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# A Framework for Modelling Cause-of-Death Mortality and Implications of Cause-Elimination

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(joint work with Daniel Alai and Michael Sherris)

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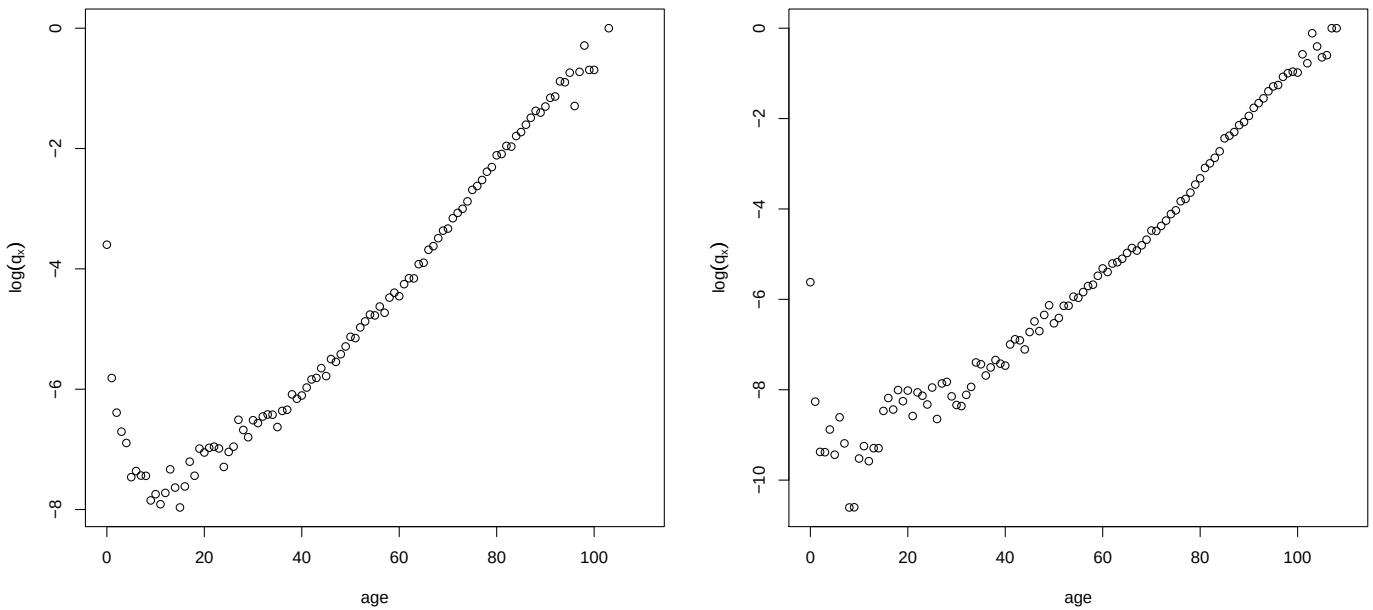
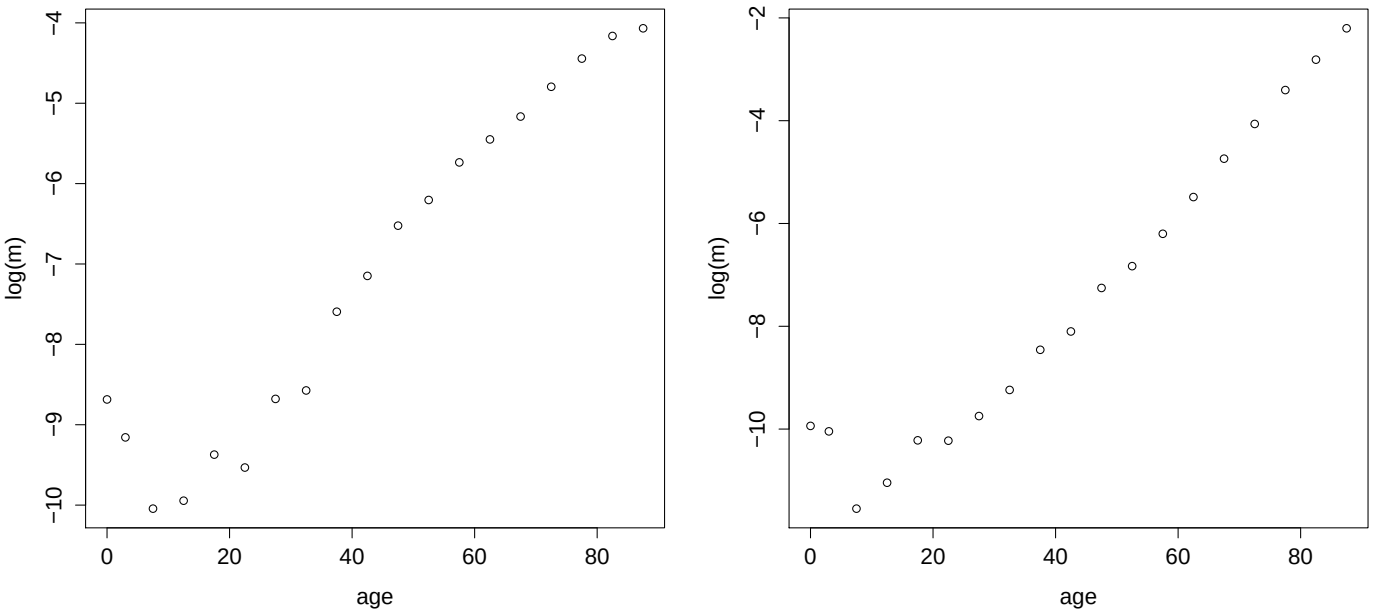
# Why should we look at mortality by cause of death?




(a) 1950 (b) 2005

Figure: Log-mortality over ages, Switzerland, females

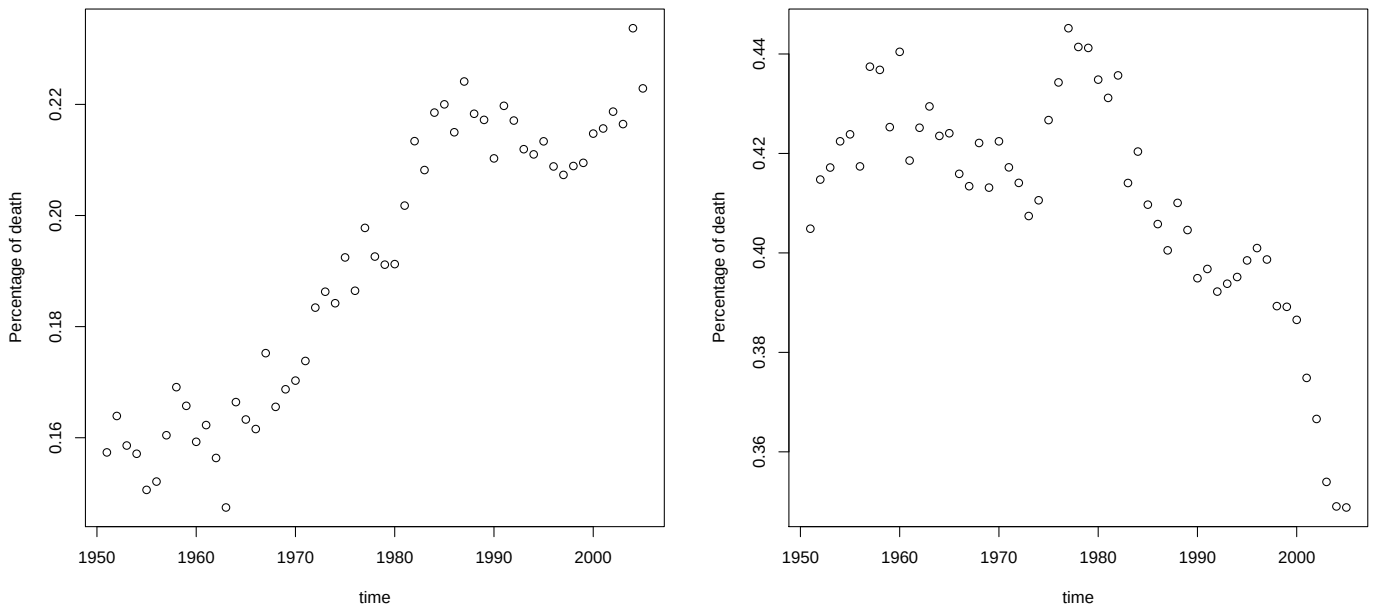
# Why should we look at mortality by cause of death?




(a) Cancer (b) Circulatory system

Figure: Log-mortality over ages, Switzerland, females, 1955

# Why should we look at mortality by cause of death?




(a) Cancer (b) Circulatory system

Figure: Percentage of deaths by cause, ages 65 and over, Switzerland, females

# Why are causes of death not so often analyzed?

Many problems arise:

- Differences in interpretation of international rules, in coding practices and in training of physicians;
- Cause of death reporting less reliable at older ages where most of the deaths occurs (inaccuracy of reported age at death, sampling error);
- Different causes may impact different age-groups;
- Multiple causes;
- Misclassifications of deaths by cause;
- ...
- Causes of death = competing risks $\rightarrow$ a dependance exist.

[Booth and Tickle(2008)] and [Richards(2009)]

# Aim

What? Get a better understanding of mortality by causes of death
→ especially the dependance
→ improve the forecasting performance

# Data

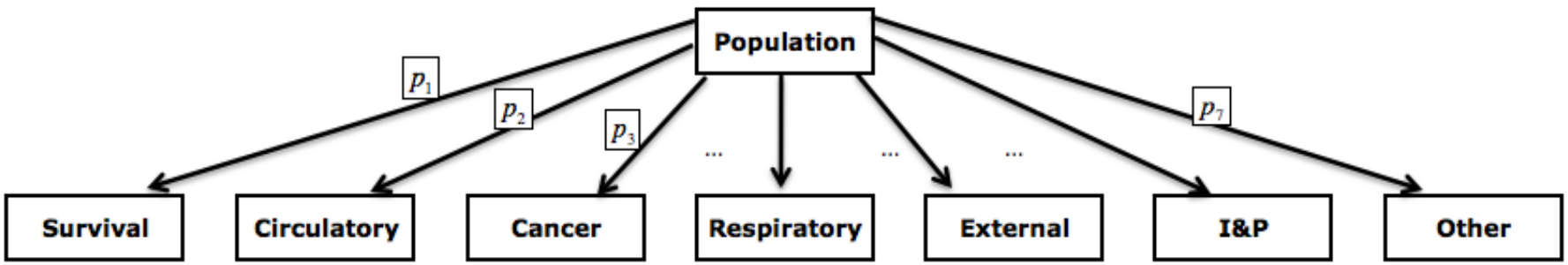
Countries:

- USA (1950 - 2007)
- Japan (1950 - 2009)
- France (1952-2008)
- E & W (1950 - 2009)
- Italy (1951 - 2003)
- Australia (1950 - 2004)
- Sweden (1951 - 2010)
- Switzerland (1951 - 2007)
- Singapore (1955 - 2009)
- Norway (1951 - 2009)

Causes of death:

- Diseases of the circulatory system
- Cancer
- Diseases of the respiratory system
- External causes (mainly: accidents)
- Infectious & parasitic diseases

# Multinomial logit models




- Typically used for a response with several unordered categories

# Multinomial logit models

$$
\begin{aligned}
\log\left(\frac{q_1(x,t)}{p(x,t)}\right) &= a_x^{(1)} + b_x^{(1)} \cdot t + c_x^{(1)} \cdot t^2 \\
\log\left(\frac{q_2(x,t)}{p(x,t)}\right) &= a_x^{(2)} + b_x^{(2)} \cdot t + c_x^{(2)} \cdot t^2 \\
&\dots \\
\log\left(\frac{q_6(x,t)}{p(x,t)}\right) &= a_x^{(6)} + b_x^{(6)} \cdot t + c_x^{(6)} \cdot t^2
\end{aligned}
$$

The *logit* probabilities depend on a set of factors: the age and a period effect that interacts with age.
$\rightarrow$ each age has its own period effect.

# Shocks in the multinomial model

ASSUMPTION: If one competing outcome is eliminated, we assign its probability proportionally to the other outcomes.

$$\Rightarrow p(x,t)^{multinomial} < p(x,t)^{Chiang}$$

# Do we have a good fit?

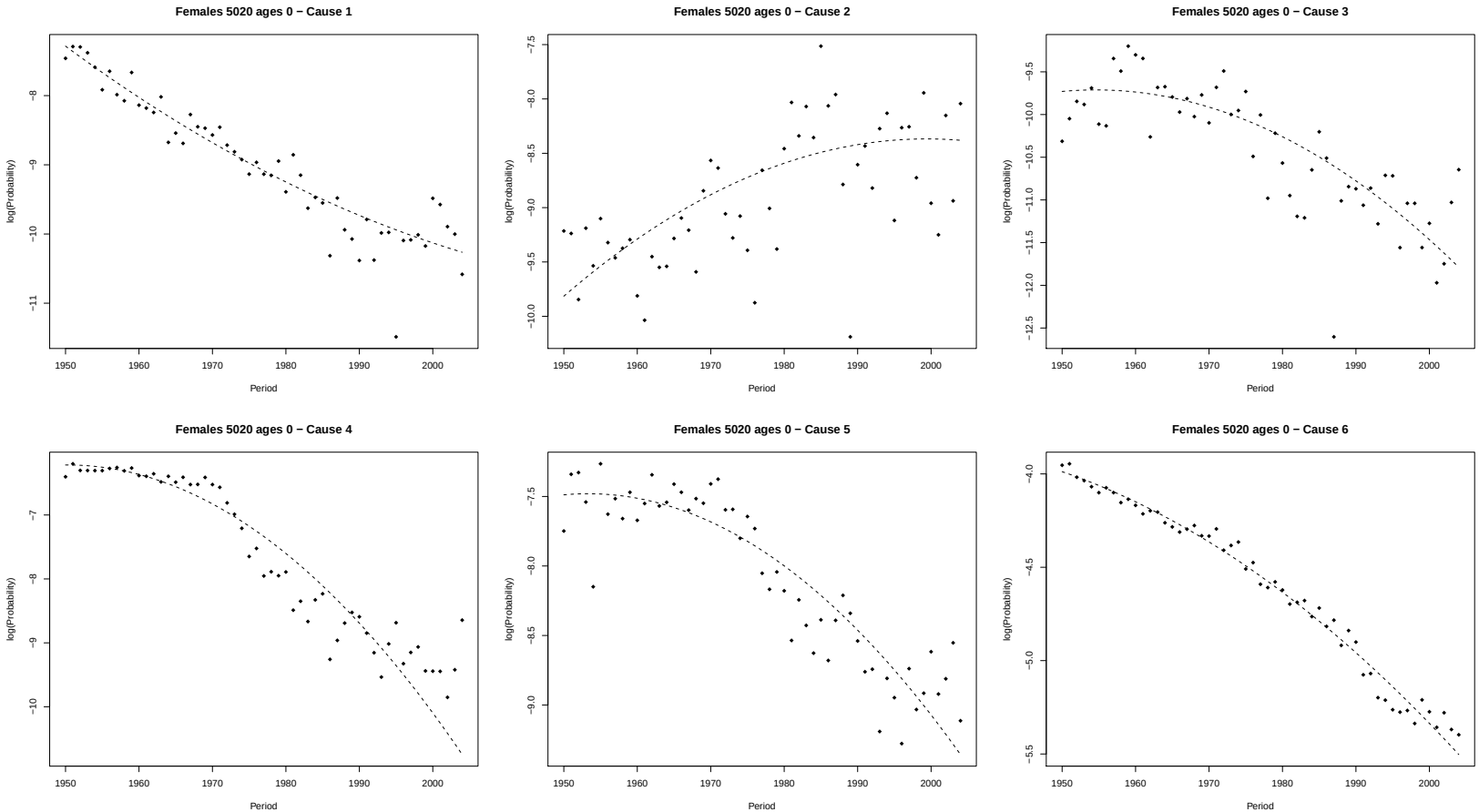



Figure: Data versus model at age 0, females, Australia

# Do we have a good fit?

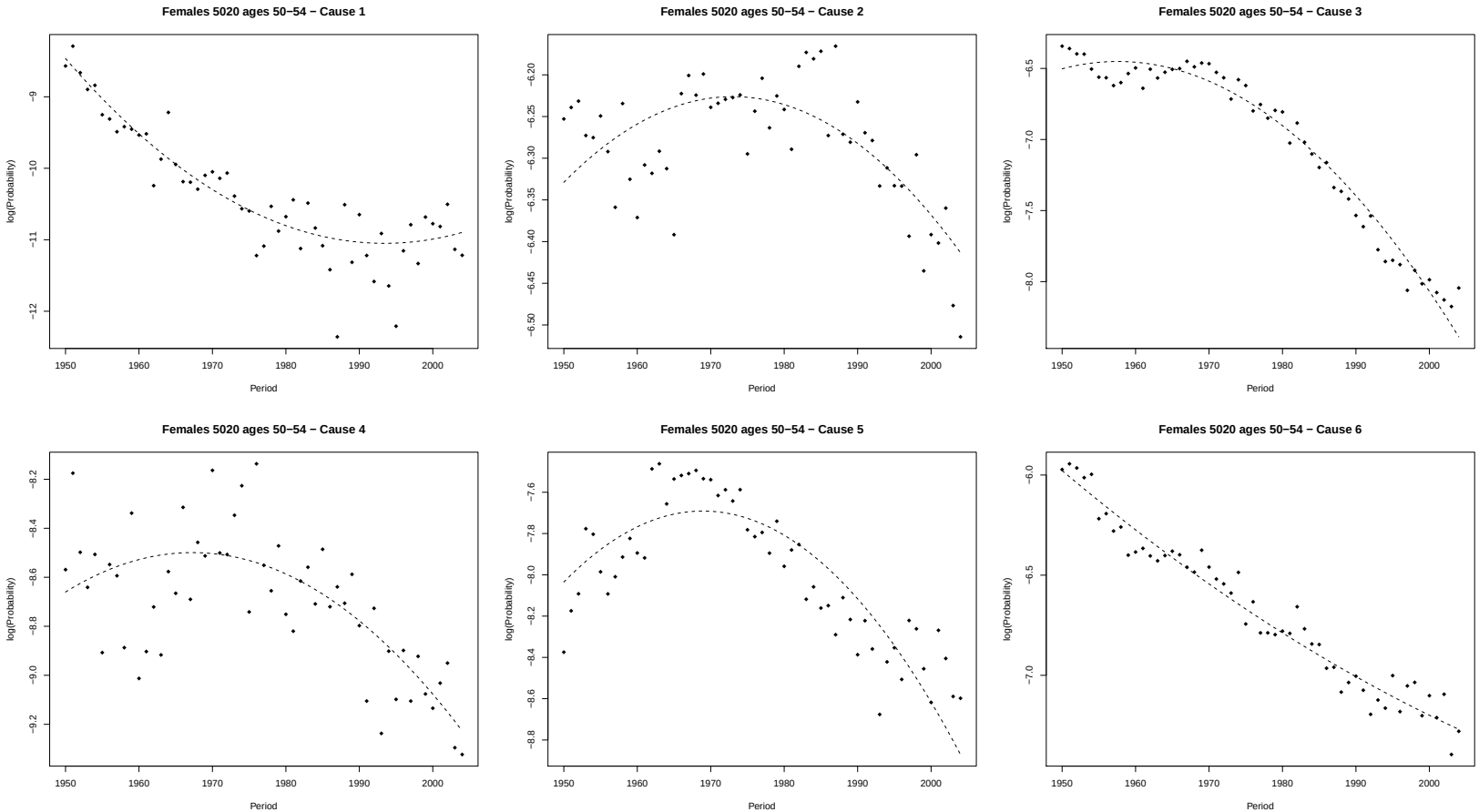



Figure: Data versus model at age-group 50-54, females, Australia

# Do we have a good fit?

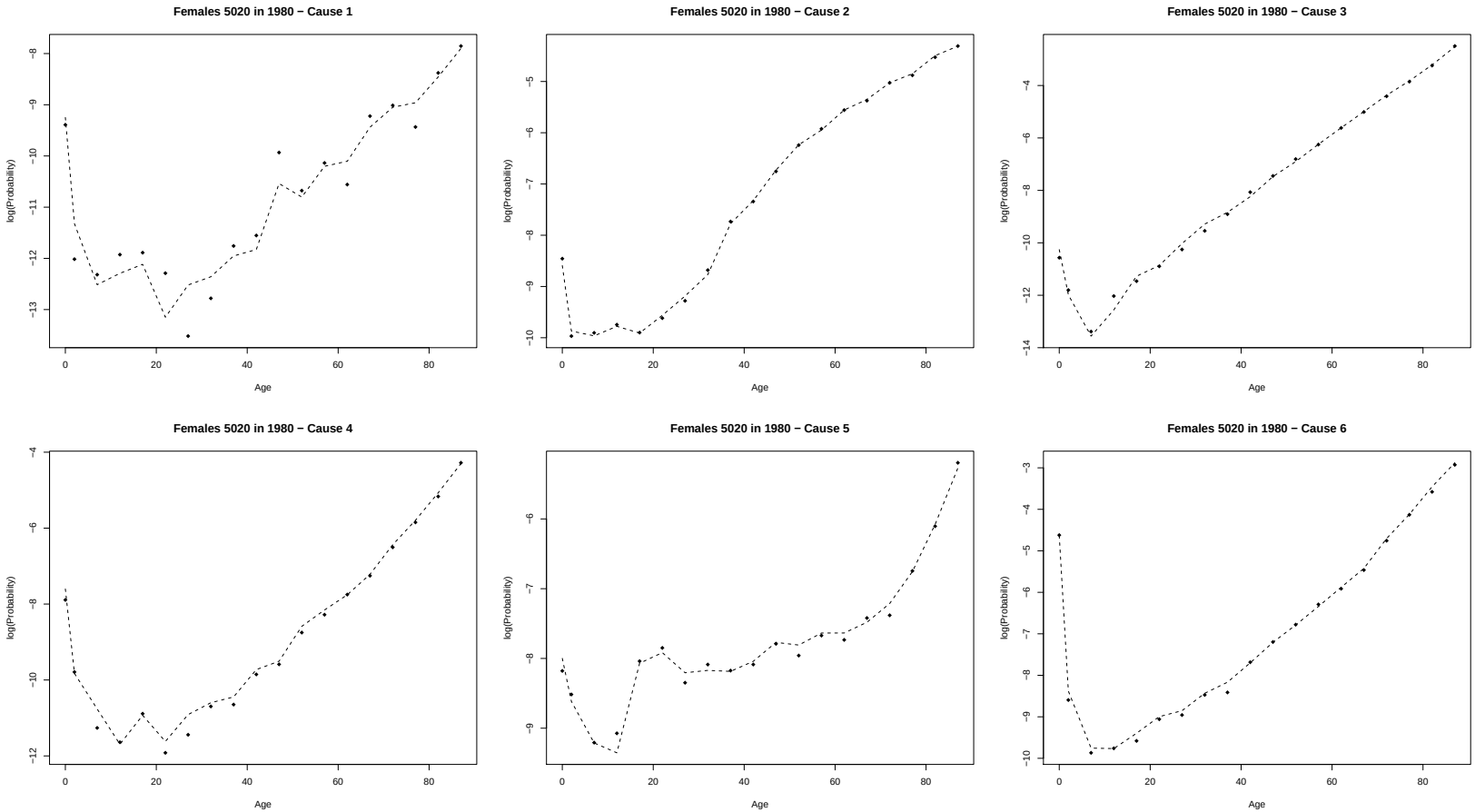



Figure: Data versus model in 1980, females, Australia

# Do we have a good fit?

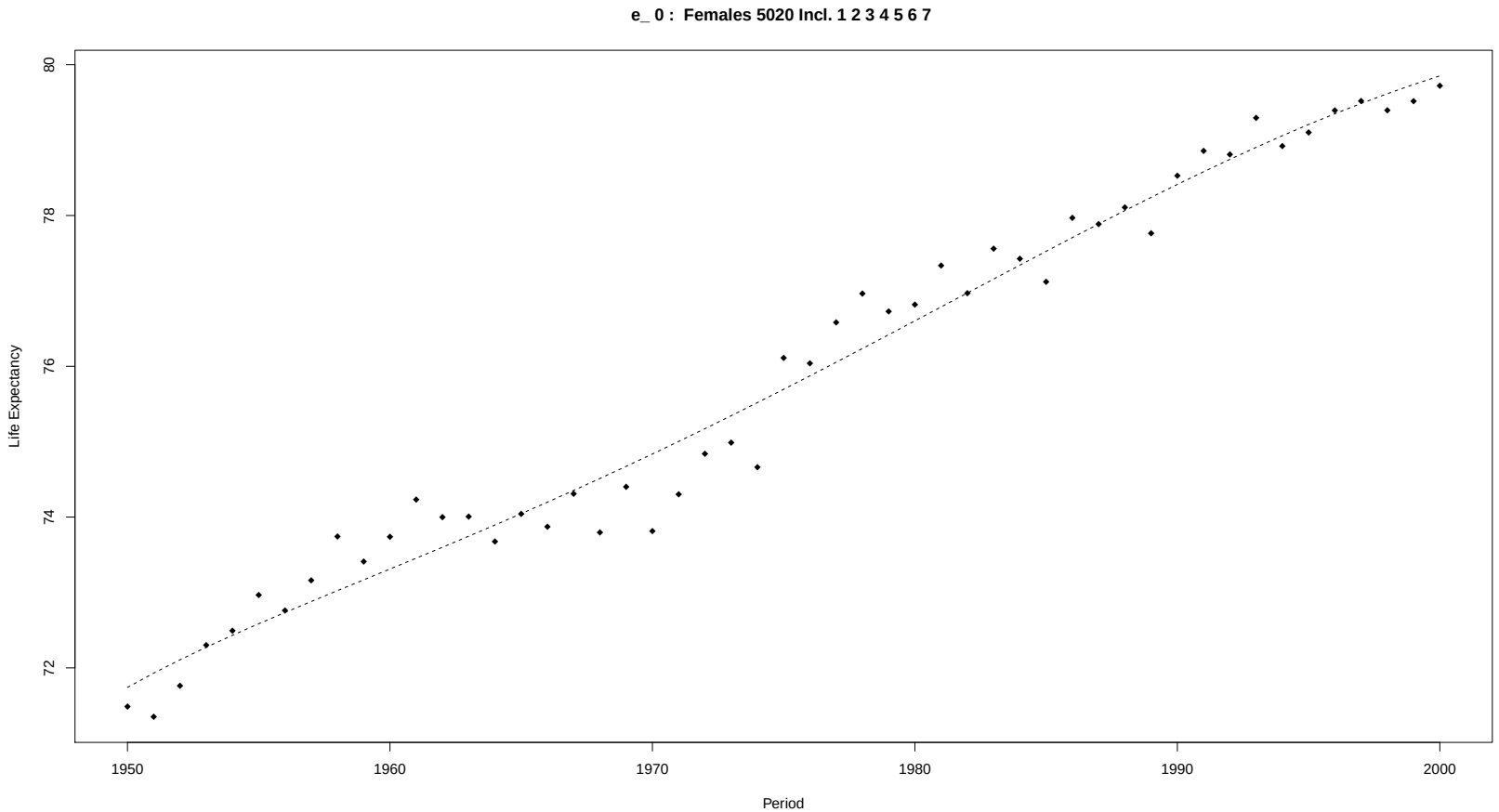
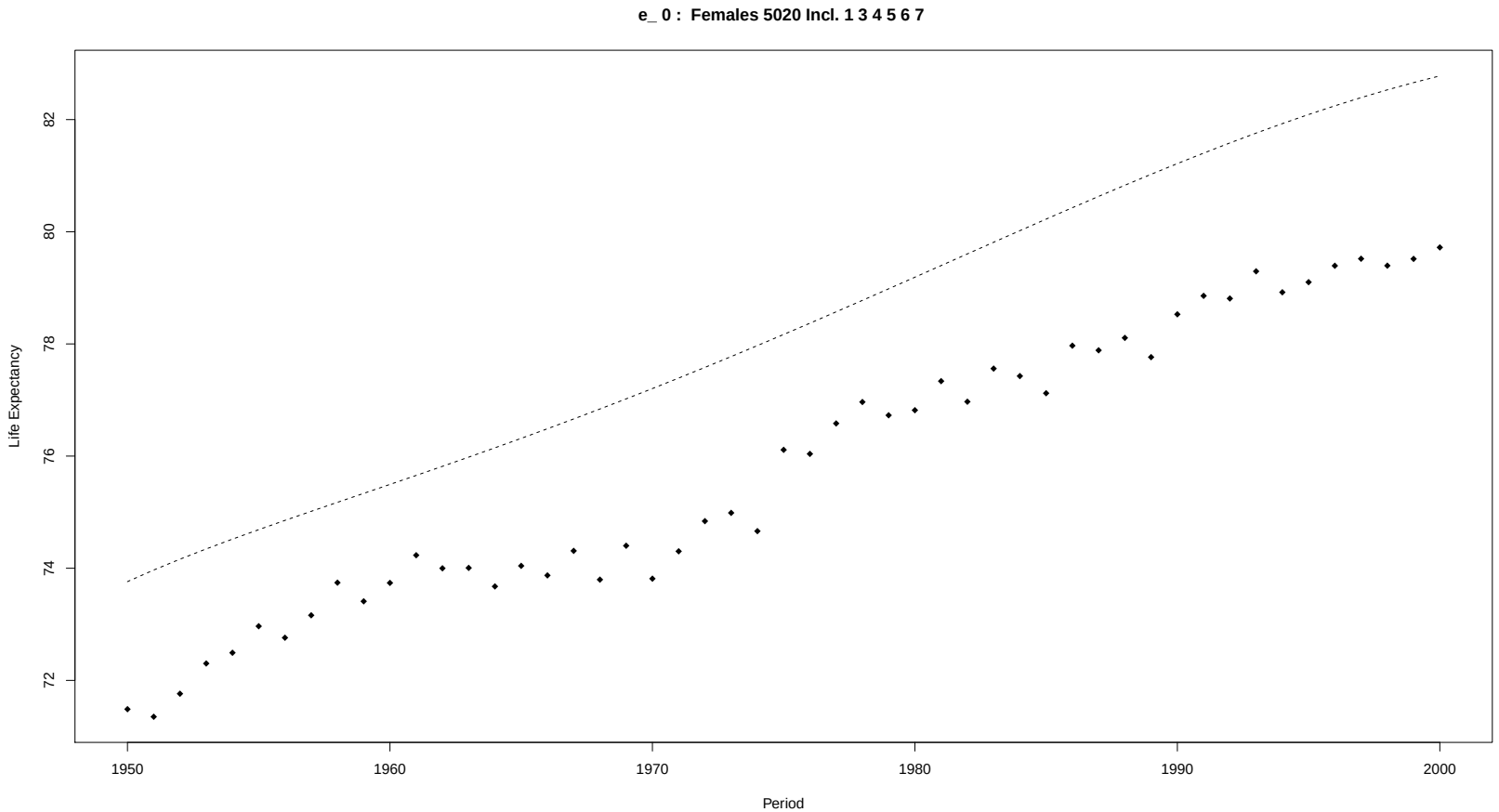



Figure: Life expectancy at age 0, females, Australia

# What happens if a cure for cancer is found?

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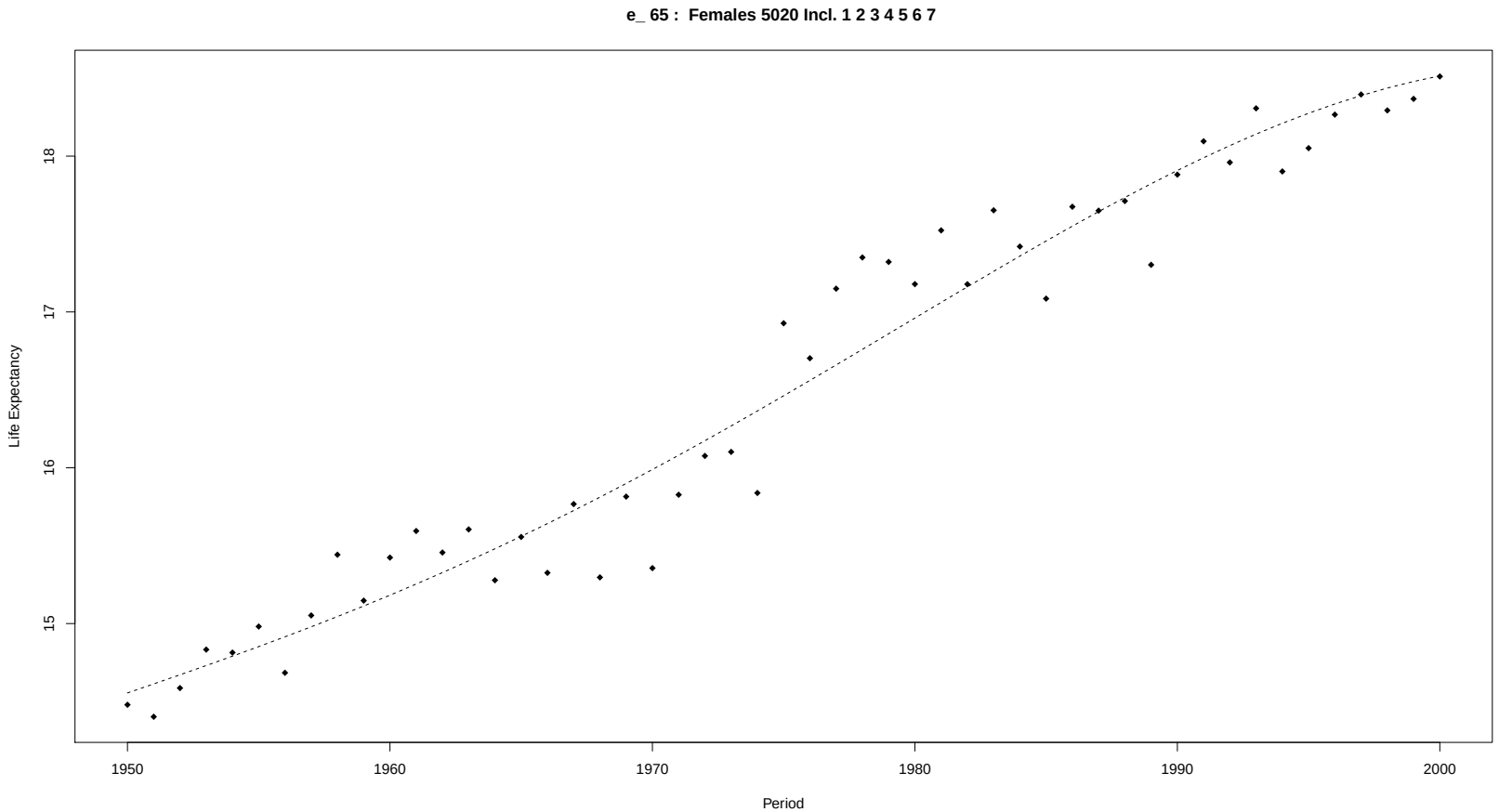


Figure: Life expectancy at age 65, females, Australia

# What happens if a cure for cancer is found?

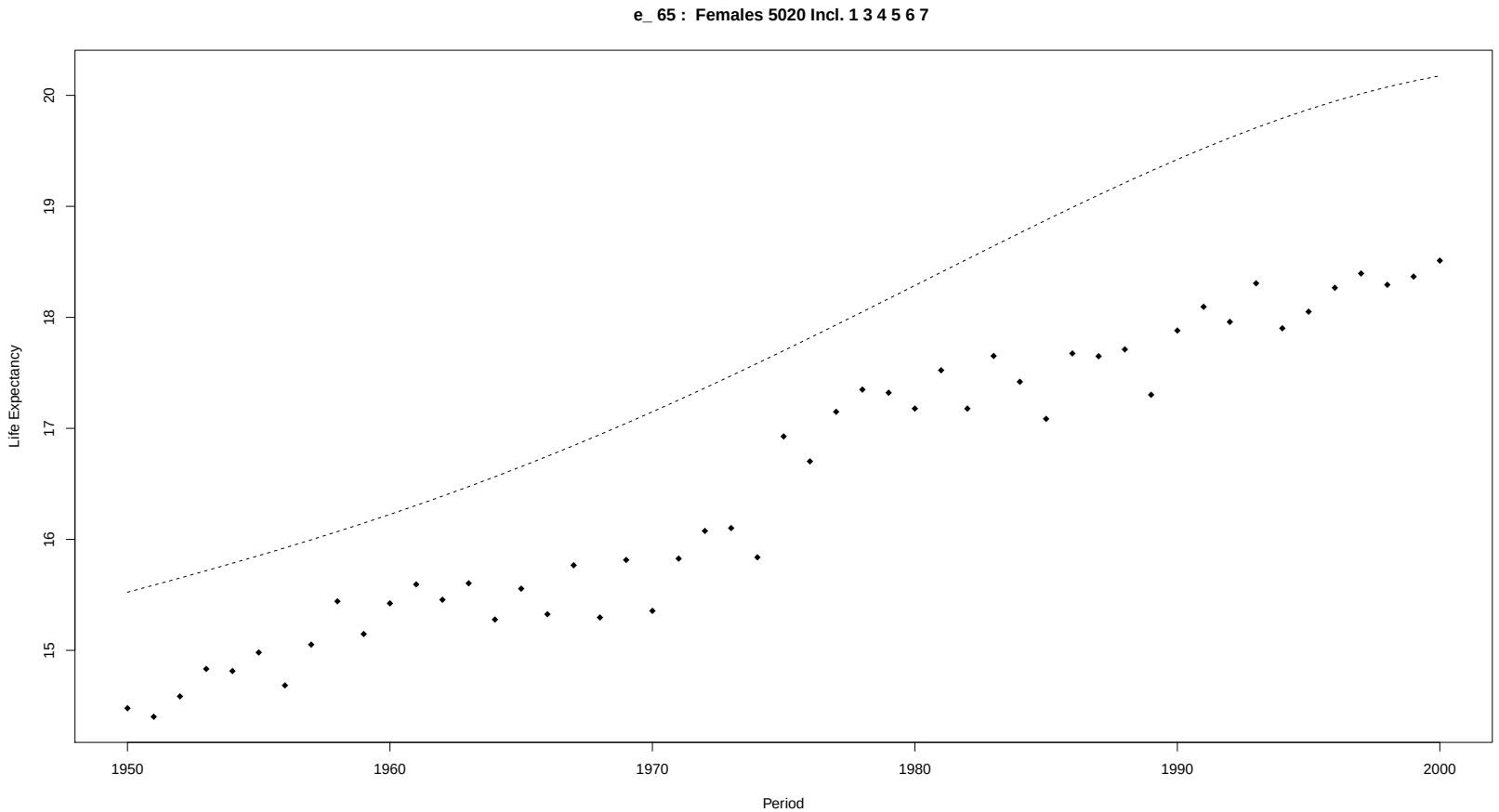


Figure: Life expectancy at age 65, females, Australia

# Next step

Can we use these models for forecasting?

# Cause-of-death mortality forecasts

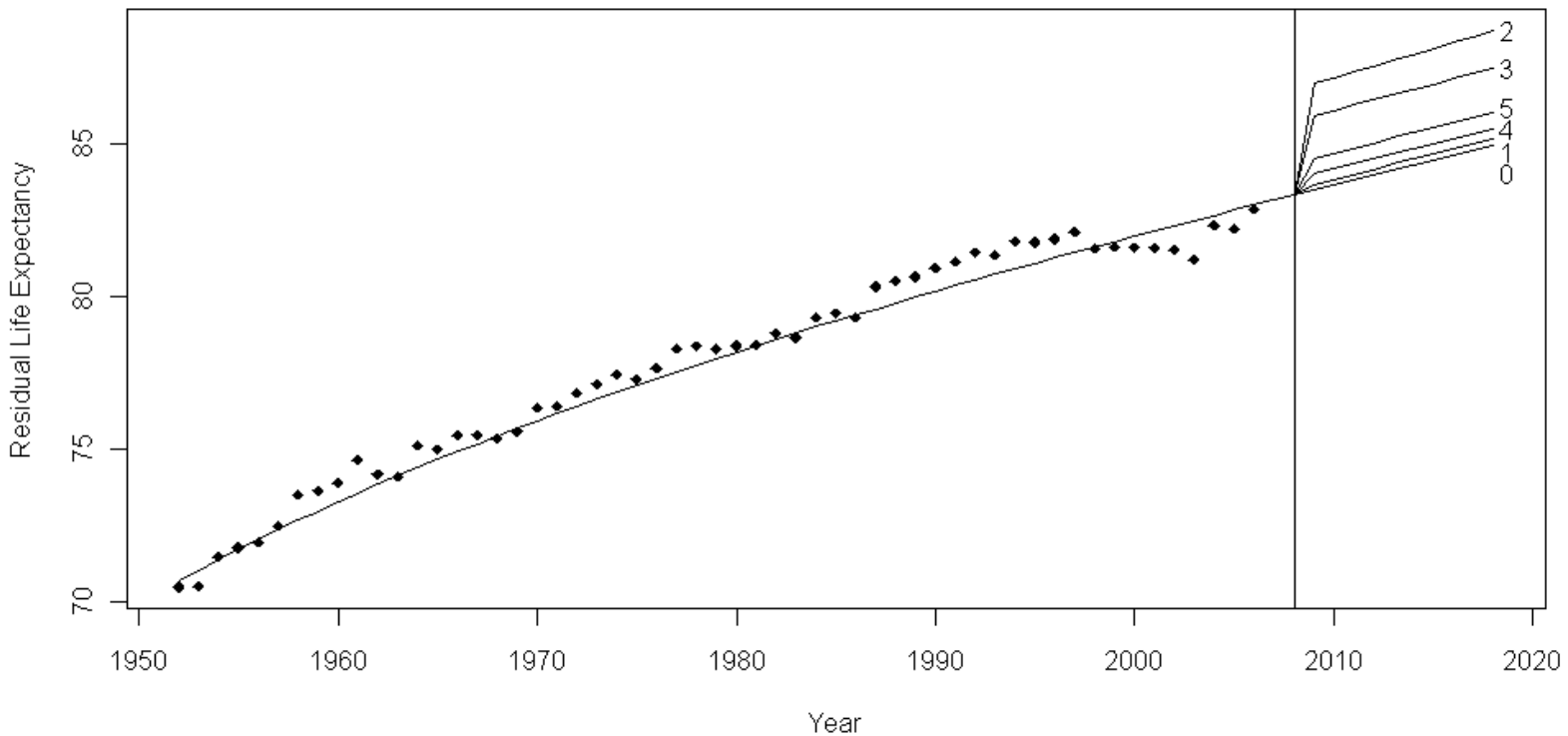


Figure: Life expectancy at age 0, females, France

# Cause-of-death mortality forecasts - continue

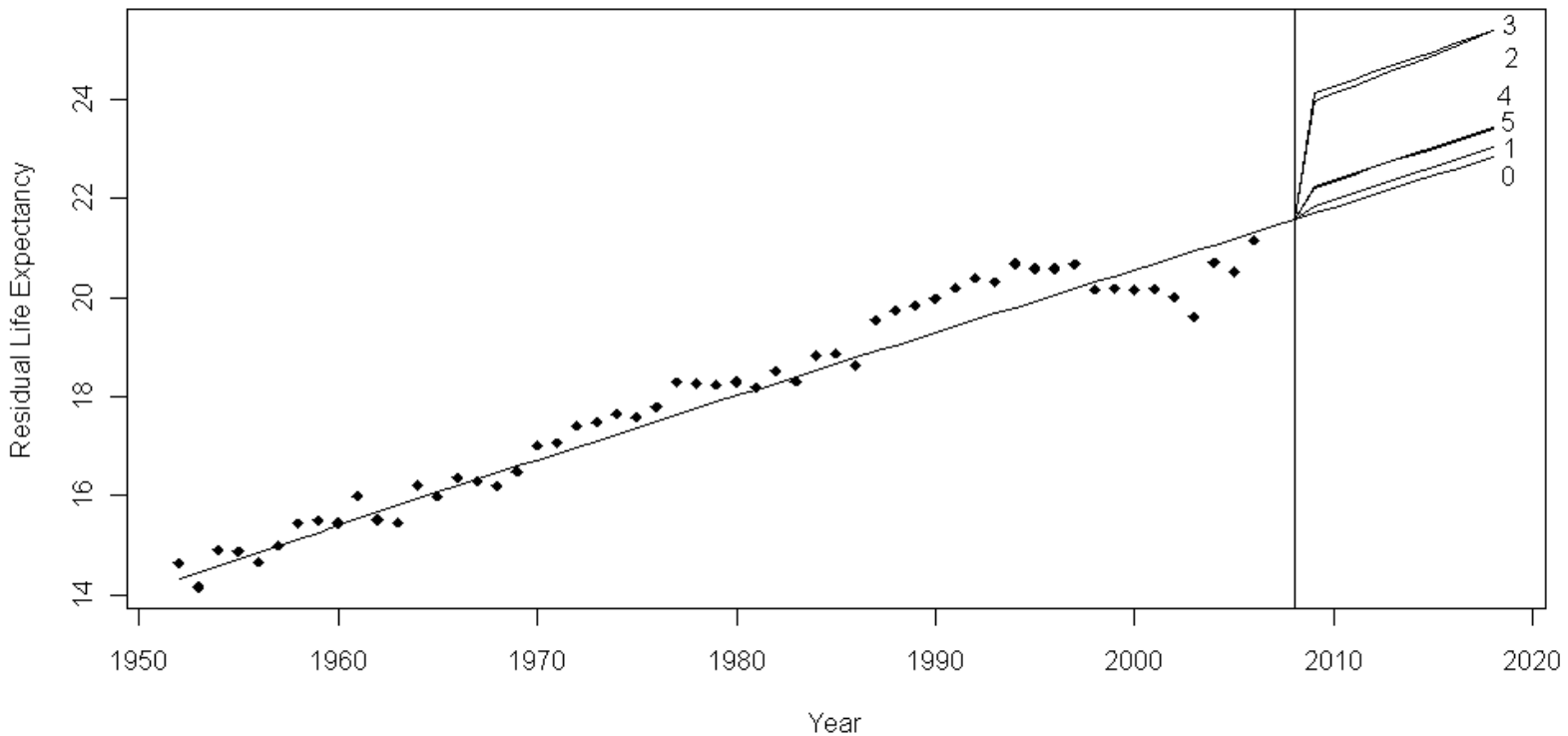


Figure: Life expectancy at age 65, females, France

# Concluding remarks

- Multinomial logit model is an interesting and easy to understand framework

  → very useful for cause-elimination analysis

  → allows for a straightforward implementation of information with respect to known links between the various causes

  → need to be careful for forecasting purposes

→ Models incorporating this information need to be further developed

# Bibliography


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Mortality modelling and forecasting: A review of methods.
*Annals of Actuarial Science*, 3:3–43, 2008.


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*British Actuarial Journal*, 15:267–283, 2009.

# Thank you for your attention!