Cohort Effects and Structural Changes in Mortality Trend

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Outline

- Background and motivation
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Motivation

- Males born in Portugal during the late 1940s and 1950s experience a non-declining and even increasing mortality.
- The Lee-Carter model captures the major trends in Portuguese male mortality data, but shows some difficulties in fitting at particular ages.
- A sort of ripple effect is found in the residuals by year of birth.
- These patterns are consistent with the hypothesis of cohort influences in male mortality. Little attention given to cohort effects in Portugal.
- Structural changes in overall mortality time trend were found in Portugal and in other countries.
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• Problem

✓ Are there cohort effects in male mortality in Portugal?

✓ If cohort effects are present, are structural changes in the overall mortality trend due to model misspecification?

✓ What are the impacts of misspecification of the model?
Methodology (1)

- Analysis of the Portuguese mortality patterns and residuals from the Lee-Carter model.
- Separate the contribution of age, period, and cohort effects estimating the APC model and adding interaction terms with age.
- Explore the association between the presence of structural change and cohort effects, extending the analysis of the residuals to other developed countries where a structural change was found.
- Conduct a simulation.
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• **Methodology (2): Models**

  ✓ **Lee-Carter (LC) model:** \( \ln(m_{ij}) = \alpha_i + \beta_i^{(1)} k_j + \varepsilon_{ij} \)

  ✓ **Classical Age-Period-Cohort (APC) model:**
  \[
  \ln(m_{ij}) = \delta + \alpha_i + k_j + \gamma_{j-i} + \varepsilon_{ij}
  \]

  ✓ **Renshaw and Haberman (RH) model:**
  \[
  \ln(m_{ij}) = \alpha_i + \beta_i^{(1)} k_j + \beta_i^{(2)} \gamma_{j-i} + \varepsilon_{ij}
  \]

  - \( m_{ij} \): death rate for age \( i \) in year \( j \)
  - \( \alpha_i \): age-effects
  - \( k_j \): period-effects
  - \( \gamma_{j-i} \): cohort effects
  - \( \beta_i^{(1)} \): age-period interaction
  - \( \beta_i^{(2)} \): age-cohort interaction
  - \( \delta \): constant
  - \( \varepsilon_{ij} \): error term
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Age-specific death rates, 1950-2007, Portugal
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- LC Model

Residuals, Males, Portugal, 1950 – 2007

[Graphs showing deviance residuals by age, calendar year, and year of birth.]
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LC Deviance Residuals - Portugal

Males, 1950-2007

Break date: 1996
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- **Estimation results (1):**

APC Model

Estimated parameters, Males, Portugal, 1950-2007
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- **Estimation results (2):**
  APC Model Residuals, Males, Portugal, 1950-2007
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- **Estimation results (3):** RH Model Estimated Parameters, Males, Portugal, 1950-2007
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- **Estimation results (4):**
  
  RH Model
  Residuals, Males, Portugal
  1950-2007
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- **Portugal – male mortality**

  ✓ Evidence of cohort effects from the analysis of male death rates and in the residuals of the Lee-Carter model.

  ✓ The results from the estimation of the APC and RH validate the presence of cohort effects.

  ✓ Coelho and Nunes (2011) found statistical evidence of structural changes in the overall mortality time trend slope for male mortality.

  ➠ Is the structural change a result from model misspecification
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• Structural Breaks and Cohort effects (1)

✓ Coelho and Nunes (2011) found statistical evidence of structural changes in the overall mortality time trend in several other developed countries, particularly for male populations.

✓ We extend the analysis of the residuals for some of these countries:
  o England and Wales (1979)
  o France (1985)
  o Italy (1983)
  o Belgium (1976)
  o West Germany (1975)
  o Japan (1955).

✓ The residuals were obtained from estimating the Lee-Carter model for each country.
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• Structural Breaks and Cohort effects (2)

✓ The inspection of the residuals allows to identify two types of cohort effects:

⇒ affecting only a particular year of birth; and

⇒ the typical ripple effect associated with a cohort effect described by Renshaw and Haberman (2006).

✓ These two types of cohort effects are confirmed by the diagonal patterns in the residual level plot over calendar year and age:

⇒ either as a single diagonal line, or

⇒ a diagonal region with relatively larger or smaller values.
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LC Deviance Residuals - England & Wales Males, 1950-2007

Break date: 1979
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LC Deviance Residuals – France
Males, 1950-2007

Break date: 1985
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Break date: 1983
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LC Deviance Residuals – Belgium

Males, 1950-2007

Break date: 1976
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LC Deviance Residuals – West Germany

Males, 1950-2007

Break date: 1975
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LC Deviance Residuals – Japan

Males, 1950-2007

Break date: 1955
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- **Structural Breaks and Cohort effects (3)**

  - Cohort effects are found in Belgium, England & Wales, France, Italy, Japan, Portugal, and West Germany.
  
  - Structural changes in the overall mortality trend obtained from the LC model found in all these countries.
  
  - We perform the same structural change tests, but now applied to the period effect coming from the RH model.
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- **Structural Breaks and Cohort effects (4)**

  ✓ Structural change tests applied to the period effect from the RH model no longer show evidence of a structural change for Belgium, England & Wales, Italy, and Portugal.

  ✓ One possible explanation for this finding is that a misspecification of the model may have lead to spurious structural changes being found in the estimated overall mortality trend.
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• **Simulation (1)**

  - **DGP:** Data with cohort effects
  - **Model:** Lee-Carter model

  Spurious age-period interaction term.

  - **DGP:** Data with age-period interaction effects
  - **Model:** APC model

  Spurious cohort effect
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• **Simulation (2)**

✓ Simulation of the impact of omitting cohort effects in structural change tests – work still in progress

• **DGP:** Data with cohort effects
• **Model:** Lee-Carter model

Spurious structural change?
• Conclusion

✓ Evidence of the presence of cohort effects in male mortality in Portugal.

✓ A model allowing for period and cohort effects with different influences at different ages is the most adequate to describe male mortality pattern in Portugal since 1950.

✓ Consequences of a misspecification of the model, in particular the omission of cohort effects and omission of age-period interaction.

✓ The misspecification of the model may lead to spurious structural changes in the overall mortality trend.
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• Future work

✓ Under development: impacts of omitting cohort effects in structural change tests
✓ Forecasting mortality allowing for cohort effects.
✓ Factors that might explain cohort effects in Portugal.
✓ Explanatory variables in model specification.