CZECHIA VS GREECE: A LONGITUDINAL ASSESSMENT OF THE AVERAGE LIFE SPAN, HEALTHY LIFE EXPECTANCY, GINI COEFFICIENT, E-DAGGER AND KEYFITZ ENTROPY H.

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Abstract

Czechia and Greece, being now members of the European Union, have a discrete political, economic, and social history. Over time, their unique characteristics solely affected their demographic history, causing convergences and divergences in the levels of the demographic indicators and in their temporal trends. The scope of this paper is the comparative analysis of mortality between the two countries. More specifically, the average longevity trends (life expectancy at birth) will be studied using the Arriaga decomposition methods. Secondly, the healthy life expectancy in the two populations and their temporal trends will be presented. The third part of this paper will explain the dispersion of the life table's deaths within the two countries. Gini coefficient, e-dagger and Keyfitz entropy H are the relevant dispersion measures used. Results indicate the aforementioned convergence-divergence scheme among the two populations. Overall, life expectancy at birth is higher in Greece for both genders. The most critical factor governing the two countries' differences springs from the mortality differentials in the age groups 45-64 and 65-84 years. Healthy Life expectancy increases over time, though Greece has enlarged its differences from Czechia in recent years. Finally, a gender-specific effect on mortality due to the economic crisis was found in Greece.

Key words: Czechia, Greece, average life span, healthy life expectancy, Gini coefficient, e-dagger, Keyfitz entropy H.

JEL Code: J1, J11, J16.

Introduction

Greece and Czechia have a very diverse modern history. In the 1960s, Greece was a poor country of the western world, with little growth potential. The new era for Greece starts in 1974 and the restoration of Democracy. The country followed a rapid developmental course, became a member of the European Union and Eurozone and faced a severe economic crisis after 2008.

Czechia was part of Czechoslovakia in the 1960s and a member of the so-called eastern block of Europe. In 1989, after the velvet revolution, it separated from Slovakia and followed in the years after a rapid developmental course. In 2004, Czechia became a full member of the European Union.

The research question that will be addressed in this paper is related to the mortality developments in the two countries since 1981. Therefore, the mean duration of life expressed as the life expectancy at birth (e0) and healthy life expectancy trends (HLE) will be studied. A decomposition procedure will be applied on e0 differences in order to identify mortality pattern differentials and evaluate their effect on the observed longevity differences. Afterwards, the diversity of age at death and life spans will contribute as a proxy to examining the effectiveness of their health systems and the possible existing inequalities in each country. These will be presented in the data and methods, and results sections.

Data and methods

Data come from the human mortality database, consisting of the full life tables of Greece and Czechia per gender, closing at the age of 110. After evaluating the e0 differences between the two countries, these were decomposed by applying a stepwise decomposition method according to Andreev et al. (2002) and Shkolnikov and Andreev (2010).

Afterwards, following Skiadas and Skiadas (2020), the Healthy Life Years Lost (HLYL) because of diseases and disabilities will be calculated corresponding to:

$$HLYL = max \frac{xm_x}{\sum_0^x m_x}$$

where x is the age and m_x the age-specific mortality rates of a life table. According to this method, which originates from stochastic analysis, the healthy life expectancy results from the substruction of HLYL from Life expectancy at birth.

Generally speaking, the well-known Gini Coefficient is an index of diversity or inequality in society (Sitthiyot & Holasut, 2021). When calculated on life table data, it expresses the inter-individual variability in the age at death (Wilmoth and Horiuchi, 1999): it is the mean of the absolute differences in the individuals' length of life to the average length of life in a population (Shkolnikov et al., 2003). The formula for the calculations is following.

$$\text{If } F_x = \frac{\sum_{t=0}^{x} d_t}{\sum_{t=0}^{\omega} d_t} = 1 - \frac{l_{x+1}}{l_x} \text{ and } \Phi_x = \frac{\sum_{t=0}^{x} d_t * \bar{t}}{\sum_{t=0}^{\omega} d_t * \bar{t}} = \frac{T_0 - (T_x + x l_x)}{T0}$$

then, the Lorenz curve at age 0 is approximated as:

$$G_0 = 1 - \sum_{x=-1}^{\omega-1} (F_{X+1} - F_x)\ (\Phi_{x+1} - \Phi_x)$$

where x is the age, ω the oldest age in a life table and $\bar{t}$ is the mean age of individuals dying between the exact ages t and $t+1$. In that way, the Lorenz curve is defined as a set of points of a complete life table with horizontal coordinates Fx and vertical Φ_x (Shkolnikov et al., 2003).

The second method of calculating the diversity of deaths and inequalities in life spans among people is the $e^{\dagger}$. According to Vaupel and Canudas-Romo (2003), $e^{\dagger}$ corresponds to the average number of person-years lost due to deaths in a life table.

As the value of $e^{\dagger}$ increases, so do the inequalities and vice versa. Additionally, there is a negative correlation between the increase in life expectancy and $e^{\dagger}$ developments. According to Shkolnikov and Andreev (2014), the e-dagger ($e^{\dagger}$) corresponds to:

$$e_x^{\dagger} = \frac{1}{l_x} * \sum_{y=x}^{\omega-1} \lfloor d_x(e_{y+1} - a_y \rfloor + \frac{l_\omega}{2\lambda_x} e_\omega$$

and Keyfitz's (1977) entropy to:

$$H_x \cong \frac{e_x^{\dagger}}{e_x}$$

where x represents age, ω the last age of the life table, e the life expectancy or life losses, l the survivors at the beginning of each age x (or ω), and α_x, the percentage of person-years lived at an age. Therefore, the entropy Hx of a life table is the proportional expression of $e^{\dagger}$ in respect to life expectancy.

At the same time, age $\alpha^{\dagger}$ will be calculated, which separates deaths into early and late ones. If the life table entropy is less than one, the age $\alpha^{\dagger}$ corresponds to an age where (Zhang και Vaupel, 2009):

$$e^{\dagger}(\alpha) = e(a)*(1-H(a))$$

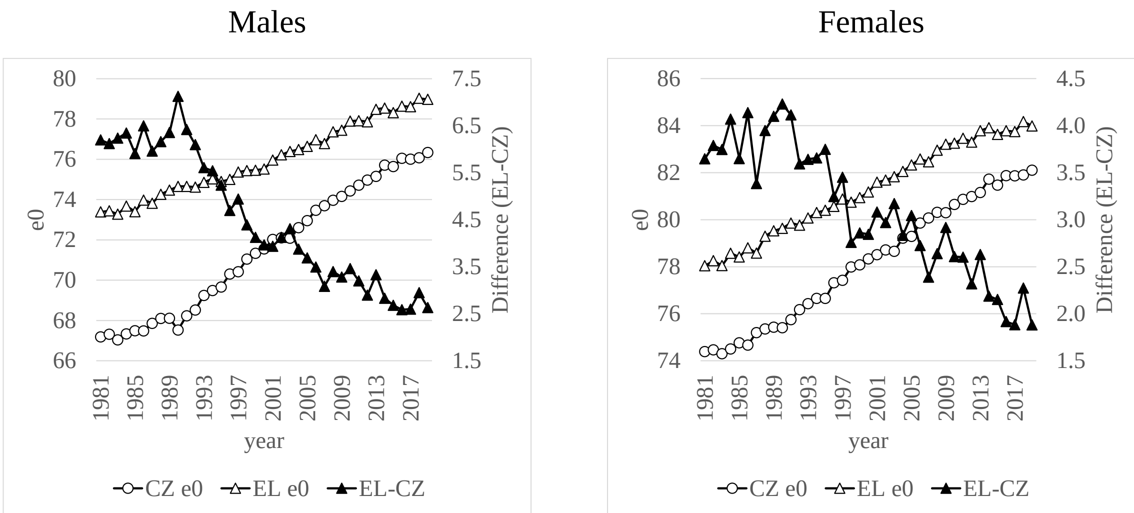
where, α is the age, and H is the system's entropy at that age. The exact value of $\alpha^{\dagger}$ will be calculated with linear interpolation between two known ages, in which the differences of the terms of the equation above are minimized. Vaupel et al. (2011) found that an increase in average life span was accompanied by a decrease in life span inequalities between individuals, and consequently an increase of $\alpha^{\dagger}$. Therefore, both variables give valuable information about the health system and, ultimately, social cohesion in a country.

1.1 Results

Life Expectancy at birth

The life expectancy at birth increases in both genders, but with different rhythms overtime (Fig. 1). In general, it is higher in Greece for both genders, though a solid but incomplete convergence trend has been observed between the two countries, especially after the 1990s, i.e. when the well-known velvet revolution was over. In the recent era, the differences with Greece have become smaller, even with significant fluctuations. A slowdown in the rates of longevity changes (i.e. e0 changes) in both genders and countries characterizes the most recent years.

Fig. 1: Life expectancy at birth in Czechia and Greece. 1981-2019.

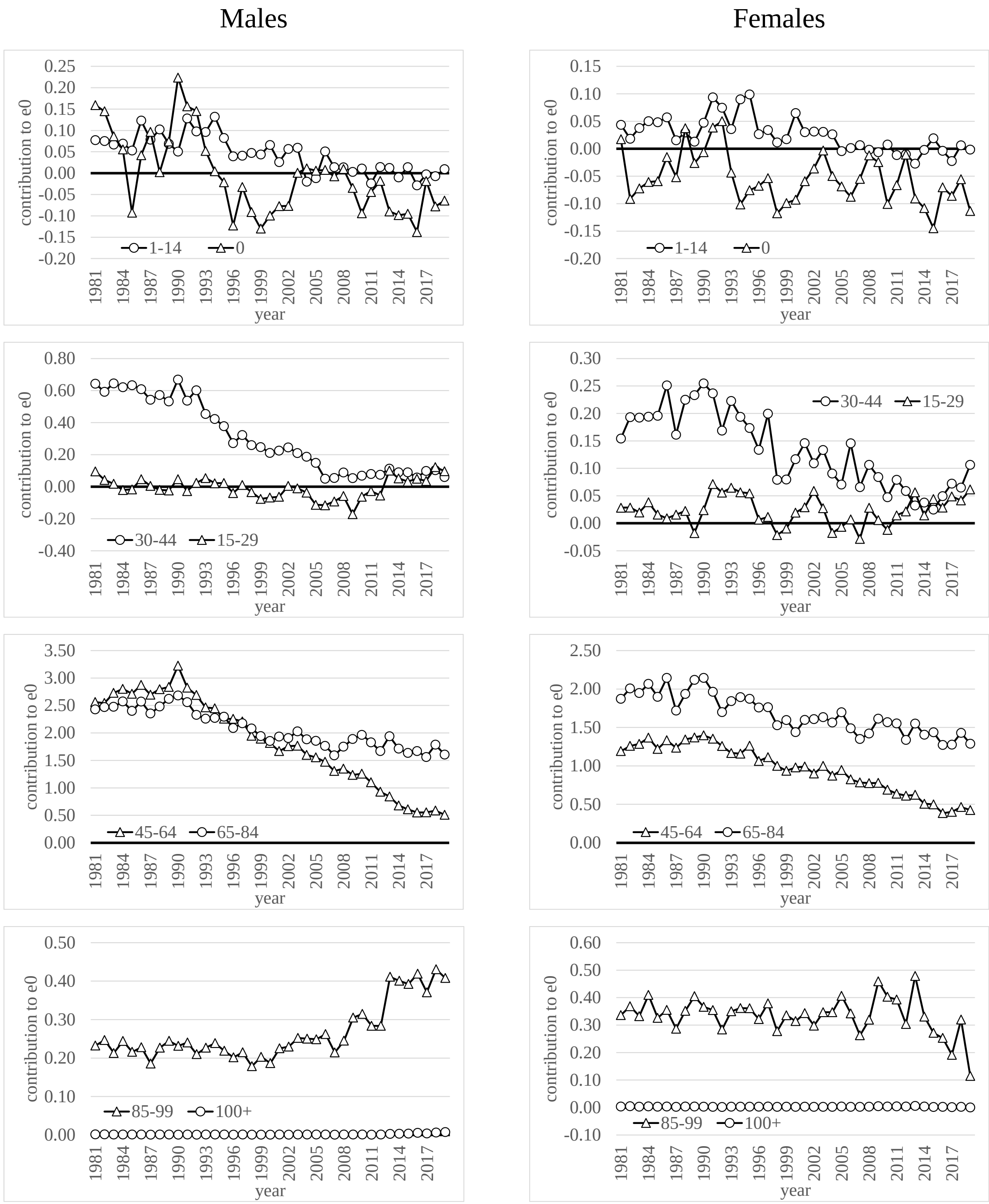


Source: Human Mortality Database (https://www.mortality.org/), own calculations.

These developments are related to the temporal changes in mortality patterns within and among the two countries. The by-age decomposition of the e0 differences among males and females in Greece and Czechia is seen in Fig. 2. According to this analysis, infant mortality is in favour of Greece until the beginning of the 21st century, when the two countries practically have minimal differences in both genders. Besides its fluctuating character, it contributes positively to Greece's e0 differences from Czechia. On the contrary, the mortality of children 1-14 years fluctuates wildly, favours Czechia, and reduces e0 differences after the 1990s. However, comparing these two groups with the others in Fig 1., it seems that any effects are minor.

The same happens with the age group of 15-29 years. The 30-44 age group contributes to enlarging the two countries' differences in e0, though these largely converge after 2005. The same happens in females, but the positive contribution to Greece is smaller, besides the overall decrease of the differences. Most of the differences between the two countries are related to the differential mortality in the 45-64 and 65-84 groups.

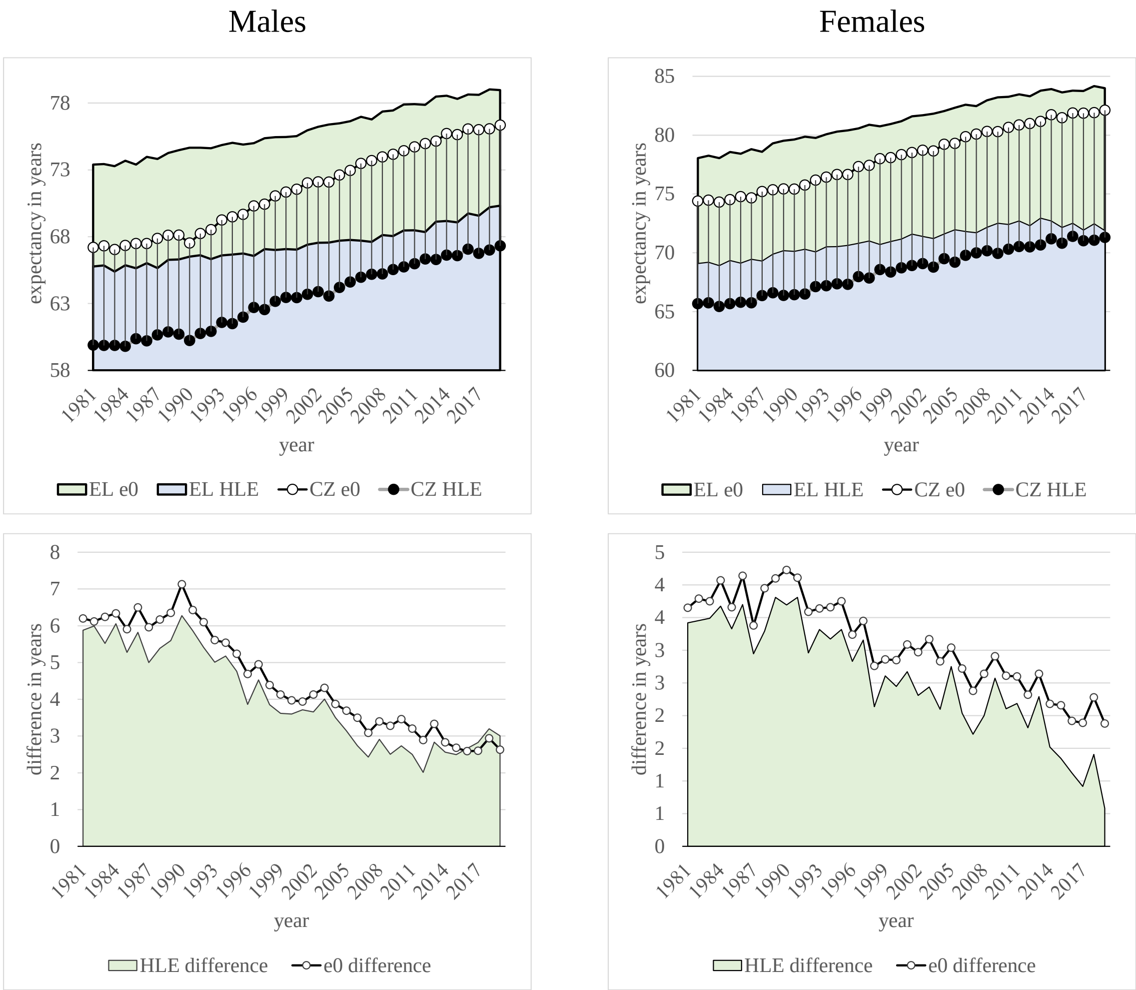
Fig. 2: Age decomposition of the differences in e0. 1981-2019.



Source: Human Mortality Database (https://www.mortality.org/), own calculations.

Due to the fact that mortality is higher in the Czech Republic during the later working ages (45-64 years), Greece has a significant advantage that enlarges the e0 differences. However, a clear convergence trend is observed between the two countries, which was not yet competed in 2019. This advantage is more pronounced in males than in females. The most crucial effect comes from the 65-84 age group. Being in declining order until the early 21st century, afterwards, to a large extent, it stabilizes, and despite fluctuations, it favours Greece. The effects are more significant in males than in females. The last age group of extremely old adults has a negligible effect on the e0 differences between the two countries. The very old people (85-99 years) exhibit a more moderate effect on e0 differences, which the last years of the study increases in males and decreases in females.

Fig. 3: Healthy life expectancy. 1981-2019.



Source: Human Mortality Database (https://www.mortality.org/), own calculations.

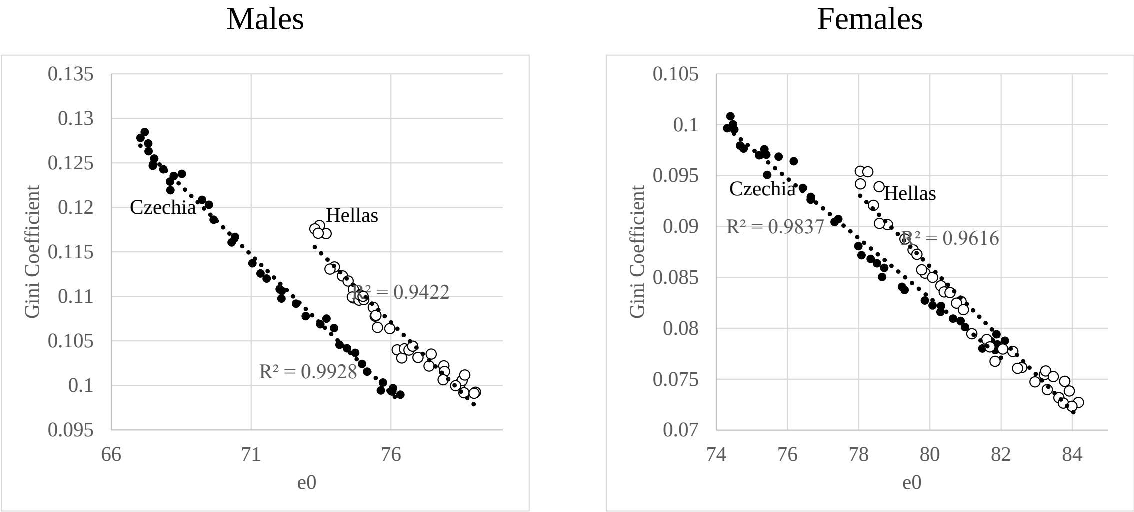
Healthy Life Expectancy

Healthy life expectancy largely follows the temporal trends of life expectancy at birth (Fig. 3). At first sight, these differences are linear, so one would expect them to find a positive correlation between them. However, when differences between e0 and HLE per gender are compared, such a finding is not confirmed. This is very obvious in the last years in males, in which their differences in HLE are larger than those of e0. Additionally, females have much smaller HLE than e0 differences. These facts reflect the different burdens of diseases and levels of HLE in the two genders in the two countries, at least in the most recent years of the study.

The measures of diversity

As discussed before, the Gini coefficient accounts for the variability in the ages of death in a population. Simultaneously, it constitutes a measure of rectagularization of the life table's survival curves. Ideally, one would expect an almost linear relationship with the life expectancy at birth.

Fig. 4: Gini Coefficient. 1981-2019.



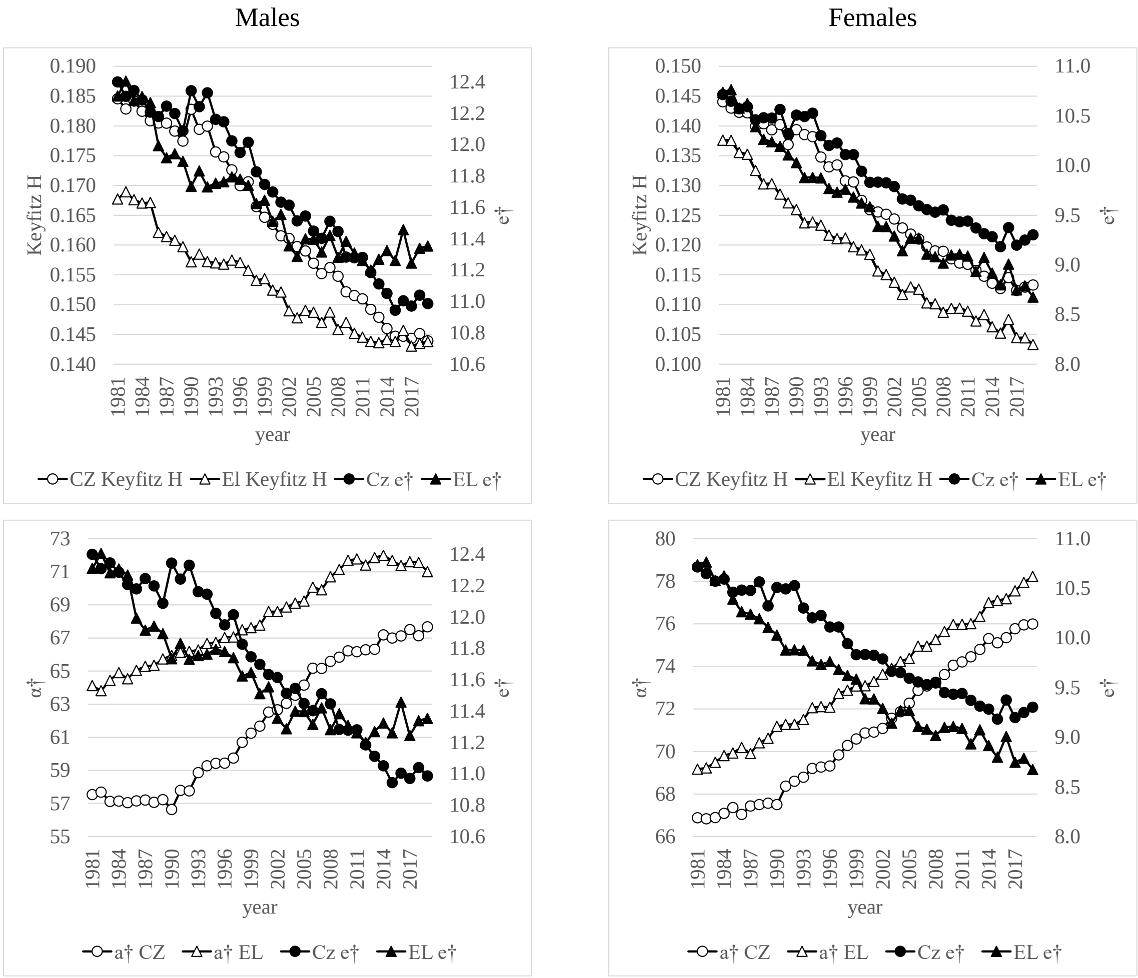
Source: Human Mortality Database (https://www.mortality.org/), own calculations.

This is the case with Czechia. There is an almost perfect relationship between the average length of life (e0) and the Gini Coefficient, which is somewhat more robust in females (Fig. 4). In Greece, this linear relationship is also evident, but it is somewhat weaker compared to Czechia in both genders, where the most striking deviations from linearity are at the time series' beginning and end. Note that after 2008, Greece was burdened economically, socially and even culturally because of the emergence of the economic crisis. One can reasonably hypothesize that Gini's Coefficient temporal trends' final disturbance is connected with this crisis. As for the first one, the data quality has played an important role.

As said before, the $e^{\dagger}$ (e-dagger), is a measure of the diversity of deaths and inequalities in life spans among people. As the value of $e^{\dagger}$ increases, so do the inequalities and vice versa. The

Keyfitz H measures the mortality system's disorder, as it is the proportional expression of $e^{\dagger}$ to e0. Finally, $\alpha^{\dagger}$ is the age which separates early from late deaths. All of them are seen in Fig. 5. The system's disorder and $e^{\dagger}$ tend to decrease as long as life expectancy at birth increases. An obvious fact in the females of Greece. As the mortality transition has moved considerably ahead in them and irrespective of the adverse environment of the socioeconomic crisis, the life span inequalities become smaller.

Fig. 5: Keyfitz H, $e^{\dagger}$ and $\alpha^{\dagger}$. 1981-2019.



Source: Human Mortality Database (https://www.mortality.org/), own calculations.

However, this is not the case for the male population, for which any developments halted some years before the emergence of the economic crisis (i.e. in 2008). Some years after this crisis, a significant deterioration is observed. One can reasonably hypothesize that the temporal trends existing before the crisis consolidated after it. In Czechia, the previous developments of Keyfitz H and $e^{\dagger}$ slowdown, or they are getting worse in both genders.

This finding needs more examination to consider the epidemiological and socioeconomic characteristics, not to forget that the financial crisis of 2008 affected almost all the European countries but at a different rate. Therefore, in three out of four cases, a general inability of the health and social security system to limit the inequalities of people's lifespan is recorded.

Such a statement does not consider the temporal trends of $\alpha^{\dagger}$. Over time, an effective health and social cohesion system will shift early deaths to older and older ages. Indeed this is the case in males of Czechia, where the separating age of early and late deaths did not change significantly in 1980, but afterwards, a rapid increase in this age took place, even if in the last years of the study these developments slow down. The same happens in females, where the increase is more apparent than in males.

Thus, during the last years of the study, the health system cannot reduce life inequalities significantly, but at the same time, it can protect more and more people from early death by moving the separating age higher and higher.

This is not the case for males in Greece. In the last years of the study, the health system cannot improve the situation of men in the country. The inequalities tend to remain consistently higher than several years in the pre-crisis period and fluctuate, while at the same time, the age of separation of the deaths remains stable and even decreases in the last year of the study. Besides a minor deterioration, the country's female population does not face this problem. Epidemiological, social and cultural factors may have affected this divergence between the two genders. Therefore, a possible explanation could be that part of the population (i.e. the males) has already faced the first effects of the economic crisis on mortality. Of course, more research is needed to confirm and evaluate this statement.

Conclusion

The life expectancy at birth increases in both genders, but with different rhythms over time and in general, it is higher in Greece for both genders, despite the convergence trends observed in the most recent era. The most critical factor governing these differences is the mortality differences in the age groups 45-64 and 65-84 years. Healthy Life expectancy increases over time, though Greece enlarges its differences from Czechia in the last years. Also, there has been a slight disturbance in the development of the Gini coefficient in Greece in the most recent years. One can reasonably hypothesize that this disturbance relates to the economic crisis that afflicted the country after 2008. The analysis of $e^{\dagger}$ revealed that the most crucial effect is on males. This finding must be seen in relationship to the temporal trends of $\alpha^{\dagger}$ to establish some kind -if any- relationship with the economic crisis. In Czechia, irrespective of the gender, the situation is very different. The details of this diversification, which are discussed in the text above, suggest that there was probably a kind of gender specific effect on mortality in Greece during the economic crisis.

References

Andreev, E. M., Shkolnikov, V. M., & Begun, A. Z. (2002). Algorithm for decomposition of differences between aggregate demographic measures and its application to life expectancies, healthy life expectancies, parity-progression ratios and total fertility rates. *Demographic Research,* 7:14, 499-522.

Keyfitz, N. (1977). *Applied Mathematical Demography*. New York: John Wiley.

Le Grand, J. (1987). Inequality in health: some international comparisons. *European Economic Review,* 31, 182-192.

Shkolnikov, V. M., & Andreev, E. M. (2014). Spreadsheet for calculation of life-table dispersion measures. *MPIDR TECHNICAL REPORT* 2010-001 MAY 2010 (REVISED JUNE 2014)

Shkolnikov, V. M., & Andreev, E. M. (2010). Age-decomposition of a difference between two populations for any life-table quantity in Excel. *MPIDR TECHNICAL REPORT* 2010-002 MAY 2010

Shkolnikov, V., Andreev, E., & Begun, A. Z. (2003). Gini coefficient as a life table function. *Demographic Research*, 8, 305–358. https://doi.org/10.4054/dem-res.2003.8.11

Sitthiyot, T., Holasut, K. (2021). A simple method for estimating the Lorenz curve. *Humanities and Social Sciences Communications*, 268. https://doi.org/10.1057/s41-599-021-00948-x

Skiadas C.H. and Skiadas C. (2020). Relation of the Weibull Shape Parameter with the Healthy Life Years Lost Estimates: Analytical Derivation and Estimation from an Extended Life Table. In: Skiadas C.H., Skiadas C. (eds) *Demography of Population Health, Aging and Health Expenditures.* The Springer Series on Demographic Methods and Population Analysis, vol 50. Springer, Cham. https://doi.org/10.1007/978-3-030-44695-6_2

Vaupel, J. W., Zhang, Z., & van Raalte, A. (2011). Life expectancy and disparity: an international comparison of life table data. *BMJ Open* 1, e000128.

Vaupel, J.W., & Canudas-Romo, V. (2003). Decomposing changes in life expectancy: A bouquet of formulas in honor of Nathan Keyfitz's 90th birthday. *Demography,* 40(2), 201–216.

Wilmoth, J.R., & Horiuchi, S. (1999). Rectangularization revisited: variability in age at death within human populations. *Demography,* 36(4), 475-495.

Zhang, Z., & Vaupel, J. W. (2009). The age separating early deaths from late deaths. *Demographic Research*, 20, article 29, 721-730

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