Longevity Dispersion in Portugal from 1940 to 2007

Serap Ünlü and Miguel Gouveia

FCEE, Catholic University of Portugal

June 2010

Comments Welcome

Abstract

The first part of this paper studies the dispersion in the distribution of longevity with the same tools that are employed to measure income inequality and poverty. An historical sequence of life tables for Portugal covering the period 1940-2007 is used to examine how the longevity mean (life expectancy) and dispersion have evolved. The results show a remarkable decline in the levels of longevity inequality and poverty over the years.

The second part of the paper uses co-integration analysis and Granger causality to explore the factors driving the evolution of inequality and poverty. The results are not completely clear cut but they suggest that inequality and poverty in longevity have a positive time-trend, decrease with life expectancy and GDP per capita but increase with total per capita health expenditure. Disturbingly, Granger analysis suggests that the direction of causality goes from total health expenditures to longevity inequality.

“Said Brown: 'I can't afford to die
For I have bought annuity,
And every day of living I
Have money coming in to me:
While others toil to make their bread
I make mine by not being dead.'

Said Jones: 'I can't afford to die,
For I have books and books to write.
I do not care for pelf but I
Would versify my visions bright;
Emotions noble in my breast
By worthy words should be expressed.'

Said Smith: 'I can't afford to die,
Because my life is kindly planned;
So many on my care rely,
For comfort and a helping hand.
Too many weak ones need me so,
And will be woeful when I go.”

1. INTRODUCTION

As Robert William Service makes clear in his light poem “Longevity” above, longevity has been one of the most salient aspirations of humankind. It is unquestionably a quantitatively important component of human well-being. For instance, Becker *et al.* (2005) highlight that overall economic welfare depends on both the quality and the quantity of life: annual income matters but so does the number of years over which this income is enjoyed.

There has been an increase in the average length of life brought by mortality rates decreases at all ages, but historically higher at younger than at older ages. We will study to what extent the increase in longevity is distributed among all people. Anand et al. (2001) believe that the economic approach to measuring inequality can be applied to individual variations in the quantity and quality of life. They consider life-table dispersion as a reflection of inter-individual inequality facing death. The dispersion measurement captures the total amount of inter-individual differences independently of specific socioeconomic or demographic groupings. Inequality in longevity is basically a function of the dispersion of life durations for a given cohort. Poverty in longevity is a function of how much of the life duration distribution falls below a minimum standard. By using an historical sequence of life tables, in this paper it will be shown that there has been a considerable decline in longevity inequality and longevity poverty for Portugal between 1940 and 2007.

Then, we will proceed with an empirical investigation in order to find out the determinants of longevity dispersion. We consider the time-series of the measures of inequality and poverty in longevity and their relationship with aggregate data such as GDP per capita, life expectancy and total health care expenditures as shares of GDP. These variables are chosen in order to separate the income/wealth effect from the intervention/health resources effect.

The structure of the paper is outlined as follows. The next section of the paper presents the literature review. As the paper relies on the application of two distinct methodologies, section 3 outlines the inequality measures and poverty indices characterizing each distribution of longevity and section 4 presents the empirical results regarding this methodology. Section 5 outlines econometric methodology and related empirical results are presented in section 6 and last section summarizes the main results and concludes the paper.

2. LITERATURE REVIEW

At a conceptual level, this paper is going to subject longevity data to the same treatment usually applied to income data when we study income inequality, a treatment that is presented systematically in Cowell (1995) or Lambert (1993). Is that a sensible thing to do? As le Grand (1987) mentions and Deaton (2001) reminds us, the axioms of income inequality measurement, in particular the normative evaluations of income-preserving spreads, do not apply so easily in the realm of longevity. Still, despite being easier to picture policies that redistribute income than policies that redistribute longevity, one can imagine different longevity distributional impacts for different health policies. Also, even if no redistribution of longevity were feasible, there remains a normative interest in knowing about and measuring the extent of longevity dispersion and the standard toolkit available is as good or better as any other for the job.

Most research on equity and health does not study the univariate distribution of a scalar measure of health but rather how measures of health and health resource consumption are associated with income, a literature surveyed for instance by van Doorslaer and Masseria (2004). The focus of this paper is different as we treat longevity in a manner similar to wealth itself and put an emphasis on finding out how large inequality longevity is and how it has been changing over time rather than in the inequities found in the cross sectional associations between income and health. The perspectives are different but complementary.

In this paper we use an historical sequence of life tables for Portugal to examine not only how the mean of longevity (life expectancy) has evolved but also the dispersion around that mean. There is some literature regarding this topic and a few notable papers deserve mention. We will first survey papers with a positive, empirical approach and then remark on a normative contribution by Williams (1999).

As far as we know, Le Grand (1987) is the first paper to study systematically the distribution of longevity using the standard approach to inequality measurement. The paper measures inequalities in health for 32 developed countries by using data on age-at-death. He calculates three sets of inequality measures which are the Absolute Mean Difference (AMD), the Gini coefficient and the Atkinson Index for age-standardised aggregate (males and females) deaths. According to all three measures, of the Scandinavian countries Sweden and Finland have the lowest inequality levels, whereas the southern European countries of Greece, Portugal, Spain and former Yugoslavia all show relatively high inequality. Furthermore, Le Grand undertakes regression analyses, where the dependent variables are age-standardised mean age-at-death and AMD and the independent variables are health care expenditures, per capita GDP and a measure of income inequality. Because of the unavailability of the data, two sets of regressors are used where only one includes income inequality. The equations with the mean age-at-death as dependent variable are unsatisfactory; the AMD equations have more interesting results. For the smaller regressor set (with more observations), the results suggest that per capita GDP has a negative effect explaining health inequality levels and that more per capita medical care is associated with more health inequality. The results are replicated in the regressions with a larger regressor set with the addition that the income inequality variable has a negative and highly significant coefficient.

Becker *et al*. (2005) incorporate longevity into the analysis of the cross-country evolution of welfare and inequality. The evidence shows that there is no income convergence across countries in contrast with the evidence that convergence in life expectancy has been taking place in the last 50 years as countries starting with low longevity tended to gain more in life expectancy than countries starting with high longevity. They extend the income accounts to incorporate survival rates throughout a person's life cycle. A "full" income measure is computed to value the life expectancy gains experienced by 49 countries between 1965 and 1995. Growth rates of "full" income for the period average 140% for developed countries, and 192% for developing countries indicating that longevity changes since 1965 reduced the disparity in welfare across countries. Furthermore, they disaggregate mortality data by causes of death to understand the determinants of the cross-country convergence in life expectancy. Changes in mortality due to infectious, respiratory and digestive diseases, congenital and perinatal conditions, and "ill-defined" conditions are the most important factors determining the convergence in life expectancy; whereas changes in mortality due to nervous system, senses organs, heart and circulatory diseases worked against convergence, as mortality for these causes fell more rapidly in rich rather than in poor countries.

Peltzman (2009) explores the historical evolution of longevity differences across individuals. The history of mortality inequality occurred in the context of substantial increases in average life expectancy. Most of the data used in Peltzman (2009) comes from life tables. Peltzman describes two important sub-categories of mortality inequality which are inequality due to gender and geography. A female born today can expect to live around 10 percent longer than her male counterpart. He points out that the relative female advantage in life expectancy is the same today as it was in 1750 and the same as it has averaged since then. Then he reviews the history of mortality differences across US states and counties. In the US, between 1900 and 2005 there was a substantial decline in differences among states (and regions) driven by the ubiquitous near-elimination of premature mortality. Moreover, he covers the period 1970-2005 for counties and uses two datasets to estimate regressions where the dependent variable is a county mortality measure, such as life expectancy or the longevity inequality within a county and the independent variables are county characteristics such as income, education, race composition and family structure. In terms of the sign of the effects estimated, the only surprise is the robust and large positive effect of education inequality on life expectancy. Overall, regional and within county mortality inequality has not changed much in the last two or three decades. Additionally, he shows that mortality inequality has an important role in overall social inequality and provides a history of this mortality Gini by replacing "income" with "life years". Over the 50 years after 1900 mortality inequality declined significantly in all developed countries but in the last 50 years it has continued to fall modestly. This dramatic decline in mortality inequality in the 20th century has transformed a major source of social inequality into a minor one. Today's poor countries have considerably more mortality inequality than rich countries, but their recent experiences suggests that this gap will be steadily eliminated thereby improving the overall social inequality in those countries.

A very different but germane paper is Williams (1997) which explores the trade-off between equity and efficiency when prioritizing health care by concentrating on one particular equity principle that is the concept of 'fair innings' and its implications for intergenerational equity. He argues that everybody should be entitled to some common target quantity of lifetime health, ideally measured in terms of QALYs (Quality-adjusted life years). The implication is that anyone who dies without having achieved this 'fair innings' has in some sense been cheated, while anyone that gets more than this is 'living on borrowed time'. It has strong quantitative implications. Death at 25 is viewed very differently from death at 85. These 'fair innings' equity weights have particular salience for the issue of intergenerational equity. It calls for self-restraint by the elderly and especially by those of who have flourished in health terms throughout their lives. This notion of intergenerational equity requires greater discrimination against the elderly than would be dictated simply by efficiency objectives. Williams work is relevant for our analysis because his concept of "fair innings" for longevity plays a role very similar to the one played by poverty lines in the analysis and quantification of poverty as can be see for instance in Ravallion (1994). Much as having income or consumption below a poverty line is considered to generate a state of deprivation, so having a quantity of life below the fair innings levels is another form of deprivation of the most basic of all goods: life itself.

3. METHODOLOGY

Since this paper addresses two major questions, it will rely on the application of two distinct methodologies. In the first part, we start from the distributions of longevity over the years, given by period life-tables, and compute inequality measures and poverty indices characterizing each distribution of longevity. We also try to provide some intuition about the results obtained. In the second part, we will proceed with an empirical investigation considering the time-series of the measures of inequality and poverty in longevity and their relationship with aggregate data such as GDP per capita, life expectancy and total health care expenditures as shares of GDP.

A procedure for the estimation of Coefficient of variation (CV), Gini Index, Atkinson's Index and Theil Index from life tables is developed and these indices are taken as measures of inequality in the length of life for females, males and for the total population.

Applying this framework to mortality-by-age schedules, a person's years lived from birth to death can be treated as "income" and the cumulative death numbers as the "population". Then the Lorenz curve can be constructed from the life table distribution by age at death.

Since the longevity data will come from mortality tables, longevity will be modeled as following a discrete distribution, with age a going from 0[1] up to 110, and the probability of each level a being given by $0 \leq \pi_a \leq 1$, with $\sum_{a=0}^{110} \pi_a = 1$.

Take x as the random variable longevity. The CV is defined as the ratio of the standard deviation to the mean. It is calculated as

$$c_v = \frac{\sigma}{\mu}$$

where the mean is life expectancy.

The second measure of inequality considered is the Gini Index. It is customarily defined as the area between the diagonal and the Lorenz curve, divided by the whole area below the diagonal. Take the percentile P_a, with $0 \leq P_a \leq 1$ to be the cumulated probability distribution of a population ordered by increasing age a, assuming that the maximum life expectancy is 110.

---

[1] In practice infant mortality cases are assigned a low but strictly positive life duration. All other deaths are assumed to occur mid year.

The Lorenz curve is represented by the function $L(P_x)$, with $P_x = \sum_{a=0}^{x} \pi_a$ and $L(P_x) = \sum_{a=0}^{x} a\,\pi_a / \mu$. It is helpful to define a function $R_x = \sum_{a=0}^{x-1} \pi_a + \pi_x / 2$. The Gini index can be expressed as $G = 1 - \sum_{a=1}^{110} (LP(a) + LP(a-1))(P_a - P_{a-1})$ or as a weighted covariance: $G = (2/\mu) Cov_\pi(a, R_a)$ (see Lambert (1993) or van Doorslaer and Masseria (2004) for the formulas).

Then, Atkinson's Index which is based on the assumption that increased inequality diminishes the overall capability of the economy where lower index values correspond to less potential gains to social welfare by means of redistribution is defined as a new measure of inequality:

$$A_\varepsilon = 1 - \frac{x_{EDL}}{\mu} \quad \text{where} \quad x_{EDL} = \left[\sum_{a=1}^{110} \pi_a a^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}$$

and for ε=1, $A_1 = 1 - \frac{1}{\mu} Exp\left(\sum_{a=1}^{110} \pi_a \ln a \right)$,

where x_{EDL} is the equally distributed longevity.

Finally, Theil index is computed and it can be expressed as:

$$T_0 = \sum_{a=1}^{110} \pi_a \left(\ln \frac{\mu}{a} \right)$$

One of the advantages of the Theil index is that it is a weighted average of inequality within subgroups, plus inequality among those subgroups. Therefore for the decomposition analysis of inequality by gender, we use the Theil Index expressed as:

$$T_0 = \sum_{i=1}^{2} s_i T_{0_i} + \sum_{i=1}^{2} s_i \ln\left(\frac{\mu_i}{\mu} \right)$$

where s_i is the population share of each gender.

After defining the measures of inequality in the distribution of longevity, we proceed by including a new measure of "longevity poverty" in our data. In the same way we can have an absolute poverty line for income; we can have a "minimum age at death". The poverty or deprivation measure is then the proportion of the population that dies before that age. In this paper, both the relative and absolute poverty lines are computed for the total population. For the former case, the relative poverty line is assumed to be 75% of life expectancy; whereas the latter is assumed to be 70 years, the same figure international institutions such as the OECD use when computing premature life years lost or that Williams (1999) uses as an example for defining ‘fair innings’. We use the classical poverty measures developed by Foster Greer and Thorbeck (1984).

Defining the poverty line as *z*, the poverty measures P_0, P_1 and P_2 are calculated using the formula below:

$$P_\alpha = \sum_{a=1}^{z} \pi_a \left(1 - \frac{x_i}{z}\right)^\alpha$$

where, P_0 gives the poverty rate, that is the head-count of individuals below the minimum longevity line as a proportion of the total population; P_1 gives the poverty gap which is the mean distance separating the longevity of population dying prematurely as a percentage of the minimum longevity line and last P_2 is the poverty intensity and gives more weight to premature mortality situation the more premature death is.

4. INEQUALITY MEASURES AND POVERTY INDICES: EMPIRICAL RESULTS

The source of the longevity data is a set of life tables drawn from the Human Mortality Database (Human Mortality Database (2010)) covering the period 1940-2007.

The data shows an increase in life expectancy and a decrease in the standard deviation of longevity over time, so there is a downward trend in the CV. We also find that the inequality among men is slightly higher than among women for the years under analysis, as illustrated in Figure 1. Furthermore, between 1940 and 1975, there are some sudden downturns and upturns followed by a smooth decline afterwards.

Figure 1 here

The results of the Gini Index are consistent with the CV as can be seen in Figure 2. In Portugal in 1940, the Gini was around 0.33. Over the next 67 years this figure declines to a value close to 0.09, marking a large decline in inequality.

Figure 2 here

Figure 3 and 4 show the evolution of two Atkinson indexes of inequality for the cases where $\varepsilon=1$ and $\varepsilon=2$. Atkinson 1 reaches the same conclusions with our previous indices. Atkinson 2 is extremely sensitive to low longevity[2] (infant mortality) and so we get results that are very close to 1, but we can see the downward trend in inequality.

Figures 3 and 4 here

Our last measure of inequality, the Theil index, is also generates results that are consistent with the previous measures, as Figure 5 shows.

Figure 5 here

In Figure 6 the evolution of overall inequality measured by the Theil index is decomposed into the evolution of inequality among men, inequality among women for ten years intervals.

Figure 6 here

The results for relative and absolute longevity poverty are shown in Figures 7 and 8, respectively. The downward trend in "longevity poverty" can be easily seen in the graphs.

Figures 7 and 8 here

It is worthwhile mentioning that P1 and P2 estimates for longevity are much larger than the estimates of the same indices for income. The reason behind this difference is that few people have zero income in real life; however, for longevity, when infant mortality is high, by definition there are many people with longevity close to zero and that fact leads to the very different results that can be seen in Figures 7 and 8.

[2] In fact, one single observation of zero longevity would make this index impossible to compute, so one needs to keep in mind footnote 1.

Overall, both for inequality and for poverty we find a consistent and robust downward trend proving that at least these components of the distribution of well-being have been changing substantially towards greater equity.

5. ECONOMETRIC METHODOLOGY

Most of the economic series we have estimated in the earlier section are upward (*downward*) slopping and non-stationary. Such series cause spurious regression problems that prevent the application of the classical estimation methods. Therefore, the alternative method, cointegration analysis introduces the idea that even if the underlying time series are non-stationary, linear combinations of these series might be stationary. But we need to check whether the series in question are indeed non-stationary and have the same integration order. This is done by employing unit root tests.

5.1. Unit Root Tests

5.1.1. Augmented Dickey-Fuller Test:

Dickey and Fuller (1979, 1981) framed a procedure to formally test for non-stationarity where testing for non-stationarity is equivalent to testing of a unit root. Thus, the test takes into consideration the AR (1) model of the form:

$$y_t = \rho y_{t-1} + \varepsilon_t \qquad (5.1.1)$$

Where y_0 is a fixed constant and ε_t is a sequence of independent normal random variables with mean 0 and variance σ^2. The estimator ρ and the regression t test furnish methods of testing the hypothesis that ρ =1.

The Dickey and Fuller test is based on the assumption that the disturbance term is white noise. As this assumption is unlikely to hold, Dickey and Fuller extended their test procedure to a higher order AR process, AR (p+1), suggesting an augmented version of the test which includes extra lagged terms of the dependent variable in order to eliminate autocorrelation. The augmented Dickey-Fuller (ADF) test is based on the regression;

$$\Delta y_t = \alpha_0 + \alpha_1 t + \beta y_{t-1} + \sum_{i=1}^{n} \vartheta_i \Delta y_{t-i} + \varepsilon_i \qquad (5.1.2)$$

Where y_t is the time series, Δ denotes the differencing operator, t is a time trend; and ε_t is the error term. The test statistic is the standard t-ratio for the estimate of β, and the rejection region consists of (absolutely) large, negative values. There is also the no-trend version of the ADF test, where the trend is dropped from equation (5.1.2).

In ADF, it is tested whether $\beta = 0$ and the ADF test follows the same asymptotic distribution as the DF statistic, so the same critical values can be used.

5.1.2. Kwiatkowski-Philips-Schmidt-Shin Tests (KPSS)

The ADF test takes the existence of a unit root as the null hypothesis. This has been the subject of much criticism. For example, De Jong et. al. (1989) argues that the ADF test has low power against stationary alternatives that are nearly non-stationary. To overcome this major problem, KPSS (1992) propose a test of the null hypothesis that an observable series are stationary around a deterministic trend. The test is the one sided Lagrange multiplier (LM) test of the null of trend stationarity that corresponds to the hypothesis that the variance of the random walk equals zero. The asymptotic distribution of the statistic is derived under the null and alternative hypotheses that the series is difference-stationary.

The KPSS test is based on the regression:

$$y_t = x_t + \beta t + \varepsilon_t \qquad (5.1.3)$$

where the time series, y_t, is decomposed into the sum of a deterministic trend; t, the error term, ε_t, and a random walk, x_t. Hence,

$$x_t = x_{t-1} + v_t \qquad (5.1.4)$$

Here, the disturbance term, v_t, is i.i.d. $(0, \sigma_v^2)$. The stationary null hypothesis is $\sigma_v^2 = 0$. If the null is accepted, then the error term disappears and x_t becomes a constant. This means that the time series, y_t, is characterized by a deterministic trend. If the null is rejected, then the time series has a unit root with a constant. The critical values of the KPSS test are tabulated in Kwiatkowski et. al. (1992)

5.2. Cointegration Analysis

Cointegration method analyzes the long run relationship of the economic time series by considering the non-stationarity problem and enables the test of the economic theory. Cointegration analyses provide the estimation of short-run disequilibrium by facilitating long-run parameters.

Granger (1981) first introduced the concept of cointegration and this concept was further developed by Engle-Granger in 1987, Engle and Yoo in 1987, Philips and Ouliaris in 1990, Stock and Watson in 1988, Philips in 1986 and 1987 and Johansen 1988, 1991 and 1995.

Granger (1986) considers initially a pair of series x_t, y_t each of which is I (1) and having no drift or trend in mean. It is generally true that any linear combination of these series is also I (1). However, if there exists a constant A, such that

$$z_t = x_t - Ay_t \qquad (5.1.5)$$

is I(0), then x_t, y_t will be said to be cointegrated, with A called the cointegrating parameter. If it exists, A will be unique in the situation now being considered.

The relationship $x_t = Ay_t$ might be considered a long-run or 'equilibrium' relationship, perhaps as suggested by some economic theory, and z_t measures the extent to which the system x_t, y_t is out of equilibrium. If x_t and y_t are I(1) but “move together in the long-run”, it is necessary that z_t be I (0) as otherwise the two series will drift apart without bound.

Engle and Granger (1987) introduced a very simple procedure that is based on a single equation approach to test the existence of cointegrating relationships. Nevertheless, there are some shortcomings of the Engle-Granger methodology. The most important problem is that this approach does not give the number of cointegrating vectors because it uses residuals from a single relationship, for this reason, it can't treat the possibility of more than one cointegrating relationship. Therefore, an alternative to the EG approach is needed and this is the Johansen approach for multiple equations.

Johansen's approach (1988, 1991) to analyze cointegrated systems has received much attention. Johansen proposes a maximum likelihood (ML) method for estimating long-run equilibrium relationship or cointegrating vectors and derives likelihood ratio (LR) tests for cointegration in a Gaussian vector error correction model.

Johansen (1988) derives a LR cointegration test based on a vector autoregressive model without a constant term. Johansen (1991) shows, however, that when a constant term is included in the model, both LR test statistic and its asymptotic distribution are altered. In addition, the analysis depends on whether, or not the series contains a trend in the non-stationary component. Johansen's approach allows testing hypotheses concerning the number of equilibrium relationships.

Johansen and Juselius (JJ) (1990) consider an autoregressive model of order p, AR (p). That is

$$y_t = \prod_1 y_{t-1} + \dots + \prod_k y_{t-k} + \mu + \Psi D_t + \varepsilon_t \qquad (5.1.6)$$

where y_t is a vector of p variables, ε_t is a vector of error terms which are $N(0, \Lambda)$, μ is a vector of constants, and D_t is a vector of exogenous variables including seasonal dummies. Many economic variables are non-stationary, so a first difference operator is generally applied to equation (5.1.6) to ensure the variables are stationary. However, this can lead to a loss of valuable long-run information unless it is done properly. Therefore, JJ reformulate equation (5.1.6) as follows:

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \dots + \Gamma_k \Delta y_{t-k-1} + \Pi y_{t-k} + \mu + \Psi D_t + \varepsilon_t \qquad (5.1.7)$$

Where $\Gamma_i = -(l - \Pi_1 - ... - \Pi_i)$ and. $\Pi = -(l - \Pi_1 - ... - \Pi_k)$

The equation (5.1.7) is obtained by subtracting Y_{t-1} from both sides of equation (5.1.6) and collecting terms on Y_{t-1}. Since all the terms in equation (5.1.6) are I(1), the model in equation (5.1.7) is assumed to contain only I(0) variables and a white noise error term.

The JJ technique decomposes the matrix $\Pi_{(pxp)}$ to discover information about the long-run relationships between the variables in y_t. In particular, if Π has a rank of r where 0 < r < p, then it can be written as $\Pi = \alpha\beta'$ where β' is an rxp matrix of r cointegrating vectors and α is a pxr matrix of adjustment speeds. So the hypothesis of at most r cointegrating vectors is formulated as the restriction $H_0 = \alpha\beta'$ where rank (Π) = r.

To determine the value of r, Johansen (1988) constructed two likelihood ratio (LR) statistics. One statistic is called the maximal eigenvalue test (λ-max) and compares the null of $H_0(r)$ with an alternative of $H_1(r+1)$. It is calculated as

$$\lambda - \max(r) = -T \ln(1 - \hat{\lambda}_{r+1}) \qquad (5.1.8)$$

Where $\hat{\lambda}_{r+1}$ is the (r+1) largest estimated eigenvalue. The statistic, trace statistic, tests a sequence of null hypotheses r=0, r≤1,...,r≤p-1 and is calculated as

$$Trace(r) = -T \sum_{i=r+1}^{p} \ln(1 - \hat{\lambda}_i) \qquad (5.1.9)$$

Where $\hat{\lambda}_{\xi}$ are the (p-r-1) smallest estimated eigenvalues and p is the number of variables. The critical values are tabulated in Johansen and Juselius (1990).

5.3. The Granger Causality Test

Granger- causality is a technique for determining whether one time series is useful in forecasting another time series and for predicting the relationship between the two variables. The Granger Causality Test takes in consideration the past values of variables.

The Granger Causality test for the case of two variables y_t and x_t, involves as a first step the estimation of the following VAR model:

$$x_t = a_1 + \sum_{i=1}^{n} \theta_i x_{t-i} + \sum_{j=1}^{m} \delta_j y_{t-j} + e_{1t} \qquad (5.1.10)$$

$$y_t = a_2 + \sum_{i=1}^{n} \beta_i x_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-j} + e_{2t} \qquad (5.1.11)$$

where y_t and x_t are two stationary time series with zero means and both ε_{yt} and ε_{xt} are taken to be uncorrelated white-noise error terms.

The definition of causality given above implies that y_t is causing x_t provided some δ_j is not zero. Similarly x_t is causing y_t if some β_i is not zero. If both of these events occur, there is said to be a feedback relationship between x_t and y_t.

6. DETERMINANTS OF LONGEVITY DISPERSION: EMPIRICAL RESULTS

6.1. Data

The analysis uses the annual data on Gini[3] and P_0[4] which have been computed before and life expectancy (EX-0), real GDP per capita (GDPPC), total health expenditure per capita (THEPC) covering the time period 1970-2006 for Portugal. Table 1 shows some descriptive statistics.

Table 1 here

These variables are chosen in order to separate the income/wealth effect from the intervention/health resources effect. Data of total health expenditure per capita are taken from the database OECD Health Data[5]; whereas, data on real GDP per capita are obtained from

[3] Analysis uses Gini for the "total" population
[4] Analysis uses relative P_0.
[5] www.**oecd**.org/statistics

Penn World Table. The regression analysis uses life expectancy, real GDP per capita and total health expenditure per capita in logarithmic form.

6.2. Unit Root Tests and Cointegration Analysis

The degree of integration of each of the time series is determined through the unit-root tests, namely the Augmented Dickey-Fuller (ADF), and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests. Table 2 reports the results of ADF and KPSS unit root tests for the variables Gini, P0, life expectancy, GDP per capita and total health expenditure per capita both in levels and first differences.

Table 2 here

In these tests, the lag lengths of the variables are chosen based on Akaike and Schwarz-Bayesian criteria in which the lowest value is always preferable. First, we perform the ADF test. The t–statistics of the ADF test for all variables in levels are lower than the critical values, and therefore we fail to reject the null hypothesis of non-stationarity; whereas we reject the null hypothesis in the first differences as the t-statistics for the ADF tests are higher than the critical values. Second, the KPSS test is performed. The t-statistics of the KPSS for all variables are greater than the critical values in levels. As a result, we reject the null hypothesis of stationarity; however, the t-statistics of the KPSS are lower than the critical values for the first differences so we fail to reject the null hypothesis of stationarity. Consequently, all of our variables clearly exhibit non-stationary characteristics in levels both in the ADF and in the KPSS tests. All variables become stationary in first differences. Therefore, we will treat all the variables as I(1) processes.

As the results of the unit root tests indicate that the series are I(1), it is appropriate to carry out a cointegration analysis. Cointegrating relationships between the sequences are shown through Johansen’s cointegration tests which are presented in Table 3.

Table 3 here

The appropriate lag length was chosen based on a VAR analysis where the Akaike and Schwarz-Bayesian Criteria are minimized. We determined the number of cointegrating vectors depending on Trace Statistics. According to these tests, for both Gini and P0 cases we have two cointegrating vectors statistically significant at the 0.05 critical level which indicates that an equilibrium relationship between Gini (P0), life expectancy, GDP per capita and total health expenditure per capita exists in the long-run.

After finding out the long-run relation between our variables, the next step of our empirical analysis is to investigate the magnitude and direction of the coefficients for life expectancy, GDP per capita, and total health expenditure per capita. The estimates are presented in Table 4. Both inequality and poverty in longevity have a positive time-trend, decrease with life expectancy and GDP per capita but increase with total per capita health expenditure.

Table 4 here

Since the negative impact of per capita health expenditure was unexpected we tried to fine tune the analysis. We used OECD data on total public social expenditure per capita (PEPC) (adding to health expenditures other variables such as social security pensions, expenditures on social solidarity programs etc.) instead of just total health expenditure per capita in our regression. We also applied the same process to both public health expenditure per capita (PUHEPC) and private health expenditure per capita (PRHEPC). The results for all three cases are shown in tables 5, 6 and 7.

Tables 5, 6 and 7 here

The results for the three Gini regressions using as alternative co-variates either public social expenditures per capita, or public health expenditures per capita, or private health expenditures per capita are that in all three cases the coefficient is positive but not significant. We interpret these results as reinforcing, weakly, the idea that there is a positive association between inequality and total health expenditures. On the other hand, for the poverty regressions we find significantly positive coefficients for private health expenditures and significantly negative coefficients for public health expenditures or for social public expenditures.

Going back to the results in Table 4, life expectancy and GDP per capita have highly significant and negative coefficients but the coefficient for the total expenditure per capita is highly significant and positive. This suggests that the historical decreases in the Gini and P0 indices are associated with the growth in life expectancy and in GDP per capita. Thus the continued improvements in life expectancy and GDP per capita translate into continued reductions of the remaining inequality and poverty. On the other hand, our results also suggest that the higher health expenditure per capita is, the higher will be the Gini, which seems rather less intuitive. Could it be that we have a situation with reverse causality, whereby positive shocks in longevity inequality trigger a response that includes increasing expenditures on health? This led us to an examination of the direction of causality by means of Granger causality tests. Table 8 and 9 present the results of these Granger Causality Tests.

Tables 8 and 9 here

The results suggest that there is a unidirectional causality running from life expectancy to the Gini and to P0 as well as from GDP per capita to the Gini. Both results can be thought of as consistent with conventional wisdom. However, P0 Granger causes GDP per capita, which seems somewhat unexpected. In terms of the direction, the positive relationship between total health expenditures per capita and the Gini can be considered puzzling as discussed above. Nonetheless, since we are dealing with a policy variable, the co-integration results could be interpreted as saying that expenditures increase to try to counteract the effects of increasing inequality, so that the positive relationship is the consequence of policy reactions. This is an alternative to saying that longevity inequality causes health expenditure per capita.

The empirical results reveal that P0 Granger causes total health expenditure per capita as it is presented in Table 9. This is consistent with the “policy reaction” interpretation. Nevertheless, the causality tests regarding the Gini, on the other hand, show puzzling results. There is a bi-directional causality between the Gini and total health expenditure per capita for the fourth lag, which implies that changes in Gini precede changes in total health expenditure per capita, as well as that changes in total health expenditure per capita cause changes in the Gini. However, disturbingly, when the first lag is chosen, we find that total health expenditures per capita Granger cause the Gini.

7. CONCLUSION

This paper studies the dispersion in the distribution of longevity. An historical sequence of life tables for Portugal covering the period 1940-2007is used to examine how not only the mean of longevity (life expectancy) has evolved but also the dispersion around that mean.

We start from the distributions of longevity over the years, given by period life-tables, and calculate inequality measures and poverty indices characterizing each distribution of longevity. The results show that there is a downward trend in longevity inequality and longevity poverty for all inequality measures and poverty indices. Peltzman (2009) who describes two important sub-categories of mortality inequality which are inequality due to gender and geography, mentions that a female born today can expect to live around 10 percent longer than her male counterpart. We also find that the inequality among men is slightly higher than among women for the years under analysis.

Finally, we undertake an empirical investigation considering the time-series of the measures of inequality and poverty in longevity and their relationship with aggregate data. We show that an equilibrium relationship between the Gini (P0), life expectancy, GDP per capita and total health expenditure per capita exists in the long-run. The results suggest that the Gini and P0 are negatively associated with life expectancy and GDP per capita. On the other hand, our results also suggest that the higher health expenditure per capita, the higher will be the Gini. The conclusions are similar for P0, but when we use separately public or private health expenditures, the signs of the effects on P0 are different, with public health expenditures per capita decrassing P0 and private health expenditures having an effect with the opposite sign.

These conclusions are consistent with Le Grand (1987) analysis who finds out that that health inequality is negatively associated with per capita GDP but positively associated with per capita medical care. In terms of the direction, the positive relationship between total health expenditure per capita and Gini (P0) could be interpreted as the results of policy reactions as public/policy variables/expenditures increase to try to counteract the effects of increasing inequity/poverty. The empirical result do reveal that P0 Granger causes total health expenditure per capita. Nevertheless, the causality tests, on the other hand, show puzzling results regarding Gini. as we find some evidence that total health expenditure per capita Granger causes the Gini.

This study can be expanded to the next level by investigating the inequality in the distribution of longevity for the remaining EU countries. Moreover, panel data analysis can be developed for this larger sample to combine cross-sectional and time-series information.

REFERENCES

Anand, S., Diderichsen, F., Evans T., Shkolnikov V. and Wirth, M. (2001), 'Measuring disparities in health: methods and indicators', Challenging Inequities in Health: From Ethics to Action, ed. by T.Evans, Oxford University Press, 49-67

Asteriou, D. (2005), Applied Econometrics: A Model Approach Using EViews and Microfit, Palgrave Macmillan.

Becker, G. S., Philipson, T.J., Soares, R.R. (2005), 'The Quantity and Quality of Life and the Evolution of World Inequality', American Economic Review, vol. 95(1), pages 277-291, March.

Cowell, FA (1995), Measuring Inequality 2n Ed, Prentice Hall.

Deaton, A. (2001), Inequalities in income and inequalities in health, in F. Welch, The Causes and Consequences of Increasing Inequality, Chicago: University of Chicago Press, pp. 285-313.

Dickey, D.A., and Fuller, W.A., (1979), 'Distribution of the Estimators for Autoregressive Time Series with a Unit Root', Journal of the American Statistical Association, 74, 427-431.

Dickey, D.A., and Fuller, W.A., (1981), 'Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root', Econometrica, 49, 1057-1072.

Foster, J., Greer, J. and E. Thorbecke (1984), 'A Class of Decomposable Poverty Indices', Econometrica 52, 761-766.

Grand, J.L., (1987), 'Inequalities in Health: Some International Comparisons', European Economic Review, 31, 182-191.

Granger C. W. J., (1969), 'Investigating Causal Relations by Econometric Models and Cross-Spectral Methods', Econometrica, 37, 424-38.

Human Mortality Database. University of California, Berkeley (USA), and Instituto Nacional de Estatística (INE) (Portugal). Available at www.mortality.org (data downloaded March, 2010).

Johansen, S., (1988), 'Statistical Analysis of Cointegration Vectors', Journal of Economic Dynamics and Control, 12, 231-54.

Johansen, S., and Juselius, K., (1990), 'Maximum Likelihood Estimation and Inference on Cointegration-With Application to the Demand for Money", Oxford Bulletin of Economics and Statistics, 52, 169-210.

Kwiatkowski, D., Philips, P. C. B., Schmidt, P. and Shin Y., (1992), 'Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root: How Sure Are We That Economic Time Series Have a Unit Root?', Journal of Econometrics, 54, 159-78.

Lambert, PJ (1993), The Distribution and redistribution of Income – A Mathematical Analysis 2nd Ed, Manchester.

Peltzman, S., (2009), 'Mortality Inequality', Journal of Economic Perspectives, 23, 175-90.

Ravallion, M (1994), Poverty Comparisons, Harwood Academic Publishers.

van Doorslaer, E., Masseria, C., (2004), "Income-Related Inequality in the Use of Medical Care in 21 OECD Countries", OECD Health Working Papers, No. 14, OECD Publishing.

Williams, A., (1997), 'Intergenerational Equity: An Exploration of the 'Fair Innings' Argument', Journal of Health Economics, 6, 117-132

APPENDIX

FIGURES

Figure 1

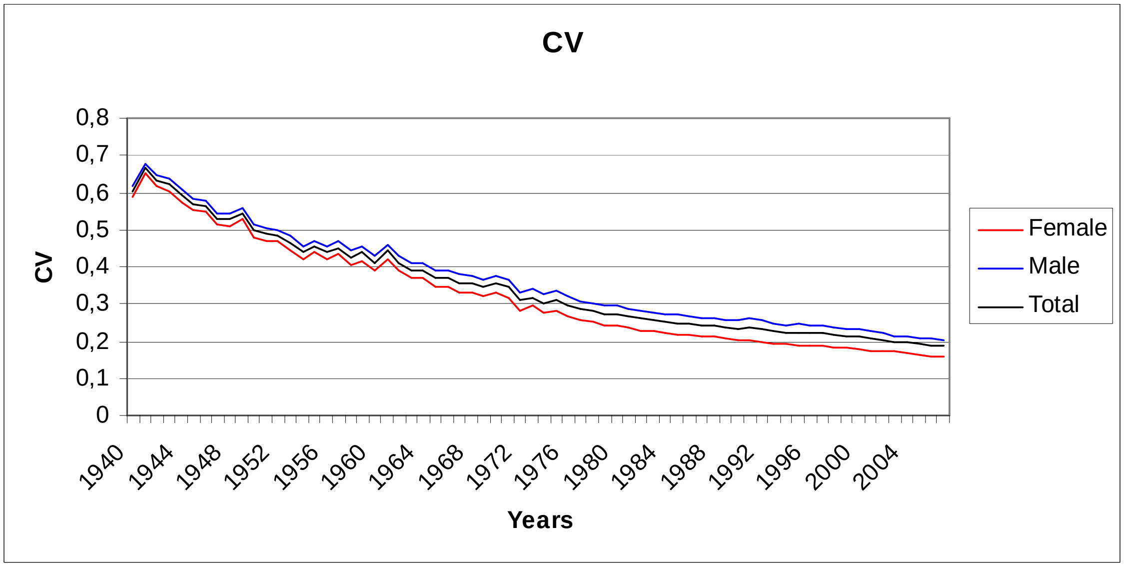


Figure 2

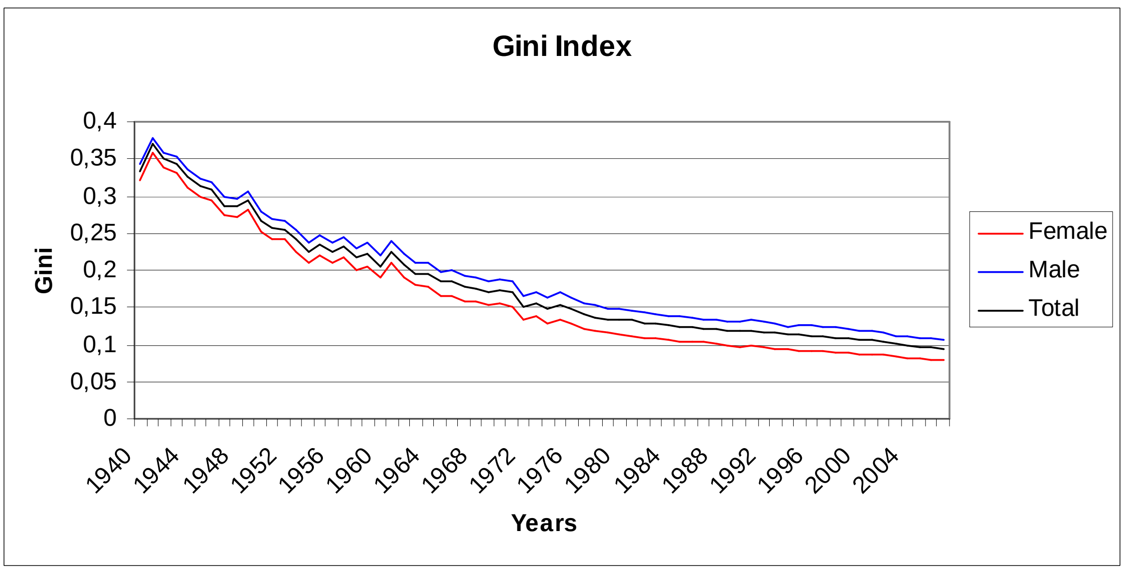


Figure 3

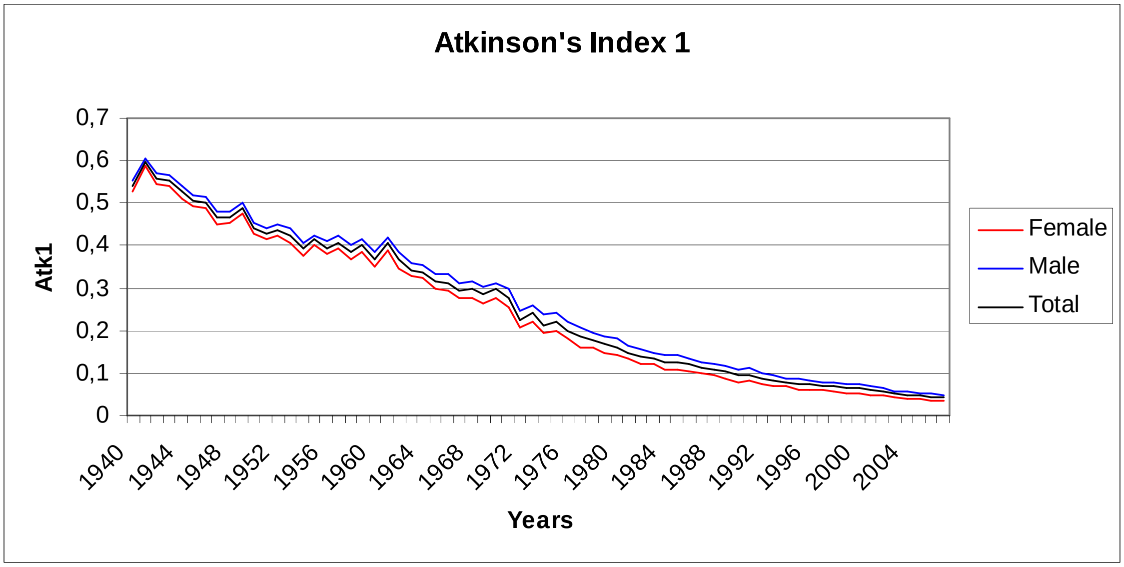


Figure 4

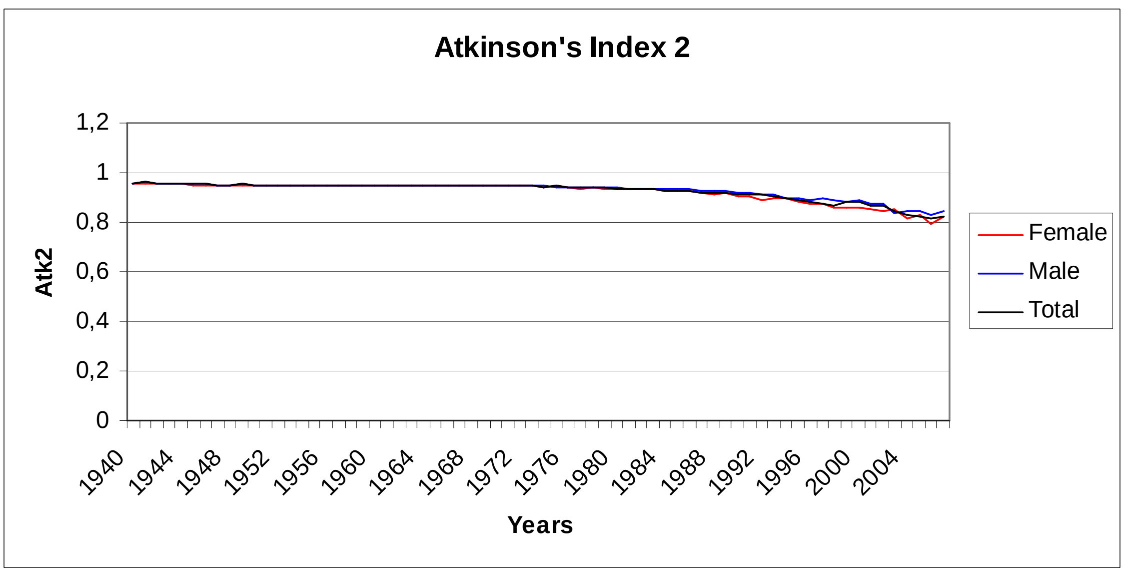


Figure 5

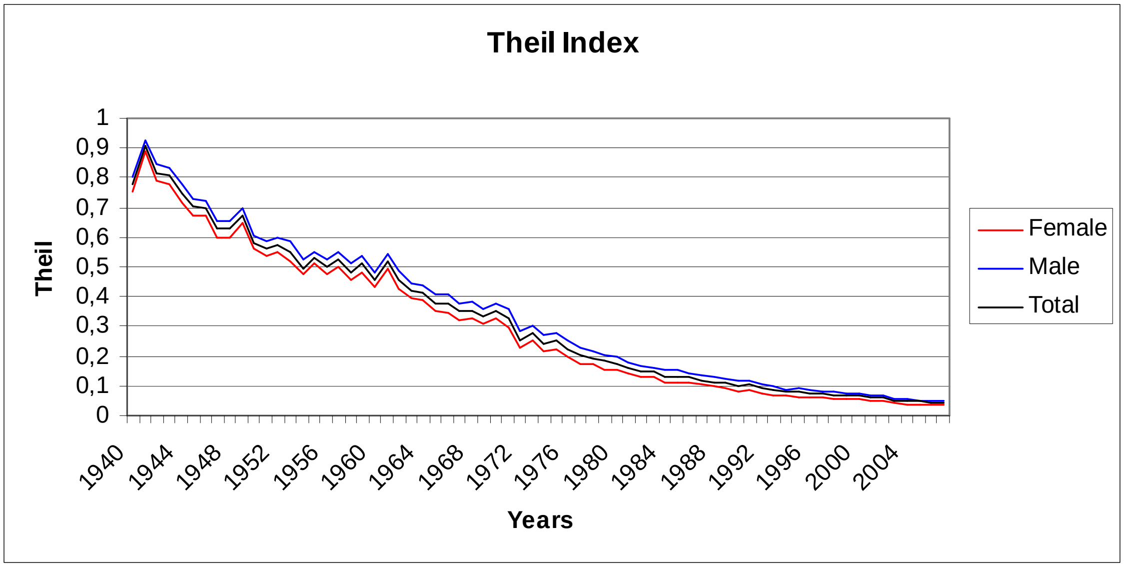


Figure 6

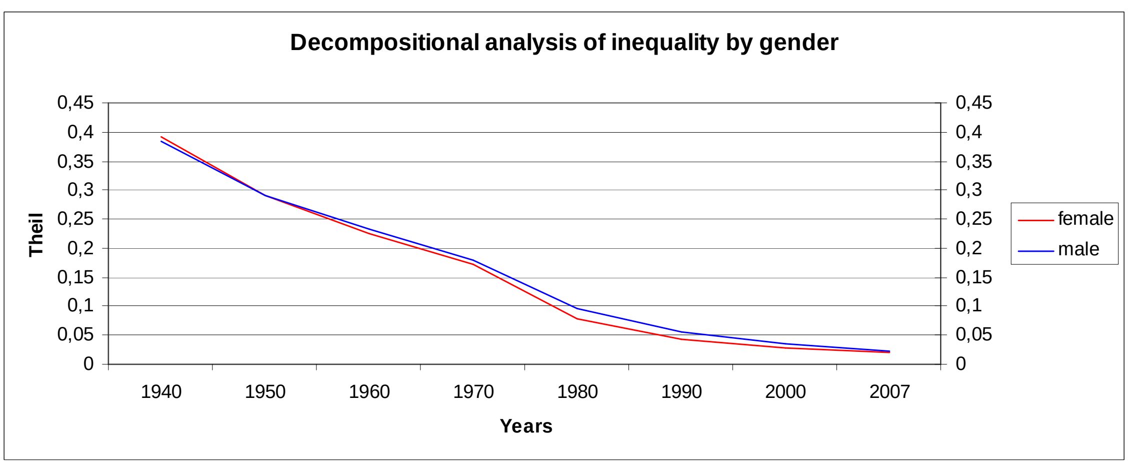


Figure 7

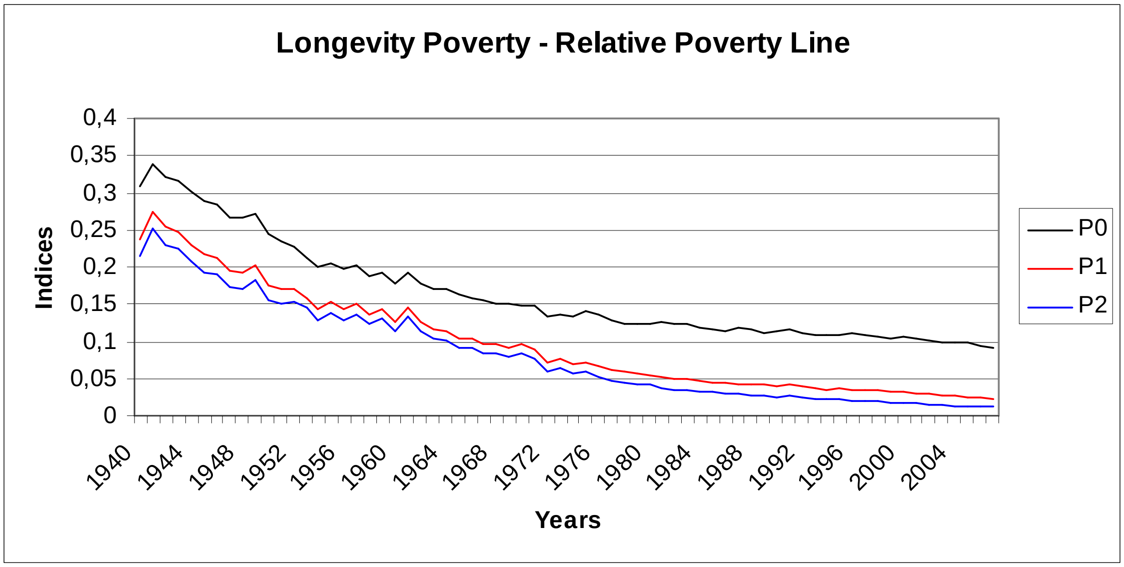
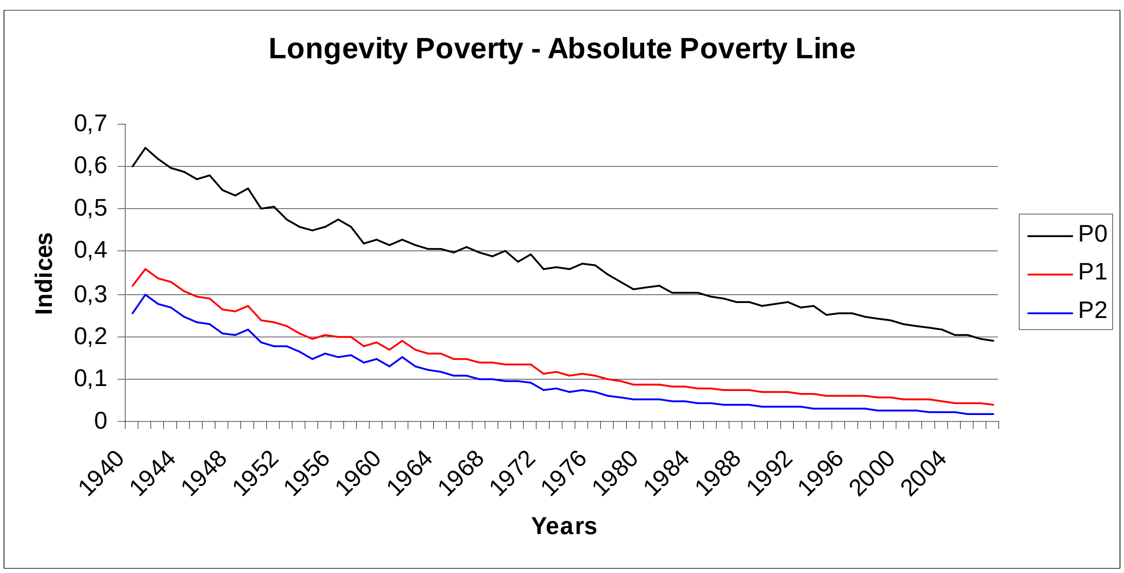


Figure 8



TABLES

Table 1: Descriptive Statistics

	GINI	P0	EX-0	GDPPC	THEPC($)
Min	0.096	0.093	66.940	7630.12	48.000
Max	0.174	0.149	78.940	19878.90	2150.000
Mean	0.125	0.117	73.560	13865.87	755.541
Median	0.121	0.115	74.070	13576.11	575.000
Standard Deviation	0.020	0.014	0.045	0.300	1.070

Standard deviations are given for life expectancy (EX-0), GDP per capita (GDPPC) and total health expenditure/capita (THEPC) in logarithmic form

Table 2: Unit Root Tests

Variable	Case	1970-2006 Unit Root Tests (Level)		1970-2006 Unit Root Tests (Difference)	
		ADF	KPSS	ADF	KPSS
GINI	Constant	-1.487 (0.521)	1.795	-7.070 (0.000)	0.424
	Constant & Trend	-1.899 (0.633)	0.355	-6.733 (0.000)	0.119
P0	Constant	-1.883 (0.336)	1.807	-5.858 (0.000)	0.081
	Constant & Trend	-3.161 (0.109)	0.294	-5.593 (0.000)	0.048
EX-0	Constant	-2.414 (0.145)	1.859	-6.125 (0.000)	0.176
	Constant & Trend	-1.658 (0.748)	0.351	-5.916 (0.000)	0.068
GDPPC	Constant	-1.126 (0.695)	1.893	-4.830 (0.001)	0.106
	Constant & Trend	-2.579	0.154	-4.790	0.051

		(0.292)		(0.003)	
THEPC	Constant	-2.794 (0.070)	1.875	-4.188 (0.002)	0.671
	Constant & Trend	-3.123 (0.117)	0.363	-4.959 (0.002)	0.092

Maximum lag is chosen as 4

For the KPSS test the critical values for the case with intercept are 0.739, 0.436 and 0.347 for 1%, 5% and 10% significance levels. The critical values for the case with trend and intercept are 0.216, 0.146 and 0.119 for 1%, 5% and 10% repectively.

Table 3: Johansen Cointegration Test

Time Period	Hypothesized No. of CE(s)	Trace Statistics	0.05 Critical Values	P-Values
1970-2006 (GINI-EX-0-GDPPC-THEPC)	r=0	142.336	63.876	0.000
	r≤1	72.512	42.915	0.000
	r≤2	21.195	25.872	0.171
	r≤3	2.882	12.518	0.890
1970-2006 (P0-EX-0-GDPPC-THEPC)	r=0	156.875	63.876	0.000
	r≤1	47.087	42.915	0.018
	r≤2	18.583	25.872	0.306
	r≤3	2.485	12.518	0.931

Table 4: Coefficients Estimates from JJ

Dependent Variable	Variable	Coefficient estimate	Standard Error
GINI (1970-2006)	@Trend	0.0041	0.0008
	EX-0	-1.9079	0.1700
	GDPPC	-0.1687	0.0176
	THEPC	0.0695	0.0152
P0 (1970-2006)	@Trend	0.0057	0.0006
	EX-0	-2.4123	0.1231
	GDPPC	-0.2670	0.0132
	THEPC	0.1092	0.0087

Table 5: Coefficients Estimates from JJ

Dependent Variable	Variable	Coefficient estimate	Standard Error
GINI (1970-2006)	@Trend	0.0020	0.0001
	EX-0	-0.7570	0.0245
	GDPPC	-0.0325	0.0038
	PUHEPC	0.0004	0.0011
P0 (1970-2006)	@Trend	0.0072	0.0001
	EX-0	-0.3578	0.0254
	GDPPC	0.0313	0.0041
	PUHEPC	-0.0151	0.0012

Table 6: Coefficients Estimates from JJ

Dependent Variable	Variable	Coefficient estimate	Standard Error
GINI (1970-2006)	@Trend	-0.00006	0.0001
	EX-0	-0.4998	0.0361
	GDPPC	0.0078	0.0033
	PRHEPC	0.0011	0.0011
P0 (1970-2006)	@Trend	-0.0011	0.0003
	EX-0	-0.2711	0.0685
	GDPPC	0.0234	0.0063
	PRHEPC	0.0051	0.0021

Table 7: Coefficients Estimates from JJ

Dependent Variable	Variable	Coefficient estimate	Standard Error
GINI (1970-2006)	@Trend	0.0021	0.0001
	EX-0	-0.7570	0.0245
	GDPPC	-0.0325	0.0038
	PEPC	0.0003	0.0011
P0 (1970-2006)	@Trend	0.0007	0.0001
	EX-0	-0.3578	0.0254
	GDPPC	0.0313	0.0041
	PEPC	-0.0151	0.0012

Table 8: Granger Causality Tests: Time Period 1970-2006

Null Hypothesis	F-Statistic	Probability
THEPC does not Granger Cause GINI (4th lag)	6.315	0.001
GINI does not Granger Cause THEPC	3.050	0.036

THEPC does not Granger Cause GINI (1st lag)	14.903	0.001
GINI does not Granger Cause THEPC	2.266	0.142
GDPPC does not Granger Cause GINI	4.990	0.007
GINI does not Granger Cause GDPPC	0.945	0.433
EX-0 does not Granger Cause GINI	7.403	0.002
GINI does not Granger Cause EX-0	2.386	0.109

Maximum lag order is chosen as 4

Table 9: Granger Causality Tests: Time Period 1970-2006

Null Hypothesis	F-Statistic	Probability
THEPC does not Granger Cause P0	1.847	0.153
P0 does not Granger Cause THEPC	6.390	0.001
GDPPC does not Granger Cause P0	1.226	0.326
P0 does not Granger Cause GDPPC	3.365	0.025
EX-0 does not Granger Cause P0	7.600	0.009
P0 does not Granger Cause EX-0	6.1E-05	0.994

Maximum lag order is chosen as 4

ANNEX

Inequality and Poverty Longevity Detailed Results

Female

Year	CV	Gini	Atk1	Atk2	Theil
1940	0,587491	0,320121	0,528363	0,95453	0,751546
1941	0,65241	0,359223	0,589047	0,958822	0,889276
1942	0,616459	0,338471	0,544875	0,95361	0,787182
1943	0,603846	0,330277	0,54047	0,955121	0,777551
1944	0,574318	0,311966	0,510918	0,952349	0,715225
1945	0,553178	0,299046	0,490993	0,951082	0,675294
1946	0,54706	0,294363	0,488892	0,95122	0,671175
1947	0,513495	0,273184	0,451429	0,947197	0,600439
1948	0,510753	0,271506	0,452001	0,947976	0,601482
1949	0,527398	0,280605	0,475673	0,950654	0,645641
1950	0,481149	0,251754	0,42813	0,949335	0,558843
1951	0,468514	0,24296	0,415887	0,948692	0,537662
1952	0,468514	0,24112	0,423096	0,949225	0,550079
1953	0,445376	0,225559	0,404387	0,949339	0,518164
1954	0,420194	0,210816	0,376536	0,950177	0,472465
1955	0,43837	0,220863	0,400949	0,950032	0,512408
1956	0,421242	0,210431	0,37978	0,948992	0,477682
1957	0,432543	0,217209	0,392709	0,949596	0,498748
1958	0,405849	0,200653	0,367455	0,950584	0,458004
1959	0,417224	0,206129	0,383651	0,950475	0,483942
1960	0,388346	0,189428	0,350771	0,950678	0,431969
1961	0,421905	0,208768	0,390298	0,950284	0,494785
1962	0,38792	0,189516	0,34717	0,949474	0,426439
1963	0,370869	0,179257	0,327005	0,949426	0,396018
1964	0,368811	0,178873	0,322443	0,949977	0,389261
1965	0,346862	0,166439	0,296228	0,949559	0,351301
1966	0,345076	0,165738	0,293958	0,949188	0,34808
1967	0,331916	0,158977	0,275051	0,947995	0,321653
1968	0,331441	0,157996	0,278626	0,949294	0,326597
1969	0,322064	0,153363	0,26472	0,94826	0,307503
1970	0,329489	0,156266	0,278429	0,949695	0,326324
1971	0,317597	0,15094	0,25553	0,945979	0,295083
1972	0,283238	0,133822	0,206155	0,945363	0,230866
1973	0,294184	0,138801	0,222511	0,94483	0,251685
1974	0,274643	0,129414	0,193011	0,941876	0,214445
1975	0,279245	0,132109	0,200601	0,944805	0,223895
1976	0,268366	0,127184	0,17933	0,93984	0,197635
1977	0,254922	0,121158	0,159547	0,936134	0,173814
1978	0,250584	0,117989	0,158074	0,940078	0,172063
1979	0,244119	0,115271	0,145473	0,933871	0,157207
1980	0,240511	0,113878	0,140532	0,93601	0,151441
1981	0,235834	0,112007	0,132494	0,932208	0,142133
1982	0,229378	0,109452	0,121595	0,930243	0,129647
1983	0,22786	0,10836	0,121164	0,930541	0,129157
1984	0,220892	0,105833	0,107391	0,92484	0,113607

1985	0,218093	0,104363	0,106528	0,92602	0,112641
1986	0,217481	0,104175	0,104609	0,9235	0,110494
1987	0,213917	0,102683	0,097319	0,916579	0,102386
1988	0,210022	0,100876	0,093709	0,913416	0,098394
1989	0,206097	0,099106	0,088164	0,915807	0,092295
1990	0,202016	0,097528	0,079912	0,904117	0,083286
1991	0,202867	0,098029	0,080403	0,904101	0,08382
1992	0,196905	0,095803	0,071783	0,891882	0,074489
1993	0,194596	0,095035	0,067718	0,892769	0,07012
1994	0,192976	0,09381	0,067392	0,893999	0,069771
1995	0,188581	0,091978	0,061497	0,881543	0,063469
1996	0,187708	0,091513	0,059342	0,874678	0,061175
1997	0,188182	0,091925	0,058895	0,873611	0,060701
1998	0,184902	0,090101	0,055451	0,861959	0,057048
1999	0,180438	0,088125	0,052148	0,857164	0,053557
2000	0,178467	0,087274	0,051364	0,857078	0,05273
2001	0,174952	0,086177	0,046275	0,853102	0,04738
2002	0,174847	0,085449	0,047859	0,846334	0,049042
2003	0,171296	0,083804	0,04501	0,852687	0,046054
2004	0,166556	0,082161	0,038337	0,81533	0,039091
2005	0,163513	0,08048	0,038187	0,826873	0,038935
2006	0,159583	0,078708	0,033696	0,789733	0,034277
2007	0,159696	0,078188	0,036494	0,820735	0,037177

Male

Year	CV	Gini	Atk1	Atk2	Theil
1940	0,616926	0,342095	0,551248	0,956747	0,801286
1941	0,676412	0,377214	0,604096	0,960095	0,926583
1942	0,644689	0,35868	0,570586	0,957021	0,845335
1943	0,634985	0,35297	0,566565	0,958049	0,836013
1944	0,607734	0,336693	0,539629	0,955276	0,775723
1945	0,584377	0,322944	0,516894	0,953841	0,72752
1946	0,577067	0,317719	0,51421	0,953947	0,721979
1947	0,545369	0,297733	0,481547	0,951374	0,656906
1948	0,544368	0,297404	0,480439	0,951396	0,65477
1949	0,560486	0,30631	0,5025	0,953578	0,69816
1950	0,515486	0,278031	0,454553	0,949488	0,60615
1951	0,50363	0,270248	0,442363	0,947762	0,584048
1952	0,501155	0,266432	0,449534	0,949591	0,596991
1953	0,485405	0,254471	0,442469	0,950422	0,584236
1954	0,456444	0,237739	0,407148	0,948559	0,522811
1955	0,469992	0,246019	0,424343	0,948836	0,552244
1956	0,456606	0,237574	0,409407	0,948605	0,526629
1957	0,468323	0,24471	0,42251	0,949295	0,549063
1958	0,444381	0,229555	0,40075	0,949557	0,512077
1959	0,456422	0,236272	0,414941	0,949873	0,536043
1960	0,428425	0,219588	0,38342	0,948939	0,483567
1961	0,460275	0,238375	0,420232	0,949641	0,545128
1962	0,430832	0,221534	0,384761	0,949907	0,485745
1963	0,410324	0,209093	0,360149	0,950155	0,44652
1964	0,408459	0,208943	0,354018	0,94909	0,436983
1965	0,390308	0,198352	0,334129	0,949765	0,406659
1966	0,390431	0,198962	0,333454	0,949531	0,405646

1967	0,378328	0,192691	0,31305	0,947701	0,375494
1968	0,376885	0,190887	0,316631	0,949253	0,38072
1969	0,36744	0,185894	0,30183	0,947827	0,359292
1970	0,373477	0,188406	0,313103	0,948827	0,375571
1971	0,367585	0,185899	0,29981	0,947227	0,356404
1972	0,330523	0,165851	0,245629	0,945649	0,28187
1973	0,338416	0,169539	0,258825	0,946771	0,299518
1974	0,324248	0,162649	0,235612	0,945945	0,26868
1975	0,334761	0,170476	0,241849	0,944413	0,276873
1976	0,320617	0,162698	0,221235	0,943951	0,250046
1977	0,308089	0,155535	0,205291	0,942737	0,229779
1978	0,301612	0,151943	0,193825	0,942019	0,215455
1979	0,295	0,148659	0,183836	0,942397	0,203141
1980	0,293853	0,148495	0,179669	0,940298	0,198047
1981	0,288146	0,146682	0,163248	0,936562	0,178227
1982	0,282004	0,143107	0,156066	0,933809	0,169681
1983	0,277155	0,14086	0,148405	0,933995	0,160644
1984	0,272436	0,13856	0,14082	0,92983	0,151777
1985	0,270985	0,137309	0,142666	0,93184	0,153928
1986	0,266297	0,135731	0,133803	0,932049	0,143643
1987	0,262892	0,134015	0,124429	0,924898	0,132879
1988	0,261894	0,133724	0,120399	0,926529	0,128287
1989	0,25845	0,131843	0,115121	0,922631	0,122304
1990	0,256211	0,131075	0,109898	0,917879	0,116419
1991	0,260603	0,133668	0,111632	0,917707	0,118369
1992	0,254385	0,131233	0,09941	0,911981	0,104705
1993	0,248483	0,127825	0,096036	0,910351	0,100966
1994	0,2415	0,124534	0,084873	0,895347	0,088693
1995	0,245397	0,126758	0,086193	0,89525	0,090136
1996	0,243529	0,126067	0,083049	0,888616	0,086701
1997	0,240115	0,124302	0,079831	0,896304	0,083198
1998	0,237536	0,122804	0,077052	0,891586	0,080183
1999	0,233259	0,12053	0,072921	0,88502	0,075716
2000	0,230412	0,118908	0,072527	0,887544	0,075292
2001	0,228377	0,118218	0,068151	0,876595	0,070584
2002	0,22304	0,115493	0,064824	0,870707	0,06702
2003	0,214749	0,111645	0,054439	0,834514	0,055977
2004	0,213559	0,110804	0,05599	0,845832	0,057618
2005	0,209119	0,108682	0,050923	0,843254	0,052265
2006	0,207375	0,107902	0,050892	0,829286	0,052232
2007	0,202311	0,105371	0,047779	0,843282	0,048958

Total Population

Year	CV	Gini	Atk1	Atk2	Theil
1940	0,603157	0,332143	0,54006	0,95572	0,776659
1941	0,665493	0,369248	0,597056	0,959555	0,908957
1942	0,631659	0,349585	0,558421	0,955505	0,817399
1943	0,620568	0,342744	0,554091	0,956734	0,807641
1944	0,592325	0,325789	0,525521	0,953912	0,745538
1945	0,570186	0,312489	0,504264	0,952566	0,701712
1946	0,563516	0,307572	0,501983	0,952706	0,69712
1947	0,530679	0,286765	0,466846	0,94944	0,628945
1948	0,528945	0,285908	0,466562	0,949807	0,628412
1949	0,544913	0,294818	0,488591	0,952077	0,670586

1950	0,499369	0,266233	0,440262	0,948713	0,580286
1951	0,48718	0,257941	0,429114	0,948249	0,560566
1952	0,485824	0,254971	0,437249	0,950172	0,574917
1953	0,466261	0,241034	0,423834	0,950047	0,55136
1954	0,439454	0,225568	0,391224	0,948669	0,496305
1955	0,455458	0,234811	0,413155	0,949577	0,532995
1956	0,439946	0,225272	0,394584	0,948839	0,50184
1957	0,451368	0,232227	0,407375	0,949446	0,523193
1958	0,426163	0,216302	0,383535	0,949412	0,483753
1959	0,438194	0,222512	0,400315	0,950416	0,511351
1960	0,409887	0,205757	0,367656	0,949318	0,458321
1961	0,442288	0,224838	0,405868	0,950121	0,520653
1962	0,410887	0,206918	0,366957	0,949949	0,457216
1963	0,392059	0,195681	0,343059	0,949019	0,420161
1964	0,390069	0,195467	0,33819	0,94953	0,412776
1965	0,370096	0,184044	0,314839	0,949605	0,378102
1966	0,369504	0,184052	0,312191	0,947438	0,374244
1967	0,357114	0,177546	0,294829	0,948032	0,349315
1968	0,355993	0,176015	0,298283	0,949443	0,354225
1969	0,34689	0,171328	0,284478	0,948338	0,334742
1970	0,353333	0,173909	0,296561	0,949445	0,351774
1971	0,344362	0,170228	0,276974	0,946432	0,32431
1972	0,30897	0,15165	0,225513	0,945326	0,255554
1973	0,318434	0,156065	0,24137	0,947143	0,276241
1974	0,302024	0,148045	0,213583	0,942334	0,240269
1975	0,310393	0,153879	0,22186	0,944606	0,250848
1976	0,297859	0,147419	0,200337	0,940376	0,223565
1977	0,284969	0,140637	0,184708	0,942195	0,204209
1978	0,2793	0,136948	0,176669	0,93943	0,194397
1979	0,272493	0,133454	0,167094	0,93953	0,182835
1980	0,270709	0,13322	0,161192	0,936586	0,175773
1981	0,26654	0,13248	0,148502	0,934224	0,160758
1982	0,259951	0,129124	0,14011	0,934869	0,150951
1983	0,25703	0,127733	0,135373	0,932063	0,145457
1984	0,251141	0,125192	0,12386	0,923696	0,132229
1985	0,24902	0,123808	0,124194	0,925358	0,132611
1986	0,24647	0,122971	0,119853	0,927767	0,127667
1987	0,243157	0,121425	0,111622	0,920656	0,118357
1988	0,241385	0,120718	0,10736	0,915637	0,113572
1989	0,237433	0,11865	0,102578	0,919139	0,108229
1990	0,234227	0,117353	0,095708	0,911164	0,100603
1991	0,237214	0,119058	0,097011	0,911143	0,102045
1992	0,231476	0,116856	0,087309	0,907963	0,091358
1993	0,227327	0,114889	0,082698	0,90155	0,086319
1994	0,222721	0,112404	0,077432	0,894696	0,080595
1995	0,223073	0,112742	0,075078	0,8885	0,078046
1996	0,221854	0,11232	0,072503	0,881792	0,075265
1997	0,220073	0,111476	0,070183	0,877449	0,072767
1998	0,217084	0,109733	0,067063	0,869219	0,069417
1999	0,213221	0,107882	0,06421	0,879685	0,066364
2000	0,210855	0,106686	0,063485	0,880668	0,06559
2001	0,207676	0,105386	0,058349	0,865304	0,06012
2002	0,204833	0,103755	0,057914	0,867767	0,059659
2003	0,198235	0,100605	0,050967	0,844491	0,052312

2004	0,195418	0,099345	0,0482	0,831787	0,049401
2005	0,191629	0,097375	0,045416	0,822964	0,046479
2006	0,188958	0,096166	0,043303	0,811343	0,044268
2007	0,186106	0,094551	0,042824	0,819253	0,043768

		RELATIVE POVERTY LINE				**ABSOLUTE POVERTY LINE**		
Year	**Poverty Line**	PO	P1	P2	**Year**	PO	P1	P2
1940	38,5725	0,309314	0,236631	0,21367	1940	0,600148	0,317742	0,256712
1941	35,9625	0,33947	0,274594	0,251959	1941	0,641689	0,35975	0,298863
1942	37,4025	0,32204	0,254132	0,229903	1942	0,61893	0,33711	0,275764
1943	38,2875	0,316369	0,247404	0,223665	1943	0,596708	0,326279	0,267038
1944	39,315	0,300174	0,2301	0,206763	1944	0,586918	0,308482	0,248372
1945	40,3575	0,288296	0,216386	0,193118	1945	0,570811	0,293018	0,233075
1946	40,2675	0,284064	0,213237	0,190689	1946	0,579388	0,290151	0,2301
1947	42,0225	0,267248	0,19441	0,171893	1947	0,542646	0,264296	0,207321
1948	42,57	0,266509	0,192762	0,171137	1948	0,530789	0,260106	0,204696
1949	41,535	0,271838	0,203071	0,182353	1949	0,547116	0,272579	0,216761
1950	43,8975	0,245355	0,1764	0,156201	1950	0,5014	0,23801	0,185708
1951	44,04	0,235475	0,169582	0,150358	1951	0,50416	0,231335	0,178988
1952	44,865	0,228048	0,169893	0,153173	1952	0,476485	0,223816	0,177253
1953	45,84	0,211488	0,159097	0,144667	1953	0,456198	0,208161	0,165132
1954	46,695	0,200166	0,142783	0,128118	1954	0,448941	0,19232	0,148292
1955	46,0725	0,20492	0,15213	0,138018	1955	0,45951	0,202465	0,158483
1956	45,93	0,197376	0,143141	0,129183	1956	0,473464	0,196809	0,150347
1957	46,1325	0,202154	0,149882	0,135806	1957	0,460069	0,200153	0,156141
1958	47,8575	0,187886	0,135409	0,122386	1958	0,420843	0,179184	0,139421
1959	47,2425	0,192054	0,143294	0,13029	1959	0,426469	0,187005	0,147645
1960	48,1875	0,176974	0,126626	0,114083	1960	0,414298	0,169735	0,13045
1961	47,1525	0,192712	0,145555	0,133007	1961	0,428614	0,189114	0,150061
1962	48,2925	0,177245	0,126874	0,114105	1962	0,414612	0,169937	0,130517
1963	48,765	0,169542	0,116346	0,103839	1963	0,407674	0,15927	0,11977
1964	48,93	0,169785	0,114701	0,101732	1964	0,407718	0,158234	0,117993
1965	49,6425	0,161925	0,103601	0,090983	1965	0,397588	0,146092	0,106381
1966	49,275	0,157567	0,102967	0,090361	1966	0,412492	0,148095	0,106517
1967	49,95	0,15645	0,096385	0,083248	1967	0,39814	0,139783	0,098955
1968	50,1825	0,151386	0,096186	0,083675	1968	0,387596	0,13725	0,098366
1969	49,89	0,149864	0,091268	0,078595	1969	0,401834	0,135279	0,094117
1970	50,3775	0,148409	0,095113	0,082915	1970	0,377946	0,134597	0,096989
1971	50,205	0,149059	0,089958	0,076914	1971	0,394636	0,132945	0,09227
1972	51,945	0,133833	0,071981	0,059302	1972	0,358312	0,110335	0,072475
1973	51,495	0,135673	0,076995	0,064189	1973	0,363737	0,116001	0,077847
1974	51,9075	0,133217	0,069056	0,055853	1974	0,358653	0,108044	0,069431
1975	51,6975	0,141874	0,072401	0,058248	1975	0,369475	0,113544	0,072909
1976	51,87	0,136142	0,066626	0,052362	1976	0,366883	0,10792	0,066981
1977	52,8075	0,129217	0,06062	0,046967	1977	0,343613	0,098093	0,059954
1978	53,1525	0,122969	0,058683	0,045267	1978	0,330257	0,093918	0,057484
1979	53,76	0,122648	0,05573	0,042468	1979	0,312774	0,088483	0,053839

1980	53,8125	0,123057	0,054695	0,041129	1980	0,316509	0,088184	0,052731
1981	53,955	0,125486	0,052622	0,038058	1981	0,317666	0,08709	0,050217
1982	54,5775	0,123708	0,049745	0,035626	1982	0,301584	0,081698	0,046773
1983	54,5175	0,123064	0,048566	0,034429	1983	0,304045	0,08102	0,045706
1984	54,735	0,119719	0,045965	0,031909	1984	0,300907	0,078063	0,042951
1985	54,945	0,11685	0,045177	0,031472	1985	0,29335	0,076215	0,042067
1986	55,245	0,113202	0,04383	0,030226	1986	0,289036	0,074157	0,040487
1987	55,5375	0,117785	0,042875	0,028869	1987	0,280089	0,071961	0,03891
1988	55,5525	0,117259	0,042209	0,028119	1988	0,281747	0,071401	0,038184
1989	55,9725	0,111643	0,040942	0,026843	1989	0,270118	0,068223	0,036353
1990	55,6875	0,113052	0,039767	0,025491	1990	0,277616	0,068398	0,035446
1991	55,6425	0,115169	0,040934	0,026241	1991	0,279737	0,069829	0,036422
1992	56,145	0,111971	0,038715	0,023756	1992	0,268063	0,066149	0,03353
1993	56,0775	0,109702	0,036911	0,022463	1993	0,272165	0,064813	0,032141
1994	56,82	0,108331	0,035474	0,021226	1994	0,250853	0,060272	0,029913
1995	56,685	0,109845	0,035926	0,021089	1995	0,253503	0,061157	0,03013
1996	56,6475	0,111432	0,035474	0,020513	1996	0,255205	0,061098	0,029694
1997	56,9775	0,108607	0,034895	0,019935	1997	0,247693	0,05933	0,02874
1998	57,135	0,105499	0,033966	0,019311	1998	0,240708	0,057546	0,027791
1999	57,27	0,103508	0,032631	0,018135	1999	0,237695	0,055843	0,026432
2000	57,63	0,106263	0,03168	0,01753	2000	0,228647	0,053737	0,025351
2001	57,8325	0,1043	0,030585	0,016435	2001	0,22406	0,052133	0,02407
2002	57,9675	0,101994	0,029574	0,015866	2002	0,221147	0,050713	0,023227
2003	58,1175	0,098101	0,027318	0,014153	2003	0,215722	0,04787	0,021177
2004	58,74	0,098583	0,026256	0,013416	2004	0,203616	0,044966	0,019769
2005	58,65	0,098061	0,025148	0,012548	2005	0,203872	0,044093	0,018909
2006	59,205	0,093369	0,024141	0,011895	2006	0,193838	0,041657	0,017693
2007	59,34	0,09127	0,023325	0,011396	2007	0,18991	0,040379	0,016979

Both the relative and absolute poverty lines are computed for the total population.

Relative poverty line is defined as 75% of life expectancy; whereas absolute poverty line is assumed to be 70 years, the figure that OECD uses for computing premature life years lost.