erdogan, E., Ener, M. and Arica, F., 2013, "The strategic role of infant mortality in the process of economic growth: An application for high income OECD countries", in *Procedia Social and Behavioral Sciences* 99, 19-25.
- Fink, G., Günther, I., and Hill, K., 2014, "Slum residence and child health in developing countries", in *Demography*, 51, 1175–1197.
- Gbesemete, K. P., and Jonsson, D., 1993, A comparison of empirical models on determinants of infant mortality: a cross-national study on Africa", in *Health Policy*, 24, 155–174.
- Gil-Alaña, L. A., Cunado, J., and Gupta, R., 2017, "Persistence, mean-reversion and non-linearities in infant mortality rates", in *Social Indicators Research*, 131, 393-395.
- Hakobyan, M., Mkrtchyan, A., and Yepiskoposyan, L., 2006, "Infant mortality in Armenia, 1992-2003", in *Economics and Human Biology*, 4, 351–358.
- Hanmer, L., Lensink, R., and White, H., 2003, "Infant and child mortality in developing countries: analyzing the data for robust determinants", in *The Journal of Development Studies*, 40(1), 101–118.
- Hathi, P., Haque, S., Pant, L., Coffey, D., and Spears, D., 2017, "Place and child health: the interaction of population density and sanitation in developing countries", in *Demography*, 1, 1-24.
- Hondroyannis, G., and Papapetrou, E., 2002, "Demographic transition in Europe", in *Economics Bulletin*, 10(3), 1–8.
- Jankowska, M. M., Benza, M., and Weeks, J. R., 2013, Estimating spatial inequalities of urban child mortality", in *Demographic Research*, 28(article 2), 33–62. doi:10.4054/DemRes.2013.28.2
- Kimani-Murage, E. W., Fotso, J. C., Egondi, T., Abuya, B., Elungata, P., Ziraba, A. K., and Madise, N., 2014, "Trends in childhood mortality in Kenya: the urban advantage has seemingly been wiped out", in *Health and place*, 29, 95-103.
- Ko, Y. J., Shin, S. H., Park, S. M., Kim, H. S., Lee, J. Y., Kim, K. H., 2014, "Effects of employment and education on preterm and full-term infant mortality in Korea", in *Public Health*, 128(3), 254–261.
- Latto, M., 2015, "Childhood mortality in Finland", in *Väitöskirja. Lääketieteenlaitos. Oulun yliopisto. Viitattu*, 7, 2016.
- Mondal, N. I., Hossain, K., and Ali, K., 2009, "Factors influencing infant and child mortality: A case study of Rajshahi District, Bangladesh", in *Journal of Human Ecology*, 26(1), 31–39.

Martínez, C. and Montañés, A., 2017, *Do international child mortality rates converge?* Working Paper. University of Zaragoza.

Montero-Granados R. and Juan de Dios Jiménez J.M., 2007, “Decentralisation and convergence in health among the provinces of Spain (1980–2001)”, in *Social Science and Medicine*, vol. 64, Issue 6, 1253–1264.

Narayan, P. K., and Peng, X., 2007, Japan’s fertility transition: empirical evidence from the bounds testing approach to cointegration”, in *Japan and the World Economy*, 19, 263–278.

Nixon J., 2000, *Convergence of health care spending and health outcomes in the European Union, 1960–95*, Centre for Health Economics, University of York.

O’Connor M.J. and Whaley S.E., 2007, “Brief Intervention for Alcohol Use by Pregnant Women”, in *American Journal of Public Health* 97, 252–258.

Phillips P C B, Sul D., 2007, “Transition modelling and econometric convergence tests”, in *Econometrica* 756: 1771–1855.

Phillips P C B, Sul D., 2009, “Economic transition and growth”, in *Journal of Applied Econometrics* 247: 1153–1185.

Quansah, E., Ohene, L. A., Norman, L., Mireku, M. O., and Karikari, T. K., 2016, “Social factors influencing child health in Ghana”, in *PloS one*, 11(1), e0145401.

Regidor E., Gutierrez-Fisac J. L. and Rodriguez C., 1994, *Diferencias y desigualdades en salud en España*, p. 145. Diaz de Santos, S. A., Madrid.

Regidor, E., Gutierrez-Fisac, J.L., Rodriguez, C., 1995, “Increased socioeconomic differences in mortality in eight Spanish provinces”, in *Social Science and Medicine*. 41,801–807.

Regidor, E., Calle, M.E., Domínguez, V., Navarro, P., 2002, “Inequalities in mortality in shrinking and growing areas”, in *Journal of Epidemiology and Community Health*, 56, 919–921.

Renton, A., Wall, M., and Lintott, J., 2012, “Economic growth and decline in mortality in developing countries: an analysis of the World Bank development datasets”, in *Public Health*, 126(7), 551–560.

Root, G., 1997, “Population density and spatial differentials in child mortality in Zimbabwe”, in *Social Science and Medicine*, 44, 413–42.

Schultz, T. P., 1993, “Mortality decline in the low-income world: causes and consequences”, in *American Economic Review*, 83(2), 337–342.

Siah, A. and Lee, G., 2015, “Female labour force participation, infant mortality and fertility in Malaysia”, in *Journal of the Asia Pacific Economy* 20, 4, 613–629.

Sidebotham, P., Fraser, J., Fleming, P., Ward-Platt, M., and Hain, R., 2014, “Patterns of child death in England and Wales”, in *The Lancet*, 384(9946), 904–914.

Silva, S., 2007, *A panel stationarity test for series with breaks in either level or trend*. School of Economics and Political Science, University of Sydney, NSW 2006.

Subramaniam, T., Loganathan, N., Yerushalmi, E., Devadason, E. S., and Majid, M., 2016, "Determinants of Infant Mortality in Older ASEAN Economies", in *Social Indicators Research*, 1-19.

United Nations, 2000, *United Nations Millennium Declaration*. Resolution adopted by the General Assembly. United Nations: New York, NY, USA.

United Nations, 2015, *Sustainable development goals. In Transforming Our World: The 2030 Agenda for Sustainable Development*. Resolution adopted by the General Assembly. United Nations: New York, NY, USA, 2015.

Wang J., Jamison D.T., Bos E., Preker A. and Peabody J., 1999, *Measuring country health performance: selected indicators for 115 countries*. Human Development Network Health and Nutrition Series 19407. Washington, DC: World Bank.

CURRICULAR INFORMATION OF THE AUTHORS

Cristina Martínez Asenjo

Doctora en Economía por la Universidad de Zaragoza. Es miembro del grupo de investigación CASSETEM. Su área de especialización es la econometría de la salud, con especial énfasis en el estudio de las propiedades temporales de los indicadores de salud más relevantes.

Email: crisma@unizar.es

Registro ORCID: <http://orcid.org/0000-0002-8326-1868>

Antonio Montañés

Doctor en Ciencias Económicas y Empresariales por la Universidad de Zaragoza. Es Catedrático de Universidad en el Departamento Análisis Económico de la Universidad de Zaragoza. Es autor de diversos trabajos en revistas internacionales de prestigio, siendo el análisis de series temporales su línea de especialización más reconocida.

Email: amontane@unizar.es

Registro ORCID: <http://orcid.org/0000-0002-5872-631X>

Appendix 1: Definition of the explanatory variables

Variable	Definition	Source
Terrain Ruggedness	Terrain Ruggedness Index	Fundación BBVA
Population density	Surface/population. 1975-2015 average.	Instituto Nacional de Estadística
GDP (pc)	Gross domestic product divided by population. 1980-2015 average.	Instituto Nacional de Estadística
Unemployment rate	2006-2016 average	Instituto Nacional de Estadística
Migration rate	Flow of immigration from abroad of a region divided by the total population of the region. 2008-2016 average	Instituto Nacional de Estadística
Public Health Exp. (pc)	Total public health expenditure divided by population. Average 1991-2010.	Fundación BBVA
Private medical insurance rate	Percentage of the population exclusively having private medical insurance.	Instituto Nacional de Estadística. Encuesta Nacional de Salud. Año 2011-2012
Female Obesity rate	Percentage of the female population older than 15 with a body mass index greater (or equal) than 30 kg/m ²	Instituto Nacional de Estadística. Encuesta Nacional de Salud. Año 2011-2012
Female smoking rate	Percentage of the female population older than 15 that admits smoking at least one cigarette a day.	Instituto Nacional de Estadística. Encuesta Nacional de Salud. Año 2011-2012
Female alcoholic beverage consumption rate	Percentage of the female population older than 15 that admits having drunk alcoholic beverages in the previous two weeks	Instituto Nacional de Estadística. Encuesta Nacional de Salud. Año 2011-2012
Fertility global rate	Total number of births by 1,000 women in fertile age (15-49). Average of the 1975-2015 period.	Instituto Nacional de Estadística.

Source: own elaboration.