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Creating portfolio-specific mortality tables: a case study

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- Consultant on longevity risk since 2005
- Founded longevity-related software businesses in 2006:

- Joint venture with Heriot-Watt in 2009:

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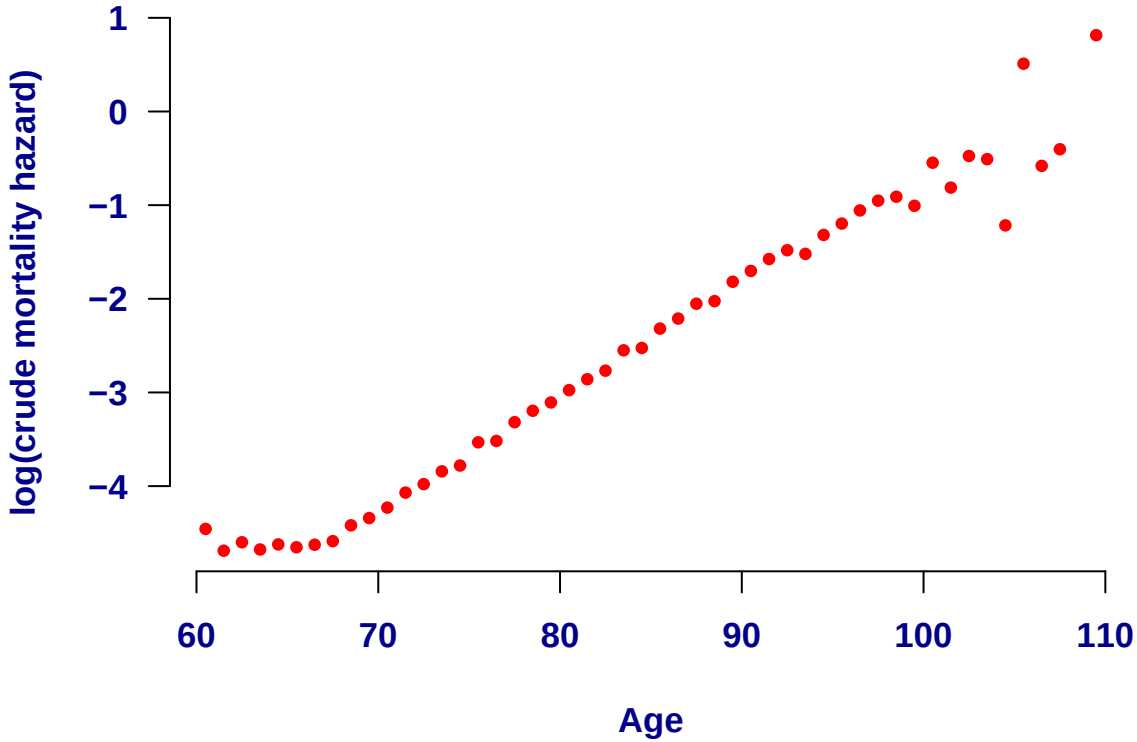
- Case study of creation of portfolio-specific tables.
- Experience data for multi-employer pension arrangement in Germany:
  - 253,444 pension records.
  - 31,842 deaths in 2007–2011.
  - 1.03 million life-years lived in 2007–2011.
- Results published in European Actuarial Journal.

Source: Richards, Kaufhold and Rosenbusch (2013).

2. Actuarial requirements

$\log_e$(crude mortality hazard) from age 60, males and females combined:



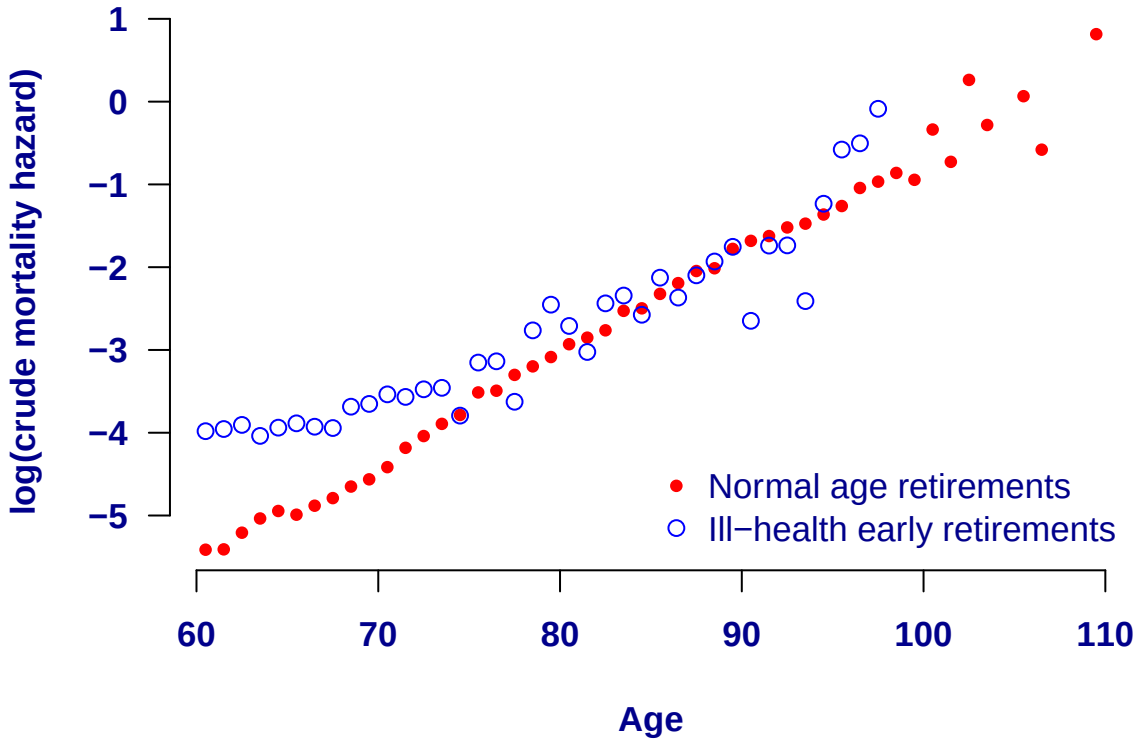
Source: Richards, Kaufhold and Rosenbusch (2013), Figure 1.

2. Actuarial requirements

- Mortality increases with age.
- Smoothing is needed to iron out random variation.
- Extrapolation is needed for highest ages.

2. Actuarial requirements

$\log_e$(crude mortality hazard) from age 60 by retirement type:



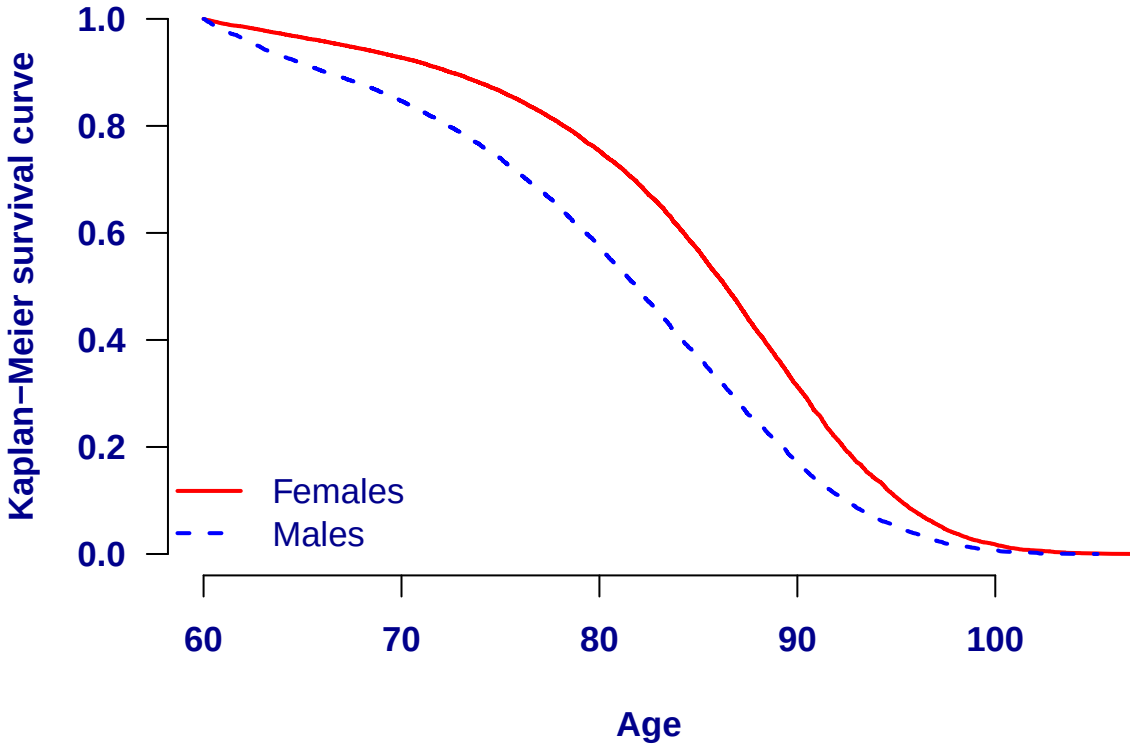
Source: Richards, Kaufhold and Rosenbusch (2013), Figure 4.

2. Actuarial requirements

- Strong excess mortality for ill-health retirals, but
- Excess ill-health mortality reduces with increasing age.
- This phenomenon is known as *mortality convergence*.

2. Other risk factors: gender

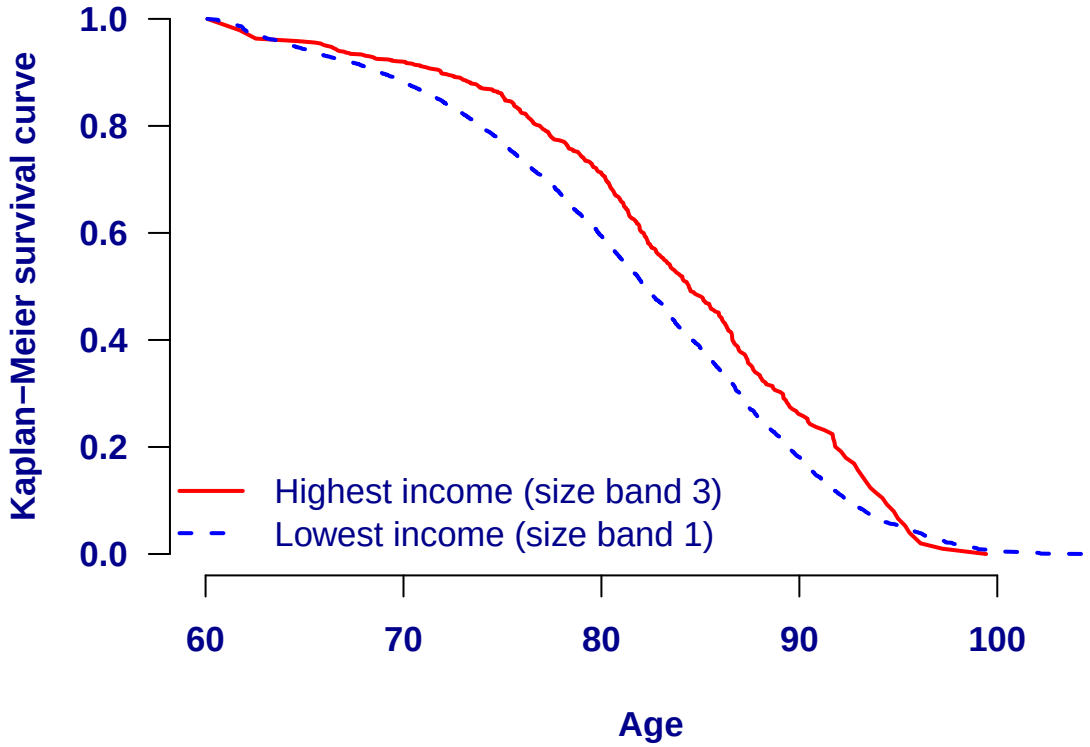
Kaplan-Meier product-limit estimator by gender from age 60:



Source: Richards, Kaufhold and Rosenbusch (2013), Figure 2.

2. Other risk factors: pension size

Kaplan-Meier product-limit estimator by income from age 60:



Source: Richards, Kaufhold and Rosenbusch (2013), Figure 3.

2. Actuarial requirements

- Unequal distribution of liabilities:
  - — 50% of all pensions are received by just 23.5% of lives.
  - — males are 34.5% of lives, but 59.7% of large-pension cases.

→ Need a methodology to separate the impact of each risk factor.

Source: Richards, Kaufhold and Rosenbusch (2013).

2. Actuarial requirements

- The data tell us what the requirements of the model are:
  - — smooth out random variation,
  - — extrapolate to higher ages,
  - — allow for multiple risk factors simultaneously, and
  - — allow risk factors to vary their impact by age.

3. What kind of model should you use?

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- We need a statistical model.
- Should we model grouped counts or individual lives?
- Modelling grouped counts demands *stratification*...

3. What kind of model should you use?

Deaths stratified by six risk factors:

Member of largest scheme	Region	Scheme type	Pension size-band	Normal retirees: Females	Normal retirees: Males	Ill-health retirees: Females	Ill-health retirees: Males	Widow(er)s: Females	Widow(er)s: Males
No	B	1	1	5,142	5,313	525	738	4,434	618
			2	824	725	39	98	36	0
			3	282	413	14	33	24	1
		2	1	2,200	1,323	308	183	628	222
			2	305	275	20	39	18	0
			3	140	206	15	18	15	1
	P	1	1	695	811	51	99	798	89
			2	138	122	7	22	9	0
			3	59	72	1	5	3	1
		2	1	174	274	26	33	166	23
			2	26	56	3	4	4	0
			3	8	41	5	2	5	0
Yes	B	1	1	480	338	41	45	224	47
			2	108	65	12	3	4	0
			3	60	45	1	3	4	0
Totals				10,641	10,079	1,068	1,325	6,372	1,002

Source: Richards, Kaufhold and Rosenbusch (2013), Table 8.

3. What kind of model should you use?

- Stratification quickly leads to cells with very small or zero counts.
- This applies even for large data sets.

$\rightarrow$ Models for grouped counts are only suitable with a few risk factors.

3. What kind of model should you use?

- Using individual data avoids stratification.
- Survival models make the most efficient use of your data.

4. What risk factors are available?

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German pension scheme with seven risk factors for longevity:

- age,
- gender,
- pension size,
- retirement status: normal, ill-health or widow(er),
- employer type,
- region, and
- time

Source: Richards, Kaufhold and Rosenbusch (2013).

4. What risk factors are available?

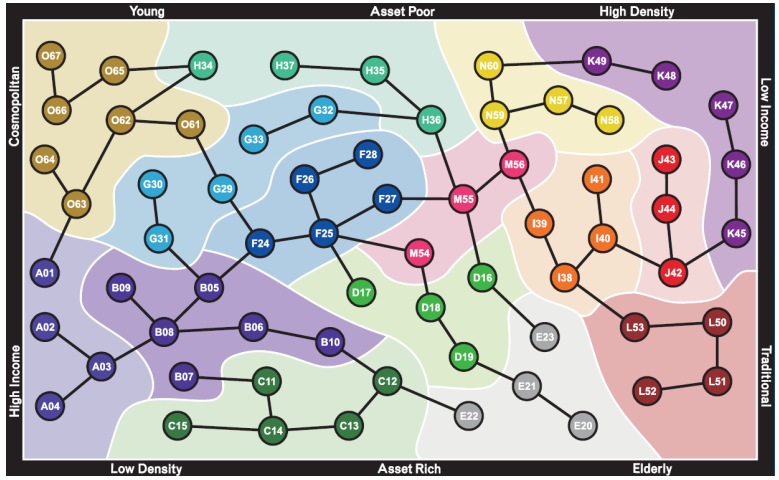
U.K. insurer with six available risk factors:

- age,
- gender,
- lifestyle (via postcode),
- duration (time since annuity purchase),
- pension size, and
- region.

Source: Richards and Jones (2004).

4. What risk factors should you use?

- Each portfolio is unique.
- Business practices determine the available information:
  - — German data had employer type and health status at retirement.
  - — U.K. data had postcodes to model socio-economic group.



Source: Experian Ltd.

4. What risk factors should you use?

- Your liabilities are your own.
- Insights from other people's data are only partially relevant.
- Fit models to your data using business-relevant risk factors:
  - — internal v. open-market annuities.
  - — GAR v. no GAR.
  - — product group.
  - — distribution channel.
  - — etc.

5. What financial impact do risk factors have?

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Financial impact of mortality risk factors for German pensioners:

Risk factor	Change	Annuity factor	Relative change
Base case	-	16.114	
Gender	Female→male	14.529	-9.8%
Retirement health status	Normal→ill-health	12.974	-10.7%
Pension size	Largest→smallest	11.717	-9.7%
Region	B→P	11.025	-5.9%
Employer type	Private→public	10.599	-3.9%
Overall			-34.2%

Source: Richards, Kaufhold and Rosenbusch (2013), Appendix 1.

5. What financial impact do risk factors have?

Financial impact of mortality risk factors for U.K. life-office annuitants:

Factor	Step change	Reserve	Change
Base case	-	13.39	
Gender	Female→male	12.14	-9.3%
Lifestyle	Top→bottom	10.94	-9.9%
Duration	Short→long	9.88	-9.7%
Pension size	Largest→smallest	9.36	-5.2%
Region	South→North	8.90	-4.9%
Overall			-33.6%

Source: Richards and Jones (2004), page 39.

6. What can a portfolio's own experience tell you?

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- Many commercial models are calibrated to large data sets.
- These are not directly related to your liabilities.
- There is a risk that your portfolio is different — *basis risk*.

6. What can a portfolio's own experience tell you?

- Return to German pensioner data with over 250,000 lives.
- The largest scheme has approximately 12,000 members.
- Does the model for the large data set explain the mortality variation in this scheme?
- How large is the basis risk from using a model calibrated to other data?

6. What can a portfolio's own experience tell you?

- Mortality around 10% lower for largest scheme.
- Effect exists *even after allowing for all seven other risk factors.*
- Result was highly statistically significant (p-value 0.0001).
- Impact was an extra 2–2$\frac{1}{2}$% on reserves.

→ Useful to know in bulk-annuity pricing!

6. What can a portfolio's own experience tell you?

Q. Why does this scheme have lighter mortality?

A. The socio-economic profile was different. This was not captured by pension size due to a large proportion of part-time workers with higher socio-economic status but lower pension amounts.

6. What can a portfolio's own experience tell you?

- Using data unrelated to your portfolio is only partially useful.
- It cannot tell you about portfolio-specific effects.
- Portfolio-specific analysis is needed, not just comparision against a larger data set.

7. Conclusions

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- Statistical models separate effects of each risk factor.
- Different portfolios will have different risk factors available.
- Data unrelated to your liabilities is only partially useful (basis risk).
- Even rich models from large data sets can't fully predict a portfolio's characteristics.
- Portfolio-specific analysis is highly advisable.

References

Richards, S. J. and Jones, G. L. **2004** *Financial aspects of longevity risk*, Staple Inn Actuarial Society, London.

Richards, S. J., Kaufhold, K. and Rosenbusch, S. **2013** *Creating portfolio-specific mortality tables: a case study*, European Actuarial Journal, DOI: 10.1007/s13385-013-0076-6.