THE PROCESS OF RECTANGULARIZATION OF THE SURVIVAL CURVE IN SELECTED EASTERN EUROPEAN COUNTRIES

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Mortality differs among various populations not only according to its intensity, but also according to its development in history, differences by sex, causes of death, changes with age and other characteristics. Some of these issues stand behind the detailed analysis of mortality presented in this paper. It focused on the study of variability of ages at death represented by the process of rectangularization of the survival curve.

The shape of the survival curve was primarily studied by biologists who did so as early as the 1920s. The concept of rectangularization of the survival curve was introduced in the mid-1950s. It was in 1956 in the book "The Biology of Senescence" from Alex Comfort (Rose, 2007; Cheung, Robine, Tu, Caselli, 2005). This topic was later discussed by many other authors. Probably the most important was James F. Fries with his articles "Aging, Natural Death, and the Compression of Morbidity" from 1980 (Fries, 1980). Fries assumed that the process of rectangularization (when the shape of the survival curve is still more and more rectangular) was a consequence of improvements in mortality, when an increasing number of people survive to higher ages. Deaths are concentrated in higher age groups because, according to Fries, a fixed maximum limit of life expectancy exists at around 85 years (Fries, 1980; Cheung, Robine, Tu, Caselli, 2005; Paccaud, 1998).

The process of rectangularization is defined as a trend toward a more rectangular shape of the survival curve thanks to an increasing number of survivors and concentration of deaths around the modal age at death in a population. It means that variability of ages at death is decreasing and deaths are "compressed" to the higher age (Nusselder, Mackenbach, 1996). The origins of this theory are traced in the work of Lexis from the late 19th century. He studied the "normal life span" or normal length of life with the use of Quételet`s model of „average person" (Cheung, Robine, Tu, Caselli, 2005). Many scholars now return to the ideas of Quételet and Lexis or to the theory of modal age at death as the best characteristics of human life span (Cheung, Robine, 2007).

In our analysis we focused on the countries for which data are available in Human Mortality Database (HMD). For this paper, we selected some Eastern European countries. We tried to analyze the situation of the Czech Republic along with some other post-communist countries where data are available (Poland, Hungary, Russia, Bulgaria). Whenever useful, we made a comparison with Sweden, a representative of developed countries with low mortality. The data from Human Mortality Database were used for all calculations. Thanks to that we know that all data are adjusted in the same way. We have to bear in mind during the analysis that in all life tables in HMD the probabilities of death were smoothed at higher ages. HMD uses the smoothing method proposed by Kannisto at all ages above 85 years or in the case when the number of deaths was lower than 100[1].

In our work we used almost 30 indicators known from literature, some of which are commonly used in demographic analysis and some were developed or adjusted specifically for the analysis of the rectangularization process. This process could be seen also through some commonly used indicators

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[1] http://www.mortality.org/Public/Docs/MethodsProtocol.pdf

connected with the standard life table – life expectancy as well as median and modal age at death. All those indicators show increasingly better mortality conditions, rising average age at death and also aging of society.

Despite many advantages, the indicators of modal age at death were only rarely used in demographic analysis until the end of the 20th century. According to Väinä Kannisto (2000, 2001), the modal age at death (denoted by *M*) and the standard deviation above the mode (*SD(M+)*) give a sufficient explanation of the length of life in adult ages in a concrete mortality pattern. He suggested two indicators *M – k*SD(M+)* and *M + k*SD(M+)*, where *k* was assumed equal to 4. These indicators lead to the estimation of so-called minimum and maximum natural length of life (Cheung, Robine, 2007) (see Appendix – Figure 1).

One of the most used indicators in the field of the study of rectangularization process is the interquartile range (IQR) – the difference between the lower and higher quartiles. It indicates the age range within which 50 percent of deaths occur. This interval is still narrower. The most important decrease could be seen since the end of the 19th century in demographically developed countries; recently it has stood at around 14 years, which means that about one half of deaths occur within 14 years of age (see Appendix – Figure 2).

Another well-known indicator is the Entropy or so called Keyfitz`s H. Entropy is commonly used for measurement of the uniformity of probability distributions. When the H is decreasing, the curve is becoming more rectangular. The indicator is useful also for the estimation of maximum life span, because the indicator H can be interpreted also as a possible increase in life expectancy if mortality rates in all ages decrease by 1 per cent. As a result, model estimation can be simply counted on how life expectancy can increase if mortality rates decrease by 100 per cent and the so-called average maximum life span can be obtained (see Appendix – Figure 3).

Another group of indicators focuses on life endurance; these are very simple indicators giving the age at which only 1/10000 or 1/100000 of the original cohort are still alive. Those ages are traditionally high and were also in history – commonly over 100 years. We could almost see a tendency toward stabilization of this indicator in demographically developed countries (Sweden) at the beginning of the 21st century – as a result, a new topic is opening there: does any limit of life span exist there and are we approaching it? The opinion of demographers differs; in fact, it is true that people living longer than 100 or 110 years are still rather exceptional and probably will also be during this century.

Various levels of mortality in selected analyzed countries could be seen in the Appendix as well as its different development in history. The specific demographic development of Russia is proved through all presented indicators. Its specificity is a consequence of Russian mortality crisis during the beginning of 1990s which was connected with economical and social changes, worsening financial situation of inhabitants and high consumption of alcohol. Other results show the fact that all analyzed countries from the Eastern Europe have still worse mortality conditions than the demographically developed countries (in this article represented by Sweden) – the Czech Republic seems to have the best position among the Eastern European countries.

However, all depicted results demonstrate that absolute and relative rectangularization is a universal, long-term trend in human mortality patterns observed in all selected countries during the last few decades. The increasing number of the elderly as a consequence of the rectangularization is likely to be associated with a greater use of health care facilities and services. This may have a major social impact in the long run, especially if it is not accompanied by a corresponding compression of morbidity – the compression of morbidity is equivalent to the prolongation of the disease-free state at older ages so that the period of bad health prior to death is significantly minimized. The longer and healthier life influences a large array of social concerns in addition to the health care areas, such as retirement age, second careers or career after retirement. The phenomenon of progressive rectangularization along with other emerging demographic and epidemiologic developments provides an important prospective look at the future population profile and emerging social concerns.

RESOURCES

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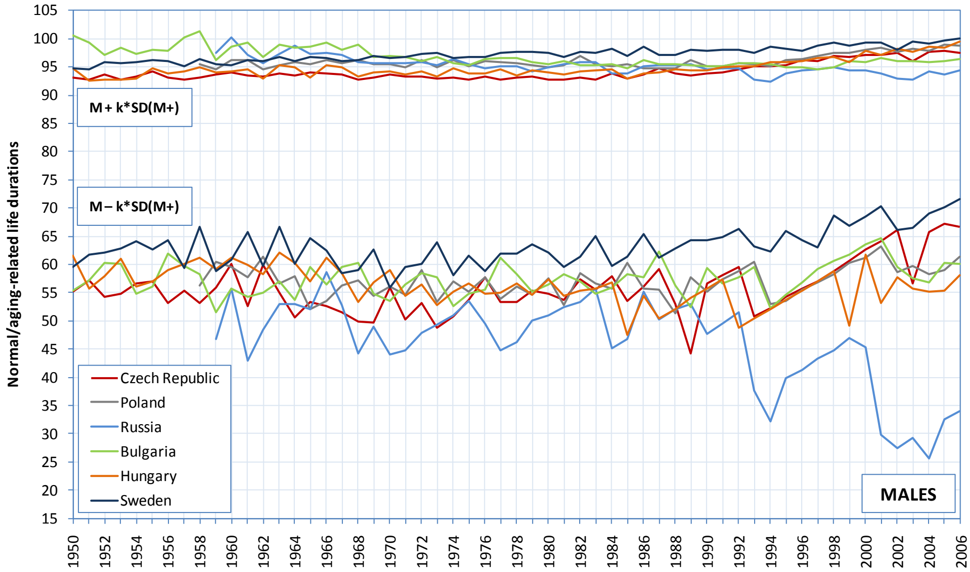
APPENDIX (Data source: Human Mortality Database; authors' calculations)

Figure 1: ***Normal/aging-related life durations;*** *selected European countries, 1950–2006*



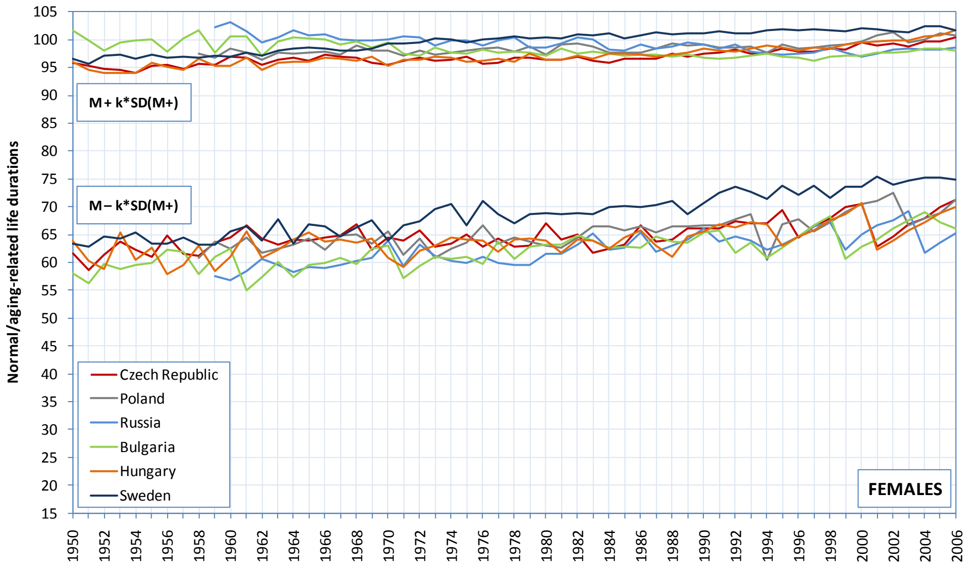


Figure 2: ***Interquartile range (IQR);*** *selected European countries, 1950–2006*

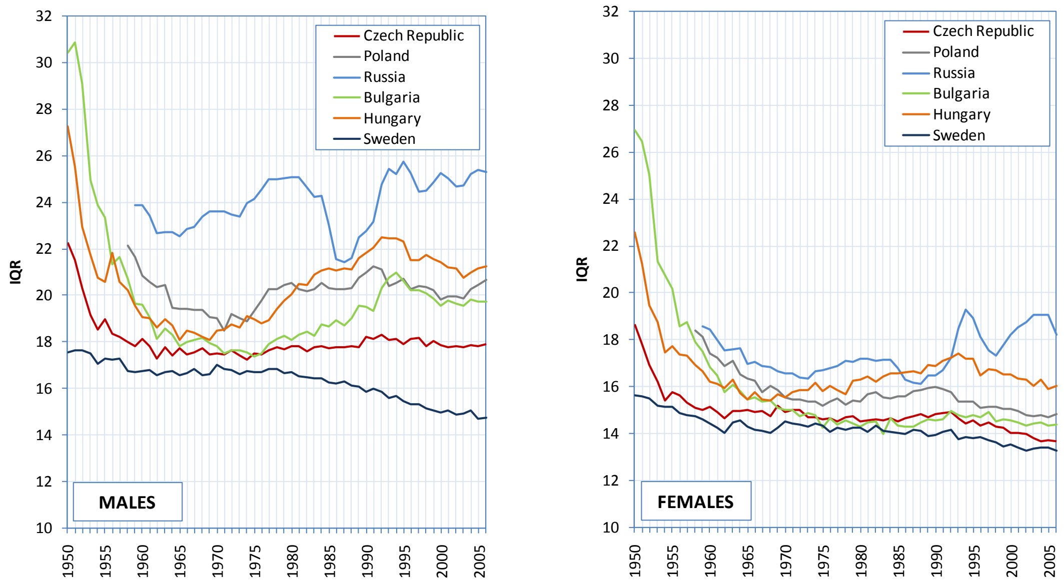


Figure 3: ***Entropy /Keyfitz`s H;*** *selected European countries, 1950–2006*