4th HMD Symposium

Life Expectancy and Lifespan Equality: A Dynamic Long run Relationship

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Introduction

- **Background:**
  - Life expectancy at birth (e_0) is one of the most widely used measures to summarize population health.
  - Most countries have improved in this indicator. Record e_0 has steadily increased by 2.5 years every decade.
  - However, it conceals variation in lifespans or **lifespan equality**.

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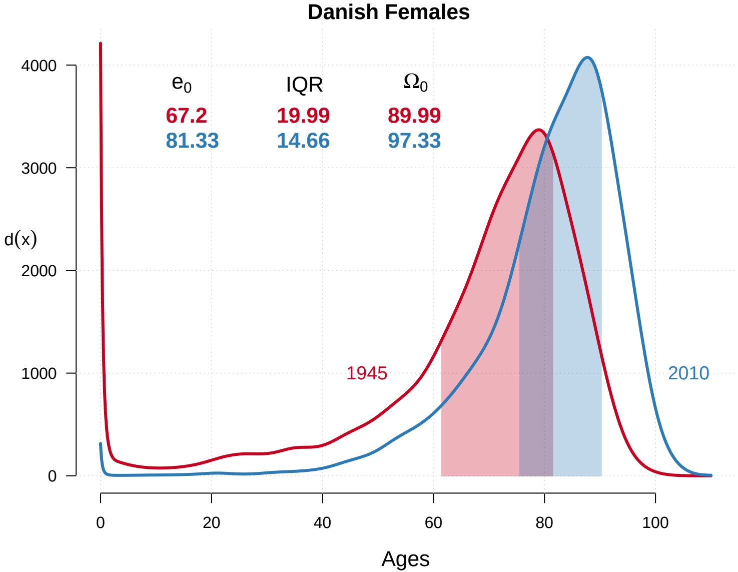
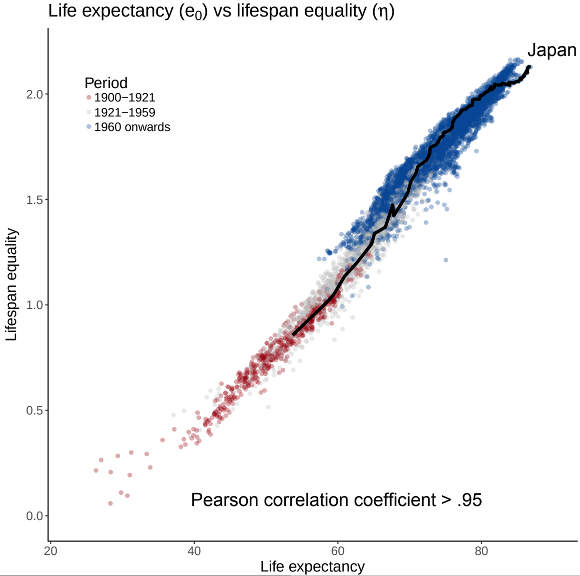
- **What is lifespan equality?**
  - Dimension that expresses a fundamental difference in survivorship among individuals.
  - It addresses the growing interest in health inequalities and its linkage with social behavior.

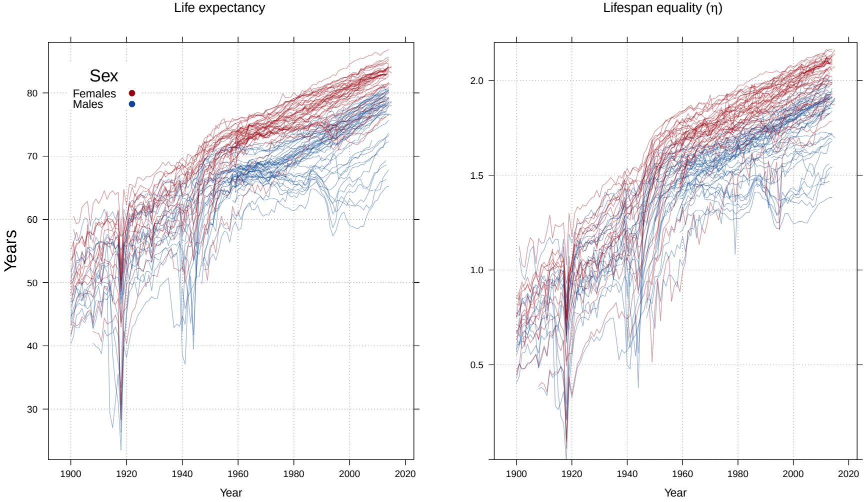
Why studying **lifespan equality** is important?



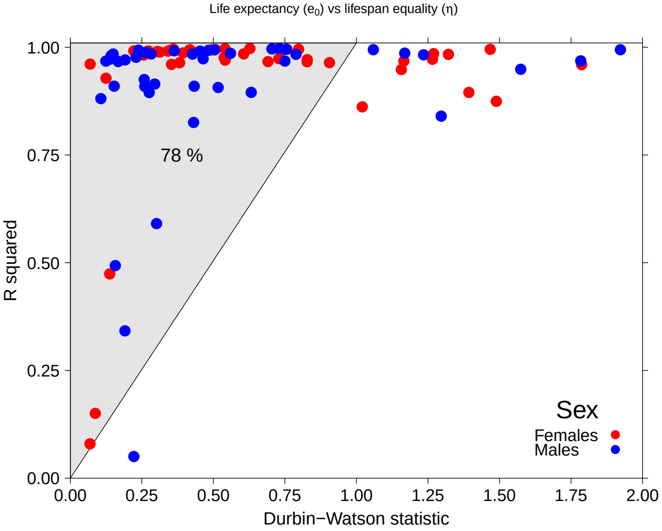
Strong **association** between life expectancy and lifespan equality



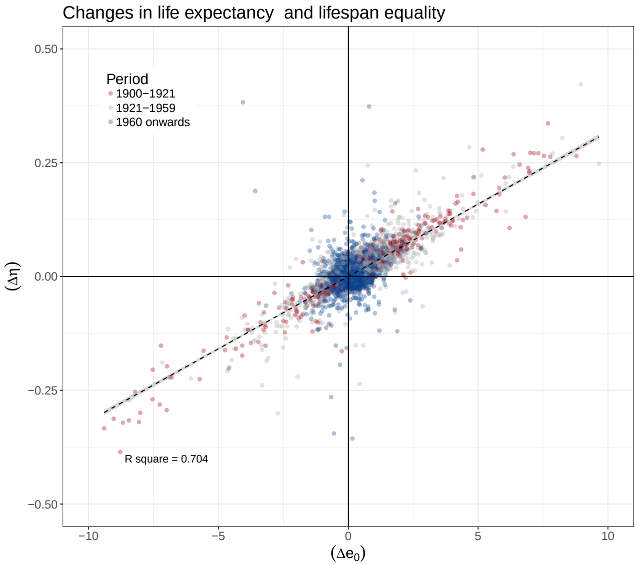
Non-stationary series



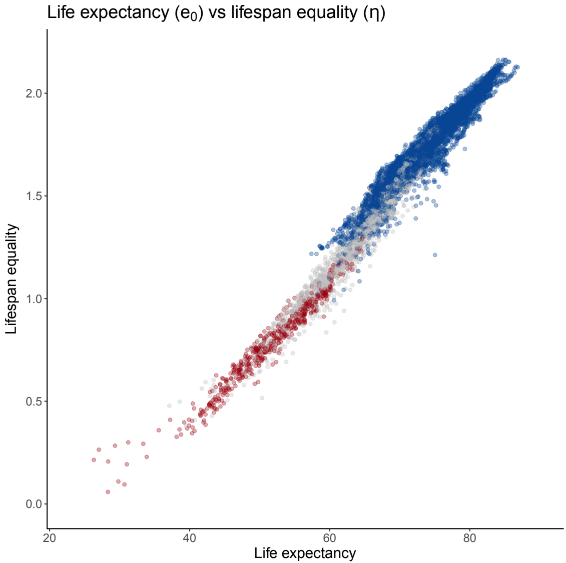
If non-stationarity $\longrightarrow$ risk of misleading results



Stochastic properties suggest analyzing both in first differences



General idea of the model



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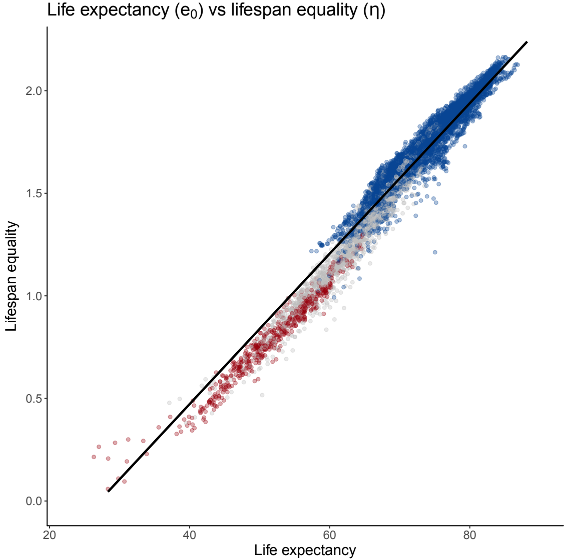

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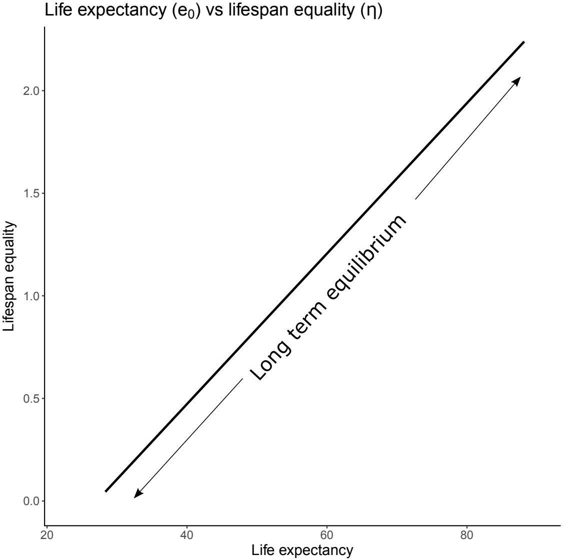

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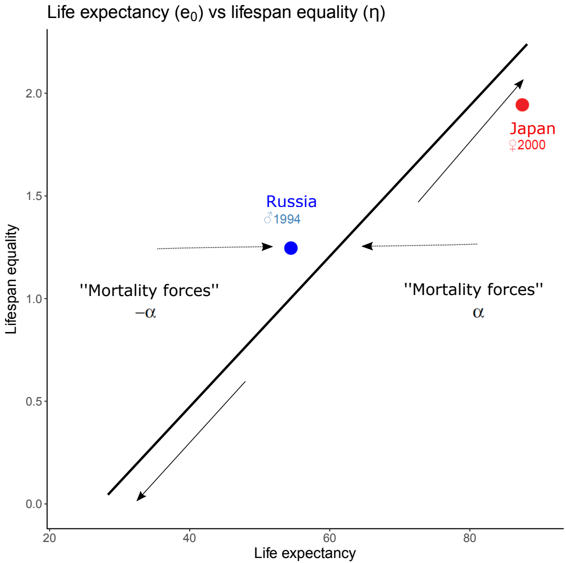

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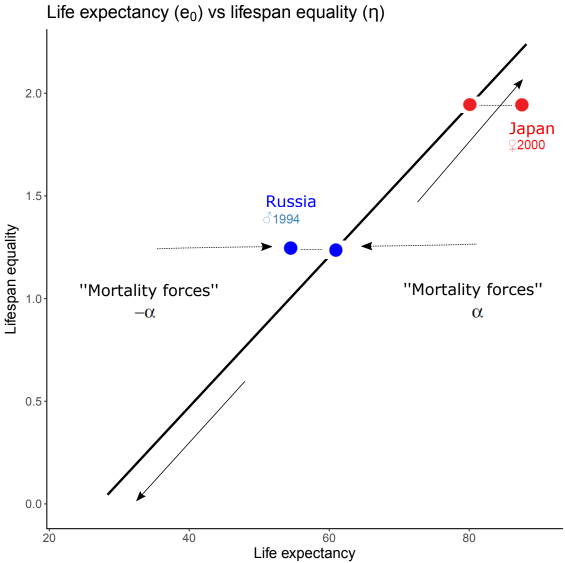

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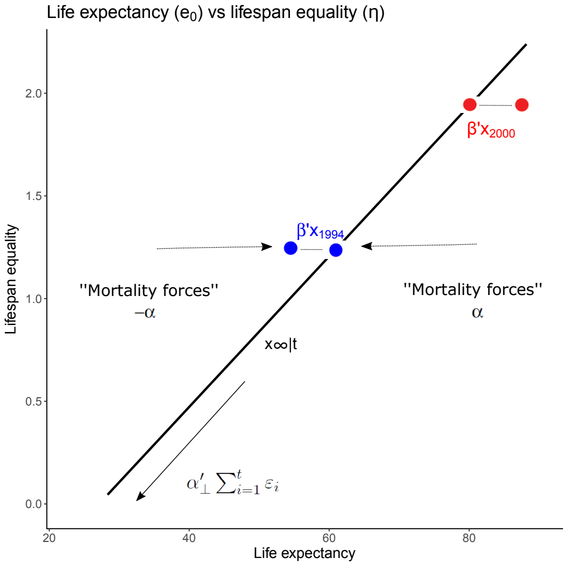


Cointegration analysis

Two-dimensional VAR model in its equilibrium correction (VECM) form:

$$\Delta Z_t = \sum_{i=1}^{k-1} \Gamma \Delta Z_{t-i} + \alpha\beta' Z_{t-1} + \mu + \Psi D_t + \epsilon_t$$

where:

- Δ first difference operator
- Z_t vector of stochastic variables, e_0 and η
- D_t vector of deterministic variables (e.g. linear trends)

Data comes from **HMD**, over 8 500 lifetables for 44 countries

Lifespan equality measures

Three measures were used:

$$\eta = -\log\left(\frac{-\int_0^\omega \ell(x)\ln \ell(x)\mathrm{d}x}{\int_0^\omega \ell(x)\mathrm{d}x}\right) = -\log\left(\frac{e^\dagger}{e_0^o}\right), \qquad (1)$$

η based on **Keyfitz**' entropy used in Colchero et al 2016.

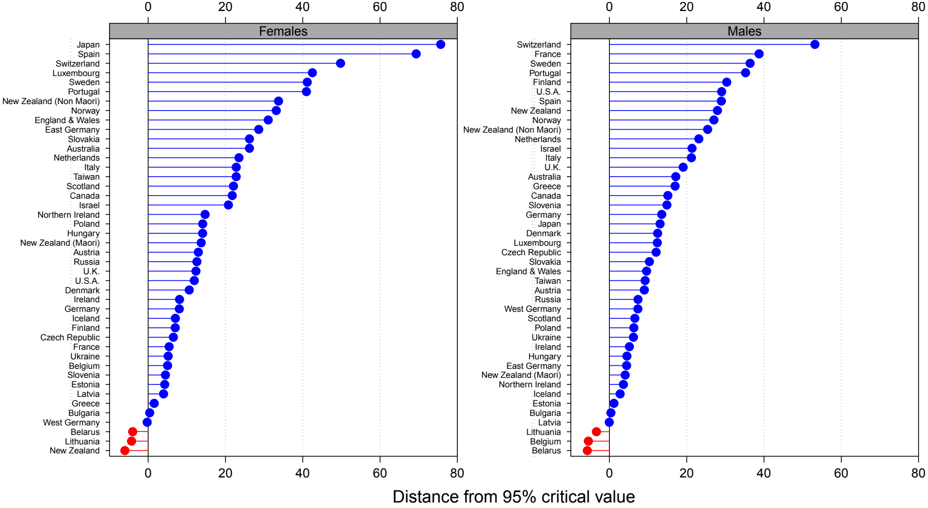
$$\bar{\ell} = -\log\left(1 - \frac{-\int_0^\omega \ell^2(x)\mathrm{d}x}{\int_0^\omega \ell(x)\mathrm{d}x}\right) = -\log\left(G\right), \qquad (2)$$

$\bar{\ell}$ a variant of the **Gini coefficient**.

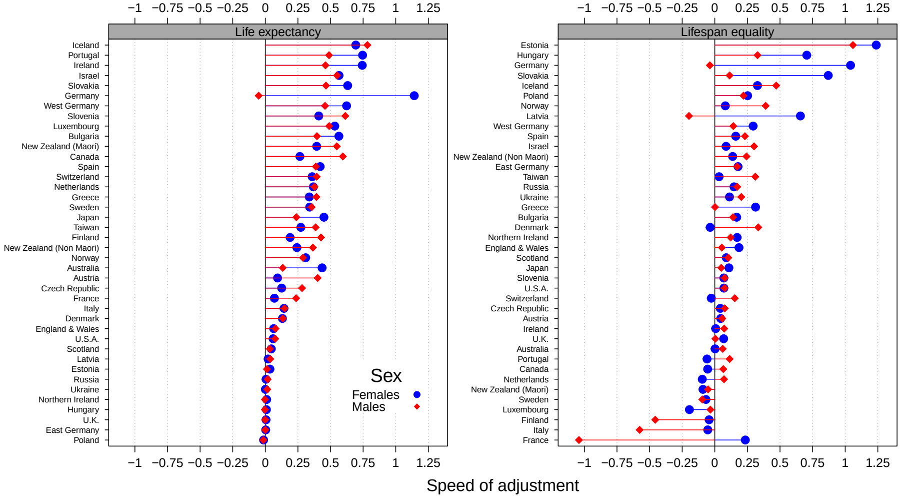
$$cv = -\log\left(\frac{\sqrt{\int_0^\omega (x - e_0^o)^2 f(x)\mathrm{d}x}}{\int_0^\omega \ell(x)\mathrm{d}x}\right) = -\log\left(\frac{\sigma}{e_0^o}\right), \qquad (3)$$

cv a variant of the **coefficient of variation**.

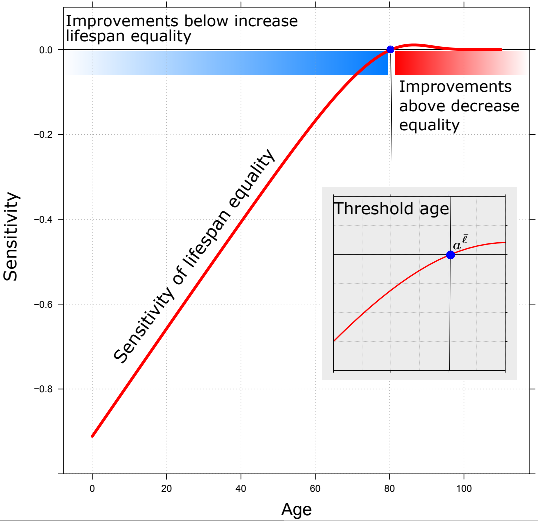
Long run relationship [Johansen's trace test]



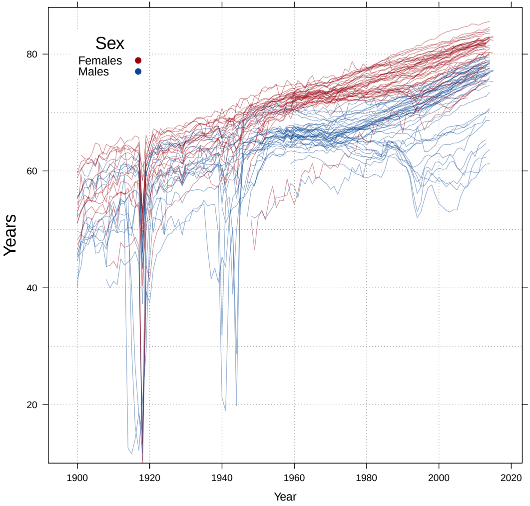
Speed of adjustment towards long term equilibrium



Include the age dimension Reducing deaths at any age increases e_0; for η, it depends whether deaths occur before or after a^i



Threshold age a^{η}



Decomposition method

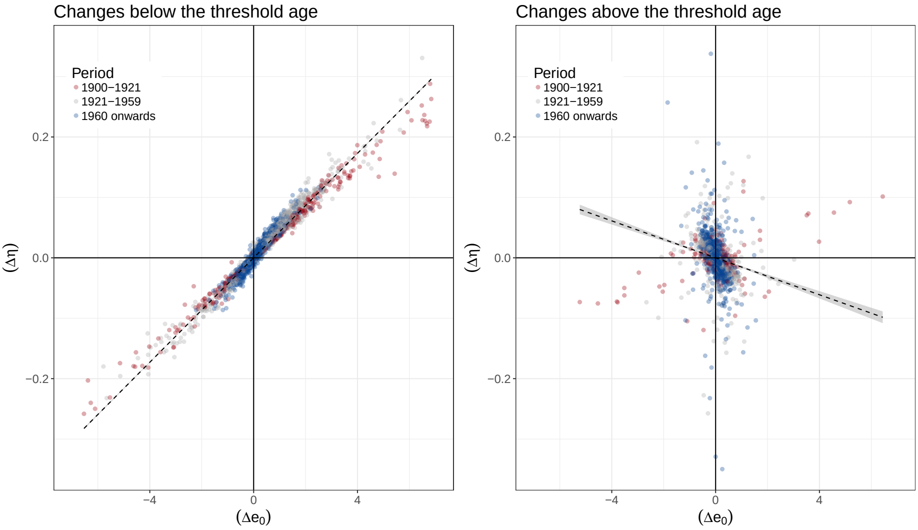
Model of continuous change: analysis based on the assumption that covariates change continuously along an actual or hypothetical dimension.[Horiuchi et al 2008 Demography; Caswell 2010 Journal of Ecology]

The effect of the i-th age group death rate on the change in e_0 and η from period t to $t+1$ can be calculated as

$$c_i = \int_{m_i(t)}^{m_i(t+1)} \frac{\partial e_0(t)}{\partial m_i(t)} dm_i(t) \tag{4}$$

Then we calculated contributions below and above the threshold age to changes in life expectancy and lifespan equality.

Age-specific contributions



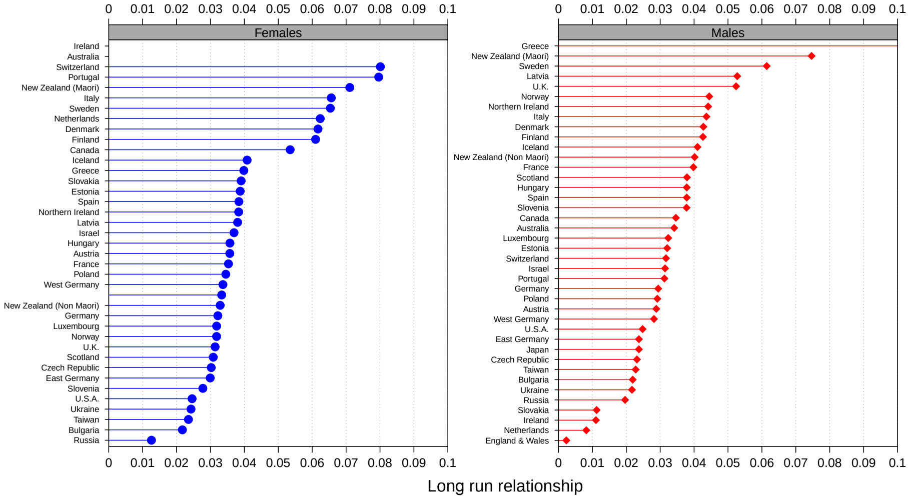
Summary and conclusions

- Strong association between changes in e_0 and η.
- We found evidence of a long term equilibrium.
- Even if in the short term they diverge from each other, there is a correction mechanism that bring them together again.
- To some extent mortality improvements below threshold age are driving the relationship.

Thanks for your attention.

Comments and/or questions?

Normalized $(\eta = 1)$ **long run coefficient** for e_0



Can we talk about **causality**?

- Granger causality $\longrightarrow$ Because e_0 and η cointegrate at least Granger causality exists in one direction.[Caution!]
  - Just a potential causality, does not take into account latent variables.
  - Temporal precedence: a cause precedes its effects in time
- Instantaneous causality: test non-zero correlation between error processes of the cause and effect variables.
  In 90% of the cases we reject the $H_0 =$ no instantaneous causality

long run relationship