Period and/or cohort mortality trends in the Czech Republic with the use of APC analysis

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INTRODUCTION

As stated in the report of the WHO for the year 2012, Europe is experiencing a decline in all-causes mortality rate. However, there are large differences in mortality levels between the European regions, especially between Western and Eastern Europe (lower vs. higher mortality rate) [*The European health report 2012*].

Currently (2013) the Czech Republic occupies the 10th position from the bottom among 28 EU+2 (Norway, Switzerland) countries with regards to life expectancy at birth (**Figure 1**). It still belongs into the Eastern Europe mortality country group despite the mortality decline experienced in recent years. There are still significant differences in age-specific mortality profiles between Western and Eastern Europe (lower vs. higher mortality rates especially in adult and old ages).

In the interbellum period, the difference in mortality level between the Czech Republic and France was negligible (**Figure 2**). This situation persisted until the early 1960s. Since then, the gap in life expectancy at birth started widening. Despite the recent mortality decline in the Czech Republic, due to a mortality reduction in adult and older ages from circulatory diseases, the country lags significantly behind France. The mortality change can also be a result of a special historical experience. The consequences of health conditions affecting the infant period or the illnesses faced in childhood can influence an individual's mortality risks as an adult or as an elderly person. The APC (age-period-cohort) analysis which looks for the existence of a link between a cohort's mortality experience early in life and a subsequent mortality rate at older age is presented below.

Figure 3 represents contour maps of observed Czech male probabilities of dying for the period 1950-2013 over the current age range 30-80 or respectively by birth cohort. The left part of the graph shows the increase in mortality with age and a volatile decline over time. Some particular features, such as mortality increase or stagnation, appeared in 1965-1985 at adult and older ages. Similarly, we can see on the right side (by age and birth cohort) some peculiar cohorts (low mortality cohorts) of males born during the first world war. In order to depict these three effects jointly APC modelling will be applied.

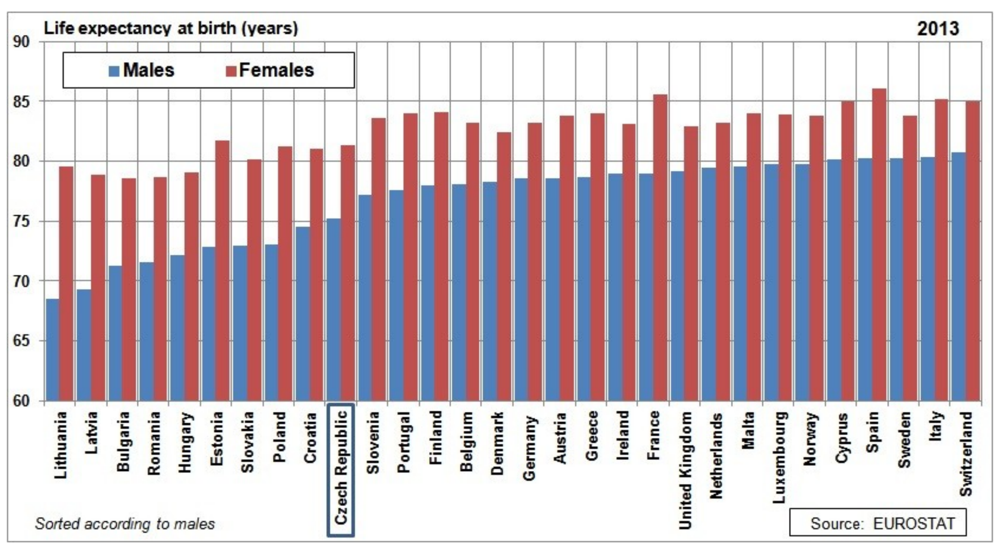


Figure 1. Country differentials in life expectancy at birth in 2013

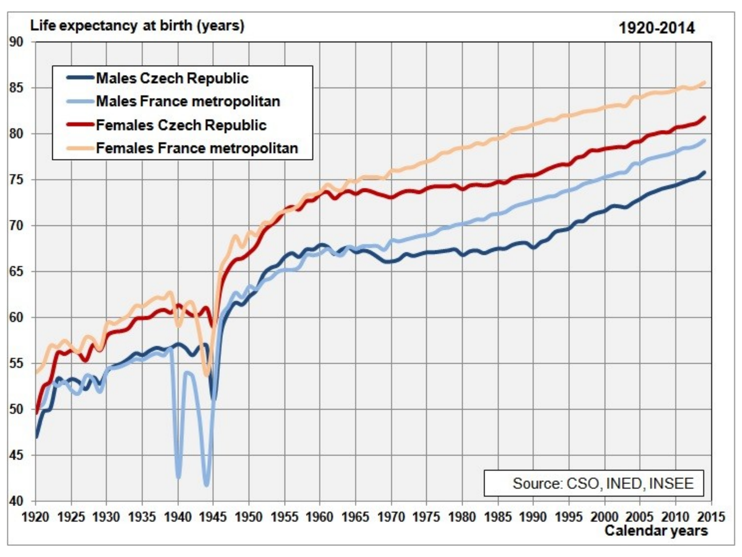


Figure 2. Trends in life expectancy at birth in the Czech Republic and France since 1920

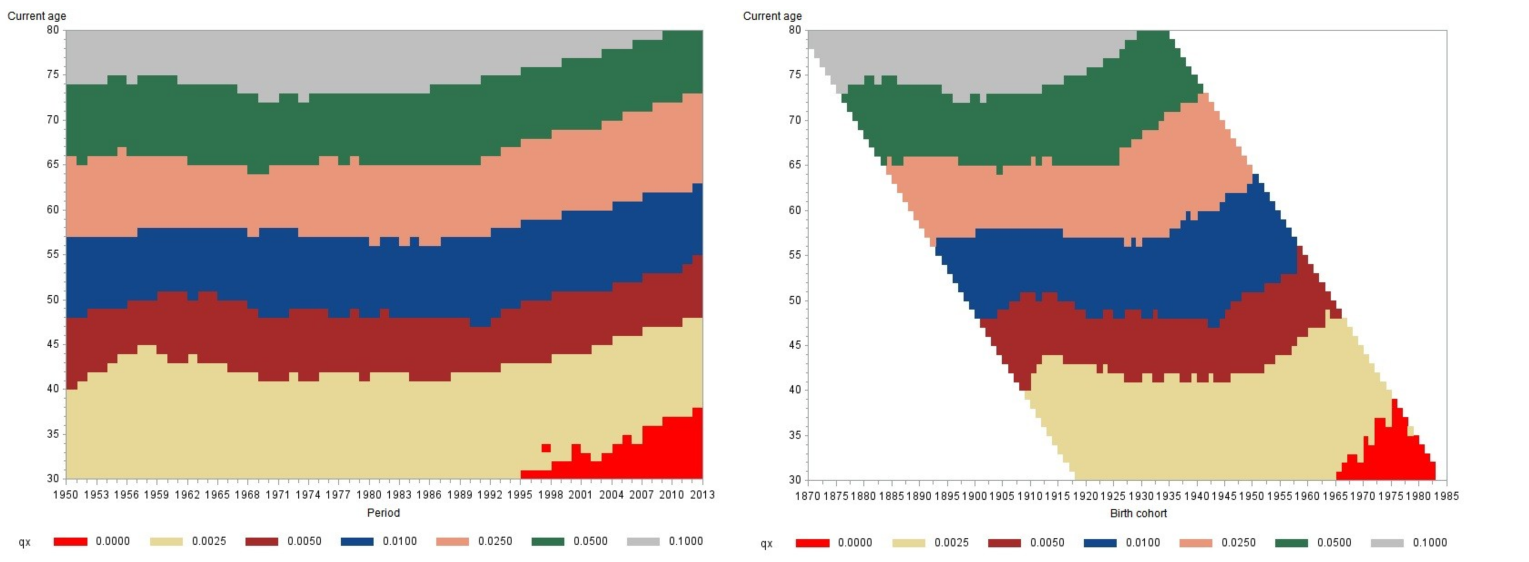


Figure 3. Probability of death (qx), men, Czech Republic

MATERIAL

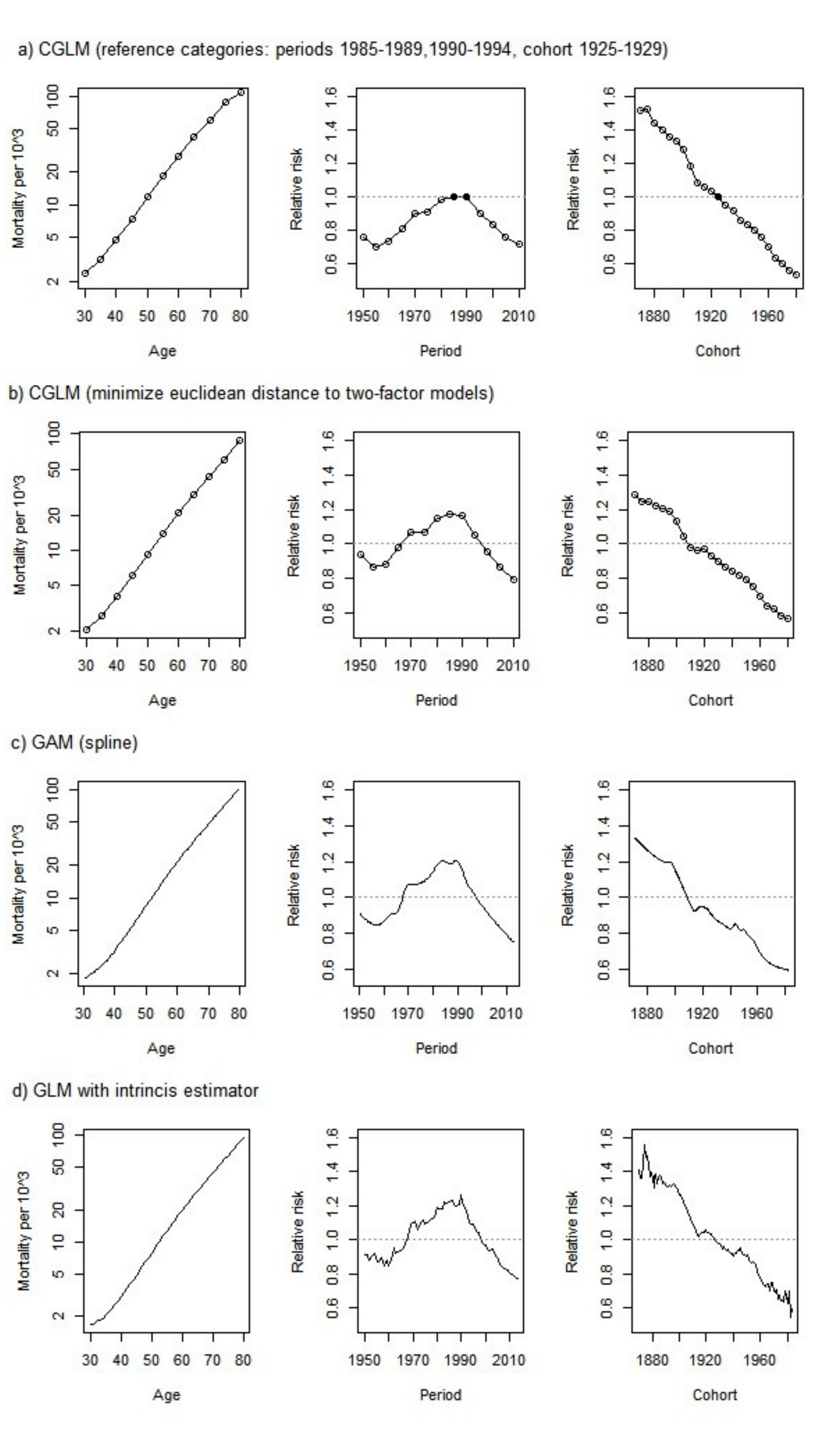
The number of male deaths classified according to current age (by birth cohorts) and male population by age at January 1 of each calendar year for the period 1950-2013 were used for the estimation of probability of dying (mortality risks). We consider only the restricted age range 30 to 84. Data come from the Czech Statistical Office (CSO).

STATISTICAL METHODS

Mortality risks are modelled with the use of the negative binomial generalized linear model $\ln(d_{ap}) = \mu + \alpha_a + \beta_p + \gamma_c + \ln(n_{ap}) + \varepsilon_{ap}$, where d_{ap} is the number of deaths in the current age *a* and the period *p* ($a = 1,..,A$, $p = 1,..,P$), μ is the parameter of the average number of deaths (on a logarithmic scale), α_a ($a = 1,..,A$) is the age parameter, β_p ($p = 1,..,P$) is the period parameter and γ_c ($c = 1,..,C$) is the cohort parameter, n_{ap} is the size of the exposed (initial) population and e_{ap} is the random error with zero mean value.

It is not easy to estimate the values of the parameters ($\alpha_a, \beta_p, \gamma_c$), because of "identification problem"; i.e. linear dependency among predictors of age, period and cohort (*cohort = period - age*). To solve this problem of identification we used these models :

A. The constrained generalised linear models (CGLM) [*Mason et al., 1973*],
B. The Euclidean distances between each two-factor generalised linear models [*Decarli et al., 2014*],
C. The generalised additive model (GAM) with spline function [*Carstensen, 2007*],
D. The generalised linear model (GLM) with intrinsic estimator (IE) [*Fu, 2000; Fu et al., 2011, Yang et al., 2013*].



[*] For a) and b): age and period in 5-years groups (e.g. the age group 30 includes the ages of 30-34 yrs., the period group 1950 includes the periods of 1950-1954), cohort in 10-years groups (e.g. the cohort 1980 includes persons born in 1975-1984). For c) and d): age, period and cohort are continuous variables.

Figure 4. Parameters estimates of negative binomial generalized linear models for men

RESULTS:

The estimated parameters of the model A are shown in **Figure 4a**. The results are dependent on what period effects are defined to be the same. We chose periods 1980-1984 and 1985-1989 assuming that age-specific death risks were alike during these periods.

The parameter estimates of the model B (**Figure 4b**) are based on the function that minimizes the euclide distance between the parameters of the submodels (age-period, age-cohort, period-cohort) and the full model (age-period-cohort).

In the model C (**Figure 4c**), the age, period and cohort parameters are estimated using cubic functions on the predefined intervals, excluding extreme intervals on which the linear functions are used.

The intrinsic parameter estimates of the model D are in **Figure 4d**.

CONCLUSIONS:

All statistical methods used above (Figure 4) consistently illustrate the known fact of **the linear (logarithmic scale) increase of the mortality risk with age**.

The impact of the period effect estimated in the models is in concordance with previously shown trends on the left contour map, i.e. a moderate **mortality reduction by the early 1960s** (increase in life expectancy at birth was mainly due to a decrease of infant mortality rate). **The period from the early 1960s to the late 1980s is known for the worsening mortality rate** in the middle and higher age. It is explained by the higher occurrence of lifestyle diseases (diseases of the circulatory system and cancer) which are primarily the result of an unhealthy lifestyle and environment as well as due to the lack of modern medical technologies. **The sharp drop in mortality rate is observed after the fall of communism in 1989**, which brought the improvement and availability of health care, more modern and advanced treatments as well as changes in lifestyle and environment.

Cohort effect on mortality rate is the weakest. Men born in the years 1910-1920 in the Czech Republic had a relatively lower level of mortality than men born sooner or later. On the contrary, the *survival* rate of those who were born in the period of the second world war, and just after it, will probably be a little *worse* (Figure 4c, 4d).

Literature

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Research Project Support: RVO:67985807 and GA CR P404-12-0883