Fundación BBVA

Documentos de Trabajo

8

2012

Francisco J. Goerlich Gisbert
Ángel Soler Guillén

Life Potential as a Basic Demographic Indicator

Fundación BBVA

Life Potential as a Basic Demographic Indicator

Francisco J. Goerlich Gisbert[1,2]
Ángel Soler Guillén[1,2]

[1] *UNIVERSITY OF VALENCIA*
[2] *INSTITUTO VALENCIANO DE INVESTIGACIONES ECONÓMICAS (Ivie)*

Abstract

This working paper proposes an indicator that integrates life expectancy with the demographic structure of the population for a given society, combining the simple indicators of mortality and aging. Life expectancy at birth is independent of the demographic structure of the population and is, therefore, adequate for measuring overall mortality. However, it neglects to take into account the fact that life expectancy increases as society ages. We propose a simple indicator that integrates life expectancy at different ages, not only at birth, with the demographic structure of the population at a given point in time. The indicator has an intuitive interpretation in terms of the life potential, or biological capital, of society; and given that it is a weighted average, its changes can be easily decomposed into reductions in mortality (gains in life expectancy) and aging for different age intervals.

Key words

Life expectancy, life table, aging, demography.

Resumen

Este documento de trabajo propone un indicador que integra la estructura demográfica de la población de una sociedad en la esperanza de vida, combinando la mortalidad y el envejecimiento de la población. La esperanza de vida al nacer es independiente de la estructura demográfica de la población y, por tanto, es adecuada para medir la mortalidad. Sin embargo, no tiene en cuenta el hecho de que a medida que la esperanza de vida crece, la sociedad envejece. Se propone un indicador simple que aglutina la esperanza de vida a diferentes edades, no solo al nacer, con la estructura demográfica de la población en un momento dado del tiempo. Dicho indicador tiene una interpretación intuitiva en términos de potencial de vida, o capital biológico, de la sociedad; y, dado que es una media ponderada, sus cambios pueden ser fácilmente descompuestos en disminuciones de la mortalidad (ganancias en esperanza de vida) y envejecimiento por intervalos de edad.

Palabras clave

Esperanza de vida, tablas de vida, envejecimiento, demografía.

La serie Documentos de Trabajo tiene como objetivo la rápida difusión de los resultados del trabajo de investigación entre los especialistas de esa área, para promover así el intercambio de ideas y el debate académico. Cualquier comentario sobre sus contenidos será bien recibido y debe hacerse llegar directamente a los autores, cuyos datos de contacto aparecen en la *Nota sobre los autores*.

The Working Papers series is intended to disseminate research findings rapidly among specialists in the field concerned, in order to encourage the exchange of ideas and academic debate. Comments on this paper would be welcome and should be sent direct to the authors at the addresses provided in the About the authors *section.*

La serie Documentos de Trabajo, así como información sobre otras publicaciones de la Fundación BBVA, pueden consultarse en: **http://www.fbbva.es**

The Working Papers series, as well as information on other BBVA Foundation publications, can be found at: **http://www.fbbva.es**

Versión: Junio 2012

EDITA / PUBLISHED BY
Fundación BBVA, 2012
Plaza de San Nicolás, 4. 48005 Bilbao

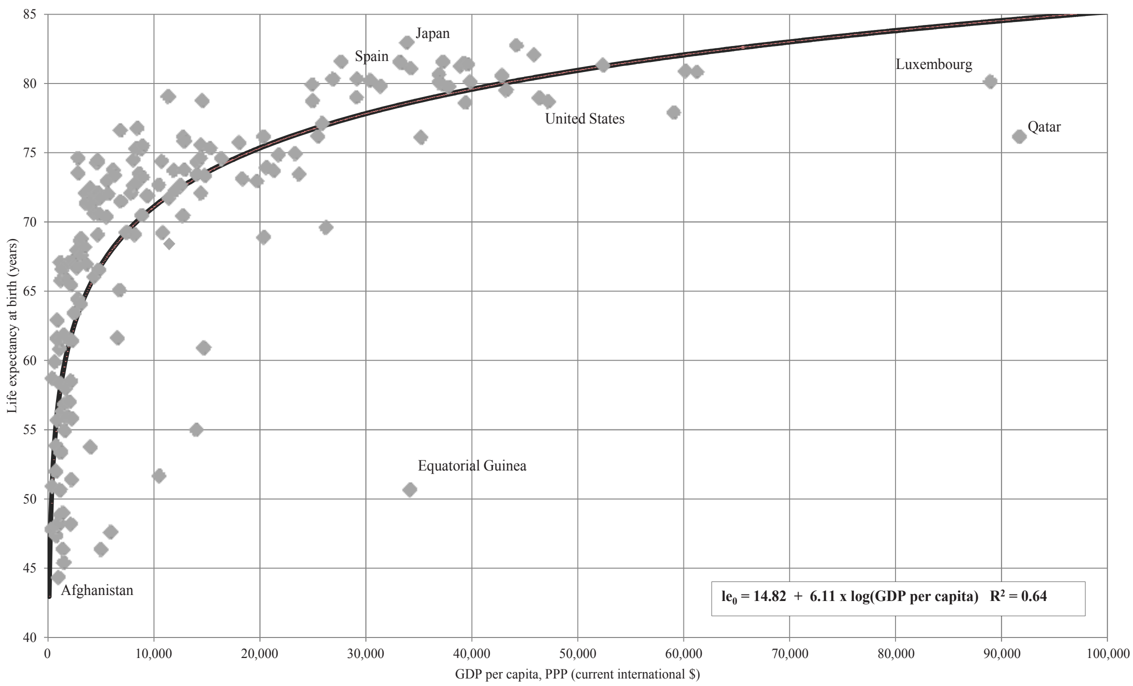
1. Introduction

LIFE expectancy at birth summarizes in a single number the mortality conditions of a given population, and it does so in a way that is independent of the age structure of the underlying population. Essentially this means that the indicator is comparable, in time and across societies, with populations having very different age structures. This feature has contributed in making life expectancy one of the most widely used indicators in international comparisons on development. Additionally, life expectancy at birth is one of the simplest summary measures of population health for a community (Murray et al. 2002), and as a consequence, of its degree of development (Sen 1998, 1999).

For all these reasons, life expectancy becomes one essential dimension in the complex and elusive concept of quality of life: without life there is no possibility to enjoy consumption opportunities as represented by per capita income, the other well-known development indicator widely used in international comparisons. However, as has been recently recognized in the Stiglitz, Sen and Fitoussi (2009) report, it is necessary to go beyond gross domestic product (GDP) in measuring the progress of current societies. This was in fact the goal of the Human Development Index (HDI) of the United Nations Development Program (http://hdr.undp.org), as well as many other proposals in including life expectancy as part of synthetic quality of life indexes (Osberg and Sharpe 2002).

It is widely recognized that there is a high correlation between life expectancy at birth and per capita income, in a given country and for a sufficiently long time span, as well as for a cross-section of countries at different stages of development. However, this relationship is non-linear, has no clear shape and moreover we may find countries with relatively low per capita income that have a far superior life expectancy than countries with a higher per capita income (Sen 1998). This relationship, known as the Preston (1975) curve, can be seen in figure 1, where we can see that on average life expectancy is much lower for countries with lower per capita income. The linear correlation coefficient between the variables represented in figure 1 is 0.62, but clearly the relationship is non-linear. The curve drawn corresponds to the regression of life expectancy at birth on the logarithm of GDP per capita, the correlation in this case rises to 0.80. Taken at face value, we need a bit more than a 16% increase in per capita GDP for a one year increase in life expectancy at birth, and so doubling per capita income represents an increment of about six years in life expectancy at birth. The relationship drawn shows a decreasing elasticity, which for our sample values oscillates from about 0.13 to around 0.07.

FIGURE 1: The Preston curve: Life expectancy at birth versus GDP per capita, 2009



Source: World Development Indicators World Bank (2011).

An important conclusion from figure 1 is that, as income increases life expectancy at birth has lower informational content regarding the development of a given country. In fact, we can see that the regression tends to over-fit the highest values of GDP per capita. At low level of income, the coefficient of variation of life expectancy for the countries shown in figure 1 is 0.121, whereas for the high level income countries the coefficient of variation is just 0.020[1], which signals the compression of life expectancy for the most developed countries[2].

What is not evident from figure 1 is that as life expectancy increases society ages, a fact that results eventually from the increase in longevity. In the first stage of the demographic tran-

[1] The World Bank defines, for 2009, low level income countries as those with GDP per capita, current PPP $ lower than 1,154.04 and high level income countries as those with a GDP per capita over 37,314.14 current PPP $. For lower and middle income countries, defined as those with a GDP per capita lower than 4,449.04, current PPP $, the coefficient of variation is 0.138.

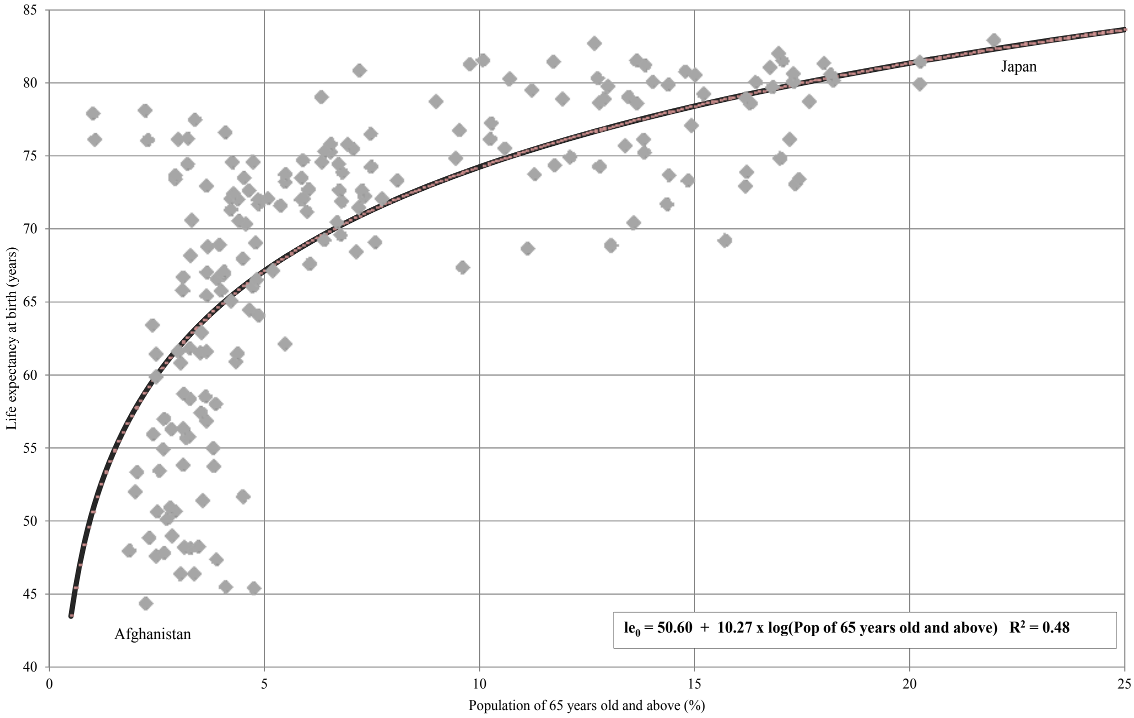
[2] Even if we do not know the upper limit, life expectancy at birth should be bounded from above. This is not true for per capita income, however. What has been true historically is that the forecasted limits to life expectancy have been broken as time has elapsed (Oeppen and Vaupel 2002; Willets et al. 2004).

sition mortality falls at early childhood (Davis 1945; Vallin 2002), so the population pyramid widens at its base, but as fertility adjusts to the new mortality conditions and mature societies advance in the subsequent stages of the epidemiological transition (Olshansky and Ault 1986) the base of the population pyramid begins to shrink, and society grows older.

Eventually, the reduction of mortality at all ages, as summarized by a continuous increase in life expectancy, goes hand in hand with a reduction in fertility. Lower numbers of births are observed in highly developed countries, and this contributes to the aging of the population.

If we substitute the logarithm of per capita GDP in the *x*-axis of figure 1, for the logarithm of the share of people who are 65 years old and over (a very simple index of aging) we get a very similar picture. This is shown in figure 2, where again a semi-logarithmic equation is drawn. Taken at face value, an additional year of life expectancy at birth is associated with an almost 10% increase in the share of older people, so we get a high correlation between development, as measured by per capita income, and aging via life expectancy at birth.

FIGURE 2: Life expectancy at birth versus aging of the population, 2009



Source: World Development Indicators World Bank (2011).

Acknowledging this correlation, however, does not provide any evidence of causality. What figures 1 and 2 imply is that either per capita income or life expectancy alone can give us an overly optimistic view of the potential development of society in the future. If life expectancy increases only because longevity increases, as is the case in advanced societies with a very low birth rate, then sustainability and quality of life can be threatened in the long run. What we propose in the sequel is a very simple indicator that integrates life expectancy at any age with the demographic structure of the population, which allows us to take aging into account, since it can affect sustainability beyond a certain point.

2. Life Potential: A Basic Demographic Indicator

WE define life potential for a given individual at age x as their (uncertain) life expectancy given their age, and the life potential for a society, L, as the aggregate over individual life potential. Hence,

$$L = \int_0^\infty P(x)e(x)dx \tag{1}$$

where $P(x)$ is the population at age x, and $e(x)$ is the corresponding life expectancy. From (1) it is clear that L is a weighted sum of life expectancies at different ages, and in the tradition of capital theory can be understood as the *biological capital of a society*, since it is an estimate of the physical support of any other form of human capital, such as education, job training or health capital (Shultz 1962; Becker 1962, 1964, 2007; Grosman 1972). Because L is difficult to compare among societies of different size, we may use life potential per capita, l. Let P be the total population, $P = \int_0^\infty P(x)dx$, we then define life potential per capita as

$$l = \frac{L}{P} = \int_0^\infty \omega(x)e(x)dx \tag{2}$$

where $\omega(x) = P(x)/P$, with the property that $\int_0^\infty \omega(x)dx = 1$. So, l is a weighted average of life expectancies, where the weights are given by population shares. Because life expectancy decreases with age (at least beyond a certain point), l is increasing in life expectancy at any age and decreasing in population aging. From the definition, it follows that l can be interpreted as the life expectancy of a given population, as opposed to the life expectancy of a cohort at a given age, which is the usual interpretation in demography[3].

Given that life potential per capita has the nature of an average; it can also be interpret as the expected remaining life of a citizen picked up randomly within the population. This is not the case for the life expectancy at birth, except for a newborn. So when integrating life expectancy with other economic variables that incorporate the demographic structure of the society, such as GDP per capita or the unemployment rate, it may be a good reason to choose life potential instead of life expectancy at birth[4].

3. Life Potential in Practice

TO build an operational measure for (1) we only need population classified by age and their corresponding life expectancies. In the absence of individual (subjective) survival curves (Gan, Hurd and McFadden 2003) individual data are not available, and therefore should rely on life expectancy from standard life tables.

Published life tables are usually of the age-period type, so age-specific mortality rates for a given period (usually a calendar year) are used to construct the life experience of a fictitious generation that is followed until it is extinguished. Life expectancy at different ages is estimated by redistributing equally all future life years lived by the survivors of the generation at a given age. In this way, period life tables represent the current mortality conditions, without taking into account future improvements in mortality. Life expectancy at birth thus represents the average time that an individual born at a given time can expect to live on average, with the current mortality conditions. Figure 3 represents this set-up.

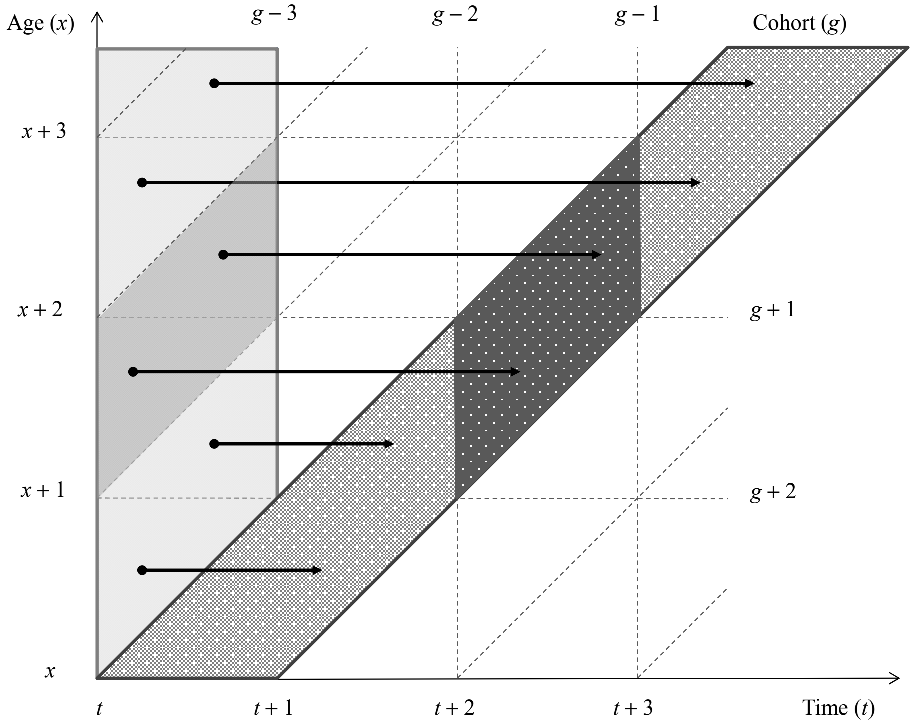
Fortunately, the Human Mortality Database (see http://www.mortality.org/) builds complete life tables for a great number of countries based on a common methodology with an open

[3] If we partition the population into exhaustive and mutually exclusive groups, such as by region, gender or ethnic groups, then L can be calculated as the sum of life potential over the different groups, and l is a weighted sum of life potential per capita, where the weights are given by the relative importance of each group in the population.

[4] This nice interpretation of l was suggested by an anonymous referee.

ended age interval of 110 years old and above (Wilmoth et al. 2007). They also offer population data by one year-age intervals covering long periods of time, and dated 1st January. All the calculations in this paper use life tables and population data from this database.

FIGURE 3: **Life tables: Age-period**



Period life tables estimate life expectancy at an exact age, x, e_x; this is at the beginning of the age interval, $[x, x + 1)$ in the case of single age years. On the other hand, population stock is dated at a given point in time, t, but it is recorded for a given age interval, $[x, x + 1)$. The empirical counterpart of (1) from discrete data with this structure is

$$L = \sum_{x=0}^{110+} P_x \overline{e}_x \tag{3}$$

where $\overline{e}_x = ½.(e_x + e_{x+1})$, P_x is the population in the age interval $[x, x + 1)$ at a given point in time and for the open ended age interval we use $\overline{e}_{110} = ½.e_{110}$.

Using the weights $\omega_x = \frac{P_x}{P}$, where $P = \Sigma_{x\geq 0} P_x$, the empirical counterpart of life potential per capita is

$$l = \sum_{x=0}^{110+} \omega_x \overline{e}_x \quad (4)$$

which is simply a population weighted average of life expectancies[5]. Figure 4 shows life expectancy at birth and life potential per capita for a selection of developed countries: Spain, Japan, the UK, the US, France and Sweden, over the same period of time; and table 1 shows the numerical values for selected years. Overall, long run tendencies in life expectancy are clear and well-known, and despite short periods related to wars or epidemics, life expectancy shows an up-ward and steady trend. In 2007, the last common year available to all the countries considered, life expectancy at birth was 82.87 years in Japan, the highest observed value, followed by France, 81.16 years, Sweden, 81.08 years, and Spain, 80.92 years. The lowest value is found in the US with 78.32 years.

Tendencies for life potential per capita are less clear cut. For some periods and most countries, life potential follows life expectancy closely. In fact, with the exception of Japan and Spain, the correlation between both series is very high, in excess of 0.88. However, as we will see in the sequel, this correlation changes abruptly with time, and life potential per capita appears to slow down, or even to fall in recent years in most countries with the exception of the UK. In fact in this country life potential per capita falls at the beginning of the XX century, even this is not shown in figure 1 and table 1. This particular evolution would be worth exploring.

It is interesting to note the particular evolution of life potential per capita in Japan and Spain. Both countries show very high life expectancy at birth, but in both cases life potential is currently falling, since the end of the 70s in the case of Japan, and since the beginning of the 80s in the case of Spain. This puts a precautionary note in the optimistic signal shown by the observation of life expectancy at birth alone, given that interpreting life potential as the biological capital of society, both countries are, in fact, destroying this kind of capital. From this point of

[5] It is worth noting that the indicator (4) was used by Usher (1973) in his imputation of the value of life in the national accounts, but keeping constant the population structure and fixed to the base year. Maintaining the population structure or life expectancies constant in (4) we can construct counter-factual life potential per capita, and thus be able to examine the evolution of l with one of its components taken as given.

view, the country with the highest biological capital is the US, which given the observed lower life expectancies signals a younger population than the other countries considered.

Given that l is a weighted average we can split the changes between two points in time, or even the differences between two countries at a given point in time, into the contributions due to changes in the demographic structure, ω_x, and the contributions due to the changes in life expectancies, e_x. This is the goal of the so called *shift-share* analysis widely used in regional economics. These types of decompositions are never unique (Kitagawa 1955), but the decomposition that is easiest to interpret is the following

TABLE 1: **Life expectancy at birth and life potential per capita. Selected years from developed countries**

	Spain		Japan		UK	
Year	**Life expectancy**	**Life potential**	**Life expectancy**	**Life potential**	**Life expectancy**	**Life potential**
1947	59,33	40,21	51,75	38,54	66,44	37,86
1955	66,78	42,74	65,77	44,41	70,21	38,88
1977	74,39	44,40	75,38	44,96	73,25	40,17
2007	80,92	42,47	82,87	41,37	79,72	42,46

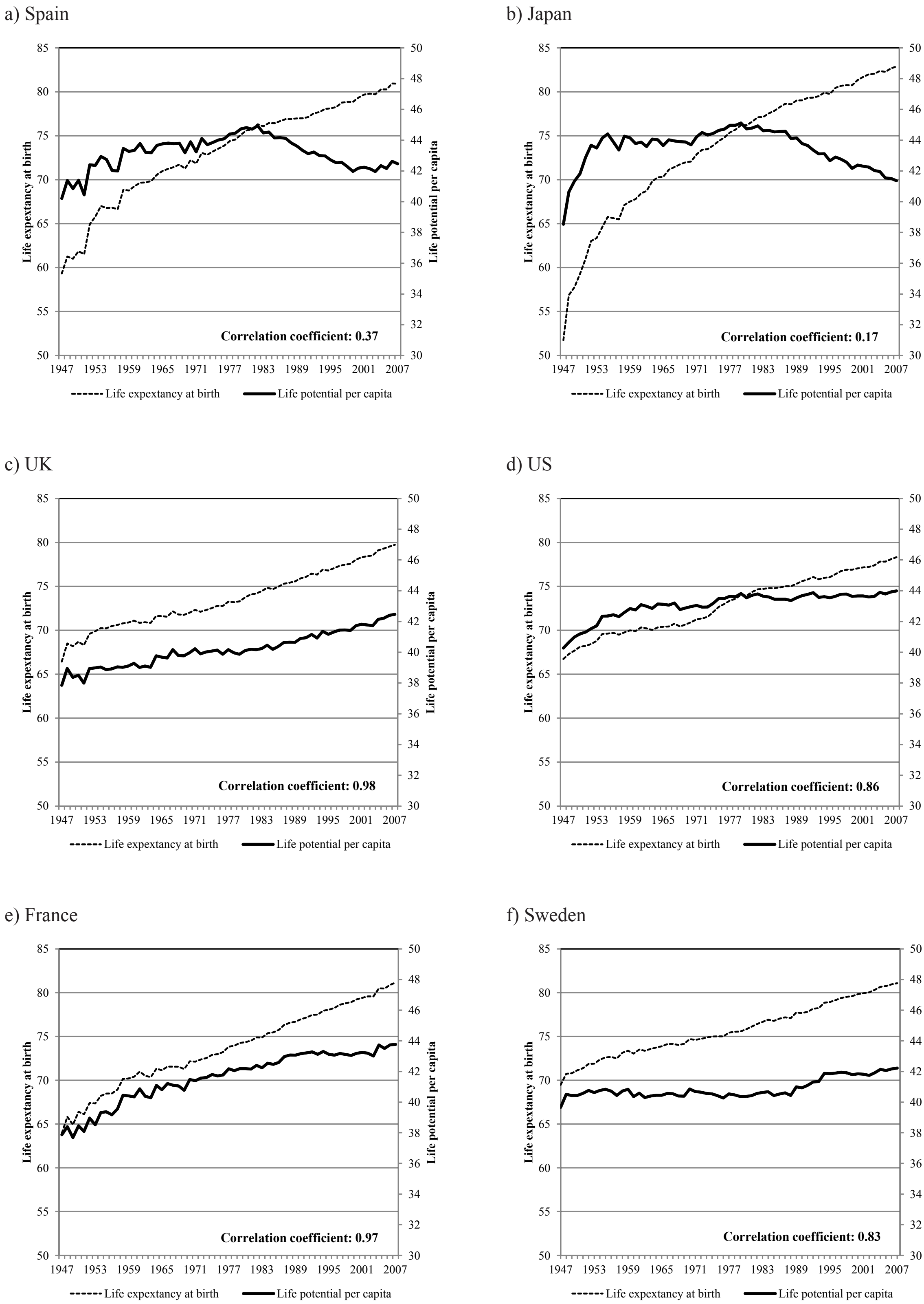
	US		France		Sweden	
Year	**Life expectancy**	**Life potential**	**Life expectancy**	**Life potential**	**Life expectancy**	**Life potential**
1947	66,73	40,27	63,98	37,87	69,47	39,66
1955	69,63	42,35	68,47	39,37	72,60	40,84
1977	73,38	43,64	73,83	42,18	75,44	40,54
2007	78,32	43,99	81,16	43,77	81,08	42,22

Source: Human Mortality Database and own elaboration.

$$l^s - l^t = \sum_{x=0}^{110+} \left(\frac{\omega_x^s + \omega_x^t}{2} \right) . (\overline{e}_x^s - \overline{e}_x^t) + \sum_{x=0}^{110+} (\omega_x^s - \omega_x^t) . \left(\frac{\overline{e}_x^s + \overline{e}_x^t}{2} \right) \quad (5)$$

where the first term can be interpreted as the contribution of changes in life expectancies, whereas the second term can be interpreted as the contribution of changes in the demographic structure of society.

FIGURE 4: Life expectancy at birth and life potential per capita. Historical international comparisons



Source: Human Mortality Database and own elaboration.

Table 2 shows, for selected time periods, the changes in life expectancy at birth and life potential per capita, as well as the correlation between the two variables for the period. It also illustrates the decomposition (5), showing the contribution of life expectancies and demographics to the change in life potential per capita.

Several facts are worth mentioning. (*i*) For the period considered, changes in life expectancy at birth are always positive, and they show no symptoms of exhaustion; a well-known fact. (*ii*) On the other hand, changes in life potential per capita are more irregular. Spain and Japan show a negative change in recent decades, which translates into a high negative correlation for these years. (*iii*) Correlation between both variables is quite sensitive to the time period considered. The almost absent correlation for Japan for the whole period, 1947–2007, is the result of a high positive correlation in the early decades and a high negative correlation in recent decades. No clear pattern emerges in this respect when we consider shorter sub-periods for the different countries. (*iv*) With the exception of the firsts years considered for United States and France, 1947–1955, where the demographics contribute slightly positive, the contribution of demographics to changes in life potential per capita is invariably negative. Moreover, this negative contribution is increasing in magnitude with time. In the two cases mentioned, Japan and Spain, the negative contribution of demographics out-weighs the positive contribution of improvements in life expectancies, resulting in the negative variation of life potential per capita mentioned earlier. This is also the case for Sweden for the period 1955–1977.

Eventually, figure 5 shows a scatter plot between life expectancy at birth and life potential per capita for 2007 and 23 European countries; these are the EU-27 with the exception of Greece, Cyprus, Malta and Romania, for which there is no data in the Human Mortality Database. This cross-section comparison at a point in time shows a relatively high association between both variables, with a correlation coefficient of 0.87, which is however far from perfect, the rank correlation coefficient being 0.81; and also a high heterogeneity between countries for the two variables considered. The previous time series analysis for individual countries warns us against a simplistic interpretation of this relationship, on the contrary, it suggest that future increments in life expectancy at birth will probably be associated with lower increments, or even decrements, in life potential per capita.

TABLE 2: **Changes in life expectancy at birth and life potential per capita. Selected periods from developed countries. Shift-share decomposition for life potential per capita**

a) Spain

Period	Changes in		Correlation	Decomposition	
	Life expectancy at birth	Life potential		Life expectancies	Demographics
1947-1955	7,45	2,53	0,959	3,43	-0,90
1955-1977	7,61	1,66	0,869	3,08	-1,42
1977-2007	6,53	-1,93	-0,894	4,78	-6,71
1947-2007	**21,59**	**2,25**	**0,371**	**10,84**	**-8,59**

b) Japan

Changes in		Correlation	Decomposition	
Life expectancy at birth	Life potential		Life expectancies	Demographics
14,02	5,87	0,996	6,42	-0,55
9,61	0,56	0,598	5,32	-4,77
7,49	-3,60	-0,964	6,21	-9,80
31,12	**2,83**	**0,171**	**16,64**	**-13,81**

c) UK

Period	Changes in		Correlation	Decomposition	
	Life expectancy at birth	Life potential		Life expectancies	Demographics
1947-1955	3,77	1,02	0,855	1,13	-0,11
1955-1977	3,04	1,29	0,943	1,80	-0,51
1977-2007	6,47	2,29	0,991	5,01	-2,72
1947-2007	**13,28**	**4,61**	**0,984**	**7,93**	**-3,33**

d) US

Changes in		Correlation	Decomposition	
Life expectancy at birth	Life potential		Life expectancies	Demographics
2,90	2,08	0,999	1,71	0,37
3,75	1,29	0,845	2,45	-1,16
4,94	0,35	0,497	3,71	-3,36
11,59	**3,72**	**0,855**	**7,82**	**-4,10**

e) France

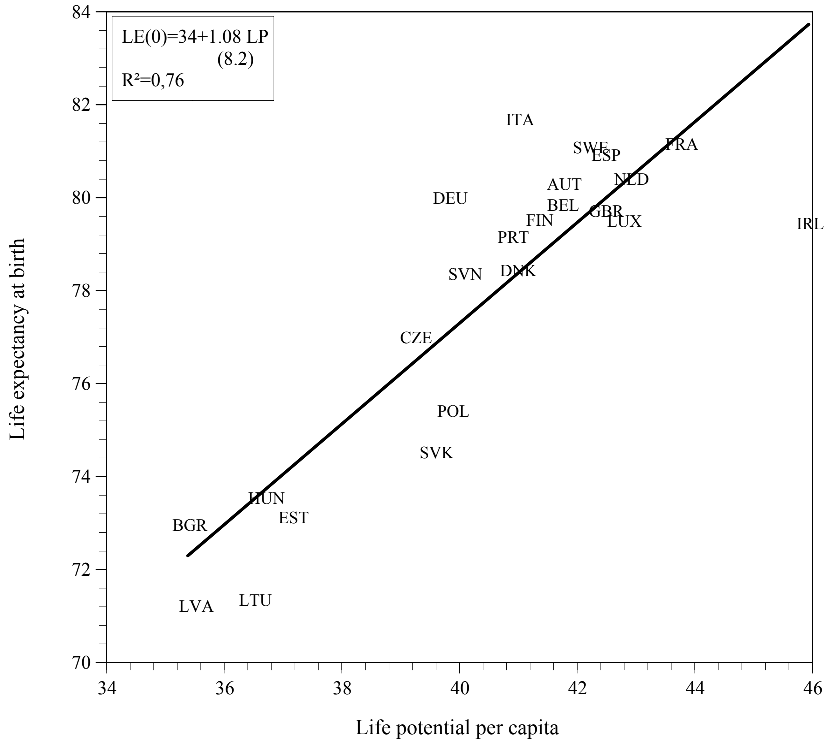
Period	Changes in		Correlation	Decomposition	
	Life expectancy at birth	Life potential		Life expectancies	Demographics
1947-1955	4,49	1,49	0,929	0,97	0,53
1955-1977	5,36	2,81	0,990	2,89	-0,08
1977-2007	7,33	1,59	0,926	5,59	-4,00
1947-2007	**17,18**	**5,90**	**0,973**	**9,35**	**-3,46**

f) Sweden

Changes in		Correlation	Decomposition	
Life expectancy at birth	Life potential		Life expectancies	Demographics
3,13	1,18	0,931	1,77	-0,60
2,84	-0,30	-0,134	1,71	-2,01
5,64	1,68	0,958	4,30	-2,62
11,61	**2,56**	**0,826**	**7,79**	**-5,23**

Note: Decomposition shows the formula (5) of the text, so it shows the contribution of the changes in life expectancies and demographics to the change in life potential per capita in the given period.
Source: Human Mortality Database and own elaboration.

FIGURE 5: **Life expectancy at birth versus life potential per capita. EU-23. Year 2007.**



Note: For Greece, Cyprus, Malta and Romania there is no data available.
Source: Human Mortality Database and own elaboration.

4. Final Comments

THIS short paper has introduced a simple demographic indicator that integrates life expectancy at different ages with the demographic structure of population. In this way, it tries to balance the observed increment in life expectancy with the aging of the population that characterizes advanced societies. Aging appears to be an inevitable consequence of development, and should therefore be incorporated in social indicators related to quality of life and sustainability.

We call the indicator *life potential*, and it has an intuitive interpretation as the biological capital of the society at a given point in time. In this way, we can see how aging societies could suffer from a loss in biological capital, thus affecting sustainability and quality of life in the long run. This is the idea behind the proposal of Herrero, Martinez and Villar (2010) who, in their reformulation of the Human Development Index (HDI), substitute life expectancy at birth for life potential per capita of a given country, in addition to other important changes in the way the HDI is calculated.

It is well known that life expectancy is independent of the population structure of society and that there are good reasons for this in measuring the incidence of mortality, essentially to avoid the *composition effect* when comparing countries with different population pyramids. But the same virtue becomes an inconvenient when we use demographic indicators to assess other aspects related to future development. By taking into account the prevailing population structure life potential provides a better estimate of future possibilities.

From a practical and computational point of view, life potential per capita is simply a population weighted life expectancy of the society. Thus, the continuous increment in life expectancy at all ages is balanced with an increase in the share of old people with shorter life expectancy. Life potential is simple to calculate and has low data requirements, not going beyond the information needed to calculate life tables. It also has an interesting interpretation in terms of the average life expectancy of the population at a given date, or as the expected remaining life of a citizen picked up at random within the population, and changes of the indicator can be easily decomposed in its two components.

A practical application for some developed countries in a historical context shows the clear and well-known tendency of increasing life expectancy, but a less clear cut tendency for life potential per capita. In general, we observe stagnation of this last variable, and in two particular cases, Japan and Spain, there is an important fall in life potential per capita in recent decades, signaling an accelerated aging of the population in these two countries. Clearly, this could be cause for concern, beyond the optimistic view that can be reached by looking at life expectancy at birth alone. Aging is an important factor in developed societies, and this should be incorporated in social indicators in a more satisfactory manner than simply looking at percentages of young or old people in society.

5. References

BECKER, G. S. (1962): “Investment in human capital: A theoretical analysis”. *The Journal of Political Economy* 70 (5), Part 2: Investment in Human Beings, October, 9-49.

——— (1964): *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*. New York: Columbia University Press for the National Bureau of Economic Research (2nd edition, NBER, New York, 1975. 3rd edition, University of Chicago Press, Chicago, 1993).

Becker, G. S. (2007): "Health as human capital: Synthesis and extensions", *Oxford Economic Papers* 59, 3, (July), 379-410.

Davis, K. (1945): "The world demography transition". *Academy of Political and Social Science,* 273, 1-11.

Gan, L., H. Hurd y D. McFadden (2003): "Individual subjective survival curves". Working Paper No. 9480, Cambridge, MA: National Bureau of Economic Research, January.

Goerlich, F. J. y R. Pinilla (2005): "Esperanza de Vida y Potencial de Vida a lo largo del siglo xx en España", *Revista de Demografía Histórica*, XXIII (II), 79-109.

Grossman, M. (1972): *The Demand for Health – A Theoretical and Empirical Investigation*. New York: Columbia University Press for the National Bureau of Economic Research.

Herrero, C., R. Martínez y A. Villar (2010): "Improving the Measurement of Human Development", Research Paper No. 2010/12, United Nations Development Programme, Human Development Reports, July. Available at: http://hdr.undp.org/en/reports/global/hdr2010/papers/HDRP_2010_12.pdf.

Kitagawa, E. M. (1955): "Components of a difference between two rates". *Journal of the American Statistical Association* 50 (272), 1168-1194.

Murray, J. L., J. A. Salomon, C. D. Mathers y A. D. López (2002): *Summary Measures of Population Health.* Geneva: World Health Organization.

Oeppen, J. y J. W. Vaupel (2002): "Broken limits to life expectancy". *Science* 296 (5570), May, 1029-1031.

Olshansky, S. y A. Ault (1986): "The fourth stage of the epidemiologic transition: The age of delayed degenerative diseases", *The Milbank Quarterly*, 64 (3), 355-391.

Osberg L. y A. Sharpe (2002): "An index of economic well-being for selected OECD countries", *Review of Income y Wealth* 48 (3), September, 291-316.

Preston, S.H. (1975): "The changing relation between mortality and level of economic development" *Population Studies* 29 (2), 231-248.

Sen, A. (1998): "Mortality as an indicator of economic success y failure". *The Economic Journal* 108, (January), 1-25.

——— (1999): *Development as Freedom.* Nueva York: Alfred A. Knopf Inc. (Spanish edition: *Desarrollo y libertad.* Barcelona: Planeta, 2000).

Schultz, T. W. (1962): *Investment in Human Beings*. Chicago: University of Chicago Press.

Usher, D. (1973): "An imputation to the measure of economic growth for changes in life expectancy", with comments by Robert J. Willis; in M. Moss, Ed. *The Measurement of Economic and Social Performance*. New York: National Bureau of Economic Research, Columbia University Press, 193-232.

Vallín, J. (2002): "The end of the demographic transition: Relief or concern?", *Population and Development Review* 28 (1), 105-120.

Willets, R. C., A. P. Gallop, P. A. Leandro, J. L. C. Lu, A. S. Macdonald, K. A. Miller, S. J. Richards, N. Robjohns, J.P. Ryan y H.R. Waters (2004): "Longevity in the 21st century", *Institute of Actuaries and Faculty of Actuaries,* March/April.

Wilmoth, J. R., K. Andreev, D. Jdanov y D. A. Glei, (2007): "Methods protocol for the Human Mortality Database". Mimeo, May 31, Version 5. Available at: http://www.mortality.org.

NOTA SOBRE LOS AUTORES - *ABOUT THE AUTHORS**

FRANCISCO J. GOERLICH GISBERT is a graduate and doctor in economics from the University of Valencia, and MSc in economics from the London School of Economics, University of London. He is currently professor in the Department of Economic Analysis of the University of Valencia and Senior Researcher at the Instituto Valenciano de Investigaciones Económicas (Ivie). His research fields are applied econometrics, regional economics and income distribution. He has published more than forty articles in both national and international specialized journals and has collaborated in more than ten books.
E-mail: Francisco.J.Goerlich@uv.es

ÁNGEL SOLER GUILLÉN is a graduate in economics and business studies from the University of Valencia (1996) majoring in general economic situations and specialising in the public sector. He was granted scholarships during his studies, among them a collaboration scholarship from the Department of Economic Analysis in 1995. He completed his postgraduate studies at the University of Valencia (1996-1998). He joined the Ivie in 1996. He is also assistant professor in the Economics Department of the University of Valencia. His specialization fields are human development, university education, labour market, immigration and human capital. He is co-author of seventeen books and is responsible for the elaboration of the Human Capital Series. He has also participated in the EU KLEMS project and in building the data series of Human Development.
E-mail: angel.soler@ivie.es

Any comments on the contents of this paper can be addressed to: Francisco J. Goerlich Gisbert, Universidad de Valencia, Departamento de Análisis Económico, Campus de Tarongers, Av de Tarongers s/n, 46022-Valencia. E-mail: Francisco.J.Goerlich@uv.es.

* The authors acknowledge financial support by the Spanish Ministry of Science and Technology, ECO2011-23248 project, and the BBVA Foundation-Ivie research programme. Results mentioned, but not shown, are available from the authors upon request. Comments from an anonymous referee and Carmen Herrero are greatly appreciated, without implicating them in our errors. Important note to readers of the cellulose versions of this paper: Many of the figures in this study are best read in the electronic color version.

ÚLTIMOS NÚMEROS PUBLICADOS – *RECENT PAPERS*

DT 07/12 *Unpaid Work, Time Use Surveys, and Care Demand Forecasting in Latin America*
María Ángeles Durán y Vivian Milosavljevic

DT 06/12 *Unpaid Care Work in Africa*
Mónica Domínguez Serrano

DT 05/12 *Regions Overburdened with Care: Continental Differences in Attention for Dependent Adults*
Jesús Rogero-García

DT 04/12 *Estimates of Worldwide Demand for Care (2010-2050): An Econometric Approach*
Montserrat Díaz Fernández y María del Mar Llorente Marrón

DT 03/12 *Childcare in Europe: A Reflection on the Present Economic Approach*
Susana García Díez

DT 02/12 *Desempeño en los centros educativos:¿Un problema de recursos o de capacidades organizativas?*
Claudio Thieme, Diego Prior, Víctor Jiménez y Emili Tortosa-Ausina

DT 01/12 *Tablas de vida de decrementos múltiples: Mortalidad por causas en España (1975-2008)*
Francisco J. Goerlich Gisbert

DT 04/11 *El* stock *y los servicios del capital en España y su distribución territorial y sectorial (1964-2010)*
Matilde Mas Ivars, Francisco Pérez García y Ezequiel Uriel Jiménez (Dirs.)

DT 03/11 *Cartografía y demografía: Una* grid *de población para la Comunitat Valenciana*
Francisco J. Goerlich Gisbert e Isidro Cantarino Martí

DT 02/11 *Who Meets the Standards? A Multidimensional Approach*
Antonio Villar Notario

DT 01/11 *Quality of Life Lost Due to Non-Fatal Road Crashes*
Patricia Cubí Mollá y Carmen Herrero

DT 12/10 *Artistic Creation and Intellectual Property: A Professional Career Approach*
Francisco Alcalá y Miguel González Maestre

DT 11/10 *Information and Quality in Expanding Markets*
Francisco Alcalá, Miguel González Maestre e Irene Martínez Pardina

DT 10/10 *Rugosidad del terreno: Una característica del paisaje poco estudiada*
Francisco J. Goerlich Gisbert e Isidro Cantarino Martí

Documentos de Trabajo

8

Fundación BBVA

Plaza de San Nicolás, 4
48005 Bilbao
España
Tel.: +34 94 487 52 52
Fax: +34 94 424 46 21

Paseo de Recoletos, 10
28001 Madrid
España
Tel.: +34 91 374 54 00
Fax: +34 91 374 85 22

publicaciones@fbbva.es
www.fbbva.es