The Changing Health Convergence For Life Expectancy and Spatial Interactions

Irene González Rodríguez (✉ igr663@alumnos.unican.es)

IDIVAL <https://orcid.org/0000-0002-6712-3254>

Marta Pascual Sáez

University of Cantabria: Universidad de Cantabria

David Cantarero Prieto

University of Cantabria: Universidad de Cantabria

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THE CHANGING HEALTH CONVERGENCE FOR LIFE EXPECTANCY AND SPATIAL INTERACTIONS

Irene González Rodríguez, Marta Pascual Sáez and David Cantarero Prieto

Health Economics Research Group, University of Cantabria and IDIVAL. Av. de los Castros s/n.,
39005, Santander (Cantabria), Spain

E-mail: igonzalez@idival.org
 marta.pascual@unican.es;
 david.cantarero@unican.es;

Corresponding Author:

Irene González Rodríguez, Health Economics Research Group, University of Cantabria. Av. de
los Castros s/n., 39005, Santander (Cantabria), Spain. Phone: + 34 942 201628.

Email: : igonzalez@idival.org

Abstract

Background: Health convergence between the European Union countries and Spanish provinces is studied considering the spatial interactions among several territories. Health status measured through life expectancy in four ways: life expectancy at birth, life expectancy at age 65, disability-adjusted life expectancy and healthy life expectancy based on self-perceived health. The period analyzed differs from one indicator to another, for the period 1998-2018.

Methods: Two kinds of convergence are studied: σ -convergence, through standard deviation, and absolute β -convergence, estimating a determined regression. Furthermore, the Moran Test is performed in order to know the degree of spatial dependencies and two models of spatial regression (Spatial Lag Model and Spatial Error Model) are used to include these dependencies in the absolute β -convergence estimation.

Results: Our findings suggest that there is a convergence process, both in σ and β , between the European Union countries and between the Spanish provinces. Therefore, dispersion is reduced, and growth rates have been higher where had lower life expectancy values at the beginning. On the other hand, β -convergence is higher in women among European countries and in men among Spanish provinces, whether we consider the model without spatial dependencies or the one which include them.

Conclusion: In general, there have been convergence processes (both in sigma and beta) inside Europe and Spain. Otherwise, the rise of the dispersion means that there is not a clear evidence about the trend in the following period. This study has a double contribution. First, it provides an updated vision of the health convergence. Secondly, it contributes to consider spatial econometrics in Health Economics research. These insights can be considered to reduce health population inequalities.

Keywords: spatial health econometrics, convergence, life expectancy, European Union.

Background

The increasing life expectancy of the older population in many countries makes ageing a key issue today. In this regard, one of the Governments objectives is to improve the quality and duration of population's lives and to promote good health among the population [1]. The state of people's health has traditionally been measured by life expectancy and mortality indicators. However, in recent years, other perspectives have been included and considered: quality of life, socio-economic environment, disease prevention, freedom from disability, etc. Even though people's health quality increases over time, disparities continue to exist in many ways.

The health convergence analysis allows to approximate the evolution of those inequalities among different territories. Convergence is understood as "*the reduction or equalizing of disparities*" [2]. Although Solow (1956) advanced the convergence hypothesis in his growth theory, the most famous studies are given by Baumol (1986) and Barro and Sala-i-Martin (1990, 1992, 1995) [3]. Inside the literature of growth empirics, there are different perspectives for measuring convergence. A significant number of papers broadly categorized it into two parts: σ -convergence and β -convergence. The first one occurs when the dispersion between the studied regions decreases, while the second one exists when the areas that have lower values of the selected indicator at the beginning of the period have the final highest growth rates. Most convergence analysis have been based on income indicators. However, there are not as many studies that analyze convergence regarding health inequalities due to the complexity of measuring people's health [4].

To deepen these convergence analyses, spatial econometrics have been used in recent years. The beginnings of spatial econometrics date back to the 1970s, when Jean Paelinck defined it as the part of applied econometrics that deals with estimation and specification problems arising from traditional econometrics [5]. By using these models, we have the possibility to consider the spatial dependence between observations, which often arises if data are collected on regions or countries located in space. In addition, these models are useful for assessing and quantifying the spillover effects in different geographical entities [6].

In this context, the two most important limitations of not considering space are spatial autocorrelation (or dependency) and spatial heteroscedasticity. When the presence of a certain phenomenon in a specific spatial unit makes it easily spread to its neighboring localities favoring its grouping, spatial autocorrelation will be positive. Meanwhile, when the presence of this factor hinders its propagation to neighboring towns, regions or countries, spatial autocorrelation will be negative [7]. Spatial heterogeneity refers to the relationship's variations in space. Most problems caused by spatial heterogeneity can be solved by standard econometric techniques [8]. For this reason, the spatial literature usually focuses on the analysis of spatial autocorrelation.

In recent years, a new branch of spatial econometrics has emerged that focuses on the health analysis: the Spatial Health Econometrics. It measures spatial relationships between agents at both the micro and macro levels, while testing health economic theories [9]. It is a good tool to reduce the degree of uncertainty about the complexity of the issues addressed by Health Economics. In this regard, the following paragraph review the most recent literature on the use of spatial econometrics in health convergence among European countries. Authors like Jaworska [10], Stańczyk [11], Mayou et al. [2] and Maynou and Saez [12] analyze life expectancy convergence in the European Union context. On the other hand, there are several authors who carry out this type of analysis but focus on the regions of a particular country, for example Eibich and Ziebarth [13], Zeren et al. [14] and Dearden et al. [15].

The main objective of this study is to estimate the health convergence between the European Union countries and Spanish provinces in the last years of the 20th century and first decades of

the 21st. Two types of convergence will be studied: σ and absolute β -convergence. Moran's Test will be used to find out if there is spatial dependence in the observations. If there is, the Spatial Lag Model (SLM) and the Spatial Error Model (SEM) will be used to estimate spatial absolute β -convergence. Additionally, the analysis is separated between men and women to show gender differences, as the difference in health patterns between the sexes presents a challenge in the field of public health [16]. The importance of the contributions of this study is twofold. First, it provides an updated vision of the health convergence in the last years. Secondly, it contributes to the incorporation of spatial econometrics in Health Economics research.

Methods

Data sources

Data were extracted from 4 different databases: World Bank Open Data [17], World Health Organization database [18], Eurostat [19, 20] and Spanish National Statistics Institute [21, 22]. It should be noted that the source of the European spatial data is Eurostat [23] and for Spanish data is GADM [24].

A small data pre-processing has been carried out to correct inconsistencies and transform them into simpler formats [25]. The main problem to correct it is the treatment of not available data (NaNs). The Romanian and Croatian time series for healthy life expectancy based on self-perceived health variable had 1 (year 2006) and 4 (years 2006-2009) NaNs, respectively. To resolve this, an attempt has been made to capture the trend through a rolling window. The accumulated growth rate for the following 7 years of the NaN has been calculated and extrapolated.

Measures / variables

To estimate health status with several dimensions and to give a broad vision of the life expectancy concept, four variables have been chosen: Life Expectancy at Birth (LEB), Life Expectancy at age 65 (LE65), Disability-Adjusted Life Expectancy (DALE) and Healthy Life Expectancy based on Self-Perceived Health (HLESPH). The study will be divided into two cases: the European Union countries and the Spanish provinces convergence analysis. For the first case, all 27 EU countries have been considered, to update the existing research on these countries. In the second case, the 50 Spanish provinces and the two autonomous cities (Ceuta and Melilla) will be analyzed. Spain has been chosen for the detailed analysis because it is one of the countries with the highest life expectancy value in recent years. Provinces data will be used to consider the spatial dependencies within the territory of this country. Furthermore, to make a more detailed research, a distinction will be made between men and women, in all cases.

Statistical analysis

Inside the literature of growth empirics this notion of convergence is divided into two broad categories: σ -convergence and β -convergence.

The first kind of convergence is estimated with the calculation of the standard deviation, and it occurs when *“the dispersion, measured say by the standard deviation of the income per capita logarithm across a group of countries or regions, declines over time”* [26]. In this study, the interest variable is life expectancy, so the Gross Domestic Product (GDP) per capita will be replaced for each selected definition of life expectancy.

The second measure of convergence occurs when the partial correlation between GDP growth per capita over time and its initial level value is negative. It is understood as the situation where *“poor economies tend to grow faster than rich ones”* [3]. The β -convergence is a necessary but not

sufficient condition for σ -convergence [27]. This study will focus on the analysis of absolute β -convergence (it occurs when all studied economies converge towards the same steady state). Following the methodology used by Sala-i-Martin [3], the following regression will be estimated with cross section data:

$$\ln\left(\frac{y_{i,t}}{y_{i,t_0}}\right) = a + b \cdot \ln(y_{i,t_0}) + u_{i,t} \quad (1)$$

where the dependent variable is the life expectancy growth rate, i are all the countries/regions in the sample, t_0 is the first year of study and t is the last one. The intercept a is assumed to be constant for all economies.

Based on this equation, there will be absolute β -convergence when the parameter b meets two requirements: be negative and statistically significant. Additionally, the annual rate of convergence to steady state is calculated as the negative value of the Napierian logarithm of 1 plus the coefficient b divided by the number of years in the period studied (T) [10], this is:

$$\beta = - \frac{\ln(1+b)}{T} \quad (2)$$

However, if the sample studied has spatial dependencies, our results may not be valid [8]. That is why, secondly, the methodology for the spatial data analysis will be used.

Among the literature of growth empirics, the most widely used test to measure spatial autocorrelation comes from a statistic developed by Moran [28]. The Moran's I statistic is used to detect the existence of spatial dependence in the samples studied. The null hypothesis of this contrast is the spatial non-autocorrelation. Based on the methodology used by Moreno et al. [8], it is formally defined as:

$$I = \frac{N}{S_0} \cdot \frac{\sum_{ij}^N w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{S_i^N (x_i - \bar{x})^2} ; i \neq j \quad (3)$$

where N is the sample size, S_0 is the scale factor equal to the addition of the weights, w_{ij} are the weights of the weight matrix W , x_i is the value of the interest variable x in the region i and $\bar{x}$ is the sample mean of the variable x . If the weight matrix is standardized, N will be equal to S_0 .

Furthermore, the interpretation of the statistic depends on its expected value, which is defined as:

$$E(I) = - \frac{1}{N-1} \quad (4)$$

If $I > E(I)$ there is positive spatial autocorrelation and if $I < E(I)$ there is negative spatial autocorrelation [10]. However, if the I value is close to zero, there will be an absence of spatial pattern, so the observations will be distributed randomly in space [29].

If there is spatial autocorrelation, the β -convergence will be re-estimated, but this time using two spatial regression who allows us to consider various spatial relationships between neighboring countries or regions [10]. Based on literature, there are several regression models that include spatial effects through dependent and / or independent variables or through the error term. To consider both cases, two different models will be used in this study.

First, it's assumed that it's the endogenous variable that is spatially correlated. In this sense, the SLM is applied, defined as:

$$y = pW_y + X\beta + u \quad (5)$$

where y is the vector of the interest variable growth rate (life expectancy) over the given time period, p is the autoregressive parameter that picks up the intensity of the interdependencies between the sample observations, W_y is the spatial delay of the variable y , X is the vector of the observations on the interest variable in logarithms in the initial year and u is the white noise error term.

Secondly, the SEM is used. This model considers that spatial autocorrelation is present in the error term and it is formally defined as:

$$y = X\beta + \varepsilon \quad (6)$$

$$\varepsilon = \lambda W_\varepsilon + \xi$$

where y and X are defined like the previous case, W is the spatial weight matrix, ξ is an error vector and λ is an autoregressive parameter in the error dependence model.

In addition, the conditions for absolute β -convergence are the same as in the model estimated by OLS: the estimation coefficient of X must have a negative sign and be significant [7]. It should be noted that the specification by OLS is no longer valid for spatial models, so the description is made using the Maximum Likelihood method, in accordance with the chosen model [10].

Results

Analysis of the European case

Sigma-convergence

Figure 1 shows the evolution of the standard deviation in all cases. The most striking feature is that, in all variables, the women's curve is like that of men, but it is underneath. This means that the dispersion among women is smaller than the same for men. The case of the HLESPH variable is the only one in which the men curve meets that of women.

All variables have a higher σ value in the first year studied than in the last one, except for men in DALE. Life expectancy at birth undergoes constant changes in trend, although LE65 is more variable. The trend of the disability-adjusted life expectancy curves is like those of the life expectancy at birth variable, although the streaks are somewhat more pronounced.

Figure 1: European Union σ -convergence

Source: Authors' estimations

Beta-convergence

As stated above, β -convergence happens when the partial correlation between the life expectancy growth over time and initial level is negative. In this case, we focus on the absolute β -convergence analysis, which will occur if the countries converge towards the same steady state [3].

Table 1 shows the results of returning the growth rate of the interest variable over the value in the initial year.

Table 1: European Union results of OLS (men / women)

OLS (men / women)	LEB		LE65		DALE		HLESPH	
	Estimate	t value	Estimate	t value	Estimate	t value	Estimate	t value
a (intercept)	1.28*** / 1.50***	4.84 / 4.85	0.24 / 0.72***	1.73 / 4.02	0.59* / 0.99**	2.50 / 3.64	1.13*** / 1.71***	6.82 / 7.33
b	-0.28 / -0.33***	-4.55 / -4.68	-0.04 / -0.21**	-0.83 / -3.47	-0.12* / -0.22**	-2.48 / -3.50	-0.25*** / -0.39***	-6.45 / -7.06
Converg. speed (annual)	1.65% / 2.02%		- / 1.87%		0.88% / 1.63%		2.92% / 4.89%	
R-squared	0.45 / 0.47		0.03 / 0.33		0.17 / 0.33		0.62 / 0.67	
Adjusted R-squared	0.43 / 0.46		-0.01 / 0.30		0.13 / 0.30		0.61 / 0.65	

***Significant at level 0.001; **Significant at level 0.01; *Significant at level 0.05; . Significant at level 0.1

Source: Authors' estimations

The *b* interest coefficient is negative and significant for men and women in all cases, except for men in LE65 (-0.04). For the most part, there is an absolute β -convergence process for males and females between in LEB, LE65, DALE and HLESPH. It can be affirmed that the countries that initially had the lowest life expectancy are those that have experienced higher growth rates and that the 27 EU countries converge towards the same steady state. It should be noted that HLESPH is the variable with the highest speed of convergence: 2.92% for men and 4.89% for women. In

all cases where absolute β -convergence exists, the necessary (but not sufficient) condition for the previous analyzed convergence (σ) to exist is fulfilled [27].

In Figure 2 we can see the negative trend between the life expectancy at age 65 growth rate and its value at the initial moment (2005).

Figure 2: European Union LE65 scatter plot (women)

All points in the figure correspond to one country (for ease of viewing, only the names of the countries with extreme values have been written).

Source: Authors' estimations

As previously anticipated, this traditional β -convergence approach might not be valid if there is spatial dependency. Hence, Moran's I statistic will be used to identify spatial dependence. Table 2 shows these results for both sexes in the four different variables. This suggests that the null hypothesis can be rejected in all cases and evidences the presence of spatial dependence in the analyzed sample. Additionally, the autocorrelation is positive because the I statistic in all cases is higher than $-\frac{1}{N-1}$ (-0.038). Therefore, the presence of a certain phenomenon in a specific spatial unit makes it easily spread to its neighboring towns, so favoring its grouping.

Table 2: European Union Moran's I statistic (men / women)

Moran's I statistic (men/women)	LEB		LE65		DALE		HLESPH	
Year	1998	2018	2005	2018	2000	2015	2006	2016
I	0.64 / 0.66	0.62 / 0.56	0.62 / 0.60	0.57 / 0.55	0.64 / 0.62	0.64 / 0.58	0.55 / 0.44	0.55 / 0.38
p-value	0.00026 / 0.00020	0.00042 / 0.0012	0.00049 / 0.00058	0.0013 / 0.0014	0.00025 / 0.00037	0.00023 / 0.00089	0.00187 / 0.01003	0.00176 / 0.0235

Source: Authors' estimations

Because of the previous results, spatial dependence between countries must be considered. This means that the absolute β -convergence must be estimated through the SLM and the SEM for the same variables and the same previous years. The conditions for absolute β -convergence to exist remain the same: b must be negative and significant [10].

Table 3 shows that there have been no major changes. All the b interest coefficients that were previously negative and significant continue to be. So that in all cases in which there was absolute β -convergence it continues to be, even considering spatial dependencies. In this sense, there is still not enough evidence to justify an absolute β -convergence in life expectancy for men at age 65. The most important thing to note is that the speed of annual convergence is bigger for women than for men, in any of the life expectancy variable studied. Regardless of the model selected, the fastest convergence is among women in HLESPH (6.26% and 4.86%, respectively).

Table 3: European Union results of Maximum Likelihood (men / women)

Spatial Lag Model (men / women)	LEB		LE65		DALE		HLESPH	
	Estimate	z value	Estimate	z value	Estimate	z value	Estimate	z value
a (intercept)	1.29*** / 1.57***	4.26 / 4.76	0.34* / 0.81***	2.54 / 4.59	0.54*** / 1.11***	2.20 / 4.25	1.31*** / 2.06***	6.75 / 9.04
b	-0.28*** / -0.35***	-4.06 / -4.63	-0.07 / -0.24***	-1.48 / -4.03	-0.11*** / -0.24***	-1.98 / -4.09	-0.29*** / -0.46***	-6.53 / -8.82
Converg. speed (annual)	1.64% / 2.14%		- / 2.08%		0.80% / 1.85%		3.45% / 6.26%	
Log-likelihood	70.85 / 82.12		58.54 / 60.96		76.08 / 88.86		72.71 / 68.31	
Spatial Error Model (men / women)	LEB		LE65		DALE		HLESPH	
	Estimate	z value	Estimate	z value	Estimate	z value	Estimate	z value
a (intercept)	1.29*** / 1.50***	4.63 / 4.78	0.22 / 0.71***	1.41 / 3.56	0.63* / 0.97***	2.42 / 4.03	1.14*** / 1.70***	6.65 / 8.11
b	-0.28*** / -0.33***	-4.35 / -4.61	-0.03 / -0.20**	-0.56 / -3.03	-0.13* / -0.21***	-2.19 / -3.86	-0.26*** / -0.39***	-6.30 / -7.82
Converg. speed (annual)	1.68% / 2.02%		- / 1.76%		0.95% / 1.60%		3.01% / 4.86%	
Log-likelihood	71.14 / 82.09		57.54 / 61.03		75.04 / 85.54		72.09 / 65.64	

***Significant at level 0.001; **Significant at level 0.01; *Significant at level 0.05; . Significant at level 0.1

Source: Authors' estimations

Analysis of the Spanish case

Sigma-convergence

The evolution of the selected variables standard deviation between 1998-2018 for the Spanish provinces is plot below (Figure 3). It can be differentiated in both cases between the dispersion curve of men and women. As in the EU countries analysis, it can be seen how the evolution of the curves is very similar between one gender and the other, but the women's dispersion is always smaller than that of men.

The variability of LEB curves is much smaller than that of LE65, so the σ evolution in the first case is much more stable. Therefore, it could be said that there is a σ -convergence process in approximately the first half of the sample studied, while in the second there is a σ -divergence process.

Figure 3: Spanish σ -convergence

Source: Authors' estimations

Beta-convergence

After having analyzed the σ -convergence in the Spanish provinces, we study the absolute β -convergence between the same years as before (1998–2018).

First, results of the traditional absolute β -convergence analysis are presented. Table 4 shows the estimation results of the model by OLS. The requirements for absolute β -convergence are still the same. Therefore, according to the estimation by OLS, there is an absolute β -convergence process in both variables for both men and women. This means that the provinces converge towards their own steady state [3]. However, it should be noted that the annual convergence rate is much higher (more than double) for men. The highest convergence speed is found by men of LE65 (4.28%). Figure 4 shows the negative slope of this regression.

Table 4: Spain's results of OLS (men / women)

OLS (men / women)	LEB		LE65	
	Estimate	t value	Estimate	t value
a (intercept)	2.00*** / 1.15***	8.37 / 5.40	1.78*** / 0.85***	10.99 / 4.99
b	-0.45 / -0.25***	-8.10 / -5.21	-0.58 / -0.24**	-9.95 / -4.22
Converg. speed (annual)	2.97% / 1.46%		4.28% / 1.37%	
R-squared	0.57 / 0.35		0.66 / 0.26	
Adjusted R-squared	0.60 / 0.40		-0.66 / 0.25	

***Significant at level 0.001; **Significant at level 0.01; *Significant at level 0.05

Source: Authors' estimations

Figure 4: Spanish LE65 scatter plot (men)

All points in the figure correspond to one country (for ease of viewing, only the names of the countries with extreme values have been written).

Source: Authors' estimations

Then, it is needed to know whether the sample data is subject to spatial dependency or not. As said before, the traditional estimation results of absolute β -convergence may not be valid if there is spatial autocorrelation in the sample [8]. Table 5 shows these results. Both variables reject the null hypothesis of no autocorrelation for the initial and final year. There is enough evidence to justify the presence of spatial dependence between the different Spanish provinces.

Table 5: Spain Moran's I statistic (men / women)

Moran's I statistic (men/women)	LEB		LE65	
	1998	2018	1998	2018
I	0.44 / 0.40	0.47 / 0.41	0.49 / 0.62	0.55 / 0.51
p-value	7.092e-07 / 3.318e-06	1.648e-07 / 2.94e-06	5.366e-08 / 1.267e-11	1.292e-09 / 8.367e-09

Source: Authors' estimations

Furthermore, it is useful to consider the spatial dependencies affecting the sample. For this reason, the SLM and the SEM will be estimated using the Maximum Likelihood method. These results are reflected in Table 6. As mentioned above, absolute β -convergence happens when b is negative and significant [10].

As can be seen, for both men and women in both variables the requirements for convergence are met. Therefore, even taking into account spatial dependencies, there is an absolute β -convergence process. Convergence rates continue to be higher for men than for women. Whether SLM or SEM is chosen, the fastest convergence is possessed by men in the LE65 variable (4.17% and 5.34%, respectively).

Table 6: Spain's results of Maximum Likelihood (men / women)

Spatial Lag Model (men / women)	LEB		LE65	
	Estimate	z value	Estimate	z value
a (intercept)	1.92*** / 1.02***	4.26 / 4.76	1.76* / 0.88***	11.37 / 5.18
b	-0.43*** / -0.22***	-4.06 / -4.63	-0.57 / -0.25***	-10.19 / -4.40
Converg. speed (annual)	2.79% / 1.26%		4.17% / 1.44%	
Log-likelihood	184.67 / 199.56		120.49 / 132.97	
Spatial Error Model (men / women)	LEB		LE65	
	Estimate	z value	Estimate	z value
a (intercept)	2.09*** / 1.14***	8.39 / 5.55	2.00*** / 0.85***	10.76 / 6.46
b	-0.47*** / -0.25***	-8.13 / -5.35	-0.66 / -0.24**	-9.83 / -5.47
Converg. speed (annual)	3.16% / 1.43%		5.34% / 1.37%	
Log-likelihood	184.20 / 199.02		120.53 / 133.65	

***Significant at level 0.001; **Significant at level 0.01; *Significant at level 0.05; . Significant at level 0.1

Source: Authors' estimations

Discussion

The first insight here is that life expectancy is much higher for women than for men, regardless of the life expectancy concept considered. This dissimilarity is mostly explained by the different risk behaviors and habits of the working age population. Although it is true that, over time, societies are much more egalitarian. Women have entered the labor market and can carry out the same activities as men, which may favor gender convergence in life expectancy [30].

In the EU context, the σ analysis propose that stages of σ -convergence have alternated with stages of σ -divergence between EU countries (see Figure 1). It could be said that life expectancy has converged at the end of the 20th century, while the first two decades of the 21st century show an opposite trend. Both in the initial and final year, the dispersion is greater for men than for women (except for the HLESPH variable in 1998). However, it has decreased more in women than in men (except for the LEB).

Secondly, the spatial results suggest that spatial dependence should be considered. Moran's Test shows that there is a positive spatial autocorrelation. Therefore, taking into account both the results of the analysis without considering the spatial dependence and those of the study including it, the absolute β -convergence occurs in all variables, except for men in LE65 (see Table 3). This means that, for the most part, the countries with the lowest life expectancy in 1998 have had the highest growth rates. In addition, each country is approaching its own steady state. Women's convergence rates are higher than for men in all variables. Women have the fastest convergence rate with the HLESPH indicator. Results also show that there could be a spatial distinction between Western and Eastern Europe countries.

Summarizing, it is confirmed that there is life expectancy convergence among EU countries, but that women are converging to a bigger extent than men. Authors such as Jaworska [10] and Stánczyk [11] guarantee these results for the first years of the 21st century.

On the other side, the analysis results of the Spanish provinces also show that life expectancy is constantly changing between σ -convergence and σ -divergence processes (see Figure 3). Even so, two different stages could be distinguished. The first phase is from 1998 until the first years of the economic crisis in 2008 and is characterized by a sharp dispersion reduction. The second phase starts from these years and ends in 2018 and is characterized by an increase in standard deviation. Despite the fact that the gender gap is still present and that the falls in dispersion in both genders have been very similar, it has been bigger in women for LEB and in men for LE65.

Secondly, Moran's Test shows that there is a positive spatial autocorrelation in the sample. It suggests that increased life expectancy in one province has led to positive effects in its neighboring provinces. The β -convergence results are different for Spanish provinces than for European countries. Considering the results of the estimation by OLS and those of MV, there has been a convergence process in both sexes. However, this β -convergence has occurred to a bigger extent in men. Results also suggest that there are life expectancy inequalities in geographical in Spain. The northern provinces have higher life expectancy values than the southern ones.

In summary, the convergence process in σ and spatial absolute β that the Spanish provinces suffer between 1998-2018 mean that the existing inequalities (geographical and gender) are reduced. However, the trend of recent years shows that perhaps the dispersion between provinces will move away again.

One of the main limitations that have been presented is that the life expectancy convergence analysis serves to know whether life expectancies between some territories tend to get closer. However, it does not really show people's quality of life, since increased life expectancy doesn't necessarily translate into improved living conditions. Although two variables (DALE and HLESPH) have been included in this study for this purpose, they have not been sufficient to reflect the population's standard of living, as other factors may influence it.

Conclusion

This study analyses the σ , absolute β and spatial absolute β -convergence of four life expectancy definitions between men and women for the European Union countries and Spanish provinces during several periods, between 1998-2018.

The results show that there has been a convergence process in all cases, which could mean that health inequalities are lower in 2018 than at the end of the 20th century. Firstly, as the dispersion in the beginning is greater than in the final years, there has been a σ -convergence process. Nevertheless, this process has not remained constant throughout the period considered. The trend in the last years studied seems to indicate that the dispersion rises. Therefore, perhaps during the next few years health differences between some territories and others will increase again. Secondly, as the observations were spatially dependent, spatial interactions had to be considered for β -convergence. As the countries and provinces with lower life expectancy values at the beginning of the study are those with higher growth rates, there has been a β -convergence process. The speed of this process has been higher in women for European countries and higher in men for Spanish provinces. Hence, gender inequalities in terms of life expectancy have been reduced in recent decades.

Finally, our study has a double contribution. First, it provides an updated vision of the health convergence considering gender differentiated. Secondly, it contributes to include Spatial econometrics in Health Economics analysis to reduce health population inequalities.

In this sense, two lines are proposed for future research. In the first place, to estimate conditional β -convergence, using variables that measure living conditions in other areas, such as economic or environmental one [31]. Secondly, this same convergence analysis is invited to perform, but using predicted life expectancy data. In this way, it would be possible to have an estimate on whether the dispersion will really continue to increase, which could lead to divergence processes.

List of abbreviations

- EU: European Union
- LEB: Life Expectancy at Birth
- LE65: Life Expectancy at age 65
- DALE: Disability-Adjusted Life Expectancy
- HLESPH: Healthy Life Expectancy based on Self-Perceived Health
- OLS: Ordinary Least Squares
- SLM: Spatial Lag Model
- SEM: Spatial Error Model

Declarations

Ethics approval and consent to participate: Not applicable.

Consent for publication: Not applicable.

Availability of data and material: The datasets used and/or analysed during the current study available from 4 different databases: World Bank Open Data, World Health Organization database, Eurostat and Spanish National Statistics Institute. It should be noted that the source of the European spatial data is Eurostat and for Spanish data is GADM maps and data 2020 webiste at <https://gadm.org/>. The interpretation and reporting of these data are the sole responsibilities of the authors.

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Figures

Figure 1

European Union σ -convergence Source: Authors' estimations

Figure 2

European Union LE65 scatter plot (women) All points in the figure correspond to one country (for ease of viewing, only the names of the countries with extreme values have been written). Source: Authors' estimations

Figure 3

Spanish σ -convergence Source: Authors' estimations

Figure 4

Spanish LE65 scatter plot (men) All points in the figure correspond to one country (for ease of viewing, only the names of the countries with extreme values have been written). Source: Authors' estimations