Understanding Mortality Developments

History and future and an international view

Henk van Broekhoven
Mortality and trend modelling is not just a mathematical and econometric exercise.

History is a bad predictor of the future.

- Expert judgement need to be added, particularly from a medical/demographic view
- What happened in the past should first of all be understood
1. Understanding the history
2. Explaining the history
3. Trends, how to model?
4. New trend model
5. International results
UNDERSTANDING THE HISTORY
We should understand the history of life expectancy at age zero in the Netherlands.
We should understand the history

Life expectancy at age zero, Netherlands

female smoking reduced the increase of life expectancy after 1990

(1) Spanish Flu in 1918
(2) Hunger winter end of WW2
Life expectancy age 0
Norway

E(0) Norway


Male
Female
Comparison NL and Norway in life expectancy

- Norway Male
- NL Male
- Norway Female
- NL Female
Comparison mortality by age

$q(x)$ Male in 2009
Comparison mortality by age

$q(x)$ Female in 2009
EXPLAINING THE HISTORY
Explaining the history

• (1) The “Hump”
  – In the early 50\textsuperscript{ts} for the ages 45-75 for male the mortality rates went up. This was caused by:
    • Smoking of cigarettes
    • Traffic accidents
    • Heart failure
  – All these impacts are the result of behaviour
    • Smoking
    • Eating habits in combination with less healthy exercise habits
    • More driving in cars
  – This flat period of development make the insurers not aware of the potential longevity risk in their portfolio
Explaining the history

• (1) The “Hump” (cont.)
  – During the seventies all three causes changed
    • Less smoking for male
    • Traffic get safer (in 1969 yearly more than 3000 traffic deaths in NL, nowadays around 600)
    • Medical developments regarding heart attacks in combination with a healthier way of living (healthier food, more exercise)
  – ... and the mortality rates went down again
Explaining the history

• (2) Trend change in 2001
  – The increase of the life expectancy suddenly went up to more than 0.3 years per year (before that between 0.15 and 0.2), both for male and female
  – Happened in almost the whole Western World
  – Reasons
    • Continuation of less smoking (particularly male)
    • Angioplasty as a treatment in case of an heart attack. This increased the survival chance dramatically
The development of life expectancy depends on:

- Medical development
  - And is it available?
- Behaviour
  - Drinking, smoking, eating habits,...
- Environment
  - Drinking water, one of the most important reasons of the increase of the life expectancy in the developed countries
  - Pollution
    - Water, air
  - Climate
    - And so climate change
- New diseases
- Resistance against medicines (antibiotics)
We can split development in 3 parts:

Life expectancy at age zero, Netherlands

1. 1850-1880
2. 1880-1950
3. 1950-2000

Male | Female
--- | ---
2 | 1
We can split development in 3 parts

• (1)
  – No development of $e(0)$
  – High volatility
    • People less protected against extreme weather, flu epidemics
    • Tuberculosis
  – High mortality for young children
    • In 1850: $e(0)$ male: 38.3; $e(5)$ male: 50.8!
  – Comparable with the underdeveloped countries
We can split development in 3 parts

• (2)
  – After the industrial revolution
  – Steep increase of life expectancy
    • Medical developments
    • Cleaner drinking water
      – Seen as THE most important reason for improvement
    • Environment
      – Better protection: heating in houses, toilets etc.
  • Comparable with emerging countries
We can split development in 3 parts

• (3)
  – Typical for developed countries
  – Developments like the quality of drinking water are reaching the limits
  – Change in life expectancy depends more of:
    • Behaviour
    • Medical developments
  – Both can have positive or negative effects.
  – Particularly behaviour can cause more independency in development between male and female.
TRENDS, HOW TO MODEL?
How to model?

• In (1) and (2) it is rather easy to predict the future using the history
• In (3) this is very complex. History can hardly be use as dataset to predict the future.
  – More shocks (like in 2001) can be expected
  – Also a decrease of life expectancies is possible in the coming 50 years:
    • Climate change
    • Resistance of antibiotics.
    • Behaviour (obesities)
    • ...

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How to model?

• In practice we see also a movement from (2) to (3)
  – for example in Central European Countries.
How old can a human become?

- The oldest confirmed human became 122 years and 164 days
- Jeanne Calment
- Born: 25 February 1875
- Secret?

  - On all her food olive oil
  - Port wine diet
  - 1 kg of chocolate a week
How old can a human become?

• It cannot be proven that the max age is increasing
• Medical experts mention that a real life span exist per person, depending on the genetic passport, but will be limited to around 125-130 years.
• Mortality rates seem to be almost constant above age 105 at a level 0.5-0.6.
Conclusion (from my side)

• Pure mathematical models to predict the future mortality are less accurate
• Expert judgment is always needed for several decisions moments
  – Particularly input from the medical world is needed
• There is also a risk that the life expectancies are getting lower than expected
Some models

• Based on cause of death:
  – Very complex, impossible without medical input
    • And many expert judgement decisions
  – Information used not always reliable (>80)
  – Correlation between causes of death
  – Models limited to 10 years projection
Some models

• By structure:
  – Separate models for
    • Very young children (under age 5)
    • Accident hump (age 18-25)
    • Aging (exponential model)
    • Age independent part
  – Lots of parameters needed. This makes it hard to estimate and control
Some models

• Linear models like Lee Carter
  – Most likely too simple
• Short term – long term trend modelling
  – goal table approach
  – Good experience on the short term
  – Long term trend needs expert judgment
• Linear with adjustments for behaviour
  – CBS 2012: Average Western European mortality adjusted for smoking behaviour
NEW STOCHASTIC TREND MODEL
New stochastic model

• Recently developed a new stochastic model for trend uncertainty
• This model is based on a multi-drift simulation, not the one-year volatility.
• Creates both one-year risk as multi-year risk measurements
New stochastic model

• Like in Lee Carter mortality development can be split in a drift plus a one year volatility.
• Other than in LC the volatility is not used to project future mortality, but the drift is analysed.
• To reduce the volatility a two-years average is taken
  – Volatility should be modelled as a separate sub-risk (later more)
New stochastic model

- The period we are analysing is first split into 16 years periods
- Each 16-year period is split into 2 8-year periods
- Each 8-year period is split into 2 4-year periods
- Each 4-year period is split into 2 2-year periods.
Example

16 year drift
Example

16 year drift
Example

8 year drift
Example

8 year drift

Then the same exercise for
How to use?

• Now we have many scenario’s
• Before going into a simulation these scenario’s are translated into the measurement we want: e.g. life expectancy or liabilities over a portfolio
• In this way dependencies are taken into account
• The distributions are defined around the life expectancies or liabilities
  – For the e(0) in this presentation I used Normal, with some (negative) skewness
Results of the new model

Male, history + future
Dutch data
First outcomes

E(0) analyses met drift trend model
simultie obv drifts 5000 simulatie scenarios
Based in Dutch data
Some analysis for annuities

example for an immediate annuity

<table>
<thead>
<tr>
<th>Multi year model</th>
<th>Immediate annuity results:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EC related to the BE</td>
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<tr>
<td>Age</td>
<td>75</td>
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<tr>
<td>Life expectancy</td>
<td>11,4</td>
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<tr>
<td>Best estimate</td>
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<td>Confidence level:</td>
<td>Trend uncertainty calculated</td>
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<td>90%</td>
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<td>Level + Trend (diversified)</td>
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<tr>
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<td>4,52%</td>
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<tr>
<td>95%</td>
<td>8,29%</td>
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<tr>
<td>Standard model</td>
<td>10,46%</td>
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<tr>
<td>Compare: result for one year trend uncertainty according to model</td>
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<tr>
<td>99,50%</td>
<td>1,33%</td>
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INTERNATIONAL VIEW
International view

• Following the ideas countries that are in situation 3 should have comparable trend developments (save development level)

• Also following several studies the uncertainty should be comparable over the countries (I would like to add under the same circumstances) and can be used in case a lack of data exist in a country
  – Li Lee
  – CBS
Countries in (3)

Life expectancy age 0
male
Countries in (3)

Life expectancy age 0
female

- NL Female
- UK Female
- Norway Female
- Belgium Female
- Italy Female
- France Female
- Spain Female
Countries in (3)

Model outcomes for male

<table>
<thead>
<tr>
<th>Country</th>
<th>2012</th>
<th>BE 2060</th>
<th>2060 incl.</th>
<th>95% uncertainty</th>
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<tbody>
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<td>AUSTRIA</td>
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<td>88.13</td>
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<tr>
<td>BELGIUM</td>
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<td>86.28</td>
<td>90.80</td>
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Countries in (3)

Model outcomes for female

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</table>
Conclusions

• Indeed the uncertainty results of comparable countries are indeed close, but:
  – Larger countries have a somewhat lower uncertainty (still some volatility left?)
  – Need to look at Sweden and Swiss
Conclusion

• Particularly for modelling extreme events we should look more at “conditional” modelling
That’s all

Thanks