ARC CENTRE OF EXCELLENCE IN POPULATION AGEING RESEARCH

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Plenary Session - Actuarial Frontiers

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Modelling and Managing Longevity Risks

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Coverage

- Global Pensions and Longevity Risk
- Longevity Risk Modelling and Management Frontiers
- Research projects in CEPAR and School of Risk and Actuarial Studies at UNSW
- Areas:
  - consistent framework for stochastic mortality
  - age-period-cohort models
  - longitudinal mortality risk factors and Norwegian mortality
  - modelling cause of death and cause elimination
  - regulation and capital requirements for life annuities in an insurer value maximisation framework
  - residential house price risk modelling and applications
  - health risk and financing long term care including reverse mortgages

Pension Systems Asia Pacific

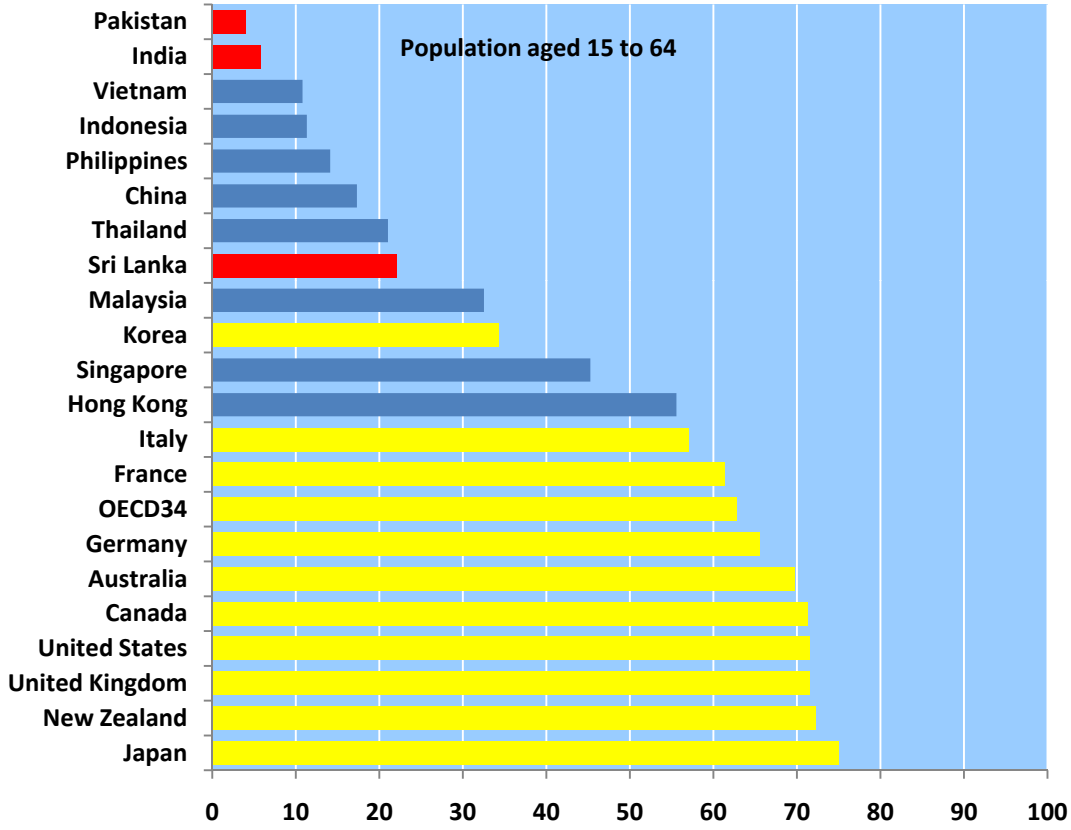
- Predominantly Public DB and DC schemes
- Private mandated DC schemes – Australia

Pensions at a Glance Asia/Pacific 2011 - © OECD 2011
Executive Summary Table 1. Pensions in Asia/Pacific
Version 1 - Last updated: 30-Nov-2011

Table 1. Pensions in Asia/Pacific

Country	Type of pension scheme			Country	Type of pension scheme		
	Public		Private		Public		Private
	DB	DC	DC		DB	DC	DC
East Asia/Pacific				**South Asia**			
China		●		India	●	●	
Hong Kong, China			●	Pakistan	●		
Indonesia		●		Sri Lanka		●	
Malaysia		●					
Philippines	●			**OECD Asia/Pacific**			
Singapore		●		Australia			●
Thailand	●			Canada	●		
Vietnam	●			Japan	●		
				Korea	●		
				New Zealand			
				United States	●		

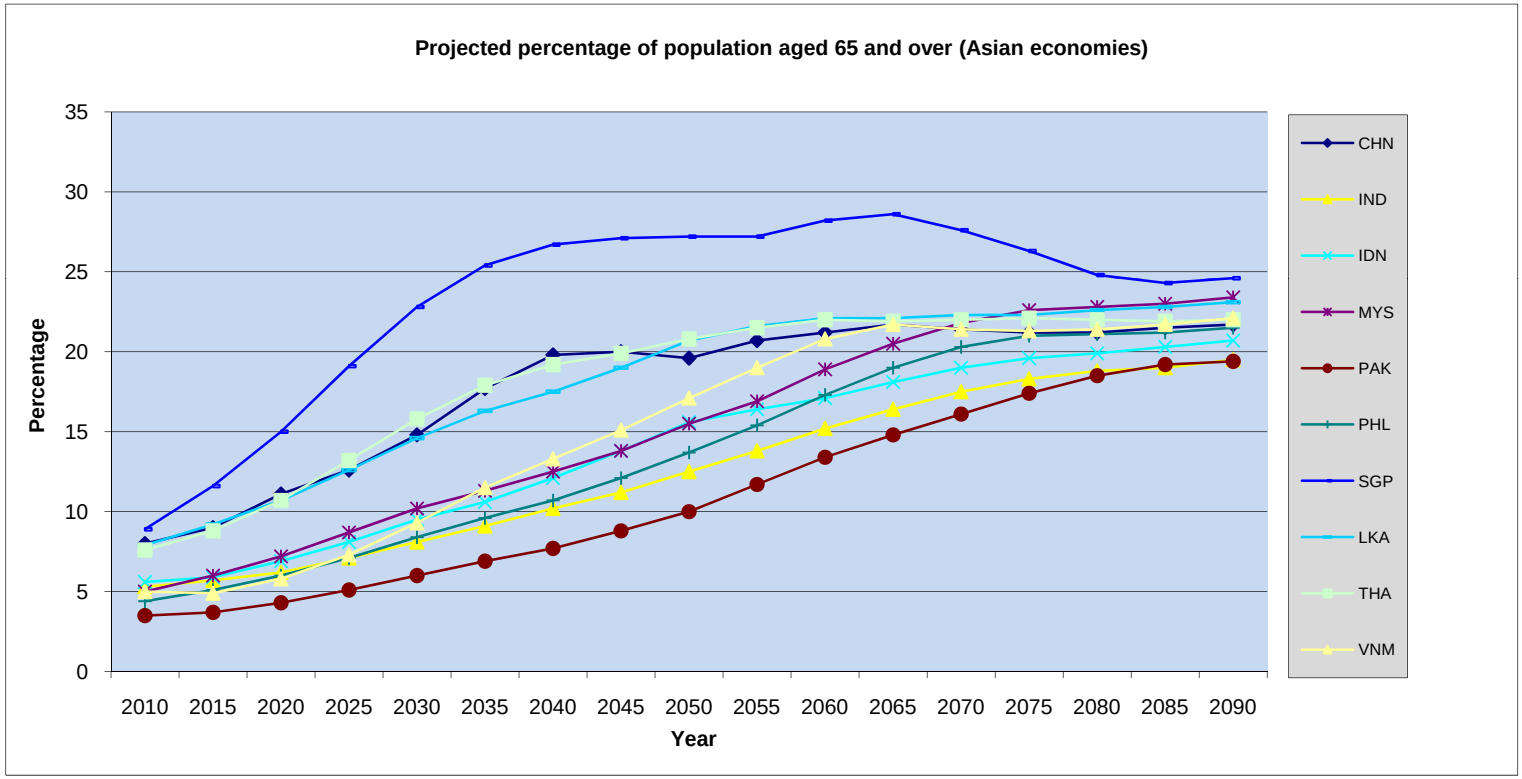
Coverage of Mandatory Pension Schemes



- Relatively low coverage in Asia/Pacific countries
- Potential future increases in coverage and funding implications

Source: PENSIONS AT A GLANCE ASIA/PACIFIC 2011 © OECD 2012 World Bank Pension Database

Population Ageing - Asia



- Ageing across the region
- Implications for retirement and long term care and health costs

Source: PENSIONS AT A GLANCE ASIA/PACIFIC 2011 © OECD 2012

Consistent Dynamic Mortality Model

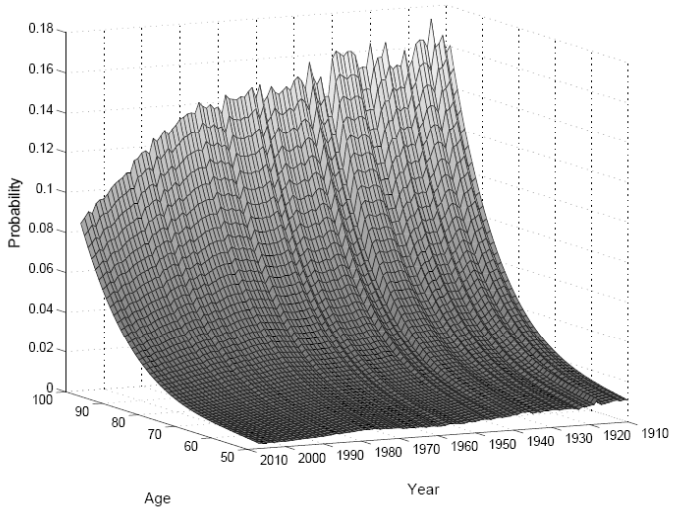
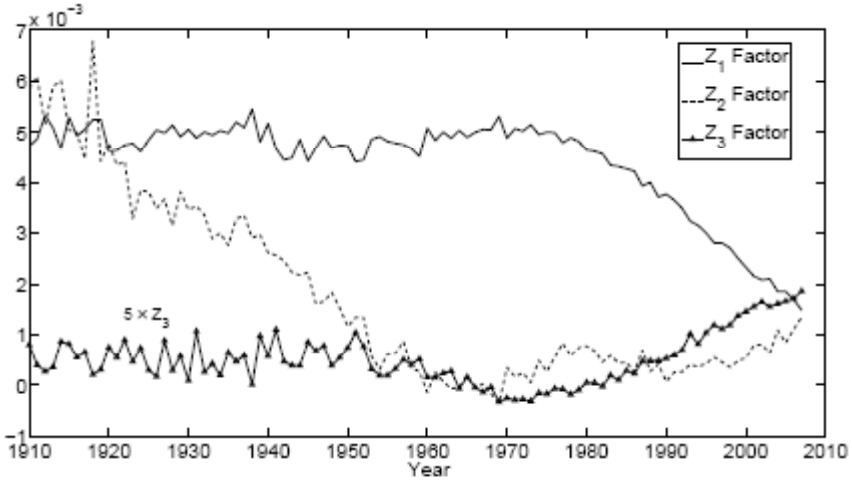
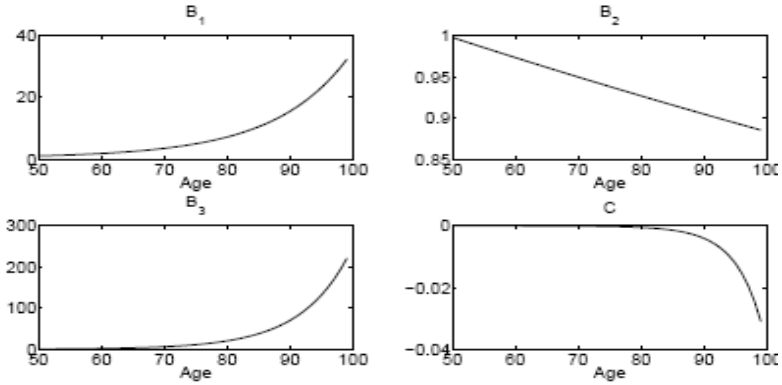


Figure 1: Population $\bar{\mu}(t,T)$



(a) Factors



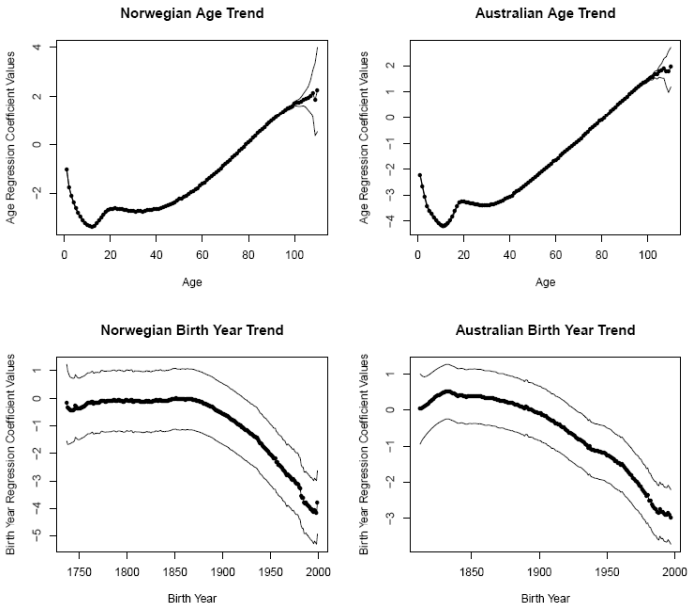
(b) Factor Loadings

Survivor curve

Multiple factors

Swedish mortality 1910 to 2007 ages 50 to 100

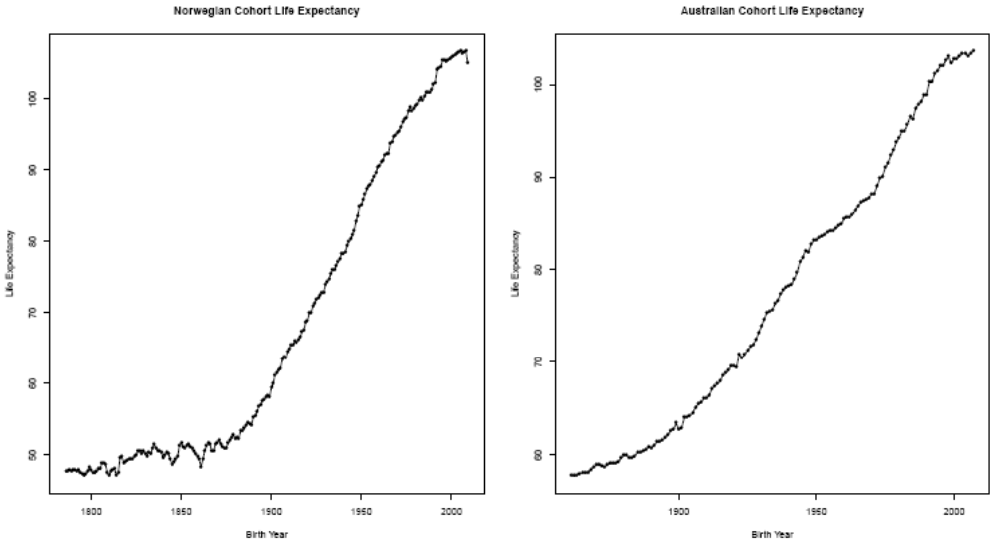
Age – Period – Cohort Models



Trend models - birth year or cohort effect a significant trend factor

Period effects less significant (Spanish flu)

Links to Lee-Carter



Longitudinal Analysis – HRS and Norwegian Data

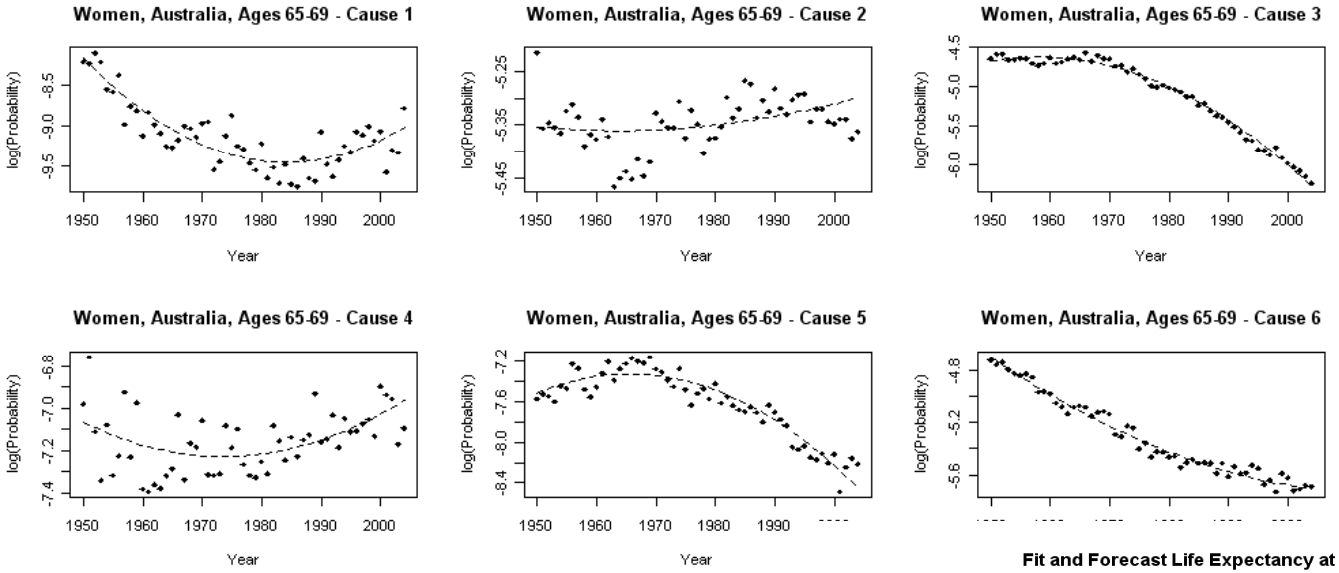
Panel data and logistic models

Mortality risk factors at an individual level

		Current Value Covariates			
		-2 LOG L		34,746	
		AIC		34,816	
		SBC		35,013	
		β_k	h_k	St.Dev β_k	
	Age	0.0571	1.0587	0.0072	***
	Male	0.4894	1.6314	0.0504	***
Education Ref: GED, HS or Some Coll.	<High School	-0.1536	0.8576	0.0510	***
	College +	0.0068	1.0068	0.0767	
Self-Report Health Ref: Good	Excellent	-0.6658	0.5139	0.1231	***
	Very Good	-0.3543	0.7017	0.0801	***
	Fair	0.5389	1.7141	0.0645	***
	Poor	1.1046	3.0181	0.0714	***
BMI Ref: Normal Weight	Underweight	0.8746	2.3979	0.1038	***
	Overweight	-0.3434	0.7094	0.0544	***
	Obese	-0.5474	0.5784	0.0697	***
	Morb. Obese	-0.4199	0.6571	0.0820	***
	Drinks Ever	-0.1214	0.8857	0.0491	**
	Smokes Ever	0.3693	1.4467	0.0592	***
	Smokes Now	0.2728	1.3136	0.0538	***
Health History	High BP	0.2425	1.2744	0.0499	***
	Diabetes	0.5452	1.7250	0.0515	***
	Cancer	0.7984	2.2219	0.0545	***
	Lung Disease	0.3922	1.4803	0.0574	***
	Heart Prob.	0.2906	1.3372	0.0504	***
	Stroke	0.3841	1.4684	0.0639	***
	Psych. Prob.	0.1200	1.1275	0.0588	**
	Arthritis	-0.1556	0.8559	0.0483	***

Table: Proportional hazards model.

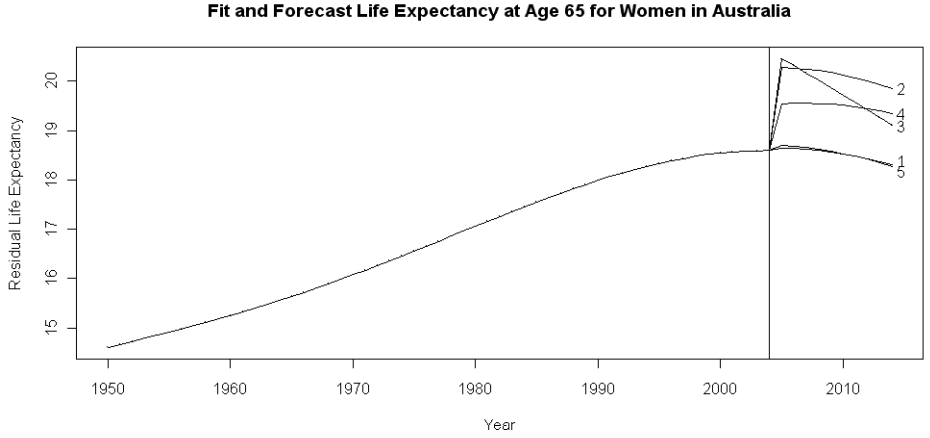
Causal Mortality Modelling



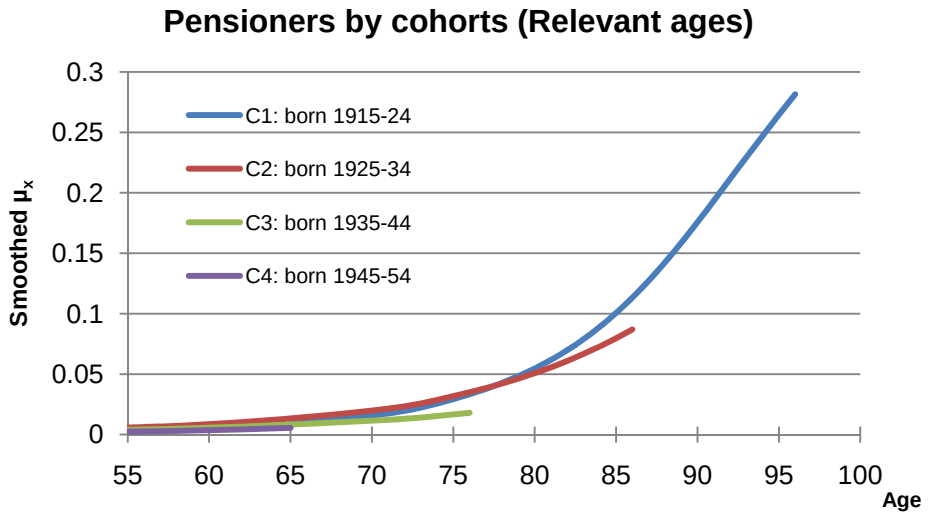
Simultaneously modelled periodic mortality trends by cause-of-death.

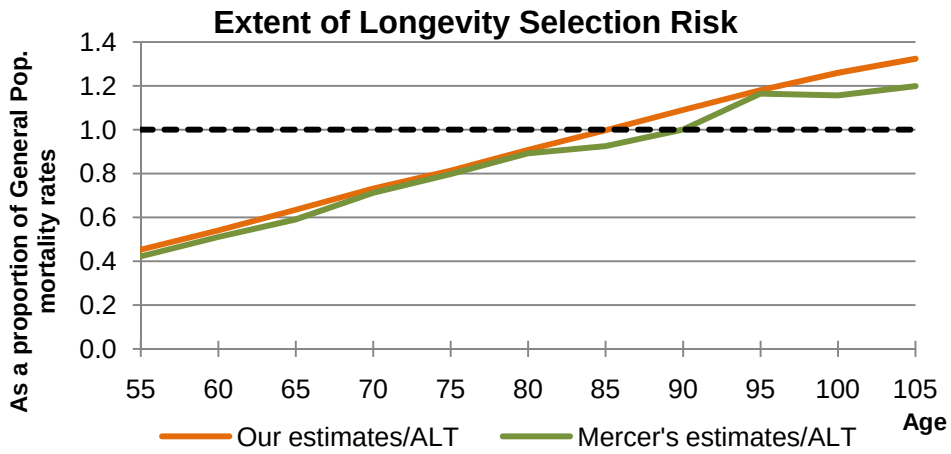
The impact on life expectancy under cause-elimination.

Inherent dependencies among *competing* causes is accounted for!



PwC-Mercer Pensioner Data





Hazard Ratios (Cox PH model)

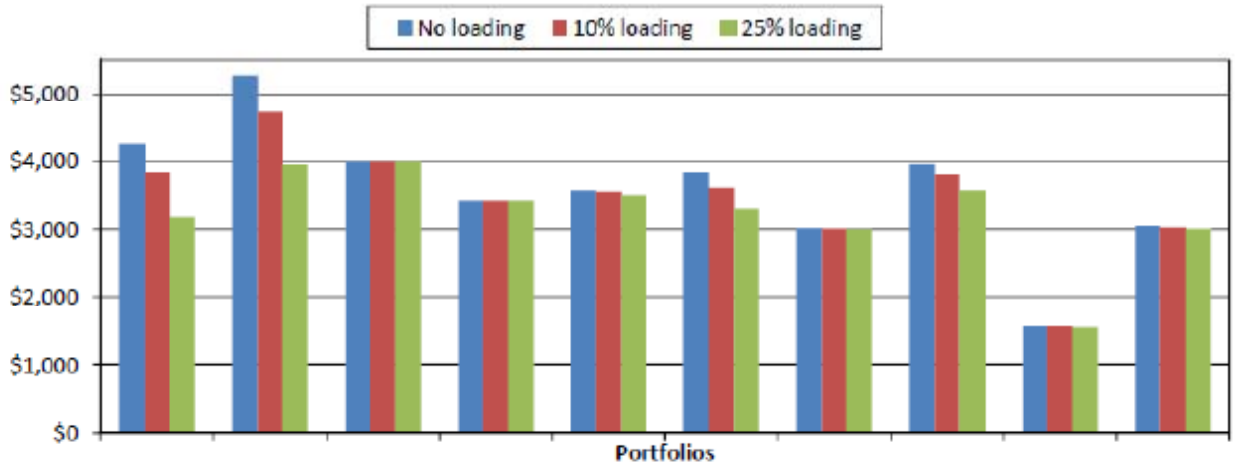
	Males	Females
Pension sizes:		
Low	1.23***	1.13***
Average (ref.)	1.00	1.00
High	0.64***	0.77***
Specific schemes:		
Federal-CSS (ref.)	1.00	1.00
Federal-PSS	0.71***	0.84
NSW-SSS	NA[(b)]	1.05
NSW-SASS	NA[(b)]	0.90
NSW-PSS	NA[(b)]	NA[(a)]
NSW-EISS	NA[(b)]	NA[(a)]
Victoria-SSS	NA[(b)]	NA[(b)]
Victoria-ESSS	1.01	0.86
South Aust-SASS	NA[(b)]	NA[(b)]
Tasmania-RBF	1.00	1.01
Western Aust-GESB	1.07**	1.16**
Queensland-SS	NA[(b)]	0.97
Queensland-PS	1.38	NA[(a)]
Grouped schemes	1.03**	1.13***
# subjects	111,257	47,350
Chi-squared	1,162	102
df	8	10
Adjusted R2	3.2%	1.1%

Retirement Income Product Portfolios

Importance of GSA (mutual risk sharing) when guarantee products include loadings (capital costs)

Indexed annuities dominate

Phased withdrawals (bequest motive) and deferred annuity



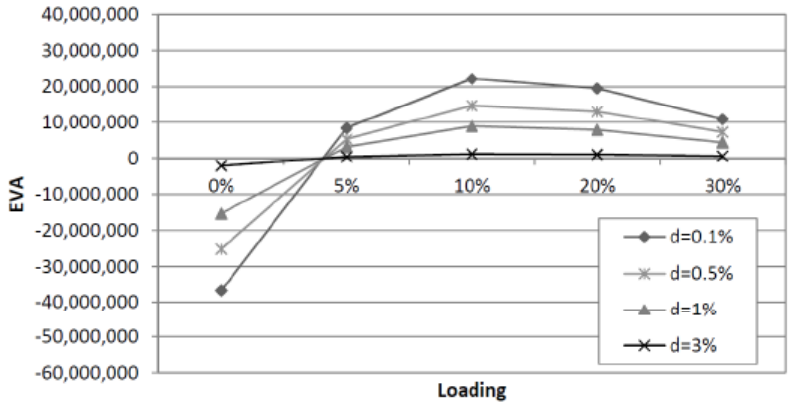
	1	2	3	4	5	6	7	8	9	10
Life annuity	100					50		35		
Deferred Annuity					25		50		75	50
Indexed life annuity		100								
Group self-annuitization			100				50	35	25	
Self-anunitization				100	75	50		30		50

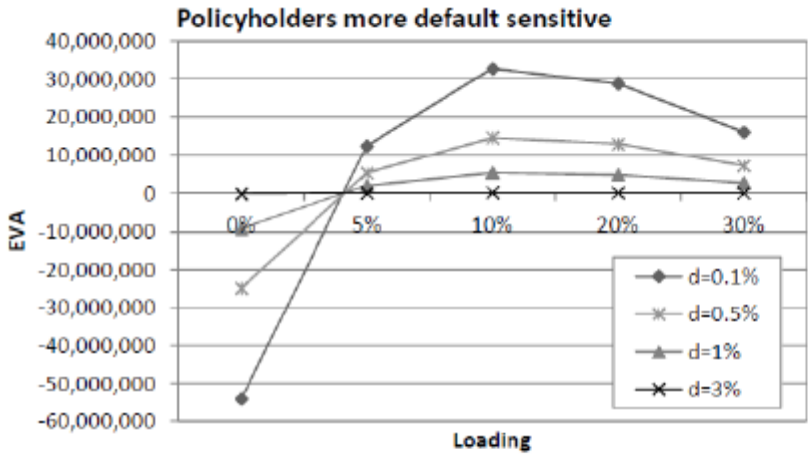
Hanewald, Piggott and Sherris (2011), Individual Post-Retirement Longevity Risk Management Under Systematic Mortality Risk.

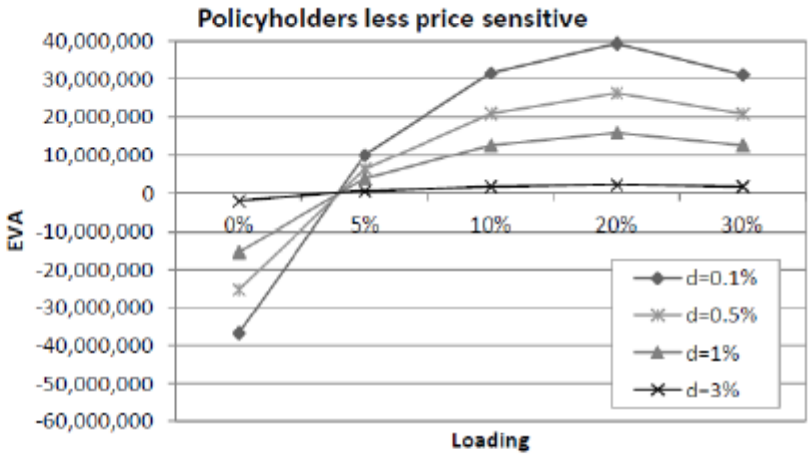
Solvency and Pricing for Life Annuities

Different default levels: optimal loading that maximises EVA

Sensitivity to solvency has important impact on value



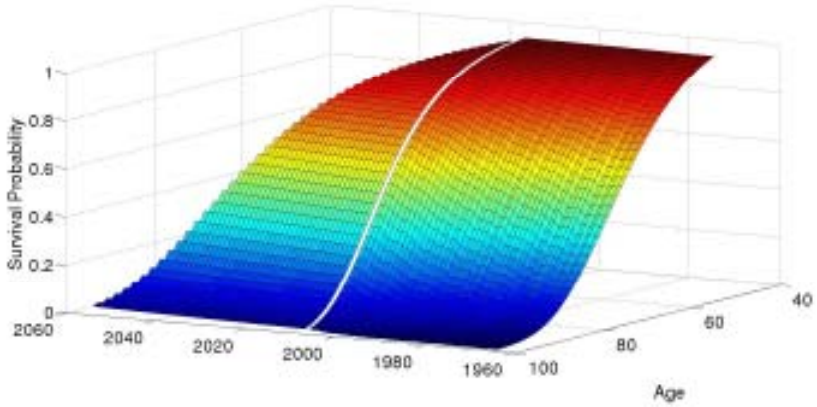




Life Insurer Longevity Risk Management

A multi-period stochastic model for an annuity provider facing systematic and idiosyncratic longevity risk

- Capital, premium loading, longevity swap, longevity bond
- Frictional costs vs. costs for transferring longevity risk



Survival curve forecast based on Affine Term Structure Model in Blackburn and Sherris (2012)

Variable	Longevity Swap	Longevity Bond
Benefits:	$b \cdot \tilde{N}(t;x)$	$b \cdot \tilde{N}(t;x)^{[\mathrm{syst}]}$
Premium:	$b \cdot (1+\lambda^{[\mathrm{LS}]}) \cdot N_0(t;x)$	$b \cdot (1+\lambda^{[\mathrm{LB}]}) \cdot \mathbb{E}_0[\tilde{N}(t;x)]$

Thank you

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Australian Research Council Linkage Grant

ARC Linkage Project 2008 LP0883398 Managing Risk with Insurance and Superannuation as Individuals Age (2009-2013)

Industry Partners: PwC, APRA, World Bank

- **Longevity Risk Models**
  - Models to quantify risks related to longevity and morbidity
- **Product Risk Management and Residential Housing**
  - Pricing, solvency, risk management and regulatory requirements for the prudential operation of longevity markets and institutions
- **Policy and Regulation**
  - Prudential and policy implications of new product innovations in both retail and wholesale financial markets

ARC Centre of Excellence in Population Ageing Research (CEPAR)

http://www.cepar.edu.au/

Collaborating universities: UNSW, The University of Sydney and the Australian National University (ANU)

- *The ARC Centre of Excellence in Population Ageing Research brings together researchers, government and industry to address one of the major social challenges of the twenty first century. It will establish Australia as a world leader in the field of population ageing research through a unique combination of high level, cross-disciplinary expertise drawn from Economics, Psychology, Sociology, Epidemiology, Actuarial Science, and Demography.*

For information:
ARC Longevity Linkage Project Research Working Papers

2009 and 2010

- S. Wills and M. Sherris: Integrating Financial and Demographic Longevity Risk Models (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1139724)
- S. Wills and M. Sherris: Securitization, Structuring and Pricing of Longevity Risk (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1139726)
- Y. Choi and C. Kim: Securitization of Longevity Risks using Percentile Tranche Methods (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1349398)
- C. N. Njenga and M. Sherris: Longevity Risk and the Econometric Analysis of Mortality Trends and Volatility (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1458084)
- A. Ngai and M. Sherris: Longevity Risk Management for Life and Variable Annuities (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1587890)
- J. Evans and M. Sherris: Longevity Risk Management and the Development of a Life Annuity Market in Australia (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1585563)
- D. Sun and M. Sherris: Risk Based Capital and Pricing for Reverse Mortgages Revisited (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1588342)
- A. Tang and M. Sherris: Spatial Variability in Mortality and Socioeconomic Factors for Australian Mortality (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1594522)
- S. Gaille and M. Sherris: Age Patterns and Trends in Mortality by Cause of Death and Implications for Modeling Longevity Risk (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1694272)
- S. Gaille and M. Sherris: Modeling Long-Run Cause of Death Mortality Trends (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1705696)
- S Gaille and M. Sherris: Improving Longevity and Mortality Risk Models with Common Stochastic Long-Run Trends (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1702029)
- J. R. Piggott and H. Bateman: Too Much Risk to Insure? The Australian (Non-) Market for Annuities (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1706900)
- C. S. Kumru and J. R. Piggott: Should Public retirement Provision be Means-tested? (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1417763)
- R. Sane and J. R. Piggott: Elderly mobility and Trade-downs in Australia

For information:
ARC Longevity Linkage Project Research Working Papers

2011

- M. Sherris and S. Su: Heterogeneity of Australian Population Mortality and Implications for a Viable Life Annuity Market (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1779442)
- C. N. Njenga and M. Sherris: Modeling Mortality with a Bayesian Vector Autoregression (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1776532)
- C. Qiao and M. Sherris: Managing Systematic Mortality Risk with Group Self Pooling and Annuitisation Schemes (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1791162)
- C. Blackburn and M. Sherris: Consistent Dynamic Affine Mortality Models for Longevity Risk Applications (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1832014)
- D.H. Alai and M. Sherris: Rethinking Age-Period-Cohort Mortality Trend Models (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1838805)
- K. Hanewald, J. R. Piggott, and Michael Sherris: Individual Post-Retirement Longevity Risk Management Under Systematic Mortality Risk (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1910961)
- K. Hanewald and M. Sherris: House Price Risk Models for Banking and Insurance Applications (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1961402)
- D. P. Blake, C. Courbage, R. D. MacMinn and M. Sherris: Longevity Risks and Capital Markets: The 2010-2011 Update (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1964636)

For information:

ARC Longevity Linkage Project Research Working Papers

2012

- J. Ziveyi, C. Blackburn, and M. Sherris: Pricing European Options on Deferred Insurance Contracts (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2005461)
- H. Chen , M. Sherris , T. Sun and W. Zhu: Living with Ambiguity: Pricing Mortality-Linked Securities with Smooth Ambiguity Preferences (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2007342)
- M. Sherris and D. TP Ho Quang: Portfolio Selection for Insurance Linked Securities: An Application of Multiple Criteria Decision Making (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2020712)
- M. Sherris and E. Veprauskaite: An Analysis of Reinsurance Optimisation in Life Insurance (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2029314)
- D. H. Alai , Z. Landsman and M. Sherris: Lifetime Dependence Modelling Using the Truncated Multivariate Gamma Distribution (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2033454)
- M. Nirmalendran, M. Sherris and K. Hanewald: Solvency Capital, Pricing and Capitalization Strategies of Life Annuity Providers (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2069594)
- J.HY. Fong , J. Piggott and M. Sherris: Public Sector Pension Funds in Australia: Longevity Selection and Liabilities (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2078683)