Mortality Improvements
Cross-country correlations

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Life Expectancy is increasing almost all over the world

- Mortality in the last decades has dropped significantly in most countries all over the world
- In West Germany the Period Life Expectancy in 1969 was 67.2 years
- 40 years later it is 77.7 years – effectively a new-born has gained more than 6 hours of Life Expectancy every day*
- Other countries in West Europe have similar high improvement rates

*Source: Human Mortality Database (HMD)
Mortality improvements for males
based on HMD data, smoothed

Comparison: UK and West Germany, average over ages 20-90 in %
Mortality improvements for males based on HMD data, smoothed

Comparison: UK and West Germany, ages 20-90 in %

- Similar developments for UK and Germany can be seen in the period from 1970-2002.
- Improvement development seems to differ between 1965 and 1970 and from 2003 onwards.
Comparing heat maps of mortality improvement reveals similarities ...

UK

West Germany

in %

- 7,5%-8,5%
- 6,5%-7,5%
- 5,5%-6,5%
- 4,5%-5,5%
- 3,5%-4,5%
- 2,5%-3,5%
- 1,5%-2,5%
- 0,5%-1,5%
- -0,5%-0,5%
- -1,5%-0,5%
- -2,5%-1,5%
- -3,5%-2,5%
- -4,5%-3,5%
- -5,5%-4,5%
- -6,5%-5,5%
- -7,5%-6,5%
Comparing heat maps of mortality improvement
... and differences

UK

West Germany

in %

7,5%-8,5%
6,5%-7,5%
5,5%-6,5%
4,5%-5,5%
3,5%-4,5%
2,5%-3,5%
1,5%-2,5%
0,5%-1,5%
-0,5%-0,5%
-1,5%--0,5%
-2,5%--1,5%
-3,5%--2,5%
-4,5%--3,5%
-5,5%--4,5%
-6,5%--5,5%
-7,5%--6,5%

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A more detailed approach

- For a detailed analysis, we set up the following model:
  \[ i(x, t) = a(x) + p(t) + c(t - x), \quad x \in \{20, \ldots, 90\}, \quad t \in \{1965, \ldots, 2009\} \]

- Idea: fit this model to the past experience by using least-squares estimators and compare the improvements component-by-component

- Problem: depending on the exact range ~200 parameters to estimate

- Possible solution: instead of estimating all parameters, we rather use B-Splines and estimate the knot values

- This leads to less parameters and additional smoothness
UK and West Germany, males
Age, Period and Cohort Component

**Age component**

- UK
- West Germany

**Period component**

- UK
- West Germany

**Cohort component**

- UK
- W. Germany
Measuring correlation
The sample Pearson correlation coefficient

- The sample Pearson correlation coefficient is defined by

\[
r = \frac{\sum_{i=1}^{n} (a_i - \bar{a}) \cdot (b_i - \bar{b})}{\sqrt{\sum_{i=1}^{n} (a_i - \bar{a})^2 \cdot \sum_{i=1}^{n} (b_i - \bar{b})^2}}
\]

- \( r \) measures the correlation between two datasets with \( r = 1 \) being perfectly positive correlated, \( r = -1 \) being perfectly negative correlated and \( r = 0 \) being totally uncorrelated.

- We calculate the \( r \) values for different countries for each component separately.

- We also calculate \( r \) for the shifted datasets as there might be delayed correlations for example within the period component.
Age components UK and Germany, males
do not seem correlated - "peak" at +4
Age components UK and Germany, males

do not seem correlated

Age components: UK shifted by 20 years and West Germany

- Remarkably high (negative) correlation at -20: \( r = -97.8\% \)
- Shifting the chart shows why…
Period components UK and Germany, males

Pearson's r has a peak around 0

Period components (UK and West Germany) and Pearson's correlation coefficient

- UK
- West Germany
- r

-20 -10 0 10 20

shift UK left shift UK right


4% 2% 0% -2% -4%

100% 50% 0% -50% -100%
Cohort components UK and Germany, males
Pearson's r has peak at +2

Cohort components (UK and West Germany) and Pearson's correlation coefficient

- UK
- West Germany
- r

Pearson's r has peak at +2
Summary of the comparison

- Highest \( r = 55.2\% \) when shifting the cohort-curve by +2 years
- In concrete terms: according to the data the center of the cohort for males in West Germany is born two years later than UK males
- Recalling the heat maps in the beginning proves this
- Moreover: so far we have only looked on the male data set – do we see the same features when looking at the female dataset?
Comparing heat maps again shows slightly different cohort effects

<table>
<thead>
<tr>
<th>Year</th>
<th>UK, males</th>
<th>West Germany, males</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1969</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td></td>
<td></td>
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<tr>
<td>1989</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- 7,5%-8,5%
- 6,5%-7,5%
- 5,5%-6,5%
- 4,5%-5,5%
- 3,5%-4,5%
- 2,5%-3,5%
- 1,5%-2,5%
- 0,5%-1,5%
- -0,5%-0,5%
- -1,5%-0,5%
- -2,5%-1,5%
- -3,5%-2,5%
- -4,5%-3,5%
- -5,5%-4,5%
- -6,5%-5,5%
- -7,5%-6,5%
UK and West Germany
Age, Period and Cohort Component for females

Age component

Period component

Cohort component
While age- and period component look quite similar for males and females, there are some differences within the cohort component.

It is common opinion that one reason for the cohort effect is that the generation born around 1930 is the first being not actively involved into World War II.

It hence makes sense that the female cohort effect differs from the male one.

In total it seems there is a correlation between the UK and the German trend.

There are other examples however where correlation is more obvious.
Improvements in Russia and Estonia for males
Lots of commonalities

Russia

Estonia

- 7.5%–8.5%
- 6.5%–7.5%
- 5.5%–6.5%
- 4.5%–5.5%
- 3.5%–4.5%
- 2.5%–3.5%
- 1.5%–2.5%
- 0.5%–1.5%
- -0.5%–0.5%
- -1.5%–0.5%
- -2.5%–1.5%
- -3.5%–2.5%
- -4.5%–3.5%
- -5.5%–4.5%
- -6.5%–5.5%
- -7.5%–6.5%
Age components Russia and Estonia, males seem highly correlated - peak at -1

Age components (Russia and Estonia) and Pearson‘s correlation coefficient

shift Russia left
-20 -10 0 10 20 shift Russia right
-1,0% -0,5% 0,0% 0,5% 1,0%

100%
50%
0%
-50%
-100%

20 30 40 50 60 70 80 90

Russia Estonia r

87,2%
Period components Russia and Estonia, males seem highly correlated as well - peak at 0
Cohort components Russia and Estonia, males 
seem highly correlated as well - peak at -1

Cohort components (Russia and Estonia) and Pearson‘s correlation coefficient

- shift Russia left
  -20  -10  0  10  20
- shift Russia right
  0%  50% 100%

-4% -2%  0%  2%  4%

1892 1908 1924 1940 1956

Russia  Estonia  r
Correlation Russia and Estonia

- All three improvement components seem correlated
- Not too surprising keeping the common history in mind
- However, the correlation of the period improvements from 1990-2009 is 94.2%, which is even higher than the correlation for the whole time span from 1962-2009 (88.8%)

- Let’s look at other examples in Western Europe
Improvements in East and West Germany for females

East Germany

West Germany


-7,5%--6,5%
-6,5%--5,5%
-5,5%--4,5%
-4,5%--3,5%
-3,5%--2,5%
-2,5%--1,5%
-1,5%--0,5%
0,5%--1,5%
1,5%--2,5%
2,5%--3,5%
3,5%--4,5%
4,5%--5,5%
5,5%--6,5%
6,5%--7,5%
7,5%--8,5%
Age components East and West Germany, females seem highly correlated - peak at -1
Period components East and West Germany, females seem not too correlated - peak at -18
Cohort components East and West Germany, females

seem correlated - peak at -4

Cohort components (East and West Germany) and Pearson’s correlation coefficient

shift East Germany left
-20  -10  0  10  20

shift East Germany right
0%  100%

-100%

-50%

-4%  4%

0%  2%  4%

63,1%

1892  1908  1924  1940  1956

East Germany  West Germany  r
Improvement East and West Germany

Summary

- In total age component und cohort component seem correlated in East and West Germany
- The period component does not seem to be correlated
- For the whole time frame from 1962-2009: \( r = 33.2\% \) (at +1 shift)
- For the time frame 1990-2009: \( r = 67.8\% \) (at +2 shift)

- This result is more or less as expected: Correlation for the whole period is much lower than for the period from 1990-2009
Improvements in France and West Germany for females
Lots of commonalities
Age components France and West Germany, females
seem highly correlated - peak at 0

Age components (France and West Germany) and Pearson’s correlation coefficient

- Shift France left
- Shift France right

- 100%
- 50%
- 0%
- -50%
- -100%

- 1,0%
- 0,5%
- 0,0%
- -0,5%
- -1,0%

20 30 40 50 60 70 80 90

France
West Germany
r
Age components France and West Germany, females seem highly correlated - peak at 0

Age components (France and West Germany) and Pearson’s correlation coefficient
Period components France and West Germany, females
seem highly correlated - peak at -1
Period components France and West Germany, females seem highly correlated - peak at 0
Cohort components (France and West Germany) and Pearson’s correlation coefficient seem correlated - peak at -3.
Cohort components France and West Germany, females seem correlated - peak at -3

Cohort components (France and West Germany) and Pearson’s correlation coefficient

-4% -2% 0% 2% 4%
1892 1908 1924 1940 1956

-100% -50% 0% 50% 100%

-20 -10 0 10 20

shift France left
shift France right

France
West Germany
r
Summary

- Russia / Estonia and France / West Germany are two examples of highly correlated mortality improvement patterns in the past.
- In fact, Latvia has also a very similar mortality improvement pattern compared to Russia / Estonia.
- An additional example of highly correlated mortality improvement patterns is Sweden / Norway.

Why do we benefit from this information?
- Correlations are helpful especially for smaller countries with less (credible) data.
- Mortality data for Estonia (population ~1.3m) is very volatile over the years, whereas Russia (population ~144m) has much less volatile data.
- But even for two big countries – like France and Germany – it probably makes sense to keep improvement projections in line with each other.