Forecasting life expectancy in the presence of structural breaks

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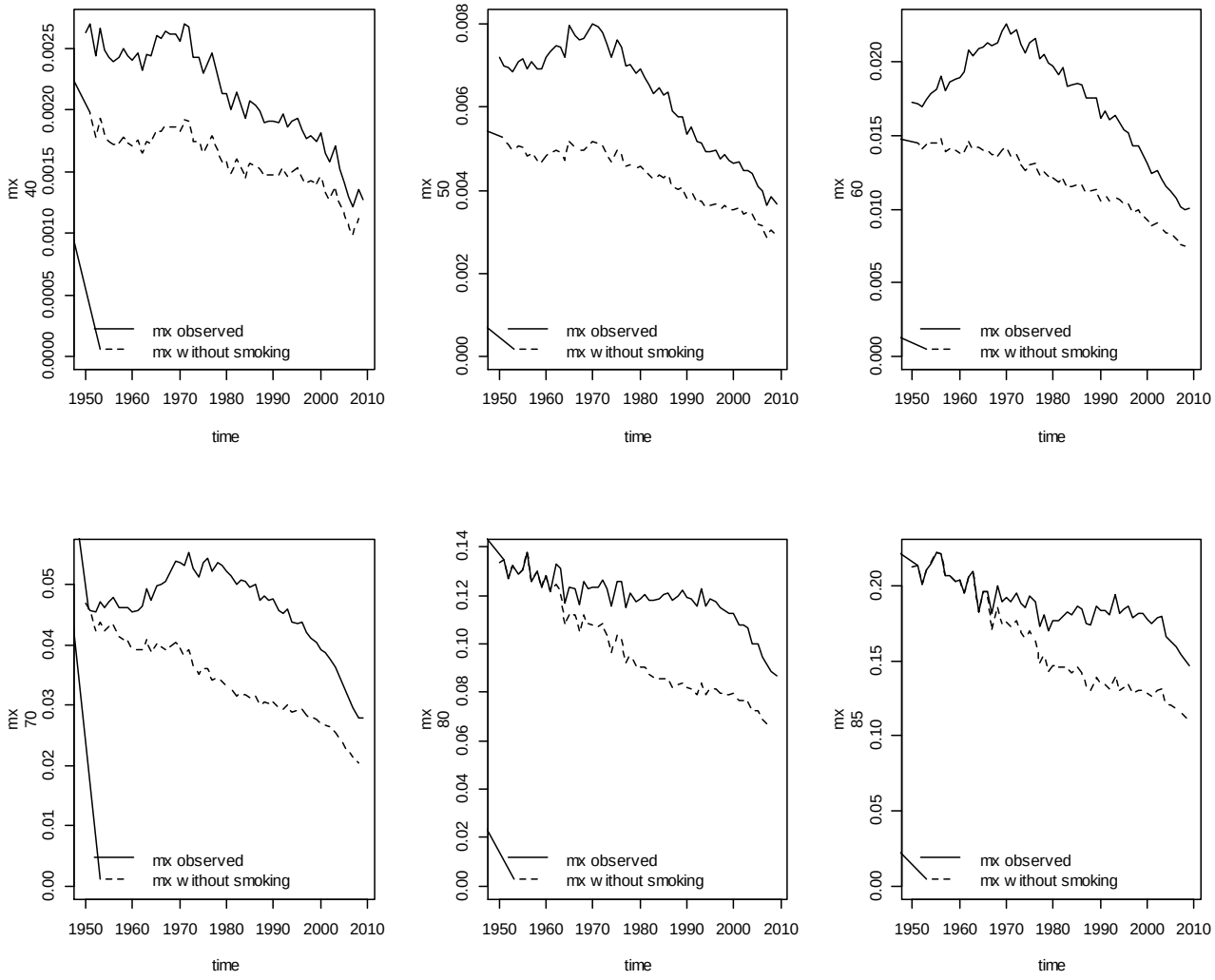
Background: To project life expectancy (LE) into the future, the Lee-Carter model (LC) is often referred as the gold standard. However, the LC is sensitive to the choice of the historical period if the reduction in mortality does not follow a linear trend.[1,2] To solve this issue it has been suggested to account for structural changes in the historical period and to project the most recent linear trend of LE only. Our goal is to demonstrate that in most developed countries the most important reason for structural breaks in LE is the progression of the cigarette epidemic. For this purpose we compare projections of LE using a LC that accounts for structural breaks by accounting for smoking.

Data&Methods: We obtained sex-specific mortality rates from the human mortality database and lung-cancer death rates from the WHO causes-of-death database in 5-year age-groups for 19 OECD countries. Smoking-attributable mortality was estimated using the Peto method and removed from all-cause mortality rates. We projected life expectancy by applying a Lee-Carter model that automatically detected structural breaks in the historical period with and without removing smoking beforehand.

Conclusion: Our paper shows that once the effects of this epidemic are removed from the time series of LE, robust projections without the need for "structural-break models" are feasible. Moreover, our results indicate possible dangers of such models, e.g. leading to highly implausibly results such as a higher life expectancy in males than in females.

Figure 1. Five-year mortality rates observed and smoking-free, Dutch males, 1950-2009



Shown in figure 1 are the time trends in mortality rates (mx) compared to trends, where the impact of smoking has been removed. While in the observed rates various structural breaks become visible, smoking-free rates do indicate a continuous mortality decline.

Figure 2. Lee-Carter forecasts of Dutch male life expectancy between age 20 and 89 with different specifications; all models account for structural trend-breaks

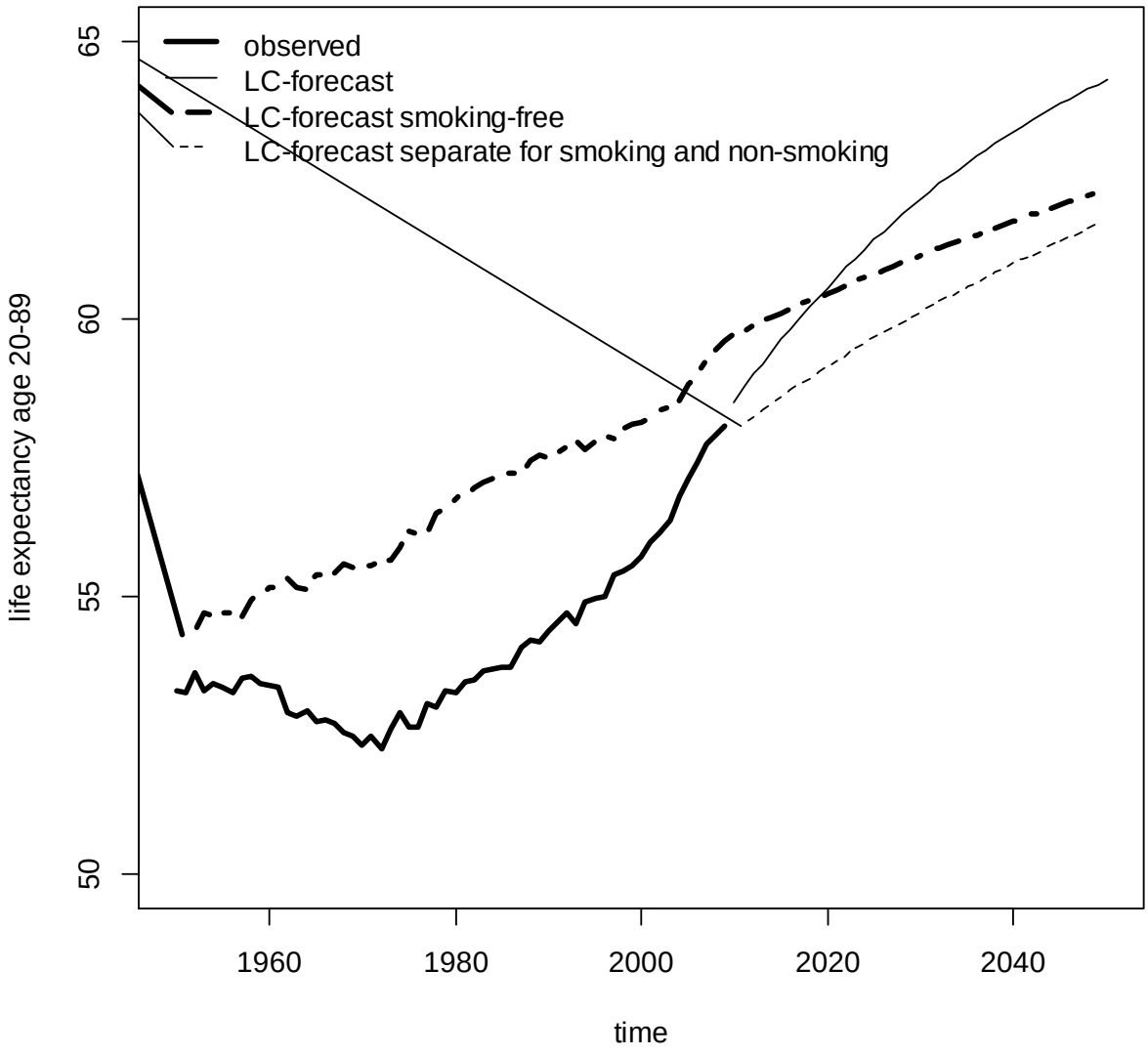


Figure 2 indicates the danger of applying a model that accounts for structural breaks. The Lee-Carter model with structural breaks extents the positive trend in life expectancy that was largely enabled by less mortality from smoking. The trend in mortality not associated to smoking arrives at much lower estimates.

1 Janssen, F. & Kunst, A. The choice among past trends as a basis for the prediction of future trends in old-age mortality. *Population Studies* **61**, 315-326 (2007).
2 Booth, H. & Tickle, L. Mortality modelling and forecasting: A review of methods. *Annals of Actuarial Science, 3* **1**, 3-43 (2008).