Cohort mortality forecasting: examples from selected European countries

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In the contemporary world the need for accurate mortality analyses and forecast is supported among others also by its connection to life insurance products or social policy. In many spheres of life information about mortality development and its expected future changes become more and more crucial.
Aim:
- to introduce an **alternative** (alternative to the traditional ones) **method of mortality estimation** and forecast focused on higher (adult) ages which is based on cohort approach and could be used for estimation of intensity of mortality for not yet extinct cohorts
- to evaluate the proposed method using data from Sweden and France where the data time-series are long enough. **Estimates** of cohort life expectancy based on presented model for already extinct cohorts **are compared with empirical life expectancy** which is already known
- to **forecaste** cohort life expectancy **for still living cohorts** in Sweden and France

Data and methodology

For illustration of the method data from the Human Mortality Database (www.mortality.org) were used and data for ages 60 and more were used.

The proposed method is based on the relationship:

$$ar_{x,z} = \frac{m_{x,z}}{m_{x-1,z}},$$

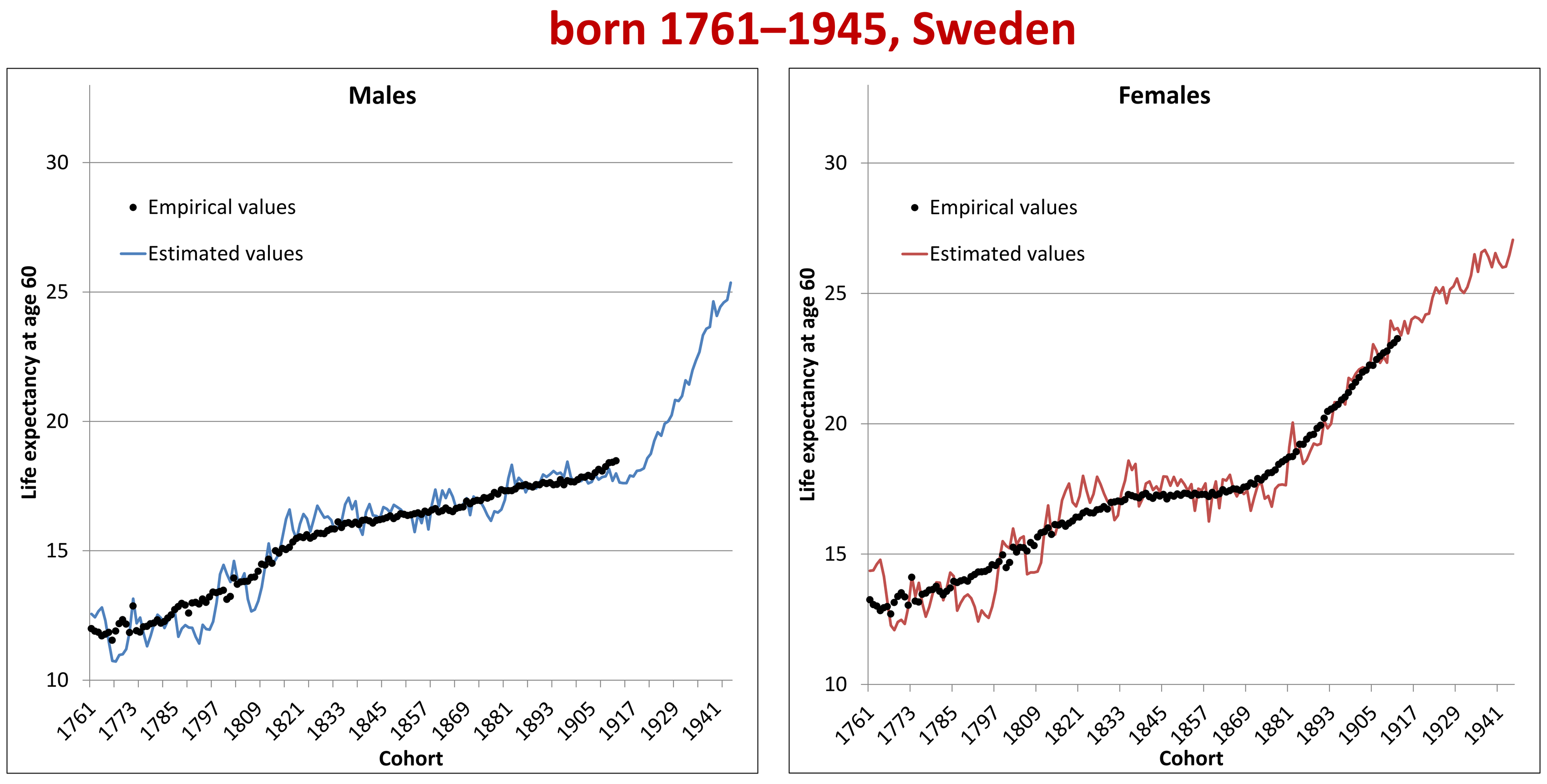
where $ar_{x,z}$ is **ratio of age-specific mortality rates *m* defined for one particular cohort**, *x* is completed age, *z* is the year of birth of the cohort.
Because these ratios are highly time-variant (differs for particular cohorts, however, it was proved that its values do not follow any particular trend), it was necessary to estimate these ratios for individual ages in a particular modeled cohort by some average measure calculated for that age ($\overline{ar}_{x,z,n,s}$). This measure was calculated from *n* previous cohorts and these average measures are used for the estimation of future values of age-specific mortality rates. There are many possibilities how to estimate $\overline{ar}_{x,z,n,s}$. Among others it is possible to use the relation:

$$\overline{ar}_{x,z,n,s} = \frac{\sum_{k=1}^{n} \alpha^{k-1} * ar_{x,z-k-x+s}}{\sum_{k=0}^{n} \alpha^{k-1}}, \text{ for } x = s,\dots,\omega-1$$

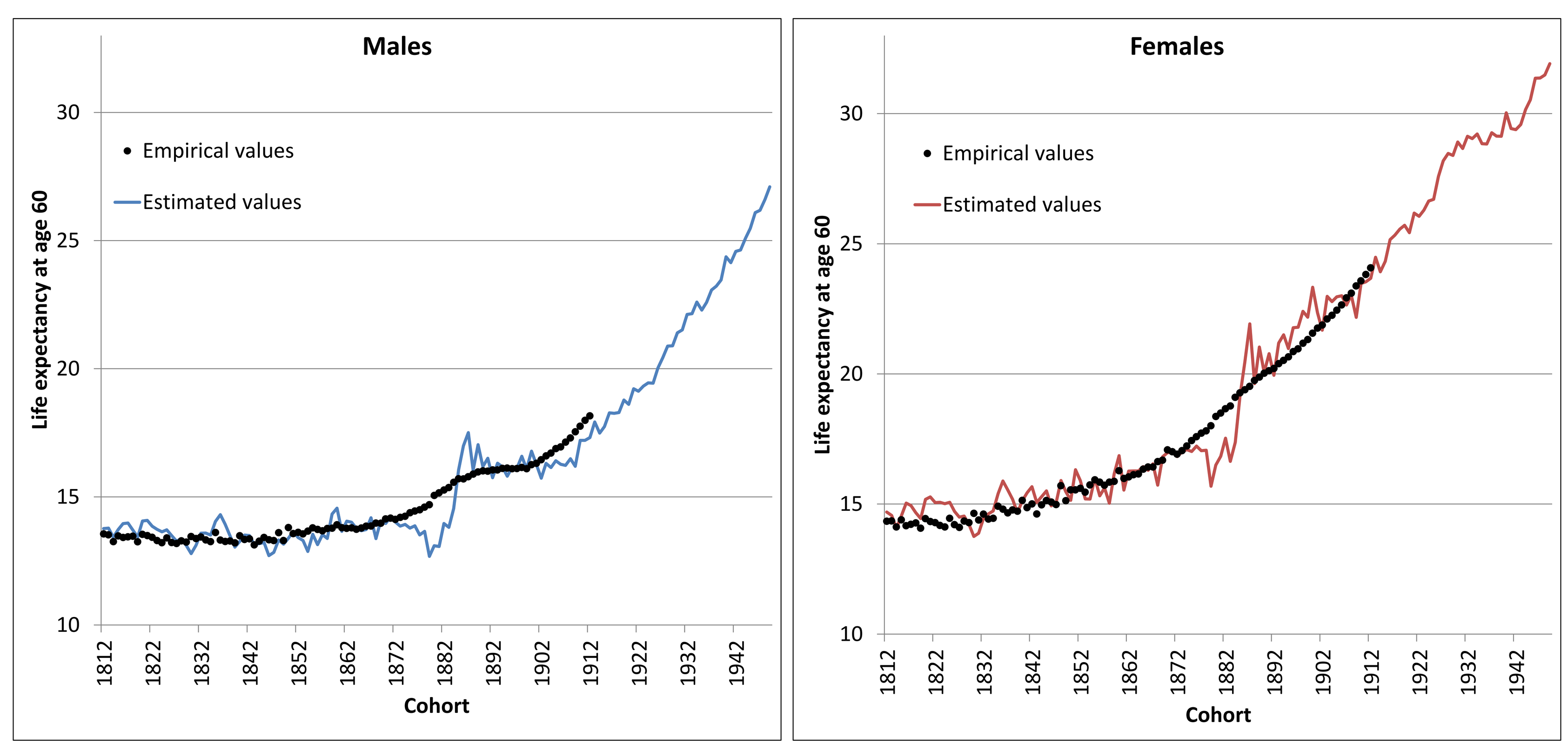
where $\overline{ar}_{x,z,n,s}$ is the **average ratio of cohort-specific rates** at age *x*, *z* is the year of birth of the modeled cohort, *s* is first age which is used for calculation (for example 60 years), *α* is weight used in the model having values from the interval (0;1). This weight could be selected subjectively according to needed "memory" of the model.
After all the average ratios are calculated for all ages (*x*) where mortality will be estimated, it is possible to calculate the first unknown mortality rate (for age *x + 1*):

$$\dot{m}_{x+1,z} = m_{x,z} * \overline{ar}_{x+1,z,n,s}$$

Comparison of empirical and modeled life expectancy at age 60, cohorts born 1761–1945, Sweden



Comparison of empirical and modeled life expectancy at age 60, cohorts born 1812–1949, France



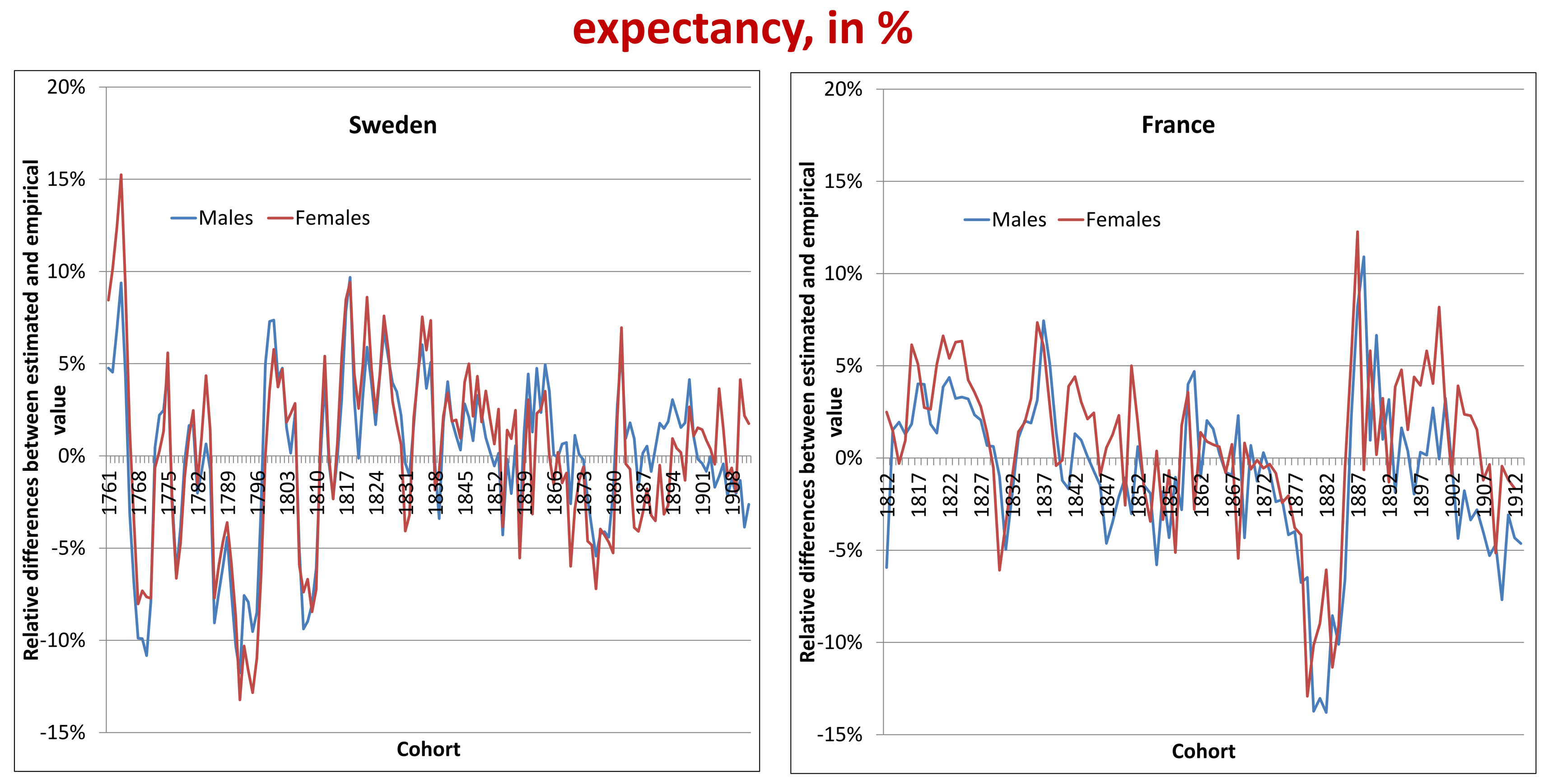
Relative comparation of empirical and modeled life expectancy

Because of increasing values of life expectancy in time and decreasing differences between estimated and empirical values of life expectancy we can calculate the relative differences for evaluation of the model as:

$$\frac{\dot{e}_{x,z}}{e_{x,z}} - 1,$$

where $e_{x,z}$ is empirical cohort life expectancy at age *x* for cohort *z* and $\dot{e}_{x,z}$ is estimated cohort life expectancy at age *x* for cohort *z*.

Relative differences between estimated and empirical values of life expectancy, in %



Conclusion

It is necessary to keep in mind that mortality patterns are very complex and depend on many other factors (cohort effect, period effect, age effect) and to find and describe all those relationships is almost impossible.
The above described model is very simple way how to estimate cohort mortality development in the future. Its advantage could be low demands for software or any other technical equipment and mathematical knowledge. It works with simple presumptions and its application is not time-consuming in comparison to the other common models which are used. Results show that estimated values are very close to empirical ones and that also changes in trends were estimated correctly. That makes this method promising for cohort mortality analyses as well as in cases where future mortality of not yet extinct cohorts should be estimated.
Forecasts of future development of life expectancy in Sweden and France are different. For both sex and in both countries we could expect increase of life expectancy. For cohorts born after second world war we could expect life expectancy (for age 60) around 25 years for males in Sweden and 27 in France and 27 for Swedish females and more than 31 years for French. Those results seem to be sharp change in trend and we could discuss if the model is correct but relative differences between empirical and estimated values were mostly around 5 % only. This shows that mortality improvement for those cohorts could be more rapid than for older cohorts.

References:

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