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THE ANALYSIS OF MORTALITY CHANGES IN SELECTED EUROPEAN COUNTRIES IN THE PERIOD 1960–2006

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ABSTRACT

Demographic changes which took place in the 20th century clearly reveal progressive ageing of whole societies. This phenomenon influences the risk connected with calculating the products of insurance companies and pension funds, where calculated mortality is one of the most important factors. The paper presents the analysis of mortality changes in male and female populations in selected countries from Central Europe (the Czech Republic, Hungary, Poland and Slovakia) and from Western Europe (France, Italy, Spain and Sweden) in the period 1960–2006. The analysis of the mortality changes has been carried out with the use of variables proposed in 2007 by J. P. Morgan in his work *Life Metrics – A toolkit for measuring and managing longevity and mortality risks.* The data used for the analysis have been obtained from www.mortality.org. The van Broekhoven algorithm has been applied for smoothing crude mortality rates across different ages. The analysis of mortality changes in selected European countries in the period 1960–2006 has shown considerable differences in the changes of initial mortality rate. Apart from obvious differences in male and female mortality, significant differences in the dynamics of mortality between Western and Central European countries were revealed. The most significant differences in the change of graduated initial mortality rate have been observed for people above 40–45 from Central and Western European countries. The period of most striking disproportions in the change of graduated initial mortality rate were the years 1970–1990, which seems to be the result of the socio-economic policy in Central European countries.

Key words*:* mortality, graduated initial rate of mortality, cluster analysis.

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1. Introduction

Demographic changes which took place in the 20th century clearly reveal progressive ageing of whole societies. This phenomenon is connected with economic growth, increased life standards resulting from an improved financial situation, advancements in medical sciences, as well as decrease in the number of children in a new family model. Ageing of populations influences the risk connected with calculating the products of insurance companies and pension funds, where calculated mortality is one of the most important factors.

In management of pension funds and insurance companies two risk sources play a fundamental role: the investment (financial) risk and the demographic risk. The demographic risk is divided into two components: the insurance risk and the longevity risk. The longevity risk is particularly important – it derives from the improvements in mortality trends, which determine systematic deviations of the number of deaths from its expected values. This risk should be assuaged by replacing traditional mortality tables used in the assessment of insurance products with projected mortality tables including a forecast of future trends in mortality.

Thus, estimating future changes in mortality trends and accurately identifying the laws governing mortality seems crucial. Mortality can be analysed from two perspectives: a statistical one and a biological one. The statistical approach takes into account historical data and, using them, analyses mortality trends in the past as a means of predicting future trends. The biological approach is based on life standards, advancements in medicine, environment, and the lifestyle of the population.

The paper presents the analysis of mortality changes in Poland and selected European countries carried out on the basis of historical data. The following countries have been chosen for the analysis: from Central Europe: the Czech Republic, Hungary, Poland and Slovakia, from Western Europe: France, Italy, Spain and Sweden. The analysis of the mortality changes has been carried out with the use of the following variables: m_x – *crude central rate of mortality*; q_x – *graduated initial rate of mortality*; e_x – *life expectancy.* These variables were proposed in 2007 by J. P. Morgan in his work *Life Metrics – A toolkit for measuring and managing longevity and mortality risks,* which has since become an international toolkit used for measuring and managing the mortality risk and the longevity risk. These tools measure both risks using standardised methods.

Life Metrics toolkit was applied to analyse mortality changes in male and female populations in selected countries in the period 1960–2006. The data used for the analysis have been obtained from www.mortality.org. The van Broekhoven algorithm1 was applied for smoothing crude mortality rates across different ages.

[1] See: van Broekhoven, H. (2002). Market Value of Liabilities Mortality Risk: A Practical Model. *North American Actuarial Journal* 6(2), 95–106.

2. Life Expectancy and the GDP

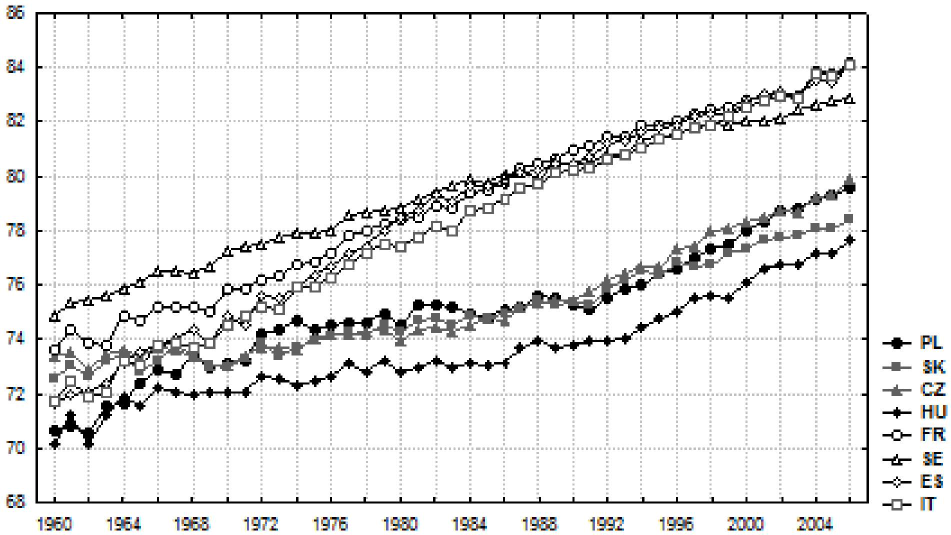
The analysis of life expectancy at the age 0 both in male (Fig. 1) and female (Fig. 2) populations has revealed a significant difference between two groups of countries. Since 1970's life expectancy at the age 0 has been substantially longer for Western European countries: France, Italy, Spain and Sweden than for Central European countries: the Czech Republic, Hungary, Poland and Slovakia. Table 1 presents the dynamics of the life expectancy growth in 2006 relative to 1960 for women and men in selected countries.

Table 1. The dynamics of the life expectancy growth in 2006 relative to 1960 for women and men in selected countries

Country	CZ	HU	PL	SK	FR	ES	IT	SE
	Czech Republic	Hungary	Poland	Slovakia	France	Spain	Italy	Sweden
Female	9%	11%	13%	8%	14%	17%	17%	11%
Male	9%	5%	10%	3%	15%	16%	18%	10%

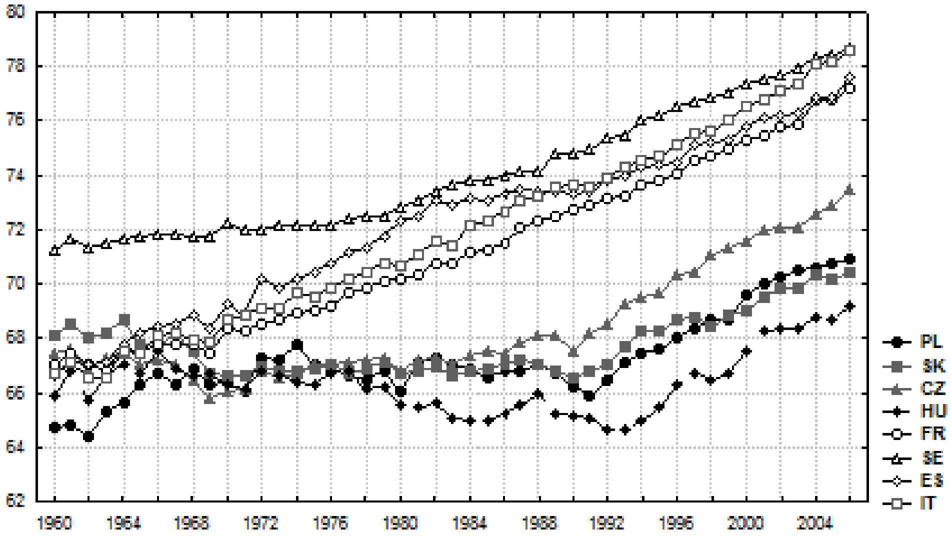
Source: Own calculations.

Figure 1. Life expectancy for men at the age 0 in the period 1960–2006



Source: Data obtained from www.mortality.org.

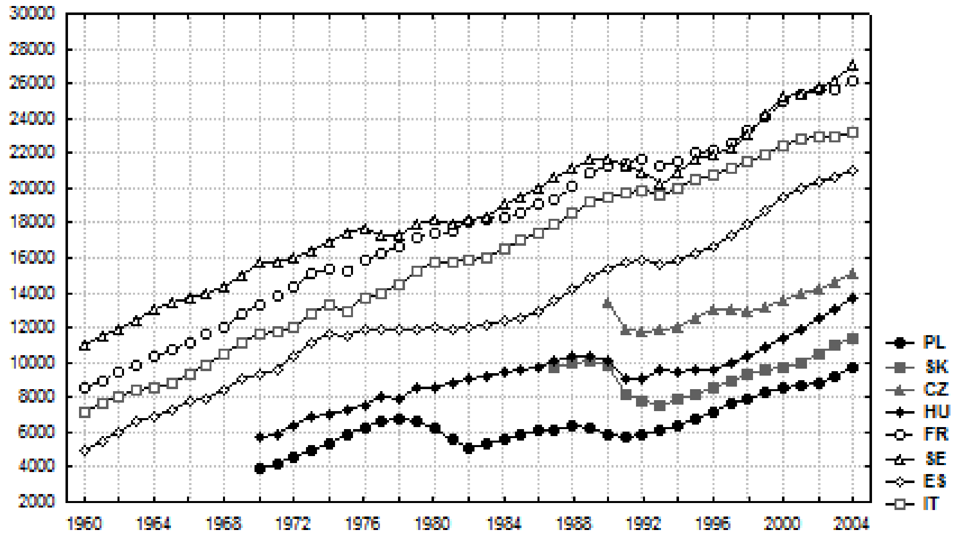
Figure 2. Life expectancy for women at the age 0 in the period 1960–2006



Source: Data obtained from www.mortality.org.

Fig. 3 presents the values of GDP per capita in the analysed countries. The analysis of these values indicates that, similarly to the case of life expectancy, two distinct groups can be observed – one with higher values of GDP (Western European countries) and the other with lower values (Central European countries). This conclusion seems to confirm the statement of a Polish demographer, Edward Rosset, that life tables are “a barometer of social progress”. Thus, the differences in life expectancy and the changes in mortality, i.e. lengthening of life expectancy, are a reflection of life conditions which consist of work, eating habits, natural environment, health care and education.

Figure 3. Real GDP per capita (Constant Prices: Laspeyres) (I$ in 2000 **Constant Prices)**



Source: Data obtained from http://pwt.econ.upenn.edu/php_site/pwt62/pwt62_form.php.

The countries selected for the analysis differ in such aspects as geography, climate or culture, yet the preliminary analysis (Fig. 1 and Fig. 2) shows that they do not have a significant impact on the values of life expectancy. It seems (Fig. 3) that the socio-economic development, which happens as a result of long-term socio-economic policy of a given country, has the greatest influence on life expectancy and mortality.

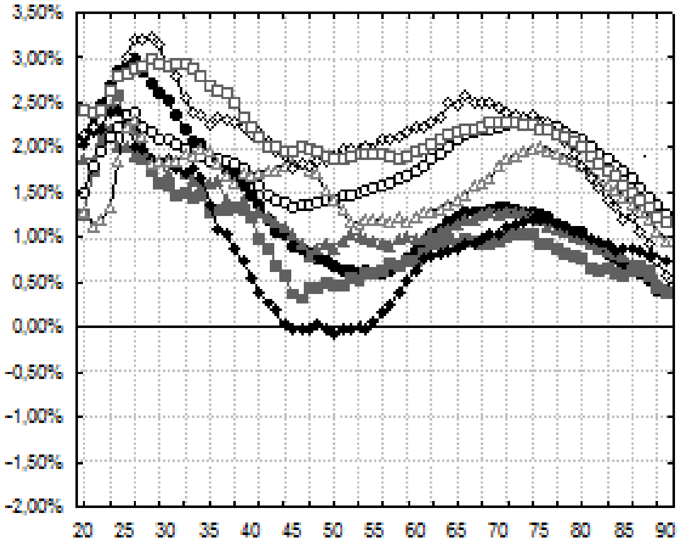
Thus, it might be useful to check from what age the changes in the course and the dynamics of mortality begin – the changes resulting from different political systems and the socio-economic development of particular countries.

3. Average Rate and Volatility of Changes of Graduated Initial Mortality Rate

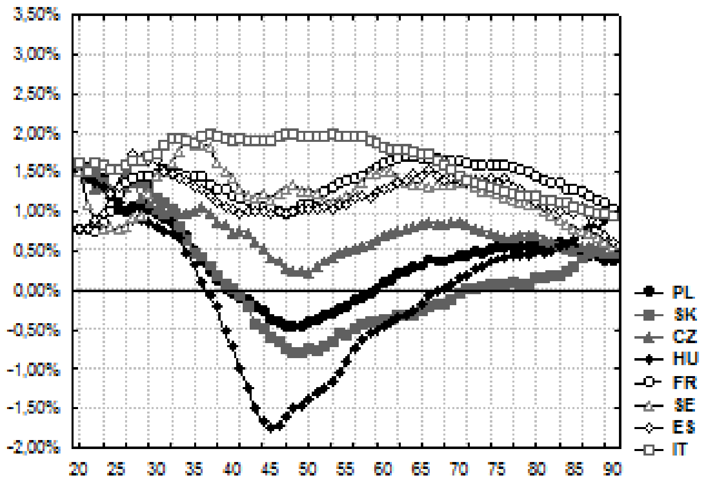
To analyse mortality first graduated initial rate of mortality (q_x) was calculated for women and men at the age 20–90, and next the average rate of change of graduated initial mortality rate for the period 1960–2005 for women and men at the age 20–90. Figure 4 shows the average rate of the change of graduated initial mortality rate for the period 1960–2005 for women and men at the age 20–90.

Figure 4. Average rate of changes of graduated initial mortality rate in the period 1960–2005 at the age 20–90.

a Female



b Male

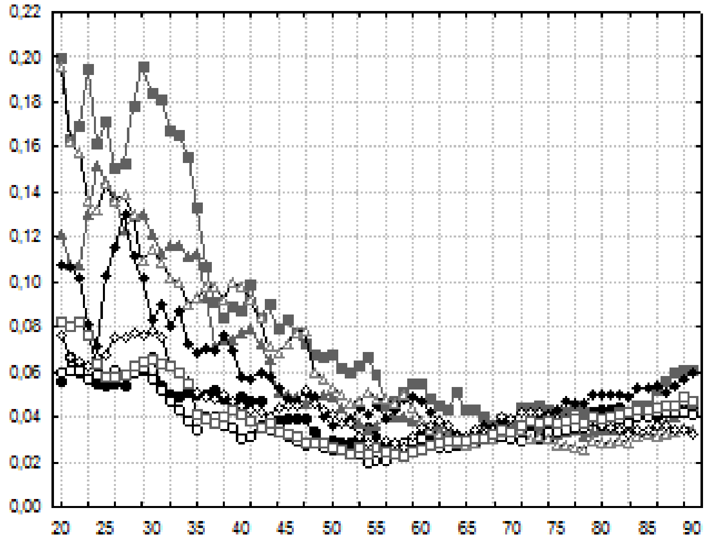


Source: Own calculations.

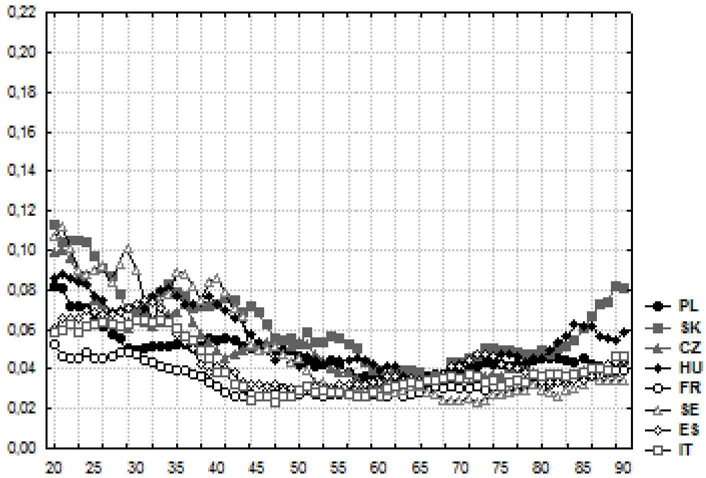
The analysis of Figure 4 reveals a considerably better situation in Western European countries as far as the average changes in the mortality rate for both men and women are concerned. It is especially true for men over 30 and for women over 40. The differences are less conspicuous for very young persons and people reaching 90. For example, in Italy, in the years 1960–2005 mortality rate for men at the age 35–57 was systematically decreasing by almost 2% every year. At the same period in Hungary mortality rate among men aged 45 increased by on average 1,73%. Such increasing mortality rate among middle-aged men was also visible in Slovakia and Poland in the period between 1960–2005.

Figure 5. Volatilities of graduated initial mortality rate changes for selected countries for males and females at the age 20–90.

a Female



b Male



Source: Own calculations.

Figure 5 presents volatility values calculated using standard deviation for selected countries for men and women at the age 20–90 in the period 1960–2005. It is worth paying attention to the curves representing women at the age 20–40, especially the high values of standard deviation for Slovakia, Sweden, the Czech Republic and Hungary.

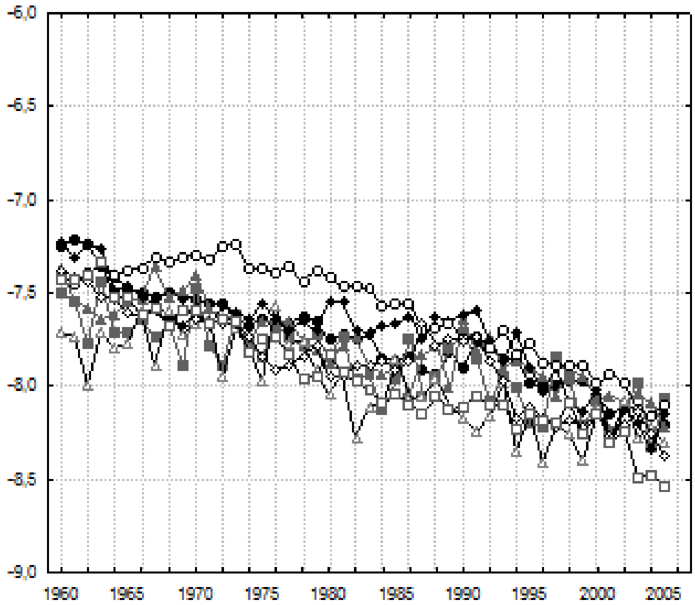
4. Cluster Analysis

Figures 6–9 present the values of q_x on a logarithmic scale at the age of 20, 45, 55 and 65 in the period 1960–2005. They show that both in male and female populations the curves in selected countries of Central and Western Europe differ. To find out at what age a significant difference in q_x can be observed, cluster analysis has been applied. After clustering, significantly "different" observations should be found in different clusters. To cluster countries into sets with "similar" q_x the Euclidean distance and Ward's method have been applied. The Ward procedure is one of the most efficient agglomerative hierarchical clustering methods. It uses an analysis of variance approach to evaluate the distances between clusters. Figures 6b–9b present the d*endrograms* of the clustering of the logarithm q_x at the age of 20, 45, 55 and 65 in the period 1960–2005 which have been done in the same scale. The analyses of particular dendrograms lead to distinct groups of countries. Tables 2–5 present groups of countries at the age of 20, 45, 55 and 65 in the period 1960–2005, which have been obtained for the arbitrarily accepted linkage distance d=3.

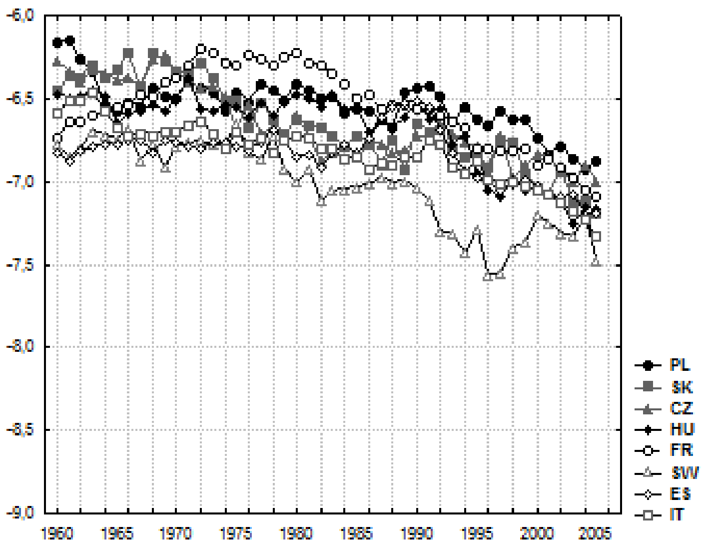
The objects of the analysis were the selected countries and the variables were the values of logarithms q_x in the years 1960–2005. So, the observation matrix consists of 8 objects and 45 variables. The calculations were obtained using the STATISTICA program. The results are presented in Figures 6–9.

Figure 6a. The values of q_x on a logarithmic scale at the age of 20 in the period 1960–2005

Female



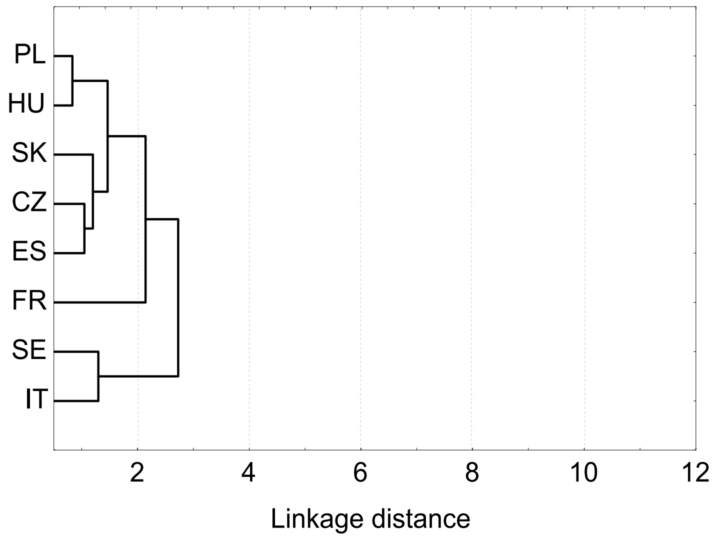
Male



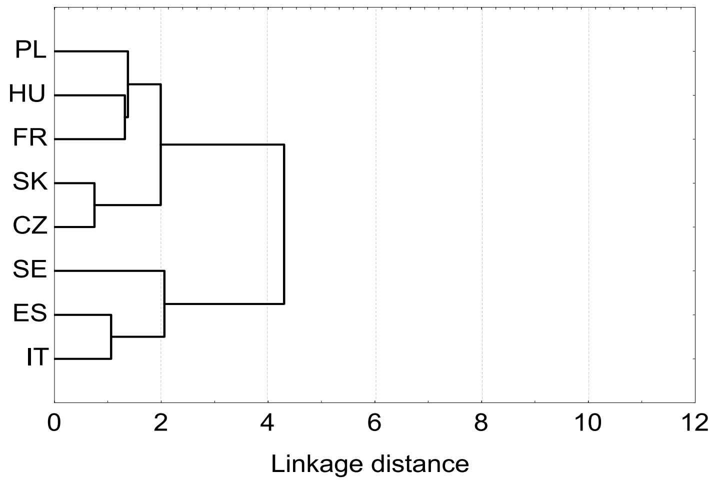
Source: Own calculations.

Figure 6b. The d*endrograms* of the clustering of the logarithm q_x at the age of 20 in the period 1960–2005 obtained using the Euclidean distance and *Ward's method*

Female



Male



Source: Own calculations in STATISTICA 8.0.

Table 2. Groups of countries obtained from d*endrograms* of the clustering of the logarithm q_x at the age of 20 in the period 1960–2005 (see: fig.6b) at the linkage distance d=3

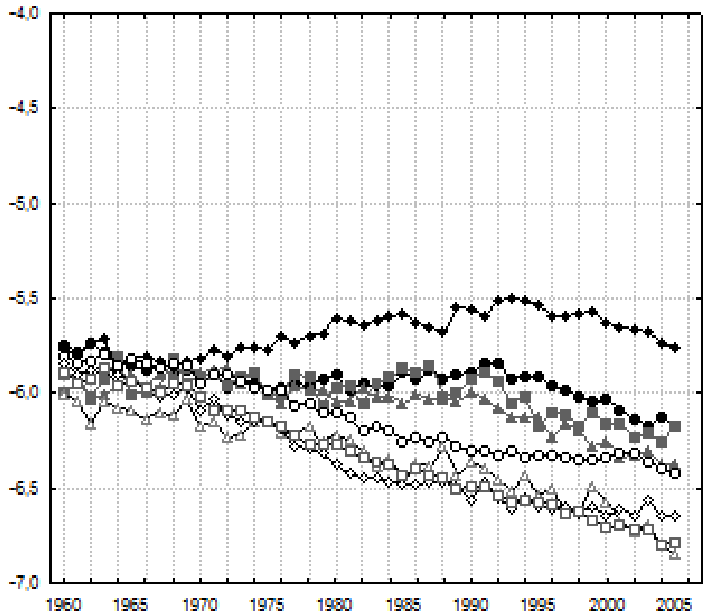
Female		Male	
Gr. 1	PL, HU, SK, CZ, ES, FR, SE, IT	Gr. 1	PL, HU, FR, SK, CZ
		Gr. 2	SE, ES, IT

Source: Own elaboration.

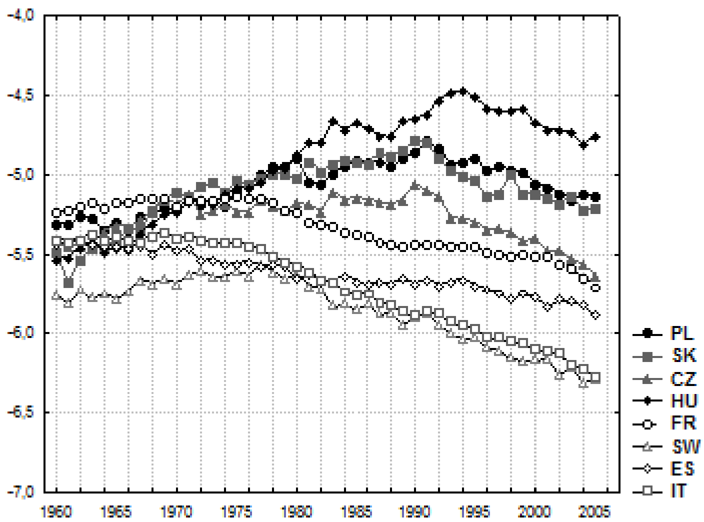
For younger populations (under 40–45) the differences in q_x (measured on a logarithmic scale) for particular countries are not very significant. For older cohorts the linkage distances are increasing, which indicates more significant differences. From 1970's lnq_x for both male and female populations in Western Europe became smaller and the improvement in mortality was faster than in Central European countries. It is most clearly visible from the age of 45 (Fig.7–9).

Figure 7a. The values of q_x on a logarithmic scale at the age of 45 in the period 1960–2005

Female



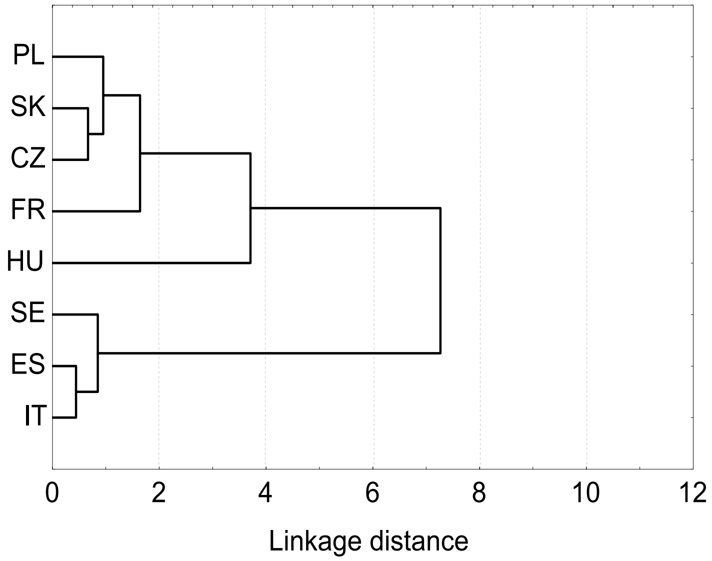
Male



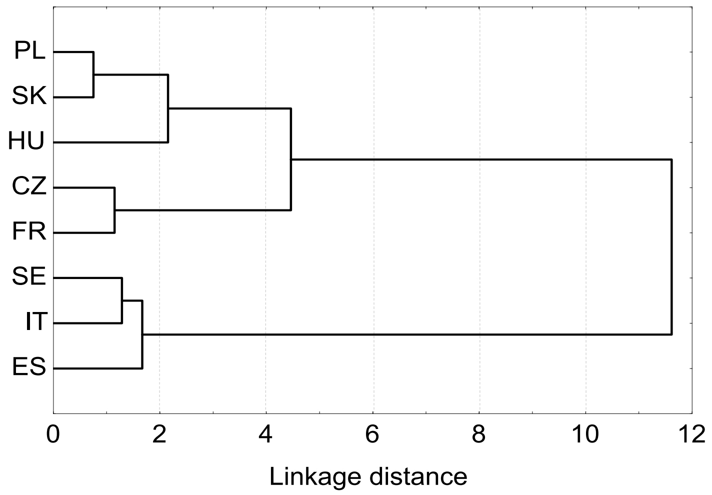
Source: Own calculations.

Figure 7b. The d*endrograms* of the clustering of the logarithm q_x at the age of 45 in the period 1960–2005 obtained using the Euclidean distance and *Ward's method*

Female



Male



Source: Own calculations in STATISTICA 8.0.

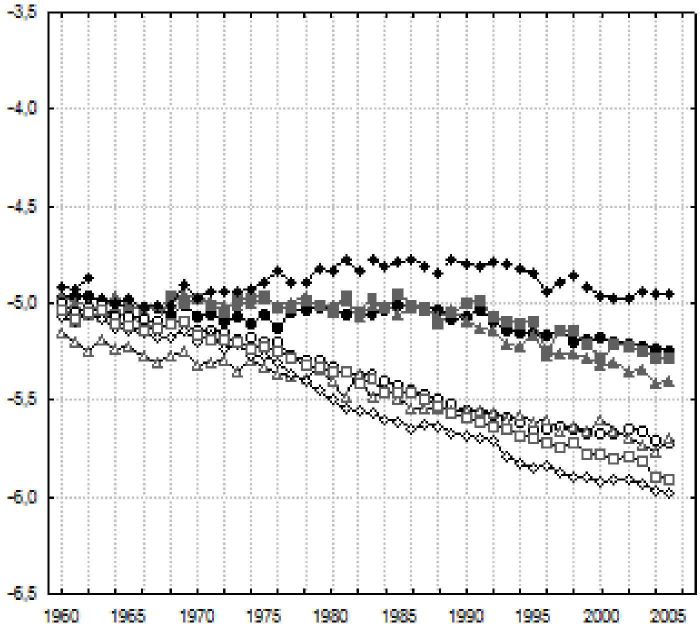
Table 3. Groups of countries obtained from d*endrograms* of the clustering of the logarithm q_x at the age of 45 in the period 1960–2005 (see: fig.7b) at the linkage distance d=3.

Female		Male	
Gr. 1	PL, SK, CZ, FR	Gr. 1	PL, SK, HU
Gr. 2	HU	Gr. 2	CZ, FR
Gr. 3	SE, ES, IT	Gr. 3	SE, IT, ES

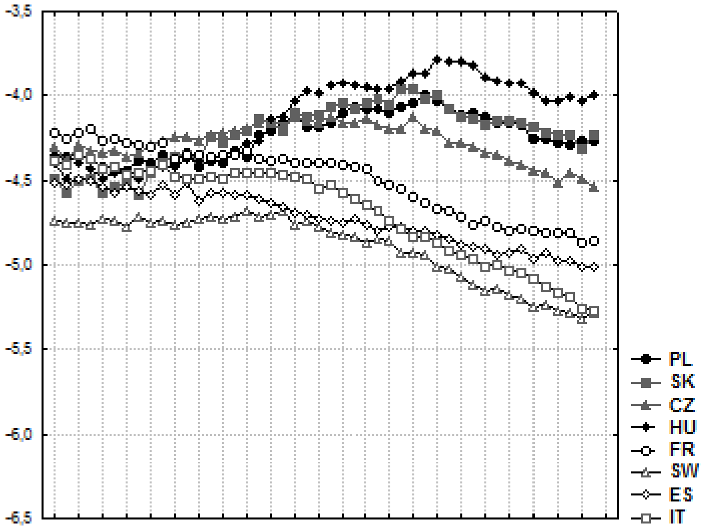
Source: Own elaboration.

Figure 8a. The values of q_x on a logarithmic scale at the age of 55 in the period 1960–2005

Female



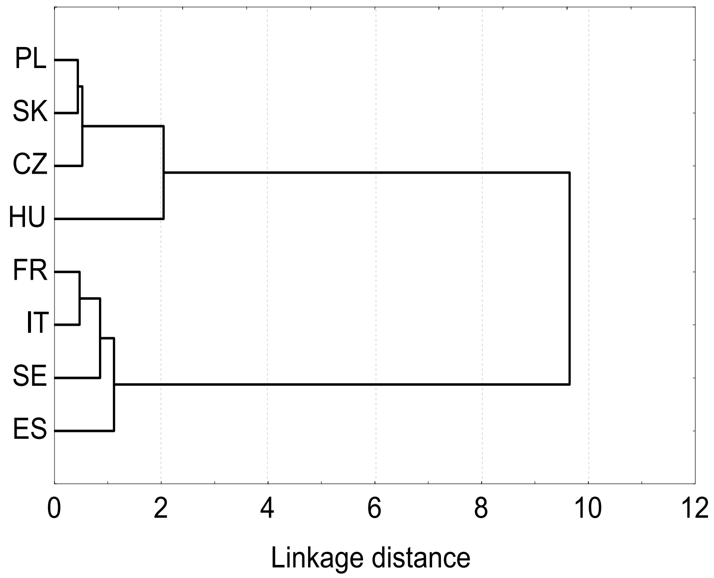
Male



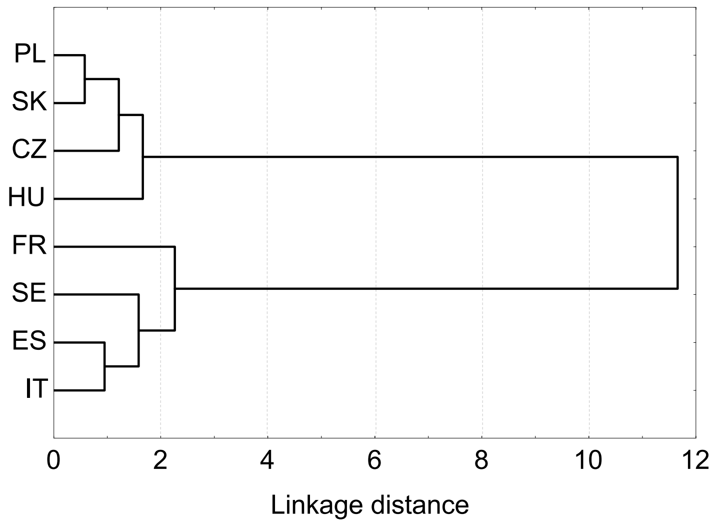
Source: Own calculations.

Figure 8b. The d*endrograms* of the clustering of the logarithm q_x at the age of 55 in the period 1960–2005 obtained using the Euclidean distance and *Ward's method*

Female



Male



Source: Own calculations in STATISTICA 8.0.

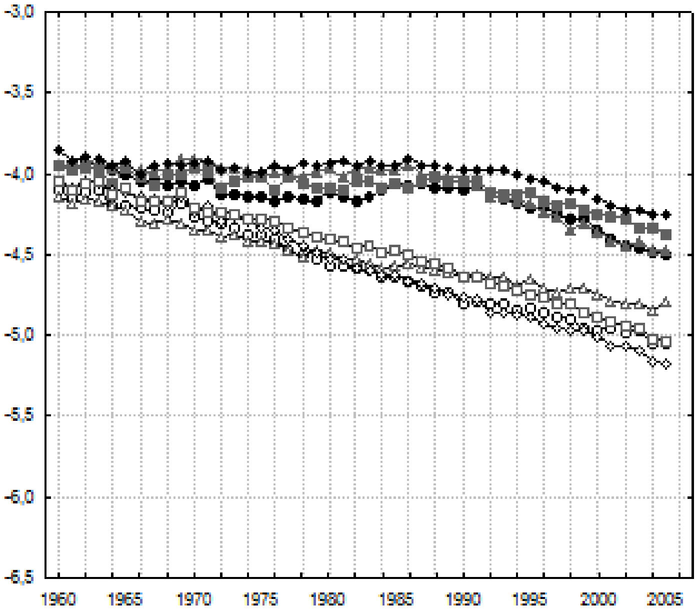
Table 4. Groups of countries obtained from d*endrograms* of the clustering of the logarithm q_x at the age of 55 in the period 1960–2005 (see: fig.8b) at the linkage distance d=3

Female		Male	
Gr. 1	PL, SK, CZ, HU	Gr. 1	PL, SK, CZ, HU
Gr. 2	FR, IT, SE, ES	Gr. 2	FR, IT, SE, ES

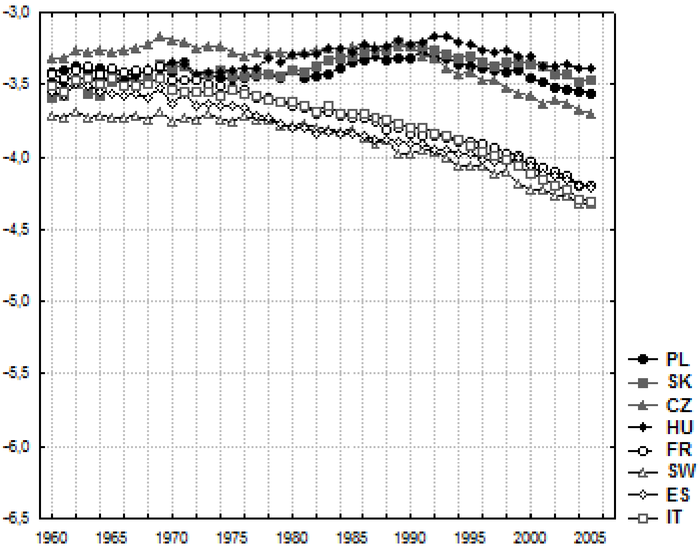
Source: Own elaboration.

Figure 9a. The values of q_x on a logarithmic scale at the age of 65 in the period 1960–2005

Female



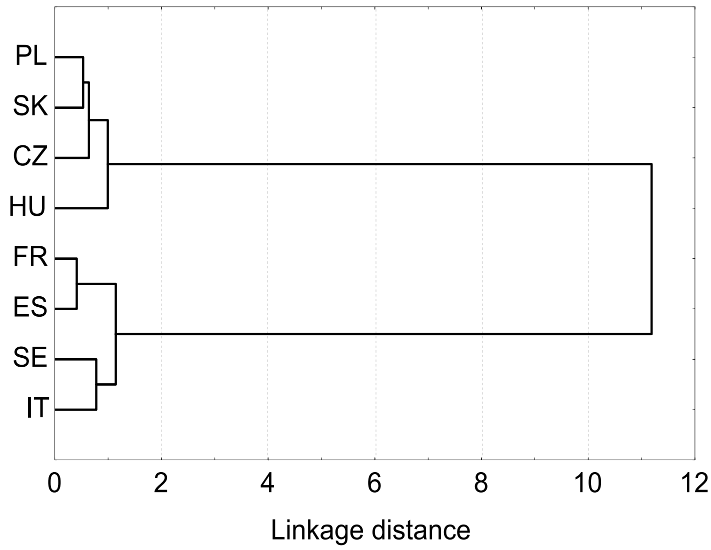
Male



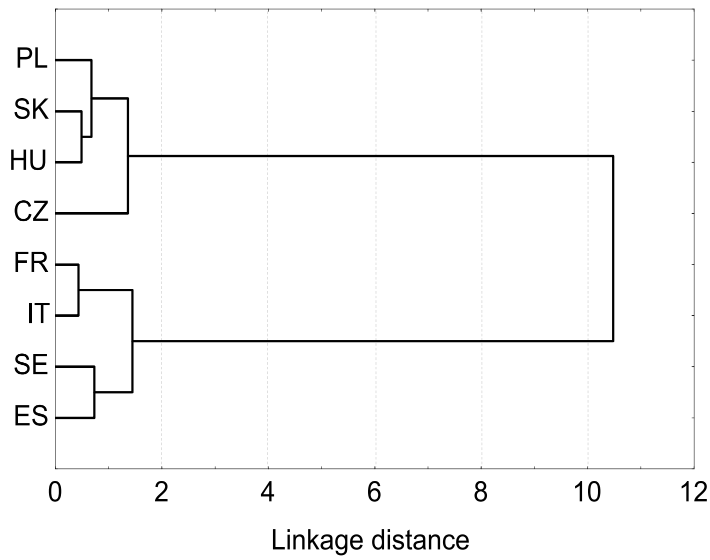
Source: Own calculations.

Figure 9b. The d*endrograms* of the clustering of the logarithm q_x at the age of 65 in the period 1960–2005 obtained using the Euclidean distance and *Ward's method.*

Female



Male



Source: Own calculations in STATISTICA 8.0.

Table 5. Groups of countries obtained from d*endrograms* of the clustering of the logarithm q_x at the age of 65 in the period 1960–2005 (see: fig.9b) at the linkage distance d=3

Female		Male	
Gr. 1	PL, SK, CZ, HU	Gr. 1	PL, SK, CZ, HU
Gr. 2	FR, IT, SE, ES	Gr. 2	FR, IT, SE, ES

Source: Own elaboration.

5. Conclusions

The analysis of mortality changes in selected European countries in the period 1960–2007 has shown considerable differences in the changes of initial mortality rate. Four distinct groups have been analysed: female populations in selected Western European countries, female populations in selected Central European countries, male populations in selected Western European countries and male populations in selected Central European countries. Apart from obvious differences in male and female mortality, significant differences in the dynamics of mortality between Western and Central European countries have been revealed. In spite of their geographic, climatic and cultural differences, the countries constituting both groups seemed quite homogenous.

The most significant differences in the change of graduated initial mortality rate have been observed for people above 40–45 from Central and Western European countries. The period of most striking disproportions in the change of graduated initial mortality rate was the years 1970–1990, which seems to be the result of the socio-economic policy in Central European countries. The transformations which took place in 1990's helped to reduce the differences in the dynamics (decrease) of mortality, yet the differences in life expectancy between the Western and Central European countries will probably still be visible in the next years (i.e. life expectancy in the Western countries will continue to be longer).

Another important phenomenon is connected with the fact that, irrespective of geographic and political factors, in the 1990's the process of aging of the whole populations began. In the future ageing can constitute a serious obstacle in the socio-economic development. Firstly, labour resources will grow old, i.e. there will be fewer and fewer young workers on the job market which will become dominated by less mobile older workers. Secondly, the number of people in the productive age will decrease, which means that maintaining a fast rate of economic growth will be possible only if productivity increases and a bigger percentage of people in their productive age continue working. One of the ways of assuaging the problem of ageing is lengthening the productive periods, also called lifting the actual retirement age, which will slow down the process of diminishing the number of professionally active workers. Such policy is also in accordance with demographic tendencies regarding lengthening life span. Lengthening the productive periods means resigning from a contemporary trend of early retirement and shortening the duration of the period of a 'well-deserved rest'. As a result, changes in the area of employment and social security are needed.

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