An EU cross-countries comparison study of life expectancy projection models

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Facing up to uncertain life expectancy

- LIFE EXPECTANCY AT BIRTH is defined as how long, on average, a newborn can expect to live, if current death rates do not change. One of the most frequently used health status indicators [OECD 2016]
- FUTURE LIFE EXPECTANCIES ARE UNCERTAIN: over the past few years life expectancy has not only been rising, but has been rising at a much faster rate than was previously anticipated
  - EU-28 IS AMONG THE WORLD LEADERS FOR LE: over the last 50 years LE at birth has increased by about 10 years for both men and women (2014: 80.9 years)
  - LE AT BIRTH IN 2014: 66.6 (Ukraine) for men and 81.1 years (in Switzerland); for women - from 76.7 (Ukraine) to 86.2 years (Spain)
  - LE AT 65 IN 2014: 12.8 (Belarus) for men and 19.7 years (in France); for women - from 17.0 (Ukraine) to 24.0 years (France)

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- Future life expectancies are uncertain: over the past few years life expectancy has not only been rising, but has been rising at a much faster rate than was previously anticipated
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Projections of life expectancy

- Past population projections from official sources have underestimated the gains in life expectancy at birth

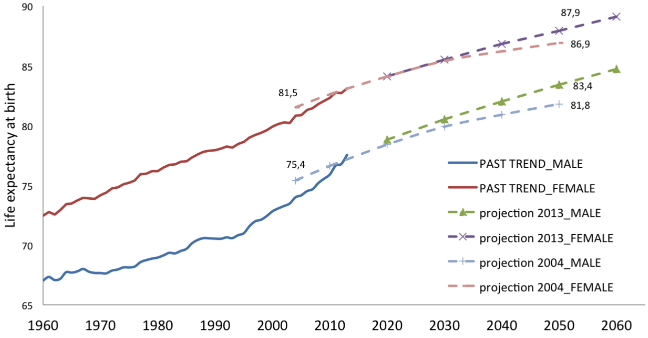
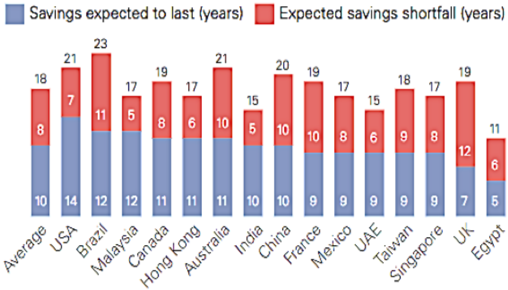


Figure 1: LE trends (in years) at 65, EU-28, EUROPOP 2004 and 2013

- "A few extra years life might not sound important, but it will cost socially and financially" (S. Jay Olshansky, University of Illinois, 2009)

Consequence of out-living average life expectancy

- Underestimation of LE, together with having too short a planning horizon, can result in inadequate provision for retirement needs
- Individuals do not feel adequately prepared for retirement: a significant shortfall between the number of years a person expects their savings to last and the number of years a person typically spends in retirement (HSBC Insurance Holdings, 2013)



Source: The Future of Retirement. Life after work? Global Report, published in 2013 by HSBC Insurance Holdings Limited, London [the survey: a representative online sample people ($>$ 16000, in 15 countries) of working age (25+) and those in retirement, July 2012-April 2013]

Questions

1. What kind of methods are used in official life expectancy in Europe?
2. What are the differences between life expectancy projections, obtained using different methods, and projections released by EUROSTAT and national statistical offices?

How is life expectancy projected?

1. From mortality to longevity models: the starting point is the age-specific death rates of the population $e_x = \sum_k^{\infty} {}_k p_x$, where ${}_k p_x$ is the probability of surviving from age x to age $x + k$
2. Methods:
   - process-based methods which use models based on the underlying biomedical processes
   - explanatory-based approaches which employ a causal forecasting approach involving econometric relationships
   - extrapolative methods (deterministic or stochastic) which are based on projecting historical trends in mortality forward
   - Some mortality projection methods include aspects of one or more approaches [Barrieu et al., 2012]
3. Deterministic versus stochastic approach:
   - projected life tables are constructed and used with or without accounting for any uncertainty
   - to create more accurate projections, actuaries carry out sensitivity tests based on the deterministic mortality assumption, by reasonably shifting the future mortality improvement rate up or down, or by adding one year of life expectancy to all ages to observe the magnitude of change

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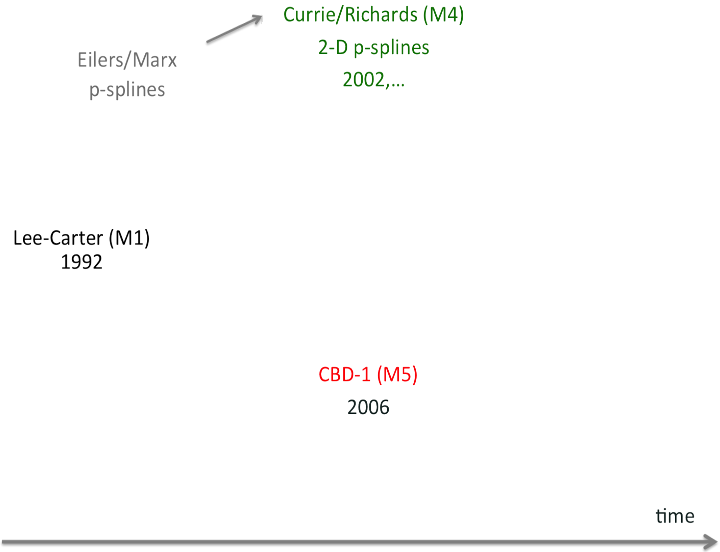
Development of stochastic mortality models (Cairns, 2012)



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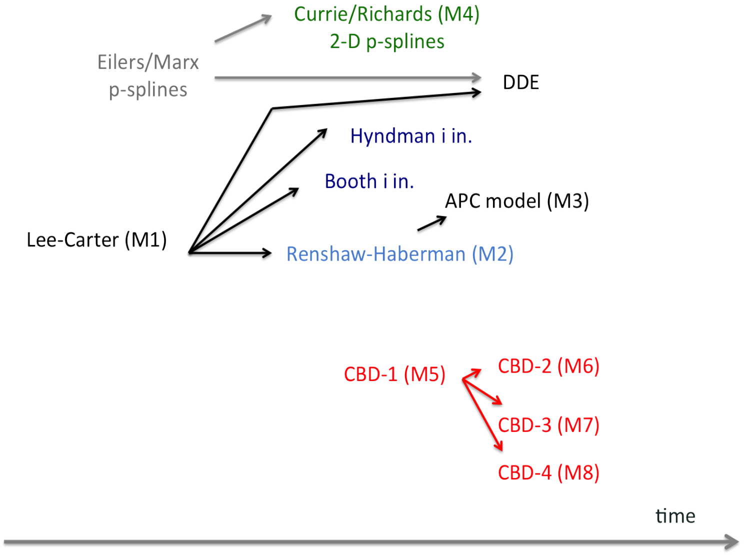

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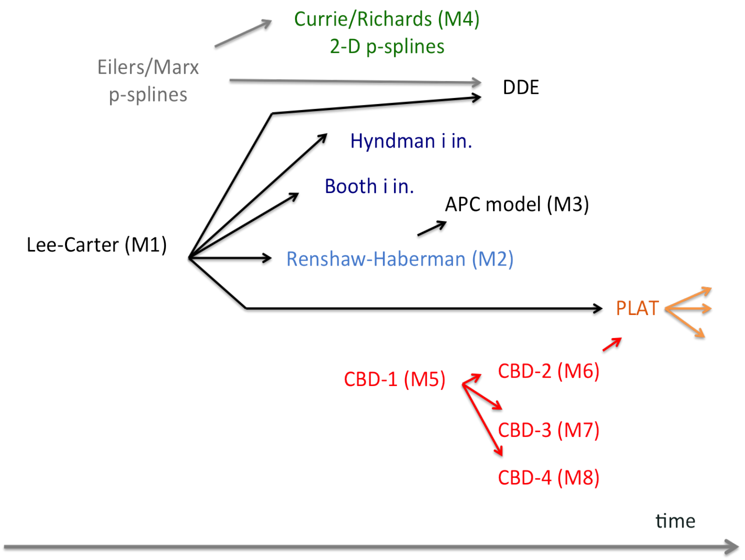

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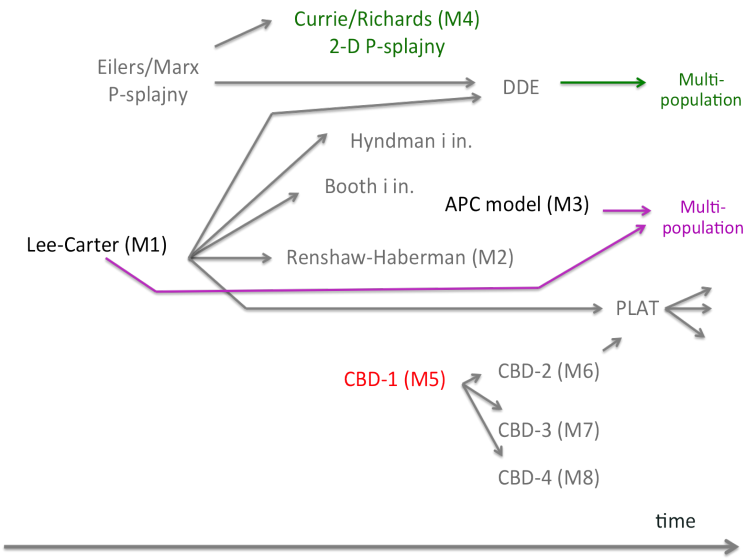

Age/Period/Cohort modelling framework (Villegas et.al, 2015)

The effects of age x, calendar year t and year of-birth (cohort) $c = t - x$ are captured through predictor η_{xt}:

$$\eta_{xt} = \alpha_x + \sum_{j=1}^{n} \beta_x^{(j)} \kappa_t^{(j)} + \beta_x^0 \gamma_{t-x}$$

- A static age function capturing the general shape of mortality by age
- Age functions and period factors governing trends in time at the same age range $N \geq 0$ is an integer indicating the number of age-period terms describing the mortality trends, with each time index $\kappa_t^{(j)}$, $i = 1, ..., N$, contributing in specifying the mortality trend and $\beta_x^{(j)}$ modulating its effect across ages
- γ_{t-x} accounts for the cohort effect with β_x^0 modulating its effect across ages

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How to select model? (Blake, 2013)

- ADEQUACY (sufficient number of terms to capture all significant structure in, and provide a good fit to the data)
- PARSIMONY (the smallest number of terms and free parameters necessary; trade off with the adequacy of the model)
- DEMOGRAPHIC SIGNIFICANCE (biologically reasonable, terms allow identification with underlying biological and socio-economic processes occurring in the population)
- COMPLETENESS (models should span entire age range and not be limited to a subset of ages by construction, and include allowance for cohort effects and be able to separate these from age/period terms)

Methods used by statistical offices in Europe. Review

- Differences in approaches:
  - Direct extrapolation
  - Lee-Carter
  - Subjective target approach
  - Expert opinions and subjective target approach
  - Direct extrapolation and expert opinions
  - Lee Carter and expert opinions
  - Lee Carter, expert opinions, direct extrapolation and cause of death
- Differences in variants and the extensions of models (e.g. adjustment for old-age mortality, re-estimation)
- Differences in used historical and projection period (long periods 100 years, short periods 15-20 years)
- Past trends determine which method and historical period is used ((non)linearity, epidemiological information)

Life expectancy projections, chosen EU countries

- Data source: Human Mortality Database HMD (2016) (mortality.org) and websites of national statistical offices (Czech Republic, Germany, Poland, Sweden, United Kingdom)
- Stochastic models: Lee-Carter (Lee and Cater, 1991), Cairns-Blake-Dowd (Cairns et al., 2006), PLAT (Plat, 2009)
- Aim: comparison of life expectancy projections, obtained using stochastic models, with projections released by EUROSTAT and national statistical offices
- Data:
  1. Historical period: 1970-2000 (exception Germany, from 1990)
     In-sample period: 2001-2014 (or 2013)
  2. Historical period: 1970-2013 (for Poland, Sweden, UK)
     or 1970-2014 (for Germany, Czech Republic)
     Projections for 2020, 2030, 2040 and 2050
     (exception Germany: only for 2060)

Lee-Carter family models used in analysis

- The Lee-Carter model (1992):

$$\log m_t(x) = \alpha_x + \beta_x^{(1)} + k_t^{(1)} \tag{1}$$

- The Cairns, Blake, and Dowd (CBD) model (2006):

$$\text{logit} q_t(x) = k_t^{(1)} + k_t^{(2)}(x - \overline{x}) \tag{2}$$

- PLAT model (2009):

$$\log m_t(x) = \alpha_x + k_t^{(1)} + k_t^{(2)}(\overline{x} - x) + \gamma_{t-x} \tag{3}$$

Life expectancy at birth projections for Poland (male)

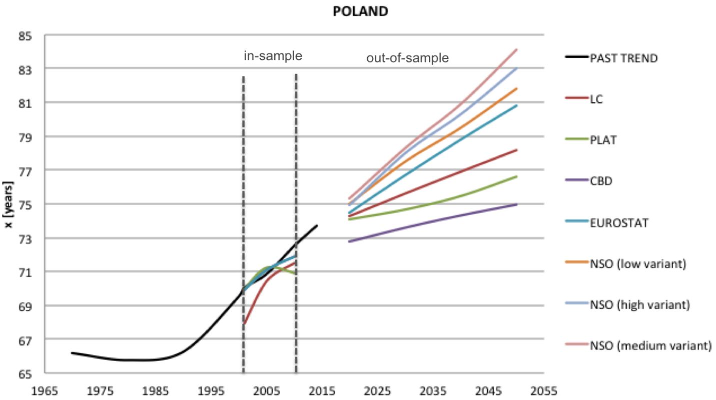

Figure 2: LE at birth projections (in years), data source: EUROSTAT and ONS

Life expectancy at birth projections for Czech Republic (male)

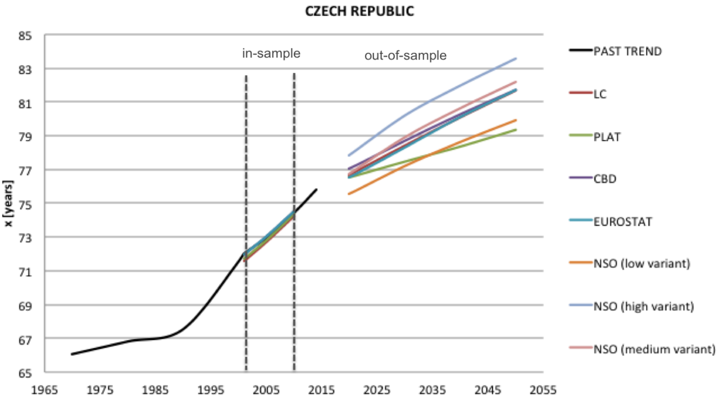

Figure 3: LE at birth projections (in years), data source: EUROSTAT and ONS

Life expectancy at birth projections for Germany (male)

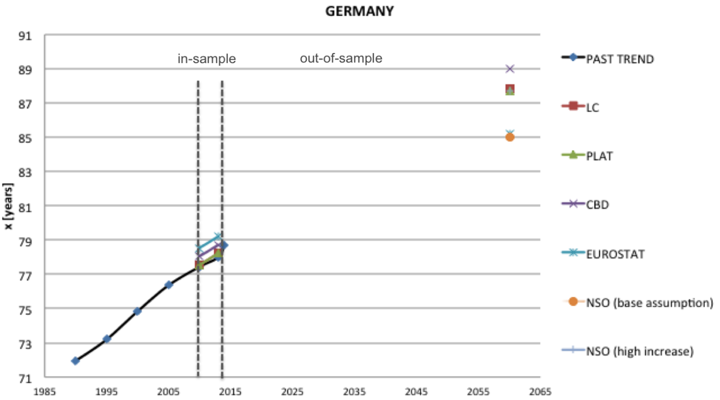

Figure 4: LE at birth projections (in years), data source: EUROSTAT and ONS

Life expectancy at birth projections for the UK (male)

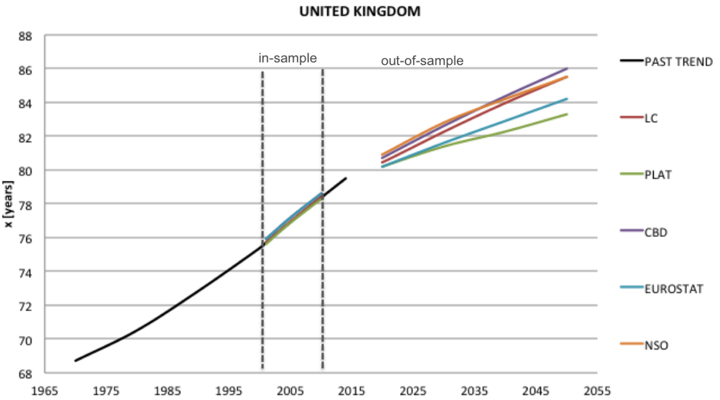

Figure 5: LE at birth projections (in years), data source: EUROSTAT and ONS

Life expectancy at birth projections for Sweden (male)

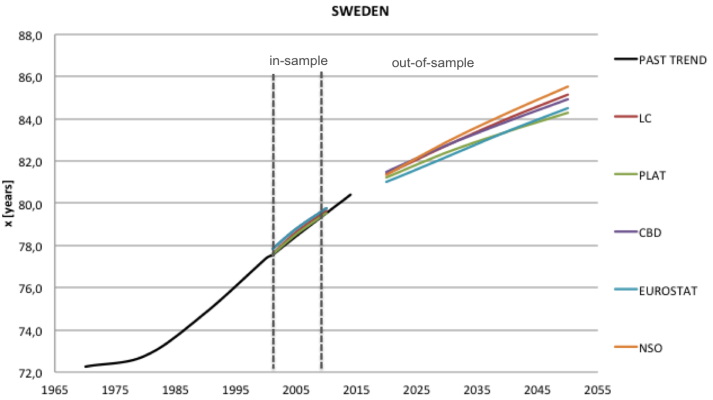

Figure 6: LE at birth projections (in years), data source: EUROSTAT and ONS

Summary

- Mortality/life expectancy projections are inaccurate largely because conventional extrapolative methods do not capture (1) the impact of lifestyle epidemics on mortality, which result in non-gradual trends over time and in large differences between men and women, birth cohorts, and countries; and (2) mortality delay: the shift in the age-at-death distribution towards older ages
- Explosion of research in last two decades on stochastic mortality models
- Too many models: general procedure for building a model
- Models - country-specific but inconsistent with commonly agreed general procedure
- To better understand and predict longevity risk, research and development efforts are now focused on stochastic mortality models

Literature

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Thank you for your attention