The effect on mortality statistics of heterogeneity in populations and the actuarial concept of select mortality

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From *The Times* 21st June 2018 – how might this be?

Business Markets

Tempus
Buy, sell or hold: today's best share tips

Charting the progress of a prize asset

LEGAL & GENERAL

Assets under mgmt £983bn	Potential market £60trn

The asset management division of Legal & General usually gets rather overshadowed in any assessment of Britain's second biggest insurer (Patrick Hosking writes). Legal & General Investment Management might be one of the biggest asset managers in Britain, with nearly a trillion pounds of assets under management, but in terms of profit generation it is still modest beside the retirement and annuities division.

L&G wants to change that perception, which explains why its capital markets event yesterday focused purely on LGIM.

The division has a strong story to tell. Over the past ten years it has produced compounded annualised growth in operating profits of 11 per cent, last year hitting the £400 million mark. A decade ago, LGIM was the 50th biggest asset manager in the world by money under management; today, it is the tenth biggest. Indeed, if it was an independent listed company, it might very well be in the FTSE 100.

LGIM probably accounts for around a third of the entire group's £16 billion market value. Of course, highly beneficial investment markets in both bonds and equities have

Here we grow again

Share price

ADVICE Buy
WHY Valuation starting to look cheap given potential

management and therefore the amount in fees creamed off. Bu LGIM appears to have outpace peers, with new mandates comfortably exceeding the outflows of clients from mature pension funds withdrawing cash to pay retirement benefits. Last year it scooped in a net £43.5 billion of business.

The days when LGIM could be

of people into pension saving will start to move the dial and LGIM, as the country's biggest provider, is an obvious beneficiary. With some of country's biggest employers, Tesco, John Lewis and otland, signed up, workplace

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L&G shares had a fabulous run on the back of booming markets between 2009 and 2015, rising fivefold, but have struggled to make progress since then. That looks a little unfair. Results in March were fine. Even without the windfall from people dying earlier than the actuarial tables predicted (it's a funny business, insurance), operating profit growth was 12 per cent.

NEWS IN BRIEF

Miner's board games

The proposed new chief executive of Petropavlovsk is urging investors to support the appointment of a new board at its annual meeting next week. Pavel Maslovskiy is stepping into a bitter dispute over control of the London-listed Russian goldminer: some shareholders have been pushing for a boardroom clearout, but the company has accused them of concealing their true identities behind a series of holding companies. In his letter to shareholders, Dr Maslovskiy says that the proposed new board has a "strong operational record".

Takeda board backed

wo proxy shareholder advisory roups have advised Takeda nvestors to vote against rebel hareholder plans. A group of 12 nvestors in the Japanese pharmaceuticals company have said that the takeover of Shire "carries overly high risks" and it wants Takeda takeovers worth more than a trillion yen, or £7 billion, to be put to shareholders. Takeda's board objects and it has received the backing of Glass Lewis and Institutional Shareholder Services.

Banker jailed for fraud

The former chief executive of a bank that played a key role in Ireland's financial crash in 2008 has been jailed for six years. David Drumm, 51, who was head of Anglo Irish Bank, was sentenced after the judge took into account mitigating factors, including time spent in a US

Questions we will answer in this lecture

1.	What key mortality assumptions underlie our work so far?
2.	Which factors cause variations in mortality?
3.	How do actuaries define “selection”?
4.	What are the main types of selection?
5.	How do we incorporate selection in probabilities and life tables?
6.	What are the key differences between life assurance and annuity contracts?
7.	Can selection only be used by insurers or perhaps by policyholders too?
8.	What are some of the commercial considerations for actuaries in this area?

The assumptions underlying our work so far

In Actuarial Mathematics I & II we defined ${}_sq_x$ as the probability a person now age x will die within the next s years

${}_sq_x$ assumes sufficiently homogeneous group of people such that mortality varies only with age x

We know this will not be the case

As a result of questioning this assumption, we will

1. Identify the important factors affecting mortality statistics
2. Begin to introduce this heterogeneity into our methods
3. Discuss some important commercial considerations

Factors causing variation in mortality (1)

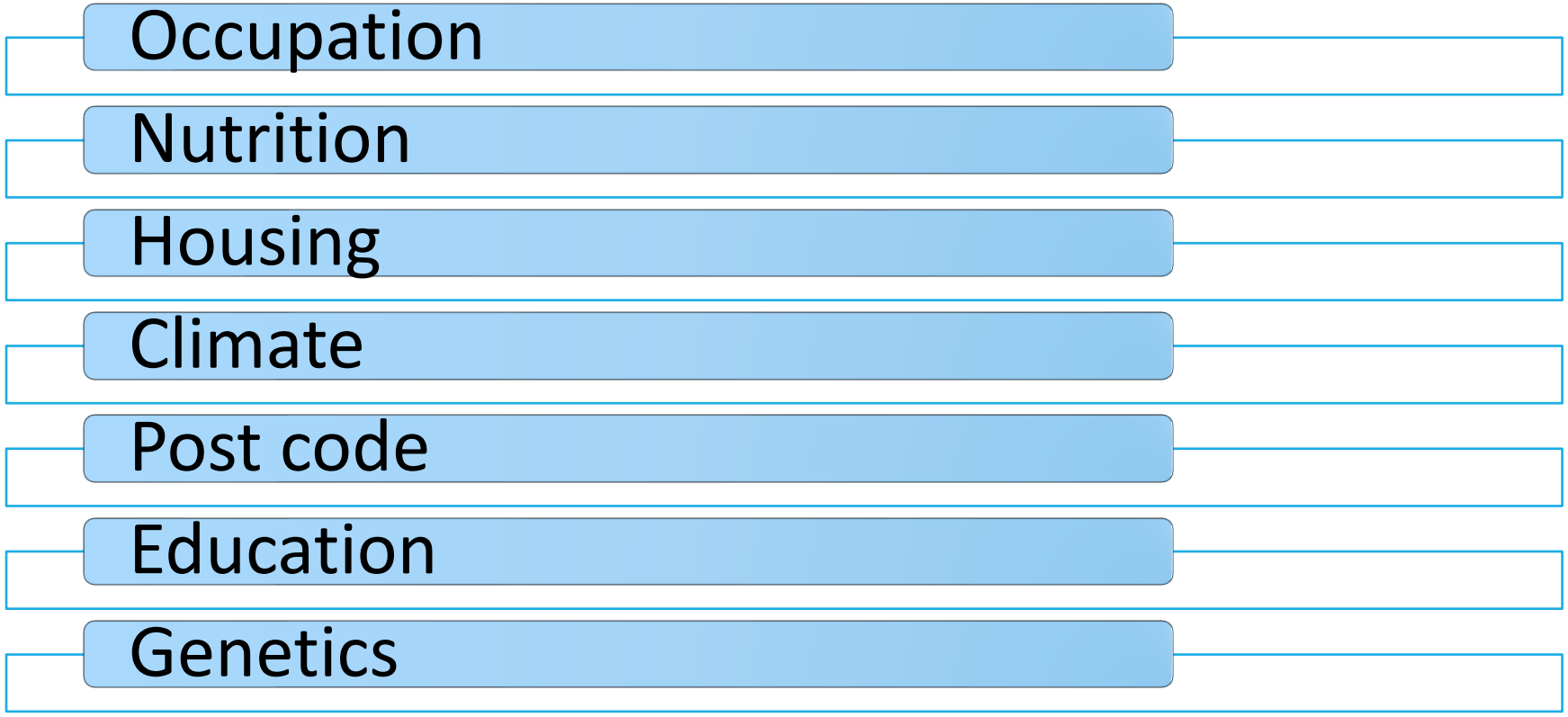
Female
Non-smoker

Female
Smoker

Male
Non-smoker

Male
Smoker

Factors causing variation in mortality (2)



A definition of “selection”

Heterogeneity versus selection

Selection = the operation of factors which influence mortality (Benjamin & Pollard, p.215)

The word comes from an insurer’s ability to select whom they offer insurance to and at what rates

Different types of selection

Class selection

Temporary initial selection

Time selection

Spurious selection

Adverse selection

Class selection

Permanent attributes which the actuary would have to differentiate between when creating mortality statistics

- Most important type of selection if e.g. mortality statistics used for resource allocation decisions in the NHS
- Less important in life assurance and pensions work where the focus is on mortality of a more narrowly defined population

Temporary initial selection

Arises from the underwriting work an insurer does before a policy begins

- Questionnaire
- Medical examination

Somebody who has just been accepted for life assurance should have a lower probability of death in the next year than someone who has not

… but the difference should diminish over time

For life assurance work, mortality depends on duration since the policy was purchased as well as on age

Select probabilities and tables (1)

${}_sq_y$ = probability someone age y will die in the next s years

${}_sq_{[x]+t}$ = probability someone age x+t who was sold life assurance at age x will die in the next s years

${}_sq_{[x]+t}$ is a “select mortality rate”

Initial selection means that:

$q_{[62]} \leq q_{[61]+1} \leq q_{[60]+2}$ .....

Select probabilities and tables (2)

However, the selection effect reduces over time

"select period" = number of years after which the selection effect is assumed to have worn off

if the select period = 3 years

$q_{[62]} \leq q_{[61]+1} \leq q_{[60]+2} \leq q_{[59]+3}$

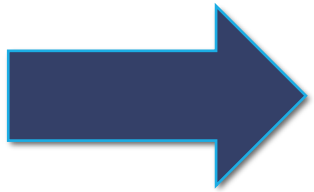
but then

$q_{[59]+3} = q_{[58]+4} = q_{[57]+5} = \ldots = q_{62}$

where q_{62} is the "ultimate mortality rate"

Select probabilities and tables (3)

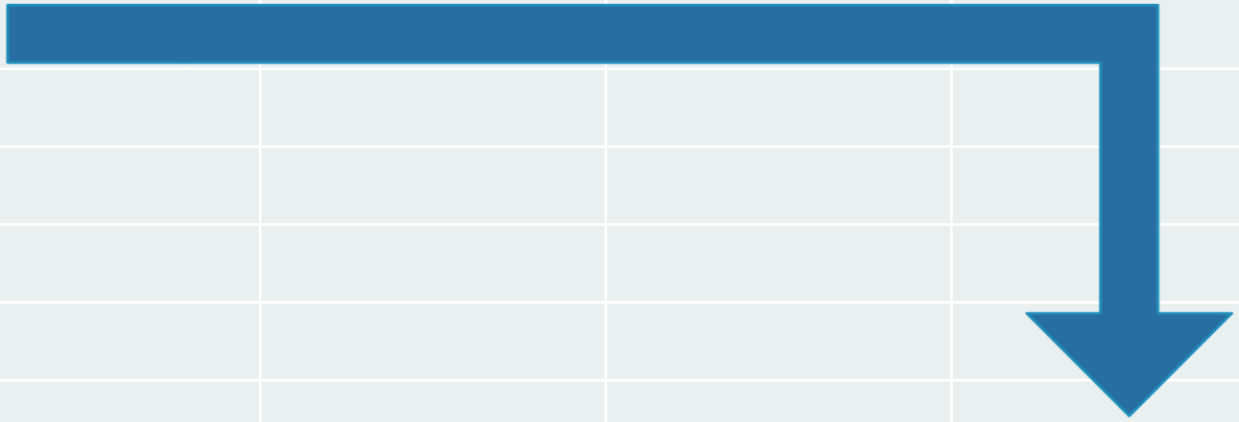
x	q_x
60	
61	
62	
63	
64	
65	



x	$q_{[x]}$	$q_{[x]+1}$	$q_{[x]+2}$	q_{x+3}
60				
61				
62				
63				
64				
65				

Select probabilities and tables (4)

x	$q_{[x]}$	$q_{[x]+1}$	$q_{[x]+2}$	q_{x+3}
60				
61				
62				
63				
64				
65				



Time selection

Mortality rates change over time

- In general life expectancy has increased due to advances in medical science and economic factors
- Although the rate of change varies considerably

2 dangers when using published mortality experience

- Tables constructed over a number of years may have heterogeneity built into them
- Historic data will tend to overestimate q_x

Potential solution would be different mortality tables by year-of-birth (a version of select tables)

- However these would miss the data we are most interested in!

Annuities (1)

Buyers of annuities generally expect to live longer than average (otherwise why buy the contract?) so the provider is exposed to longevity risk i.e. time selection in mortality.

- Allowance for reductions in q_x over time are needed
- This is difficult to quantify
- We again use select mortality type notation

Annuities (2)

Assume mortality statistics obtained in base year 2010

Someone born in 1954 was age 56 in base year so probability of death in the next year was $q_{[56]}$

Probability of (future event) death in the year following attaining age 65 is $q_{[56]+9}$

- 56 = age in base year
- 9 = duration since base year

With mortality improvement factor r over the 9 years

$$q_{[56]+9} = q_{[65]} (1 - r)^9$$

Although in practice unlikely r is a constant, so better is

$$q_{[56]+9} = q_{[65]} (1 - r_1) (1 - r_2)\ldots(1 - r_9)$$

Spurious selection

Actuaries need to guard against temporary initial selection or time selection being distorted by other factors

- Changes in underwriting practice
- Merger of two populations

This is spurious selection

Tools to manage this include shorter select periods

Remember no data set will ever be completely free of spurious selection

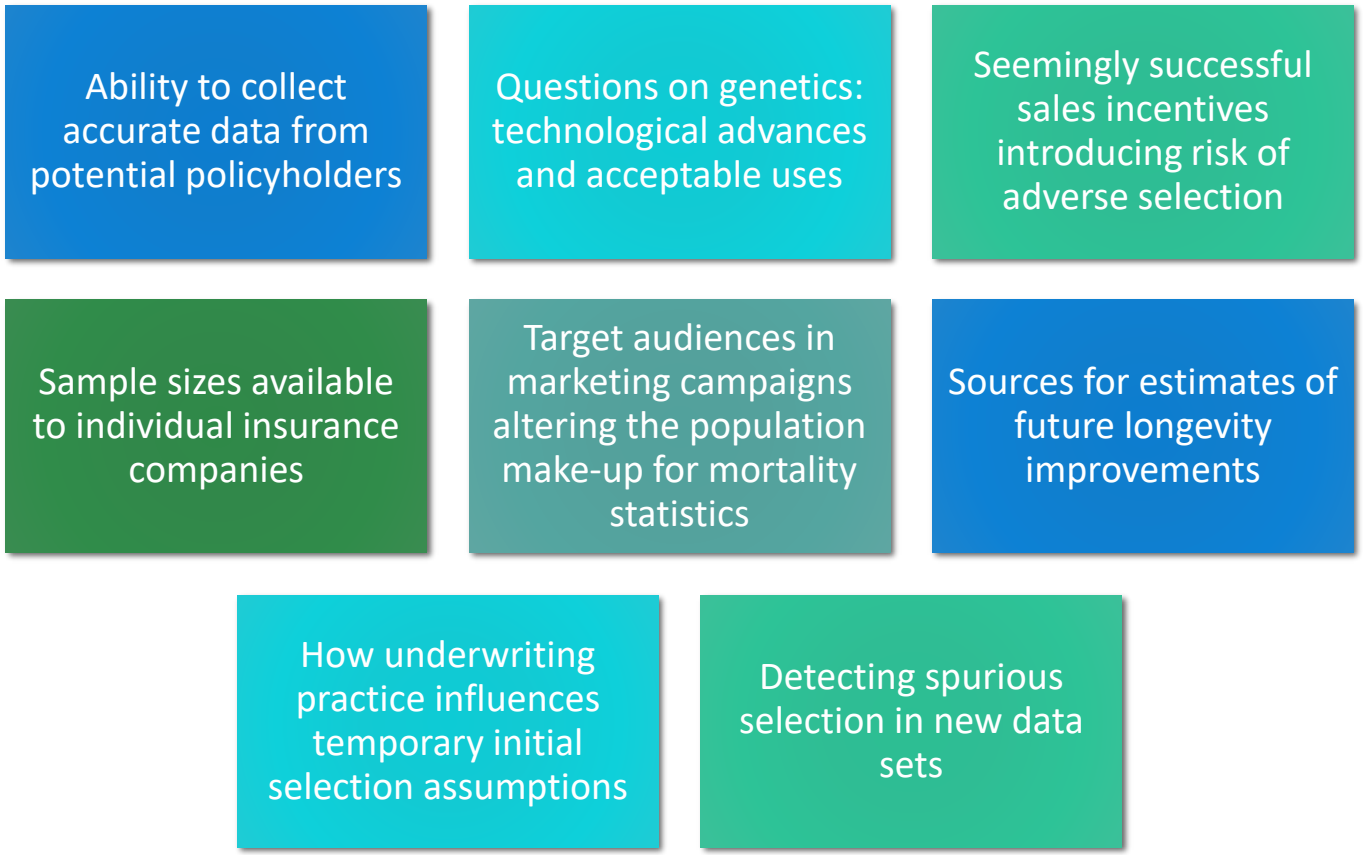
Adverse selection

Remember the word origin of the term “selection”

How can policyholders select against insurers?

- People with higher than anticipated mortality rates buying life assurance
- People with greater than anticipated longevity buying annuities
- Individuals (selection versus non-disclosure)
- Mortality characteristics of groups of policyholders
- Impact of sales and marketing practices

Commercial considerations



Summary

How mortality will vary with more than just attained age

The actuarial concept of select mortality

Types of selection and their relevance to life assurance and annuity business in particular

Select probabilities and tables

Adverse selection and other commercial considerations