Explaining Mortality Dynamics:
The Role of Macroeconomic Fluctuations and Cause of Death Trends

Katja Hanewald

Australian School of Business and CEPAR

University of New South Wales, Sydney

Summary

- Impact of macroeconomic fluctuations and cause of death trends on mortality dynamics in the Lee-Carter mortality forecasting model

- Key results:
  1. Periods can be identified in which the Lee-Carter mortality index k_t correlates significantly with macroeconomic fluctuations
  2. A few causes of death account for a large fraction of the variations in the Lee-Carter mortality index k_t
  3. Most cause-specific mortality rates show pronounced trends
     - Trends change the composition of deaths
     - Alter how total mortality reacts to external factors

Literature review

- Combine two domains of the demographic literature

(1) Stochastic Mortality Modeling

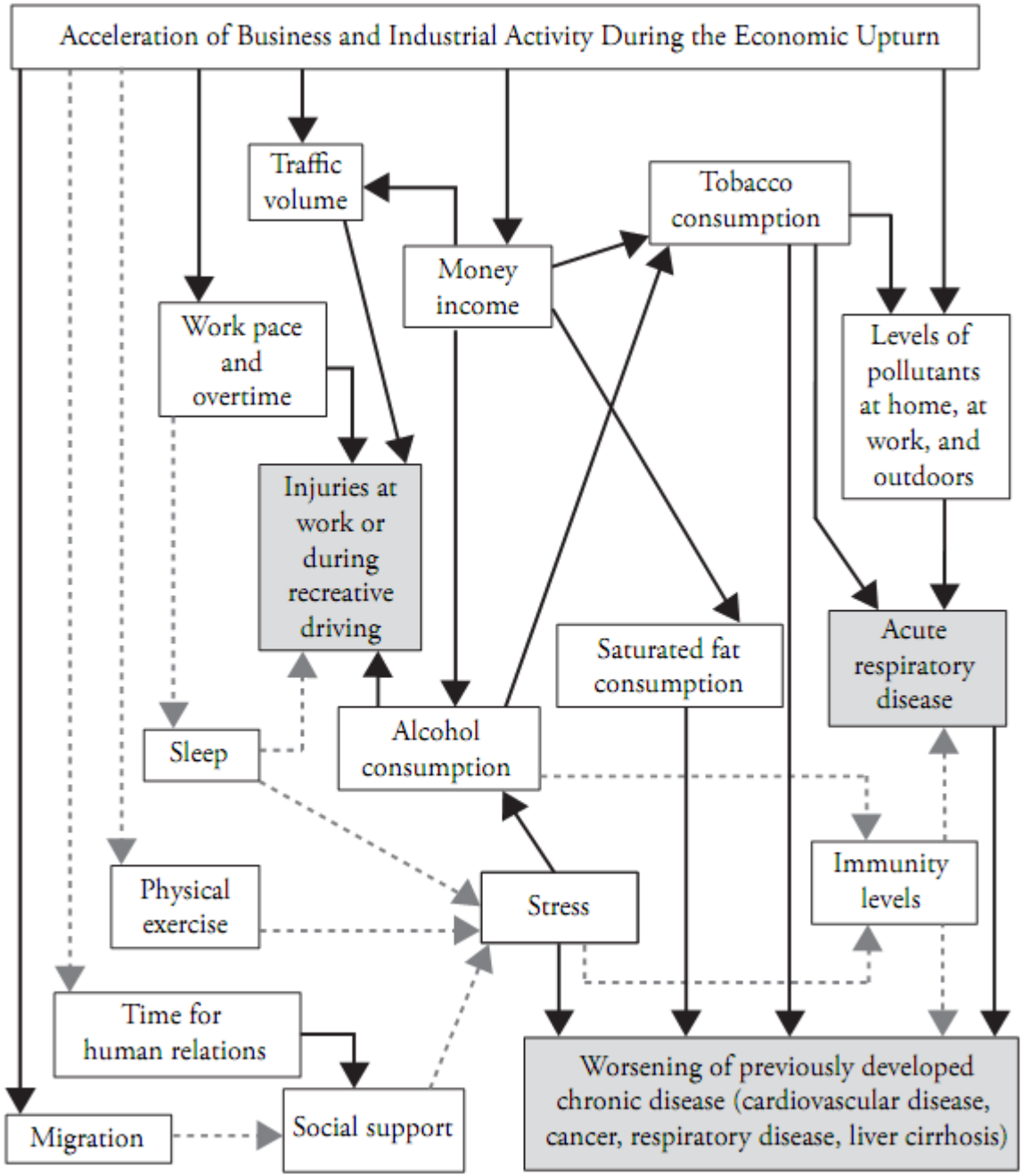
- Lee-Carter (1992): universal method, has been applied to various countries
- Brouhns et al. (2002) variant
- Two stages: $\ln(m_{x,t}) = a_x + b_x \cdot k_t + \varepsilon_{x,t}$

- Mortality index k_t : Just an unobserved latent variable?

Literature review

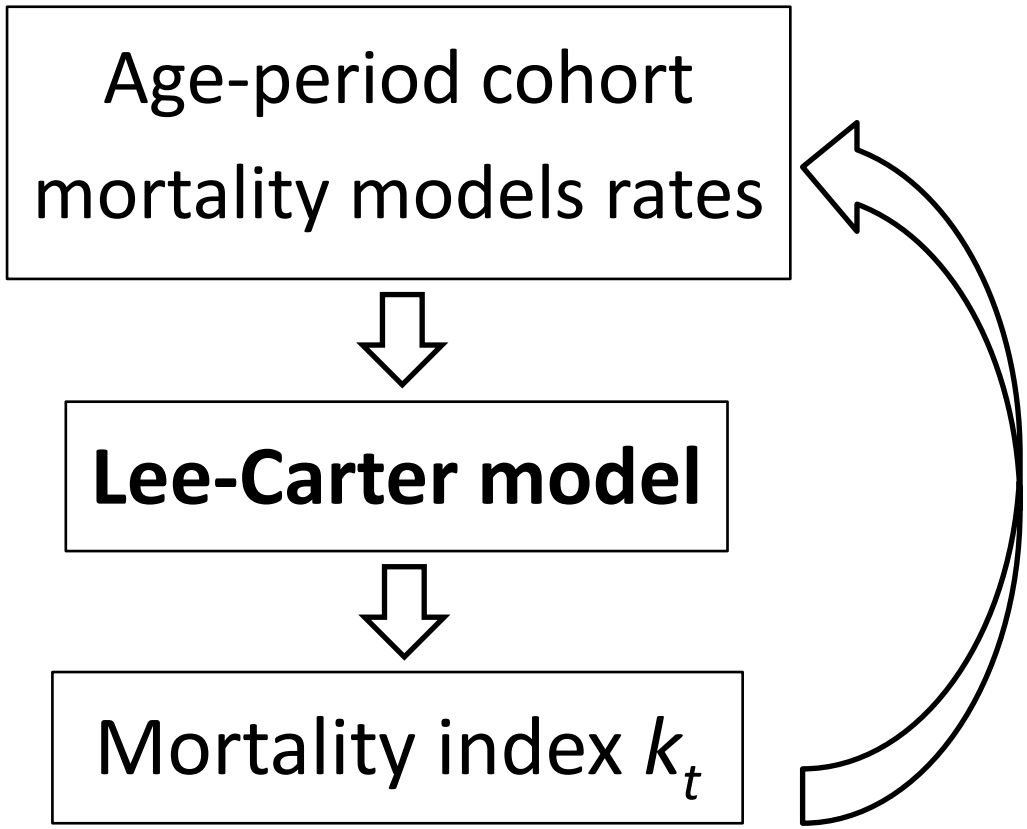
(2) Mortality and Macroeconomic Fluctuations

- Ruhm (2000): Mortality rates in the USA fluctuate procyclically over the period 1972–1991
- Similar patterns observed for:
  - USA, Spain, and Japan (Tapia Granados, 2005a/b, 2008)
  - Germany (Neumayer, 2004, Hanewald, 2010)
  - Sweden (Tapia Granados and Ionides, 2008)
  - 23 OECD countries, 1960–1997 (Gerdtham and Ruhm, 2006)
- Procyclical deaths: motor vehicle crashes, CVD, liver ailments, influenza/pneumonia
- Acyclical/countercyclical: cancer, suicide, diabetes mellitus



Source: Tapia Granados (2008), *Demography*

Central idea



Link between mortality and macroeconomic fluctuations

Impact of cause of death trends

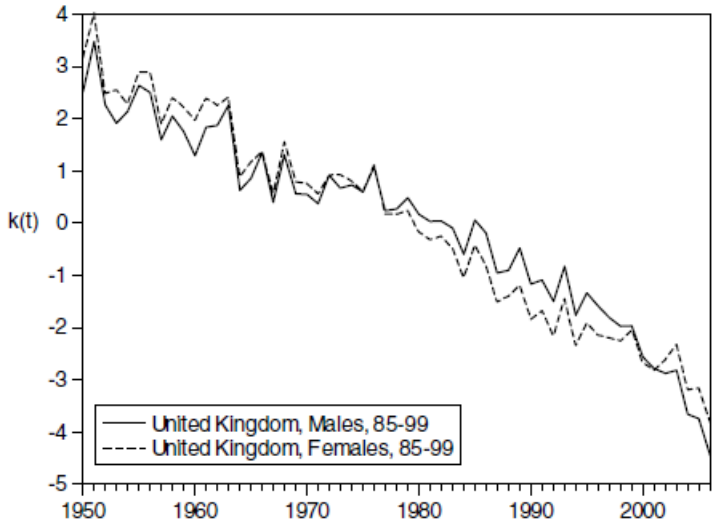
Data

- Annual death rates for six OECD countries,1950-2006
  - Australia, Canada, Japan, Netherlands, UK, USA

→ Lee-Carter mortality index k_t
  - Brouhns et al. (2002) variant
  - Males/females, ages 0-99 and four subgroups

- Cause-specific mortality rates

- Real GDP growth rates
- Unemployment rate changes



Correlation analysis

- Example: Australia
- Cor(Real GDP growth$_t$, $\Delta k_{t,Males}$), 1950-2006

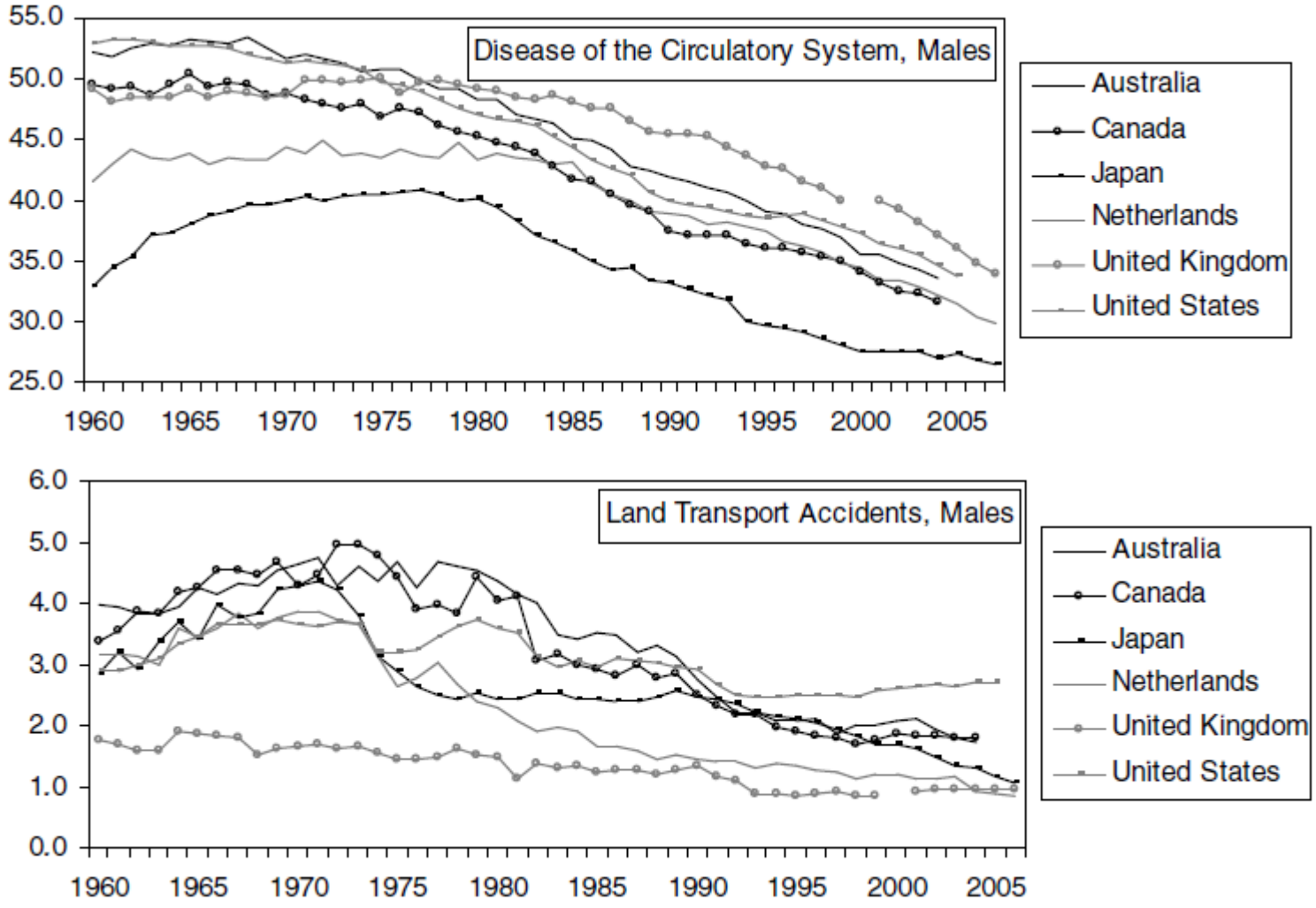
Age Group	Males	Females
25–44	0.228$^+$	0.259$^+$
45–64	0.338*	0.182
65–84	0.350**	0.250$^+$
85–99	0.272*	0.265*
0–99	0.365**	0.281*

$^+$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$

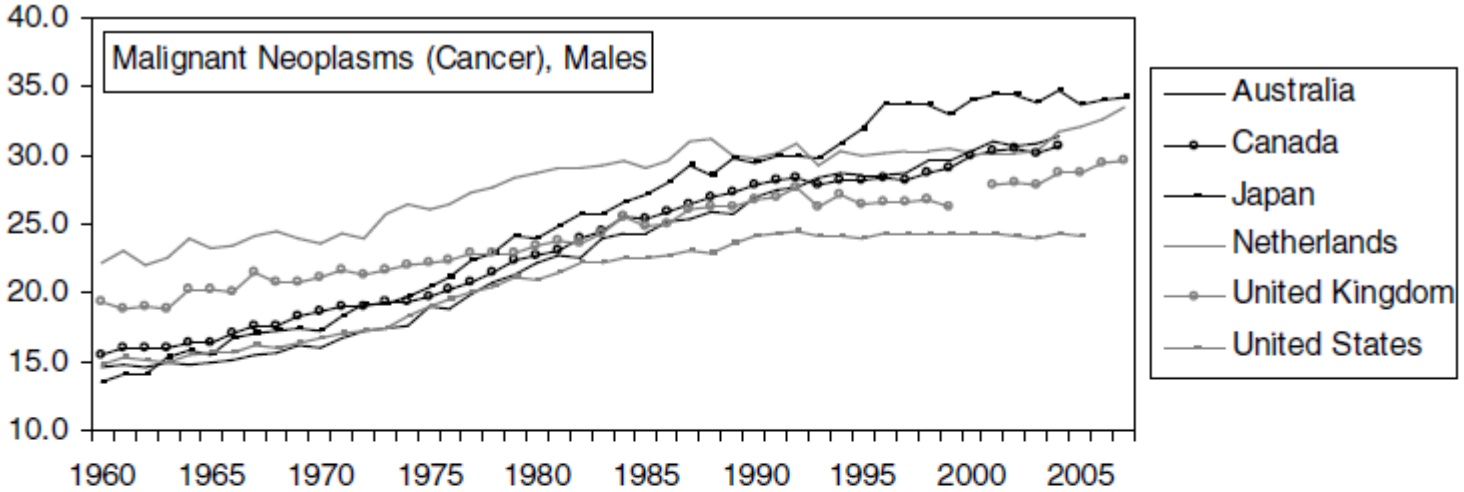
Correlation analysis

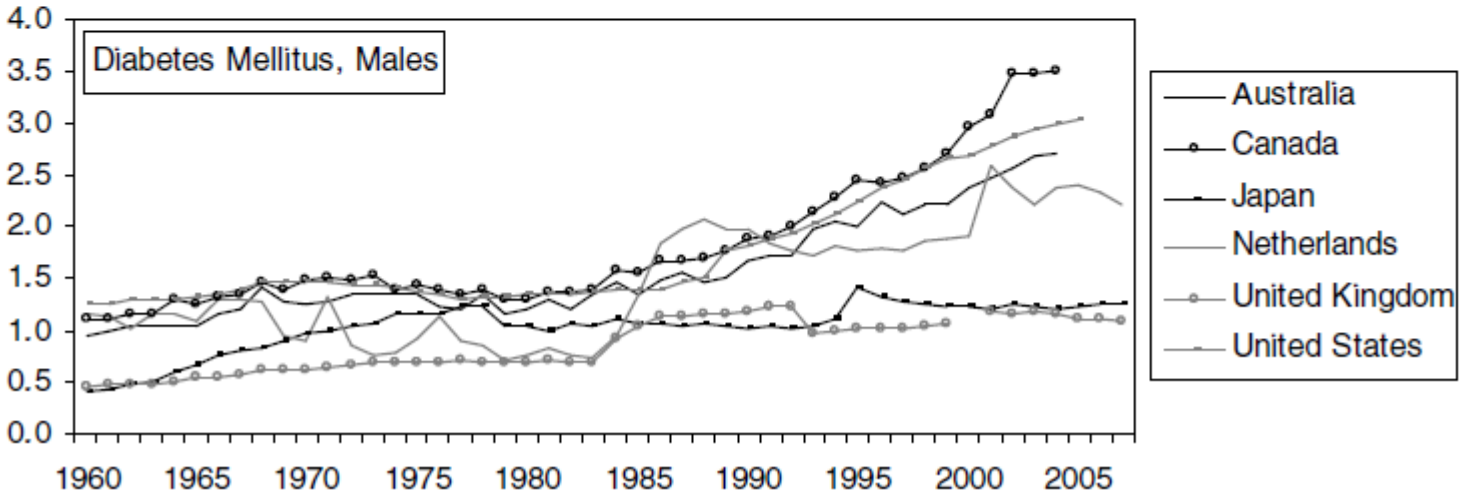
- Entire sample period (1950-2006):
  - Significant procyclical correlations observed in AU, CA, NL, UK, US
  - Mostly working ages, but also higher ages
  - JP: Significant countercyclical correlations for males and females aged 25-44
  - Mortality reacts without lag
- 1950-1979 vs. 1980-2006:
  - Structural change observed in all six countries

Trends in cause-specific mortality rates



Trends in cause-specific mortality rates





Modeling Δk_t on cause-specific mortality rates and macroeconomic fluctuations

- Example: Australia
- Dependent variable: Δk_t, age 0–99, 1960-2006

	Males		Females	
Real GDP	–15.962		–0.524	
Cancer	9.474		14.370	
Diabetes	–4.149		5.903	
Circulatory	60.583	***	52.536	***
Influenza	1.525	*	2.836	***
Liver disease	–0.682		7.913	**
Transport accidents	7.917	*	0.333	
Suicide	1.752		2.507	
Constant	0.679		–0.352	
Adj. R^2	0.849		0.819	
F-stat.	24.509	***	23.396	***

Modeling Δk_t on cause-specific mortality rates and macroeconomic fluctuations

- A few causes of death account for a large fraction of the variations in the Lee-Carter mortality index k_t
  - diseases of the circulatory system
  - influenza/pneumonia
  - transport accidents (before 1980s)
  - diabetes mellitus

- Period effects in age-period cohort mortality models can be successfully modelled on underlying causal variables

Cointegration analysis

- Engle-Granger approach; bivariate/multivariate
- For some countries and age groups: significant cointegration relations between
  - k_t and macroeconomic fluctuations
  - k_t and several cause-specific mortality rates
- Cannot reject the hypothesis that there is **no** causal relation
- But, results are too diverse to draw general conclusions for all countries and age groups

Summary and conclusions

- Periods can be identified in which the Lee-Carter mortality index k_t correlates significantly with macroeconomic fluctuations

→ Implications for life insurers: Hanewald, Post, and Gründl (2010)

- A few causes of death account for a large fraction of the variations in the Lee-Carter mortality index k_t

Summary and conclusions

- Most cause-specific mortality rates show pronounced trends
  - Trends change the composition of deaths
  - Alter how total mortality reacts to external factors

- No “broad-brush solution” for modeling mortality:
  - Mortality trends differ substantially by age and gender and across countries
  - Require careful separate analysis

Thank you!

k.hanewald@unsw.edu.au