Institute of Actuaries of Australia

LIWMPC Longevity Research Group Update 2010

Prepared by the LIWMPC Longevity Research Group

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Abstract

This paper has two distinct parts.

The first part of the paper takes the reader through some of the interesting results coming out of some longevity studies being performed by the group and identifies some early interesting results for discussion.

The second part of the paper reviews a number of papers presented to the 'Living to 100 Symposium' run by the Society of Actuaries in 2008. The aim of this review is to bring the latest research collection on the subject of longevity to the Australian actuary in a format that topics of interest can be easily identified and the relevant articles found.

Keywords: mortality, longevity, cause of death.

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1. Introduction

The first part of the paper produces some results from our research into death by cause for higher age groups. We have presented here some results that we find interesting. This is not to say, though, that the thought process on the results, how we got them or a better way of approaching the problem is final. We have taken it upon ourselves to use some broad assumptions for the purpose of developing a result that shows that something interesting is going on.

We would like to stress that we are aware of the inaccuracy inherent in some of our approaches and stress that we have performed all calculations consistently to show something interesting and would strongly recommend that the results produced here NOT be used for any commercial purpose.

The aim of the second part of this paper is to make the lives of actuaries a little easier by bringing them a collection of recent research summarised to allow items of potential interest to be brought to their attention. In some instances the abstract of the paper has been reproduced as it was considered that this provided a good review of the content.

In other cases the opinions of the individual reviewer have been given. We would like to stress that these are the opinions of the individual, not the group as a whole, the LIWMPC, the IAAust or anyone else. If you disagree with the opinion given or comments made please feel free to discuss this with other people, but please don't complain to any of the bodies mentioned above.

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2. Age-specific death rates by cause study

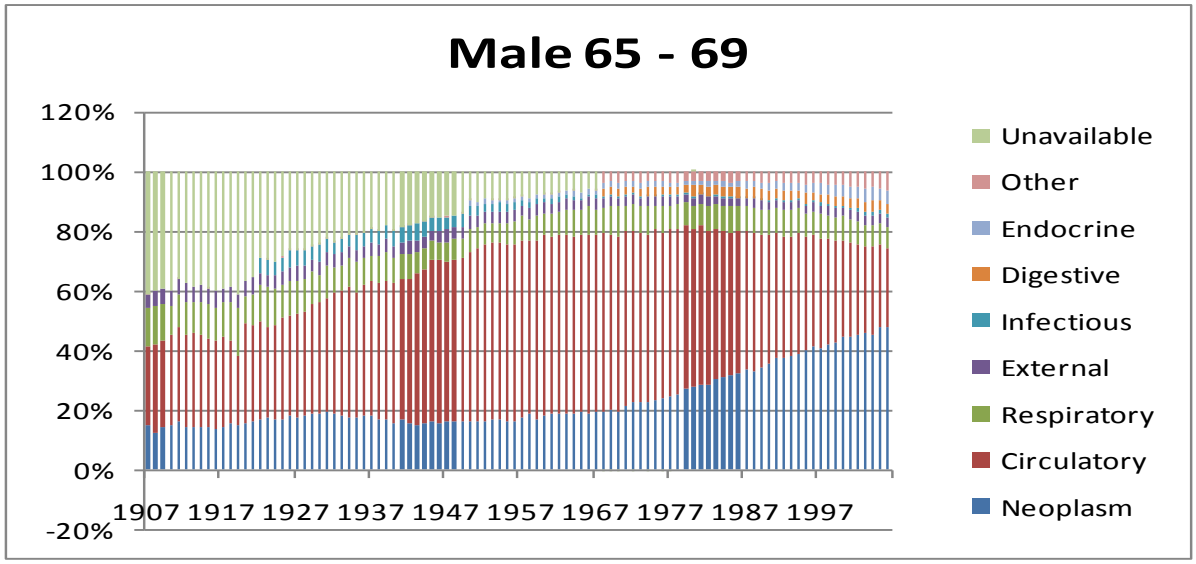
The first part of this paper looks at some of the results of our work on death by cause. This work is not finalised. However, we present it here so that members can comment on the work to date, see the results that we have, which seem interesting so far, and have an opportunity to advise on where the work goes in future.

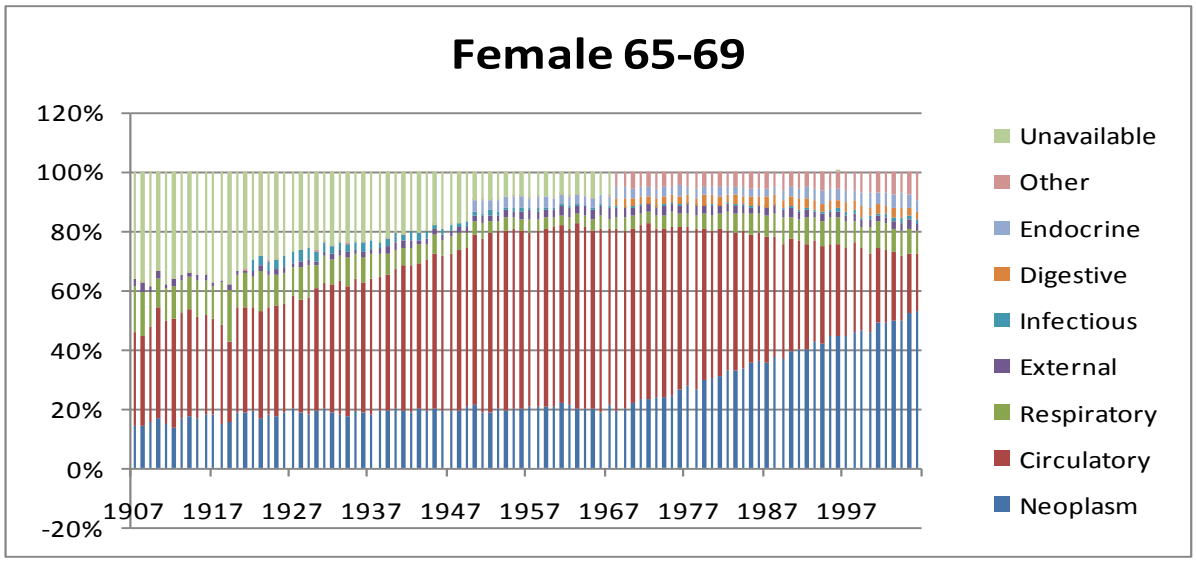
As we are primarily interested in retirees we have studied three different age groups: 65-69 year olds; 75-79 year olds; and 85+.

Data for this work has been obtained from the Australian Institute of Health and Welfare (AIHW) GRIM books, version 9, copyright 2008. We would like to thank the AIHW for providing this valuable data in the extremely accessible form that they have, it is greatly appreciated.

2.1 Proportional cause of death

The graphs below show the change over time of the proportional make up of death by cause for our study age groups, male and female separately.





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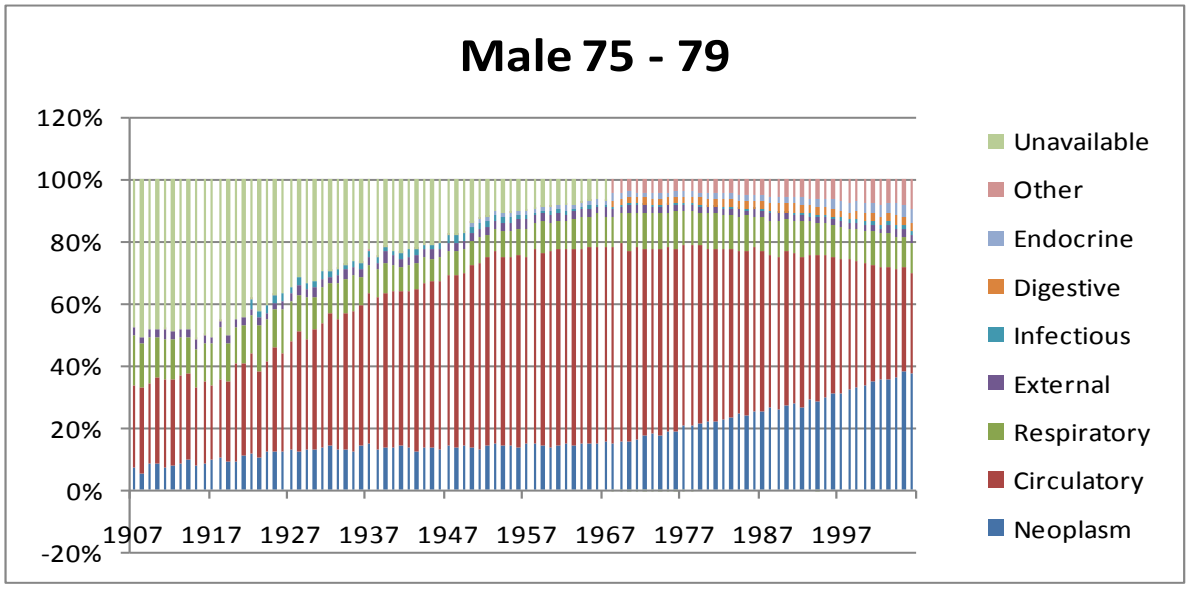
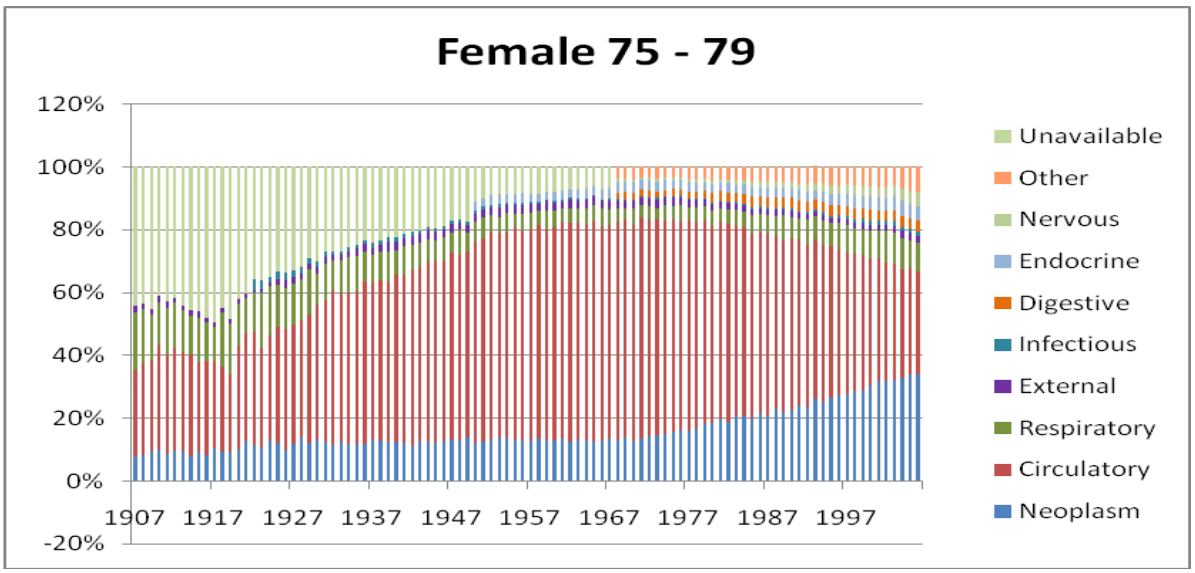
It can be clearly seen in these graphs that the cause of death for many deaths up to around 1967 was unknown, unrecorded or unidentifiable. Record keeping has improved and there are now few deaths that are unable to be attributed to a particular cause of death.

Having said this, it is interesting to note the comparative shapes of 'unavailable' and 'circulatory' in the early years of these graphs. Given the changes in shape over time it would not seem unreasonable to speculate that a good portion of the 'unavailable' were circulatory in nature.

The other interesting trend is the gradual change in dominance of neoplasm and circulatory deaths over time. While the overall age-specific death rates have reduced over time, each person who dies must die of something. The most likely explanation of the pattern seen here is that treatment for circulatory diseases for this and younger age groups has improved, thus reducing the age-specific death rate, removing a number of deaths from this cause and by virtue of the ratio of same numerator over smaller denominator, the proportion of deaths attributable to cancer increases. This explanation is consistent with later graphs in this paper.

For the 75-59 age group the graphs are as follows:





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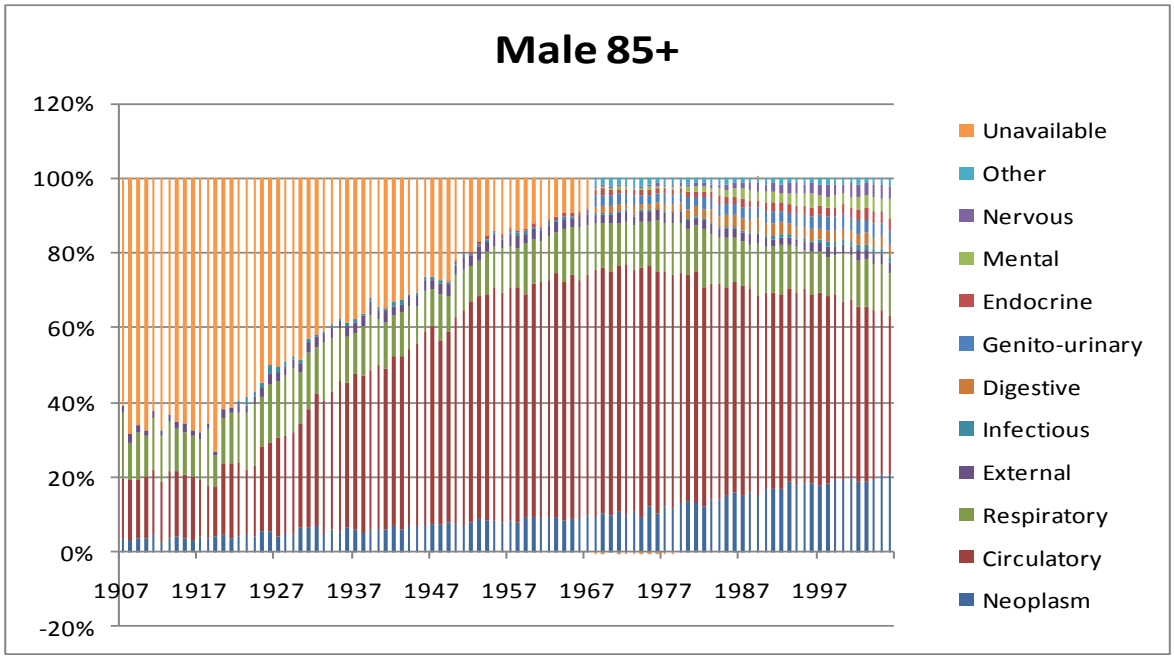
Comparison between the two age groups highlights the following features:

Both age groups have a similar pattern prior to improvements really taking effect in the late 1960's. The improvement in the proportion of deaths due to circulatory issues is much more apparent in the 65-69 year olds than the 75-79 year olds, for both males and females. The pattern of circulatory and unavailable deaths as recoding improved is similar for both age groups.
Male and female patterns have greater similarity by age group than they do by gender.

We have performed the same analysis of the 85+ age group and the graphs are below. It would have been interesting to look at data split into greater detail at the higher age groups; however, the data is only available in the 85+ category. This is, though, data that the committee would like to have available in greater detail and will be trying to obtain over time.

It can be seen, by comparing the age 85+ with previous age groups that the improvements in circulatory disease have not been as marked over time. This has resulted in a less pronounced increase in the proportion of deaths from neoplasm than for other age groups. It is worth noting the increased importance of respiratory diseases in this group.



The female 85+ shows a less pronounced increase in the proportion of deaths due to neoplasm consistent with a slower improvement in circulatory deaths.

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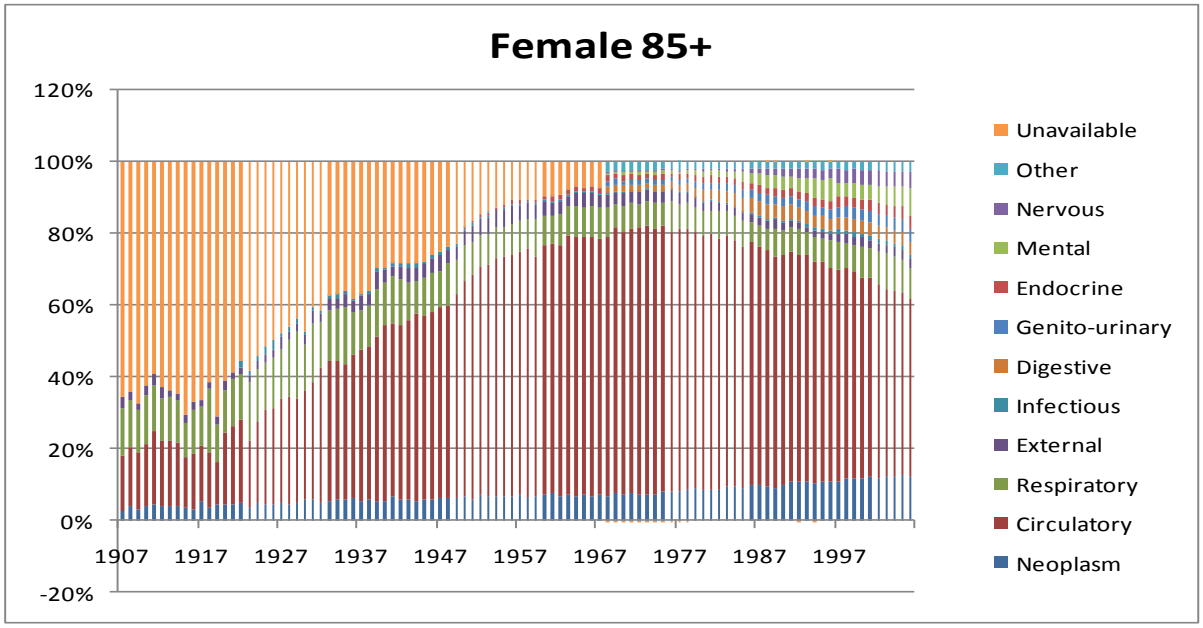

2.2 Mortality improvements

Having looked at the proportional breakdown of deaths at high ages by cause, we then progressed to looking at the effect of mortality improvements by cause.

To do this the following method was used for data in each of the same age-groups identified in the previous section:

- Raw deaths by cause and 'all causes combined' were obtained from the AIHW data (1905-1999).
- Population data for the whole population was obtained from the same AIHW data (1905-1999).
- Divide the first item above by the second item above to obtain raw age-specific deaths rates by cause and in total. Note population data from the mid point of the appropriate quinquennium was used.
- These age specific death rates (ASDR's) were not smoothed or adjusted in any way.
- The annual mortality improvement factor for each cause and all causes combined was then calculated using the simple formula $\{q_x/q_{x-1}-1\}$
- These improvement factors were then analysed and a linear least-squares regression fitted.
- The least squares regression formula was identified and this was used to project improvement factors into the future to 2050.
- These projected improvement factors were then applied to the end year data by cause and all causes combined using the same improvement factor formula as above.
- The results were then graphed.

Other causes were defined as all those other than neoplasm, circulatory and respiratory. We investigated the other categories of deaths to determine if there was value in separate analysis of these and came to the conclusion that they made up too small a contribution to all deaths to make them viable. There were also issues of data availability for early years.

We considered fitting different curves or shapes to the data. Having reviewed the data for the age groups we are interested in we decided from visual inspection that linear would seem reasonable and, given the variability of the (particularly early) data, would give a reasonable enough fit for our purposes.

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We also considered whether the regression should be conducted over shorter time periods, particularly in the later years, however, the trend does look remarkably linear. In further work we may perform and analyse different regressions on the data to determine the best fit.

The graphs of the improvement factors can be found in Appendix 1. They are placed in the Appendix as they require space to show properly.

Each graph shows the male and female raw death rates for the age group by year. A fitted linear regression is also displayed, one for males and one for females. The same data was used to identify a least squares regression formula using the form of $y = ax + c$, where y is the mortality rate for a given year x and a and c are constants. In this formula x takes the value of the four digit year, for example, 2006.

As the graphs are still a little difficult to see in detail in this format, a table is provided here of the values of a and c for each regression performed.

Age group	Gender	Cause of death	Value of a	Value of c
65-69	Male	All combined	0.00041	-0.79253
		Neoplasm	0.00012	-0.22845
		Circulatory	0.00101	-1.96499
		Respiratory	0.00015	-0.26685
		Other	-0.00005	0.11523
	Female	All combined	0.00027	-0.52104
		Neoplasm	0.00005	-0.10159
		Circulatory	0.00099	-1.90580
		Respiratory	-0.00054	1.08739
		Other	-0.00009	0.20517
75-79	Male	All combined	0.00026	-0.48768
		Neoplasm	0.00015	-0.28734
		Circulatory	0.00078	-1.51143
		Respiratory	-0.00011	0.24210
		Other	-0.00029	0.58696
	Female	All combined	0.00025	-0.47795
		Neoplasm	0.00005	-0.09062
		Circulatory	0.00086	-1.67084
		Respiratory	-0.00053	1.06546
		Other	-0.00031	0.63396
85+	Male	All combined	0.00011	-0.21186
		Neoplasm	-0.00018	0.34908
		Circulatory	0.00062	-1.22107
		Respiratory	-0.00032	0.66237
		Other	-0.00040	0.80721
	Female	All combined	0.00008	-0.15374
		Neoplasm	-0.00003	0.05772
		Circulatory	0.00062	-1.20471
		Respiratory	-0.00028	0.58569
		Other	-0.00058	1.15418

It can be seen from the table above that the slope of the fitted regression line for all causes combined is positive for all ages and genders and decreases with age.

This is not true however for all causes of death for all age groups. In particular, the gradient for neoplasm is less step and for the 85+ age group, the slope of the improvement line is actually negative, for males quite considerably so.

Initially this may appear counter-intuitive to practitioners more familiar with incidence rates and cause of death within a typical life insurance portfolio. The following two graphs for males illustrate

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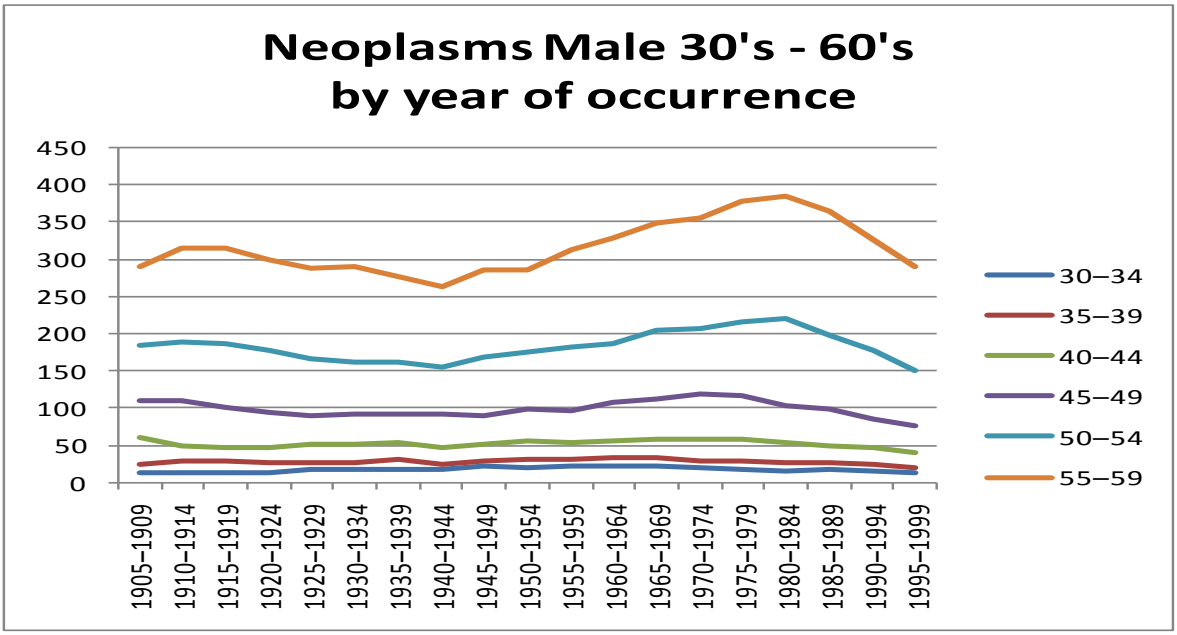
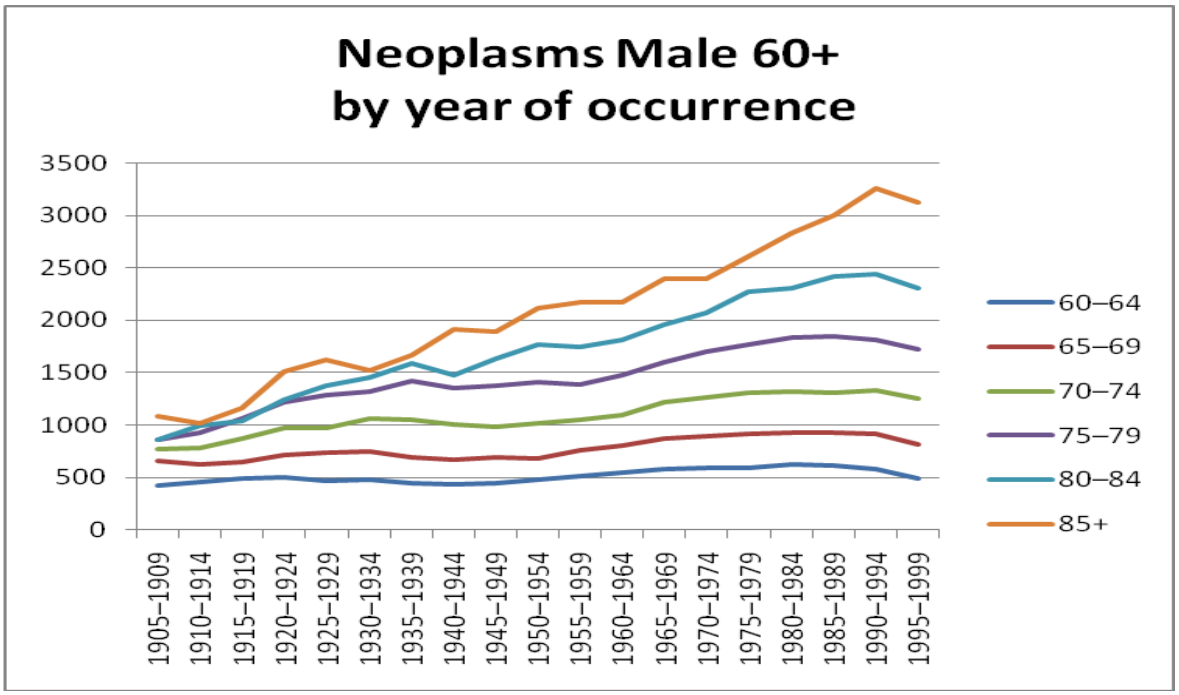
the point that the age specific population death rats for neoplasm are significantly different for 30-60 year olds compared to 60+ year olds.

It is acknowledged that some of this early pattern could be put down to reporting irregularities and classification problems. There is clearly more research and investigation required in this area.





A similar but less pronounced picture emerges with the female data, below.

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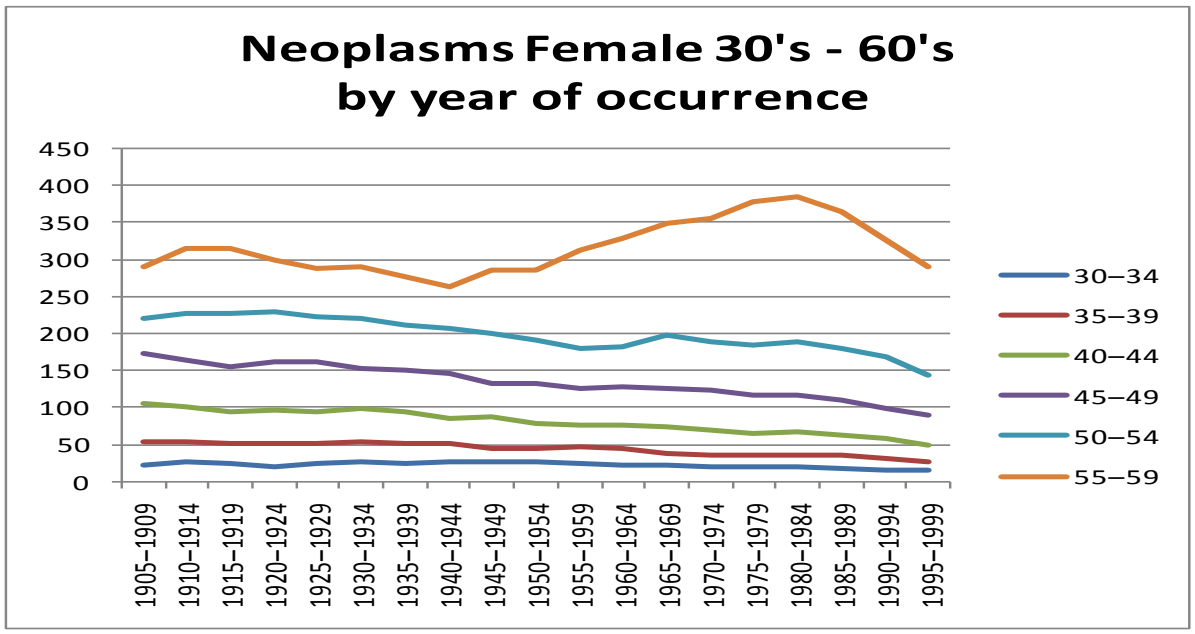

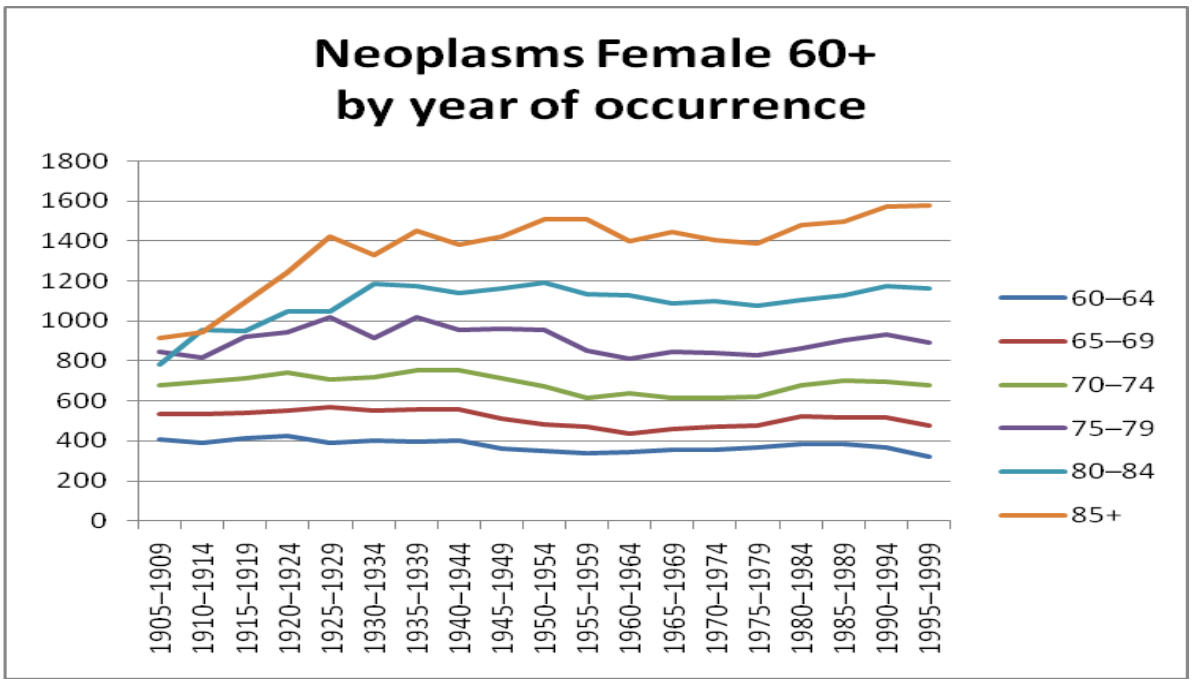

The following graph shows the mortality rates for neoplasm for males and females on the same chart.

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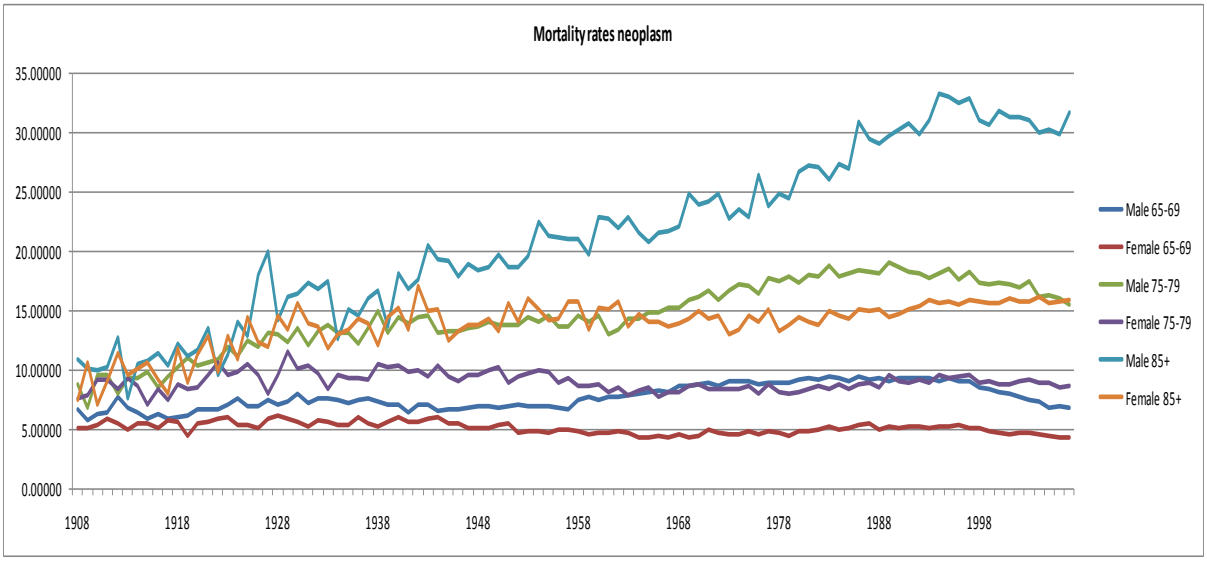

This is a very interesting result. An increase in death rates due to this cause could have been explained by recording issues at earlier dates, more deaths being classified as neoplasm over time as medical advances occurred.

This doesn't continue to hold true, though, in later years where death reporting has improved, and the rates continue to climb at older ages.

One explanation is that people that would previously have died of this or other causes at earlier ages, but for medical intervention, now have to die eventually of something and that increasingly this is cancer as the intervention continues to have results for other causes until some form of neoplasm finally kicks in. Another possible explanation that is not mutually exclusive of the previous one is that the ability to treat cancer has improved greatly for younger ages, but for the older and frailer the treatments are not as successful. Some treatments do place a considerable strain on the body of the sufferer and hence are unlikely to be appropriate for the treatment of the elderly.

If we then look at circulatory, we can see that the slope of the regression is quite large and of a similar degree of magnitude for both genders and across all age groups, with a small tailing off effect with increased age. Thus deaths from circulatory diseases are reducing at an increasing rate.

The slope for respiratory disease is largely negative, but this needs to be combined with the pattern of improvements to provide a picture of what is happening. While there has been a reduction in mortality over time for all ages, the rate of improvement is decreasing over time. Thus mortality is improving for this cause, but at a reduced rate.

Other causes taken together tell a similar story to respiratory disease in that there has been a reduction in mortality over time, but the rate of improvement is now negative, so the improvement is at a decreasing rate.

2.3 Projecting into the future

Having fitted regression lines to the data above we decided to use these to project into the future. We used two methods and compared them.

The first method was to use the combined cause of death data and project the 2006 value to 2050 using the regression parameters for each age group.

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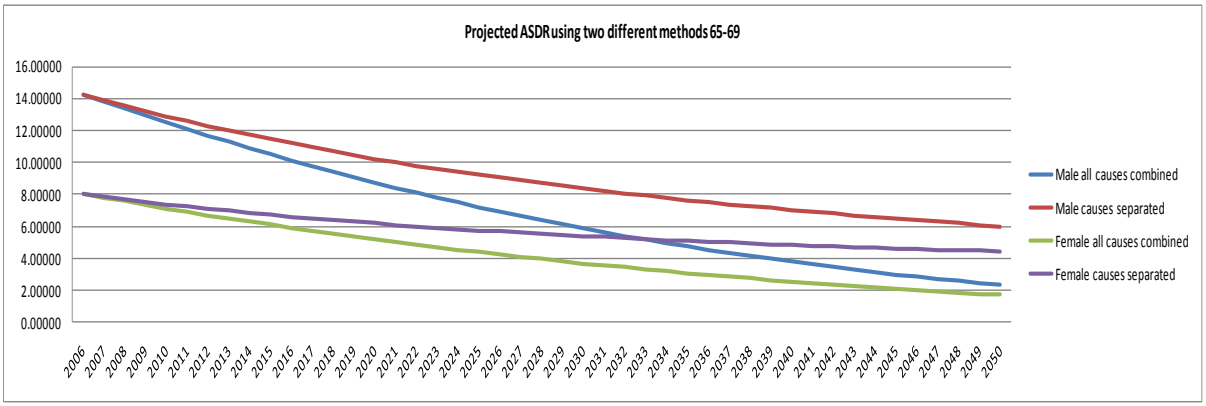
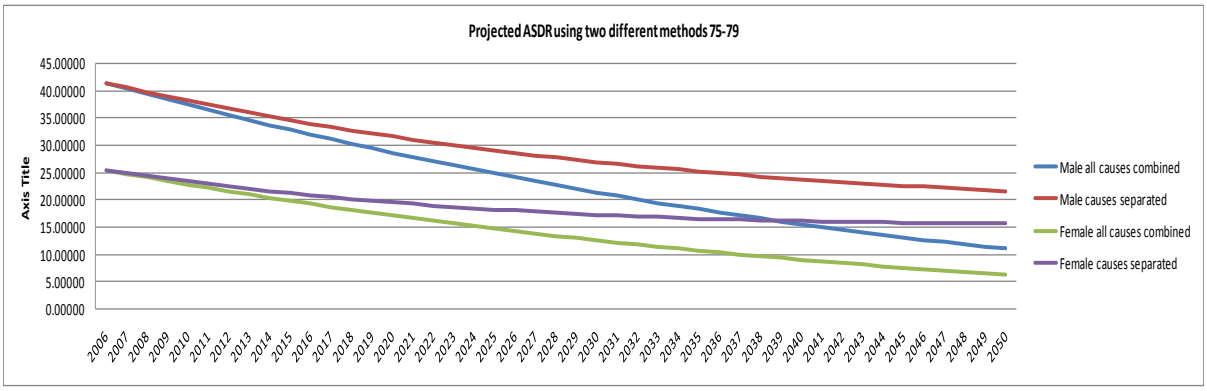
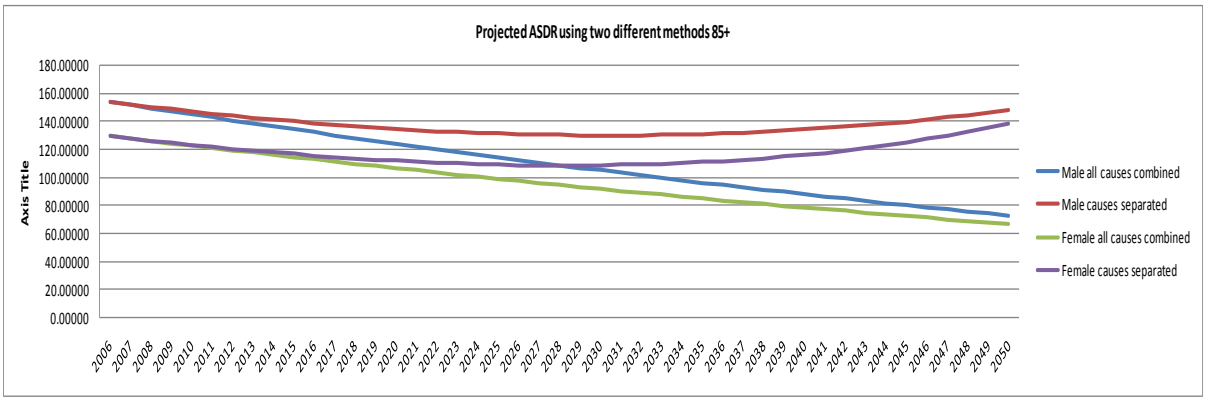
The second method was to use the separated cause of death data separately and project from the 2006 figure to 2050 for each of the main causes and for other separately and then combine the results to give the aggregate mortality rate.

Improvement rates were projected, as these had had the regression fitted to them. The resulting projected improvement rates were then used to obtain projected age-specific death rates (ASDR).

The results of this can be seen in the graphs below:







It can be seen from these graphs that the two methods give very different results. Particularly for the 85+ age group, one result has mortality decreasing over time and the other has it increasing.

The reason that this occurs is that the causes when viewed individually have their own distinct characteristics that are quite different and to some extent mask one another when the rates are taken as a whole.

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To determine the effect that this difference in approach would have, in easy to view terms, we then calculated the expectation of life for several dates both past and projected to identify the difference in behaviour of the results.

To do this we needed to apply the projected mortality rates in a not terribly scientifically rigorous manner. We determined rates for quinquennial age groups 65-69, 70-74, 75-79, 80-84 and 85+ as this was the data we had available.

To calculate the expectation of life (both past and projected) we needed to calculate annual values of l_x using the quinquennial rates available. To do this we started with a radix of 100,000 at age 65. We then applied the $q_{(65-69)}$ for five years, then the $q_{(70-74)}$ for five years and so on. For ages 85+ we applied the q_{85+} rate until the value was <100, whereupon we assumed all died in the following year. While any results using this method could not be used for pricing or any other commercial practice, and clearly the assumption of linearity is neither supported by common sense, the data or any other life table, we are not suggesting that it should be.

However, by applying the only approach available consistently to the data available we hope to at least be able to highlight the difference that have occurred in the past and to contrast the two projection methods.

The results of this exercise are shown in the following table:

Calculated expectation of life			
Male			
	e_{65}	e_{75}	e_{85}
1907	75.52	80.59	87.39
1957	76.55	81.54	88.02
2006	82.94	85.68	90.48
2050 (Method 1)	**93.58**	**94.44**	**96.90**
2050 (Method 2)	**86.15**	**87.63**	**90.73**
Female			
	e_{65}	e_{75}	e_{85}
1907	76.89	81.67	87.84
1957	79.40	82.99	88.70
2006	86.12	87.99	91.67
2050 (Method 1)	**95.62**	**96.32**	**97.85**
2050 (Method 2)	**87.61**	**88.94**	**91.19**

The difference the method makes can be clearly seen by the two distinctly different results for 2050 given above.

The conclusion is that one needs to be very careful when projecting improvement rates as there could be inbuilt interactions and bias present within the rates that can affect the results.

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3. Living to 100 symposium - program

Every three years the Society of Actuaries in the USA convenes this symposium where all people interested in the effects of longevity can gather to discuss topical issues. This is not simply an actuarial event; representatives from a wide range of professions are involved and present and attend papers on this subject.

Our group has been reviewing the sessions and papers of the most recent symposium (2008). To enable practitioners in Australia to gain an overview of what is happening in this fast moving research area we have compiled the following table to provide a quick guide to the symposium.

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3.1 Table of papers presented to Living to 100 symposium 2008

Name	Address
General Session 1	**Implications of longer life spans: What does this all mean to us?**
No papers – transcript of discussion	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-g1-rappaport.pdf
Session 1A	Distinguishing health status for advanced ages
Perspectives on a Changing Global Retirement Paradigm	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-1b-andrews.pdf
Micro Pension Plan: Indian Perspective	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-1b-bhattacharya.pdf
Retirement and Retirement Ages in Canada Revisited	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-1b-burnell.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-1b-discussion.pdf
General Session 2	Social Insurance Perspectives and Implications
Mortality Projections in the United Kingdom	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-02-gallop.pdf
Mortality Projections for Social Security Programs in Canada	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-02-menard.pdf
Mortality Projections for Social Security Programs in the United States	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-02-wade.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-02-discussion.pdf
Session 2A	Demographic Implications of Aging Populations Internationally
Challenges on Improved Life Spans in India—the Actuarial Implications	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-2a-subramanyan.pdf
Economic Sustainability of Retirement Pensions in Mexico: Is There a Link with the Mexican–Origin Population in the United States?	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-2a-chande.pdf
New Findings on the International Relationship between Income Inequality and Population Health	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-2a-brown.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-

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Name	Address
	li08-2a-discussion.pdf
Session 2B	Emerging definitions of retirement
No papers – transcript of discussion	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-2b-rappaport.pdf
General Session 3	Theories on aging
The Biology of Human Longevity, Aging and Age–Associated Diseases	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-03-hayflick.pdf
Is There a Limit to the Compression of Mortality?	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-03-cheung.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-03-discussion.pdf
Session 3A	Social Insurance Follow–up Methodologies and Implications
No papers – transcript of discussion	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-3a-gutterman.pdf
Session 3B	Quality of life of elderly
Living to 100—A Woman's Issue	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-3b-rappaport.pdf
Evaluation of Approaches to Reducing Women's Longevity Risks	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-3b-orth.pdf
Estimates of the Incidence, Prevalence, Duration, Intensity and Cost of Chronic Disability among the U.S. Elderly	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-3b-stallard.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-3b-discussion.pdf
General Session 4	Compression of morbidity
Is the Compression of Morbidity a Universal Phenomenon?	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-04-cheung.pdf
Session 4A	New models of advanced age mortality
Inference for Logistic–type Models for the Force of Mortality	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-4a-doray.pdf
Predictive Modeling for Advanced Age Mortality	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-4a-guo.pdf

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Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-4a-discussion.pdf
Session 4B	Mortality measurement and prediction
Mortality Measurement at Advanced Ages: A Study of the Social Security Administration Death Master File	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-4b-gavrilov.pdf
Typology and Review of Measures of Human Aging, Longevity and Superlongevity, with Applications to U.S. Data and Some Implications for U.S. Public Programs	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-4b-siegel.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-4b-discussion.pdf
Session 5A	Longevity risk pricing
Living to 100: Survival to Advanced Ages: Insurance Industry Implication on Retirement Planning and the Secondary Market in Insurance	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-5a-ranasinghe.pdf
Longevity Risk Pricing	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-5a-cui.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-5a-discussion.pdf
Session 5B	Prediction from data
Data Validation and Measurement of Cohort Mortality among Centenarians in Quebec (Canada) According to Ethnic Origin	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-5b-bourbeau.pdf
Physical and Socioeconomic Characteristics at Young Age as Predictors of Survival to 100: A Study of a New Historical Data Resource (U.S. WWI Draft Cards)	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-5b-gavrilov.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-5b-discussion.pdf
Session 6A	Projection and Statistical Modeling of Mortality at Late Age
On Simulation–Based Approaches to Risk	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-

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Name	Address
Measurement in Mortality with Specific Reference to Binomial Lee–Carter Modelling	li08-6a-haberman.pdf
A Study of the Lee–Carter Model with Age–Shifts	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-6a-huang.pdf
Testing Deterministic versus Stochastic Trends in the Lee–Carter Mortality Indexes and Its Implications for Projecting Mortality Improvements at Advanced Ages	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-6a-chan.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-6a-discussion.pdf
Session 6B	Health Status and Its Impact on Mortality
Health Expectancy	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-6b-albert.pdf
Human Behavior: An Impediment to Future Mortality Improvement A Focus on Obesity and Related Matters	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-6b-gutterman.pdf
Health, Wealth and Wisdom—Living Long, Living Well: An Actuary Muses on Longevity	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-6b-cowell.pdf
Discussion transcript	www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-6b-discussion.pdf

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3.2 Reviews of selected sessions from the Living to 100 symposium

General Session 1

There was no paper presented to this session, as it was designated as a discussion session.

One of the first interesting things that were identified was the difference in makeup of the audience from the previous symposium as a much greater percentage of people were now involved in product work.

While this could be because product people haven't attended in great numbers before, from the flavour of the conversation I gained the impression that it was a shift in work focus from the industry.

The process of the discussion was very ably described by Anna Rappaport as:

"So I'd like to start with the panel introducing themselves and who their stakeholder is and just a little bit about the issue from that point of view and then we're going to have two rounds of going around the panel. The first round after we finish the introduction round, they'll be talking about opportunities and pitfalls, the challenges to their stakeholder group and what they might do. And our five stakeholder groups are the individual, what people do, the customers of all the people that make these products, and then we'll have the employer and then we're going to have life insurance and annuities. We're going to have long-term care, thinking about both insurance products, but also about how do we provide it in health care and our panelists, after they introduce their stakeholder, will introduce themselves and what they do as well."

The huge challenge that is being faced in America is that there is a considerable accumulation of lump sum savings that is going to need to be managed to provide for the rest of the long lives of individuals. Another big issue is the retreat of employers from retiree medical plans.

Us research has recently found that the average amount required for retiree health costs is $US100,000. Also, there is some emerging research that the longer that people remain in active employment the healthier they are and the longer they live. Other SOA focus group research has indicated that individuals are still planning very short term.

There is a pattern that companies have left the field once products became expensive to provide. The result is that the individual is being left to manage their own retirement, often by retiring later.

Some providers are managing the accumulation stage and there are some products that manage the decumulation stage, but there seems to be no linking between the two stages.

There is also a good discussion on health care, insurance, long-term care and supply and demand of the health industry.

The personal view of the reviewer was that the paper was a good read for someone interested in understanding the issues being faced in the US, not dissimilar to here, and where the industry is at in recognising and responding to these issues.

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Session 2A

Three papers were presented in this session. This review looks at each paper in turn. The first paper is:

Challenges on Improved Life Spans in India—the Actuarial Implications

India faces some of the same problems that we do, increasing longevity and a lack of available data. They have the added problems of a social security system that can't cope, a different demographic with a large younger population and a much grander scale.

Life expectancy calculations have been carried out on census data and the result is that India is travelling a similar path to America and Europe, but at a lag of about 50 years.

The paper explores the different approaches to tracking and projecting mortality rates at high ages and discussed the ability of the different approaches to be used in the Indian context.

A very good overview of the Indian Social Security system and the agencies involved is provided.

The paper concludes with a proposal to try different ways to estimate mortality at high ages in India and a recommendation that the Social Security system needs a revamp.

The second paper from this session is:

Economic Sustainability of Retirement Pensions in Mexico: Is There a Link with the Mexican–Origin Population in the United States?

This paper looks at the interaction between the Mexican-origin population in America and the Mexican population and the effect this is having on Mexico demographically and societally. With a lower birth rate, increasing life expectancy and emigration of the working/reproductive aged populations Mexico is facing a rapid greying of the population.

The issue that Mexico is facing is very interesting. They have a rapidly changing demographic; the index of aging (how many persons over 65 for each 100 under 15 years) has moved from 6.3 in 1930 to 14.5 in 2000 and is expected to be 167 by 2050. This compares to a similar statistic for Australia (2009) of 69.6. The highest growth rate in the over 65 age group is in the oldest-old in Mexico.

They are also different to Australia and other developed economies as we have had the ability to grow our social infrastructure while the population was aging. Mexico finds itself in the position of essentially starting much of this process with a mature population.

A significant flow of funds goes from the US to Mexico in the form of remittances to the families of US workers of Mexican origin.

The author suggests that the best way for the Mexican government to manage their way through this situation in the coming years is to use the productivity that it has at present (while the dependency ratio is relatively low) to put the social infrastructure in place to allow it to support the changed population of the future.

New Findings on the International Relationship between Income Inequality and Population Health

This paper investigates the hypothesis that a negative correlation exists between income inequality and population health level. Further, it looks into that correlation by age group and gender.

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Previously, similar studies found such negative correlation did exist. The basis of the proposition is based on the absolute income and health relationship. Increase in income level is associated with improved health level. The marginal increase diminishes with level of income. So, for a given average income level, it will always increase the average health level by redistributing the income from richer to poorer. The paper is divided into a number of sections:

Objective

- Test the hypothesis that higher level of income inequality is directly related to lower levels of population health.
- Examine the above hypothesis by age group and sex, with focus on retiree age + when income distribution shift dramatically.

Data

Some data sources could be useful for future research:

- Population health data come from the United Nation Demographic Yearbook which covers over 230 countries. It can be derived obtained from : http://unstats.un.org/unsd/demographic /products/dyb/default.htm
- Income data come from WaveV of the Luxembourg Income Study (LIS) around year 2000. It covers 30 countries.

Methodology

Income inequality is measured by the Gini Ratio, which ranges from zero (perfect equality) to one (perfect inequality). A person correlation coefficient was used to measure the relationship between income inequality and life expectancy at each age and sex. Coefficients were calculated before and after adjusting for average absolute income, correlation results are weighted by population size from the LIS member countries. Then the correlation analysis was performed on both more wealthy LIS members and all LIS member countries.

Results

- Overall the data for wealthy nations do not support the hypothesis.
- Statistically significant negative correlation exists for infant age group, largely due to infant mortality.
- The association between income inequality and life expectancy at age 0 and 25 for both genders become statistically insignificant after controlling for average income.
- The analysis shows positive correlation for retirement age + group, but not statistically significant, before or after adjusting for average income.

Reviewer comments:

Intuitively the hypothesis is theoretically sound. There isn't any statistical significance except for infant age group for wealthy countries perhaps due to diminishing marginal gain health level at higher absolute income level for these countries.

Positive correlation for retirement age+ group is counterintuitive, it could be due to some data issue e.g. not including old age social security income and various other non income based benefits provided to older people.

The correlation between income and health is weaker for developed countries.

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Session 2B

A panel discussion addressed various inter-related questions. The main points arising from this are below:

What is meant by the new retirement?

Definitions of 'phased retirement' include:

flexibility of place, schedule and duties with people doing what they want to do, versus a full-time commitment;
getting to do what you really want to do, whether paid or voluntary work – it is the chance to make and define what you want to do;
when some form of non-employment income is received, e.g. state pension, or a switch from full-time to part-time work for those with the means to do so, but for many others it will have to be a continuation of full-time work.

It is likely to differ markedly depending on the socio-economic and health status in question.

Populations are not homogeneous, so those retiring as part of a connected family may make very different decisions around that compared to single people.

For individuals, what is important within the new retirement, in terms of financial, health and social wellbeing?

The goal should be long life, health and prosperity rather than 'retirement'. The desire is for someone's 'health span' to be close to their 'life span', with the important determinants for this including eating well, maintaining physical activity, managing stress, not smoking, continuing mental activity/exercise and meaningful interaction with family and friends.

The latter point is highlighted - it is vital to remained engaged with the community, involving a mix of activities which may change over time. Loneliness kills faster than cigarettes – 'retirement' should be whatever it needs to be to keep people involved, connected and contributing to their community;

In terms of purposeful work and activity, this should start before retirement – finding out what you really want to do so that moving into "retirement" involves little transition at all.

Financially, general rules of thumb from some financial advisors are that you need assets equal to 20-25 times your required annual income and then would draw down 4-5% of this per year. There is a great deal of uncertainty around these estimates, an individual may need a lot less than this, or may need a lot more.

It is hard to make inroads with the products that are currently available. For example immediate annuities, where returns may be higher, but disincentives can exist with means testing of state pensions, etc. Either way the cost of inflation-proofing future income is significant.

Cost of health care in retirement is growing significantly – an average couple aged 65 retiring today may need $200,000 - $500,000 for out of pocket health expenses. Compare this to the average 401(k) balance of $100,000 for those in their 50s and 60s!

What are the public policy or societal options for managing the fiscal and social strains of retirement?

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The three obvious options are to save more, work longer or be poorer in retirement. The third is not an option for most people/societies. Therefore a range of other options have been suggested:

- Push back the ages at which Social Security is available;
- Finland has a defined benefit system where accrual rate increases with age (1.5% from 18-52, 1.9% from 53-62, 4.5% from 63-67). This is likely to have a significant impact on early retirement;
- Make similar incentives within the taxation basis – for example Germany, where there are different rates on the public pension dependent upon the age. Retiring at age 70 – 21%; 65 – 27%; and 55 – 38%;
- Will there be a labour shortage, and if so, how to shape employer attitudes to phased retirement options and extended working lifetimes?
    - Need employers to be open to hiring older workers, despite preconceptions about their inability to learn new skills (particularly technological) and their propensity to be sick more often;
    - The important factors seem to be more flexibility, fewer hours, enjoying your work, working from home but all this is in direct contrast to most working trends in the US.

How are we impacted by increases in longevity?

- Longevity has been increasing for 50 years but from 1950-1995, retirement ages decreased for men and women across OECD countries, though this has increased slightly since 1995;
- In 1950 in the UK 17% of the working life was spent in retirement. In 2005 this was 31%, and it is this that is putting pressure on the retirement systems, which were designed to cope with the 17%;
- Not only has longevity increased but there is also more uncertainty about those increasing lifetimes. For example there are very strong cohort effects leading to heterogeneity within the population, e.g. 'golden' generation born around 1930-1940 having lower mortality than those in surrounding years;
- Most people vastly underestimate their expected lifetimes in retirement – two examples given of UK schoolteachers and Boeing engineers;
- Long term insurance providers impacted adversely by otherwise healthy people living a long time but contracting Alzheimer's and then being put into specialized care;
- The continued move to defined contribution systems is inevitable. But, how do you build in protection against loss of employment, minimum (floor) levels of protection and universal health care?
- What do you need to live on in retirement? Arguably less than when working but who knows?

General points from US SOA surveys and research

- Pre-retirees expect to retire totally differently from current retirees;
- A major risk is 'premature risk' – planning to retire at 70 but something happens at age 58 – job loss, sickness, family member gets sick. 40% of Americans retire before they planned to;
- Those retired define retirement as retiring from their primary occupation;
- From 2007 data - 77% retire before 65 and 31% before 55. Of those not retired yet, 29% expect to retire by 65 and 32% say retirement doesn't/won't apply;
- Many expect to have income from sources other than social security but do get most of their income from social security once retired. This is particularly so when a spouse dies - widows are worse off after death of their spouse. 40% of widows over 65 have only social security to rely on, and no other financial assets;
- Phased retirement will increase in the future but to meet retirement needs only 11% have/would buy long-term care insurance.

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General Session 3

This session was devoted to theories on aging and two papers were presented. These are reviewed below:

The Biology of Human Longevity, Aging and Age–Associated Diseases

This paper was written by a professor of anatomy and takes a different look at aging, death and disease to most actuarial papers. This is not to say it isn't interesting, though.

There are a lot of complex words and sentences in this paper, which does make it a little difficult to plough through, although it is only 10 pages long.

The essential premise of the paper is that if we managed to resolve all the causes of death found on death certificates this would still only result in a life expectancy at birth of around 93 years. The author then goes on to propose that the largest risk factor for death and disease is aging, so why is so much work (and research funding) going into resolving the former rather than the latter?

From an actuarial point of view, though, the difference in cost of an increase in life expectancy at birth from 78 or so to 93 is massive.

The paper looks first at the aging process and talks about aging as a process of systemic weakness and consequently failure and why, therefore, failure of a particular type occurs with people with genetic similarities. This type of process is seen as a random process.

The determinants of longevity are then reviewed. This process relates to the health of cells at the time of reproductive maturity and the bodies processes for cell maintenance and renewal. This is not a random process and is governed by the physiological reserve available at reproductive maturity.

The third aspect that is looked at is age-associated diseases. The aging process is not a disease, but it increases vulnerability to disease.

Is There a Limit to the Compression of Mortality?

In 1980 James Fries predicted (after significant study):

"Thus, under ideal conditions, 66 per cent of natural death would occur in persons 81 to 89 years and 95 per cent in persons 77 to 93 years"

His premise for this was that there was a limit to the ultimate life expectancy in humans and that as the modal age at death (M) increased there would be a reduction in the standard deviation of age at death above this modal value.

This paper provides the results of a study of 5,000 life tables covering 26 countries and maps the modal age at death and standard deviation above the mode.

The results of this work shows that there is a compression with increasing M. However, it has also shown that M has increased already above that predicted by Fries as the ultimate M (85 years) with M for females in Japan, France, and Switzerland already over 90. Fries also estimated an ultimate SD of 4 years. The study has shown that the compression around the mode is in actuality not as great as that identified by Fries, even though M is much higher already than his ultimate value.
There are a number of graphs that illustrate actual experience versus expected. It can be seen on these that Fries expected a much higher value (50,000) at M than actual experience with a greater

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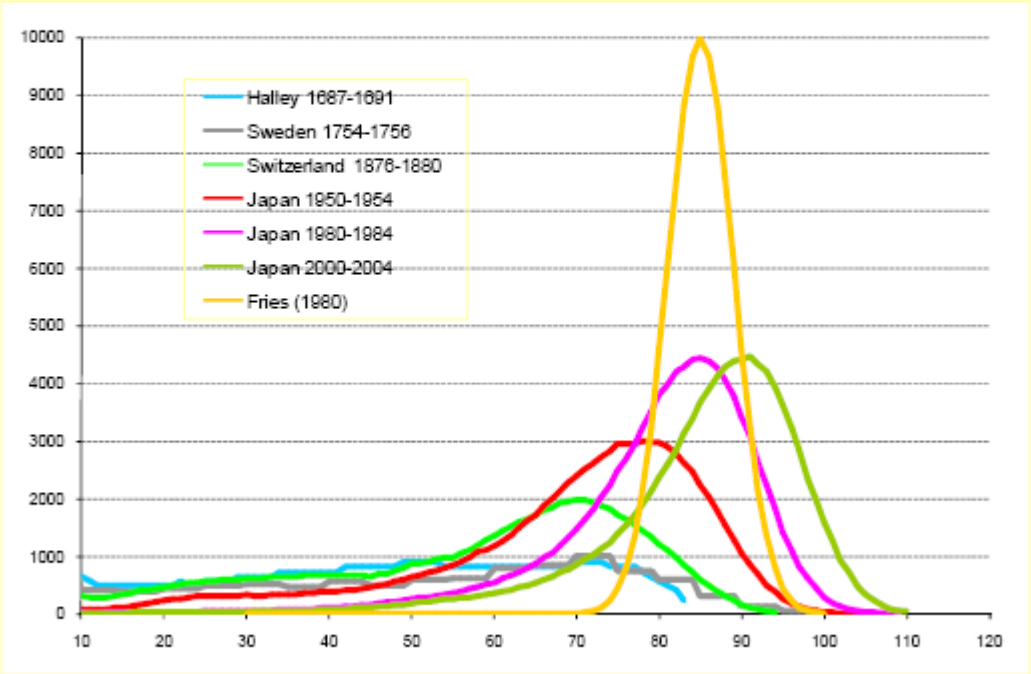
contraction. What seems to be happening is that although the distribution is contracting to some extent, the large pattern is a shift to the right.

The result in practice is that there is a much greater increase in the oldest old than expected.

Section 5 looks at the different shapes of mortality curves at different times through history. This section includes, and describes, Graph 5, which is really worth a look, so I have reproduced it here:

GRAPH 5

Distribution of Adult Life Durations: Selected Empirical Data 1687-2004 and the Hypothetical Pattern Predicted by Fries



Consider what happens to Japan 2000-2004. Prior to this time the graphs followed the pattern predicted by Fries, but when this one is added there is a clear right shift, rather than a compression.

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Session 4A

Both papers discuss the use of new statistical models for mortality projection. Both papers are highly technical in nature i.e. full of statistical notations and formulae (!) with emphasis on the derivation of formulae and ways to estimate the required parameters. The target audience would be academics and practitioners in mortality projection modelling.

Inference for Logistic-type Models for the Force of Mortality, Louis G. Doray, PhD, ASA

The paper proposes least-square methods, which can be done using any regression software, to estimate the parameters in two logistic-type models - Kannisto's and Perks' models. These two models are perceived to provide better fit to experience at ages over 85 than the traditional actuarial models like those of Gompertz and Makeham. The author then applies the models and the parameter estimates to Canadian mortality data for ages over 80. The Kannisto's model and the OLS (ordinary least-squares) estimator prove to generate excellent fit for ages 80 to 100.

Predictive Modelling for Advanced Age Mortality, Lijia Guo, PhD, ASA, MAAA

The paper applies predictive modelling tools to mortality data. Using the Decision Trees method, the paper shows how the most significant predicting variables can be identified and selected. These variables (risk drivers) include demographic characteristics, social and economic status and behavioural factors. GLMs (Generalised Linear Models) are then introduced and applied to mortality analysis. One interesting section of the paper is the development of Mortality Risk Score, which is represented by a table showing the key risk drivers and their respective multiplicative factors/weights in rating a particular risk. For Australia, one major drawback of the proposed Predictive Modelling is the requirement for a statistically significant volume of experience data.

Session 4B

Not reviewed.

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Session 5A

Two papers were presented as part of this session.

Living to 100: Survival to Advanced Ages: Insurance Industry Implication on Retirement Planning and the Secondary Market in Insurance (Jay Vadiveloo, Peng Zhou, Charles Vinsonhaler, and Sudath Ranasinghe)

This paper has two main parts, the first of which is a relatively strong statement about optimizing one's financial position at and through retirement.

Developing a framework to justify an "optimal" investment portfolio for retirees, in order to best manage their longevity risk.

The assumptions/constraints underlying the optimization include:

Maximizing current spending levels at retirement;
Maximizing estate value at death;
A fixed initial level of retirement assets;
Subject to a minimum probability of ruin.

The paper demonstrates that an allocation of assets between immediate annuities and investment products is a "better" strategy than allocating all of a retiree's assets into investment products. It highlights that some investment and mortality assumptions used are typically not apparent in practice, but nevertheless the case is made that the maximization of income and estate levels is possible through the adoption of a certain level of immediate annuities. It suggests that for most levels of initial assets, the optimal mix incorporates 25-45% of immediate annuity products, far in excess of the current levels of 2-4%.

Additional insurance products are suggested to create a complete retirement strategy:

Declining 1 year term insurance to cover the gap in estate value for death prior to life expectancy;
A deferred immediate annuity which starts making payments beyond life expectancy (a significantly cheaper alternative to cover the longevity risk compared to an immediate annuity);
A layered immediate annuity strategy which purchases a layer of immediate annuity protection each year until life expectancy.

Discussion of the need for a pricing model for the secondary market of life insurance.

It highlights the main issue in pricing within the market, that being the lack of an impaired lives mortality table. Alternatives to this are discussed, with the goal to develop some sort of 'disciplined approach to measuring and quantifying the risks".

Longevity Risk Pricing (Jiajia Cui)

This paper develops techniques (equivalent utility) to determine estimates for pricing / risk margins for longevity risk products, after reviewing theoretical approaches to this problem. It also reviews shortfalls of previous longevity securities and reasons for their lack of success to date (e.g. the EIP/BNP bond launched in 2004).

In order to determine estimates for pricing / risk margins for longevity risk products, it adopts the Lee-Carter approach to modelling mortality, but does not seem to pick up on the various pitfalls of

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that approach (e.g. that a large portion of 'risk' in the projection arises from estimation error). The longevity products which it derives minimum risk premium for are:

Coupon-based longevity bonds, concluding that the premium for this depends on the financial position of the insurer.
Deferred longevity bonds.
Longevity floors and longevity caps.

It investigates the impact of involving 'natural hedging', where holding term insurance policies in conjunction with immediate annuities impacts the risk premium of the longevity bond issuance company. The impact is that the risk premiums are more than halved compared with the case without natural hedging.

Basis risk is also investigated, where the annuitant population of the annuity provider is not the same as the reference population that the bond (coupon payments) is linked to. The presence of basis risk also impacts the risk premium.

Overall the paper's aim is to impact design implications for longevity-linked securities and longevity risk management, and it develops the beginning of a theoretical base for doing so. It seems to be light on application however and may not lend itself to immediate practical application, though it would provide useful reference and reading for those looking into this area.

Session 5B

Not reviewed.

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Session 6A

This session involved the presentation of three papers:

On Simulation–Based Approaches to Risk Measurement in Mortality with Specific Reference to Binomial Lee–Carter Modelling Steve Haberman and Arthur Renshaw
A Study of the Lee–Carter Model with Age–Shifts Jack C. Yue, Sharon S. Yang and Hong–Chih Huang
Testing Deterministic versus Stochastic Trends in the Lee–Carter Mortality Indexes and Its Implications for Projecting Mortality Improvements at Advanced Ages – Ed Lew Award Winner – 2nd Place Wai–Sum Chan, Siu–Hang Li and Siu–Hung Cheung

The Lee-Carter model has become an unofficial standard model used for projecting mortality in later ages. The original Lee-Carter model uses time series models and each of these papers represents an alternative modified approach to the original Lee-Carter model.

The first paper is mainly concerned with uncertainty and confidence intervals when using Lee-Carter type models. It is a highly technical paper and primarily compares the original Lee-Carter model to a Linear Poisson model with one or two parameters. This technical comparison is then applied to UK pensioner mortality.

The technical conclusion to the analysis was that you have less uncertainty with the proposed version of the Linear Poisson model, which will be a somewhat controversial statement given that the Lee-Carter model is probably the most widely used statistical model in this field. However, the paper and the associated discussion raised a number of more qualitative points that would lead to the opposite conclusion.

Therefore, this paper would be recommended for a practitioner with an already good working knowledge of the Lee-Carter model that wants additional understanding around how this model compares using maximum likelihood methods under a generalised linear modelling framework.

The second paper looks at the issue of parameter change over time in the Lee-Carter model. The standard model assumes constant key parameters which are not supported by empirical evidence. The authors propose an advance over the original model by assuming that the key parameters change after a cut off period. They then illustrate the point with four countries (Britain, Japan, Taiwan and the United States) where different parameters were chosen for the period 1947-1970 and 1971-2003.

The authors then test the resulting goodness of fit against the unmodified Lee-Carter model and show that their proposed model has smaller estimation errors, validating their assumption of a change in pattern of mortality improvement from 1970.

The third paper also discusses the Lee-Carter model.

The Lee-Carter model assumes that the central death rate for all ages is driven by a single time-varying component which is commonly referred to as the mortality index. The paper looks at whether the mortality indexes for Canada, England & Wales and the United States are best described by stochastic or deterministic models. The conclusion is that broken trend stationary (deterministic) models give the best empirical results. The paper also shows strong statistical evidence that the rates of mortality decline for the three populations have significantly accelerated in the mid-1970's.

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Conclusion

There are a number of comments and observations that were made in this symposium that may be of personal interest:

Improving diet, exercise and health can reduce risk of death by up to 50%
Retirement is a large risk factor for death, some of this is because ill people have to retire, some because retirement reduces social interaction, self esteem and activity.
Retirement needs to be defined carefully – a different career on a voluntary basis is now seen as not being retired, as the mortality rates between this group and the really retired vary enormously.

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4. Bibliography

The papers of the 2008 Living to 100 Symposium as identified in the table in the text of this document.

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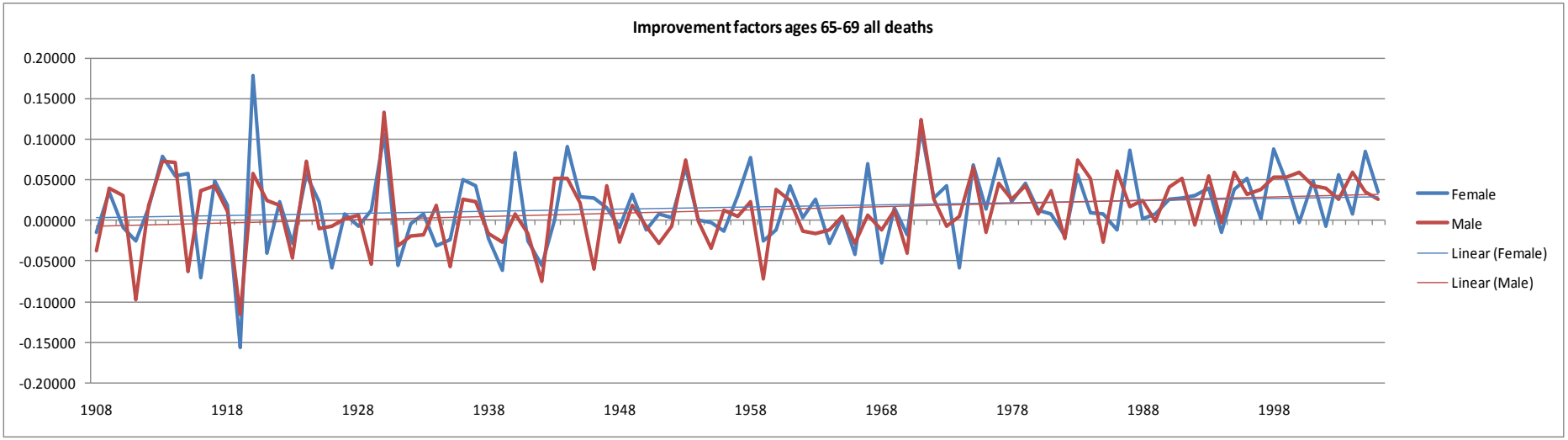
5. Appendix 1 – Improvement factor graphs



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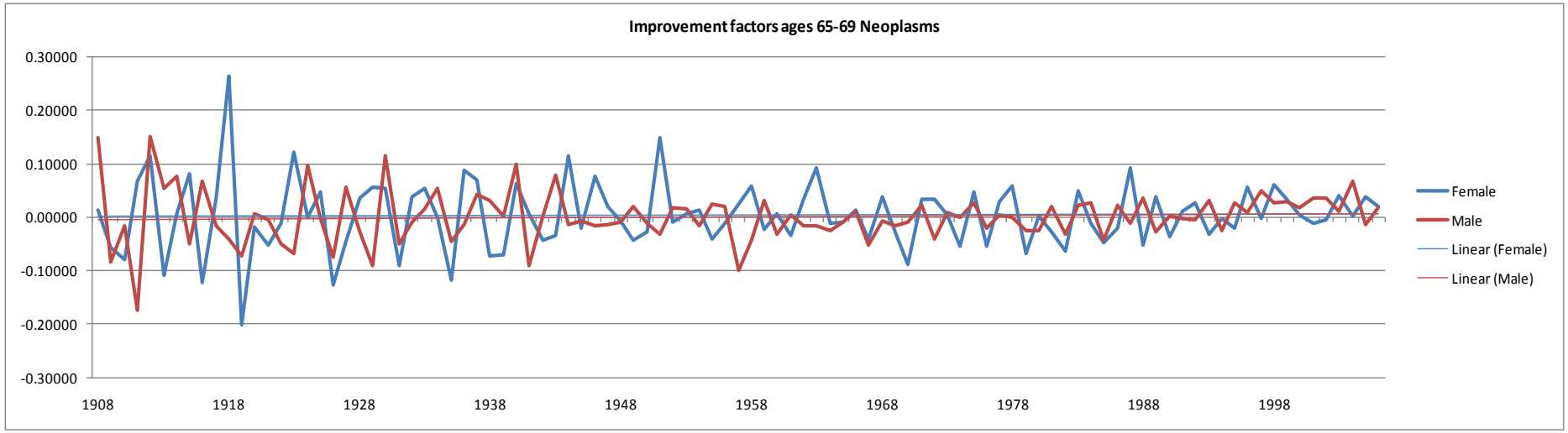

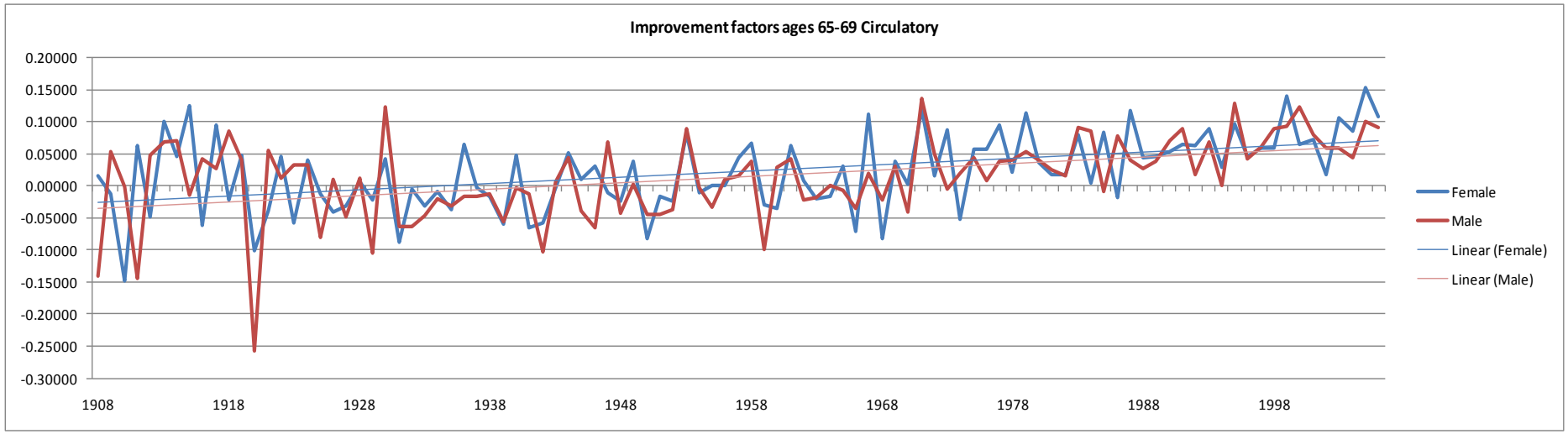

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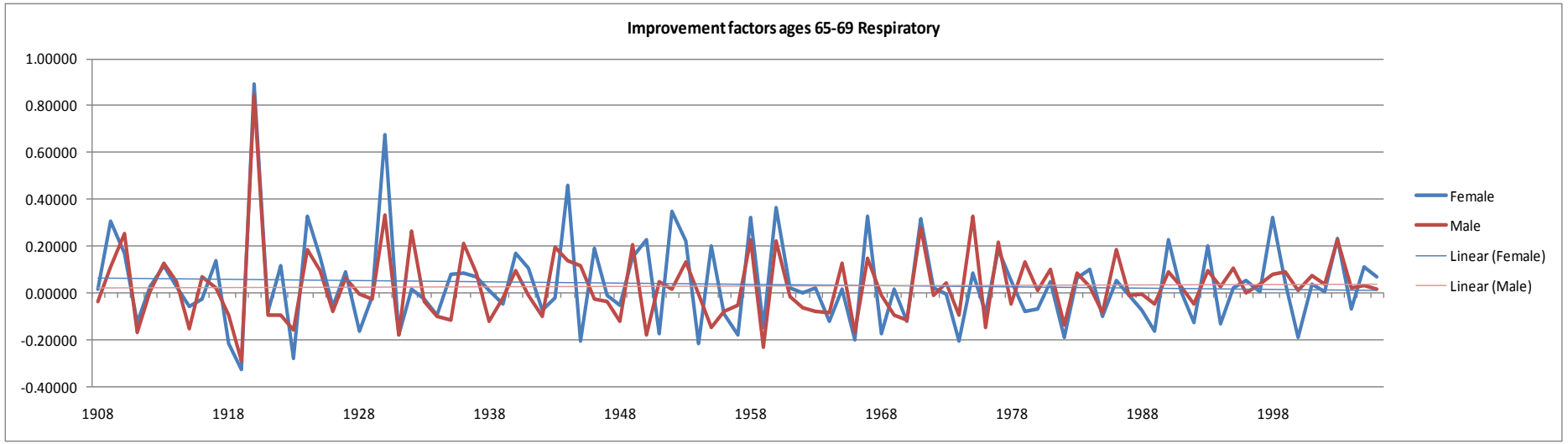

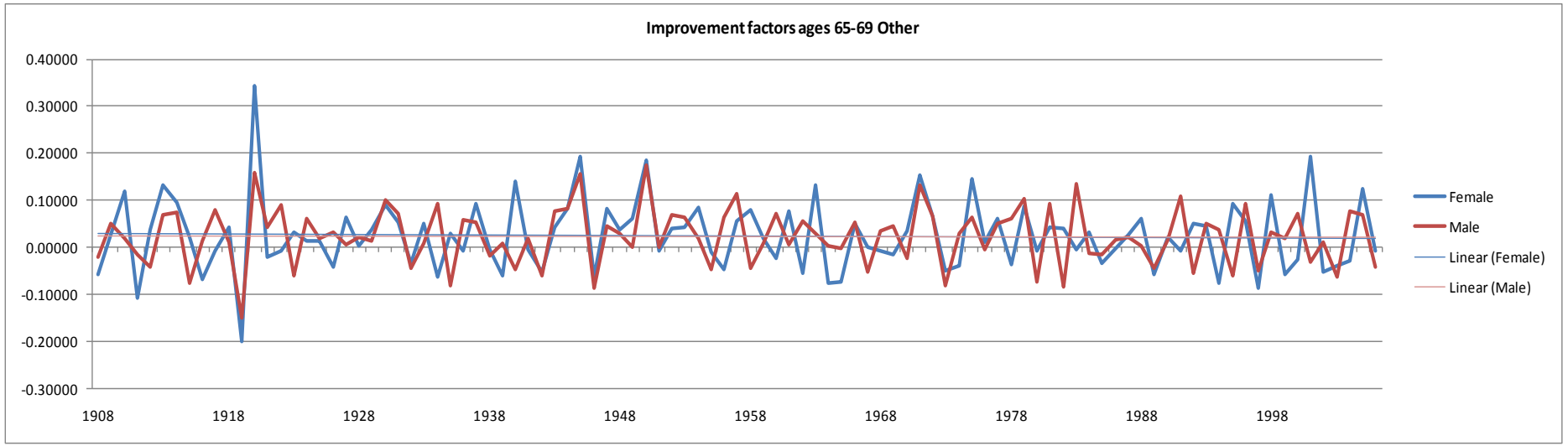

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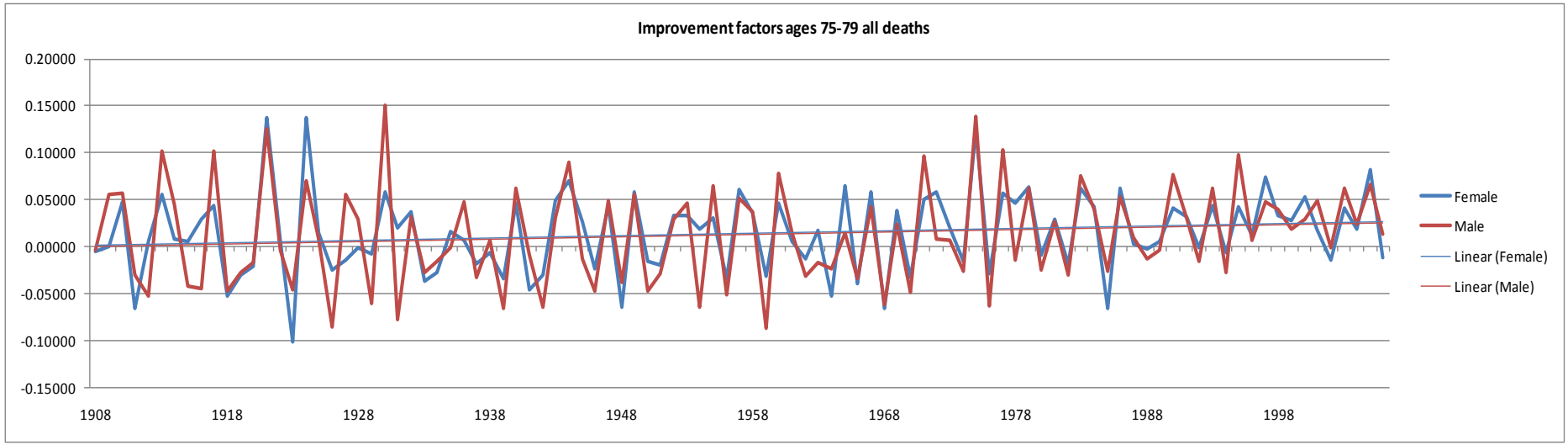

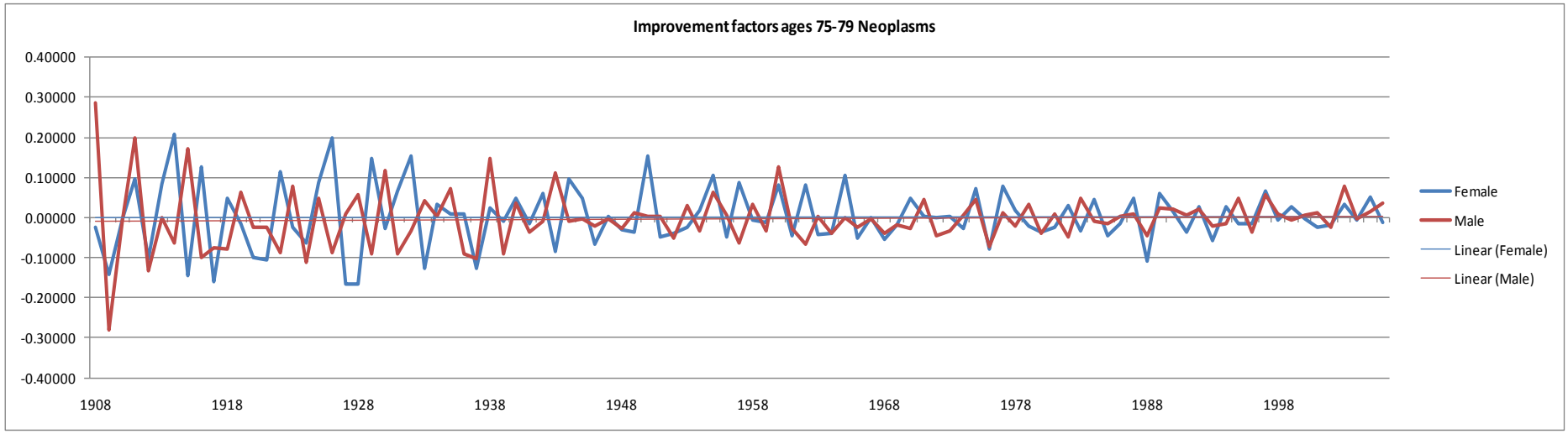

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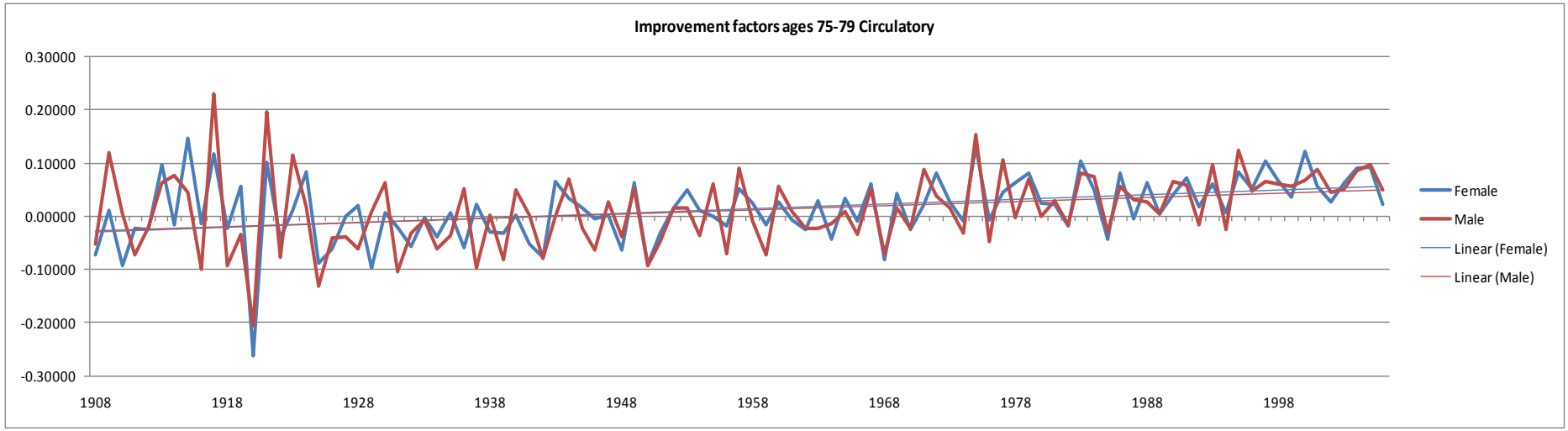

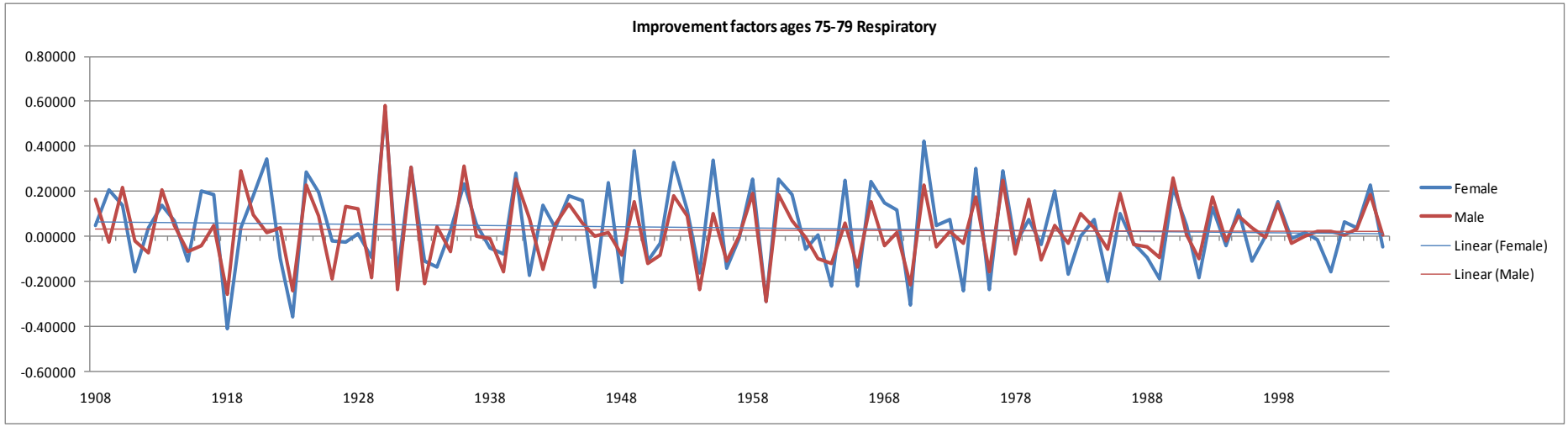

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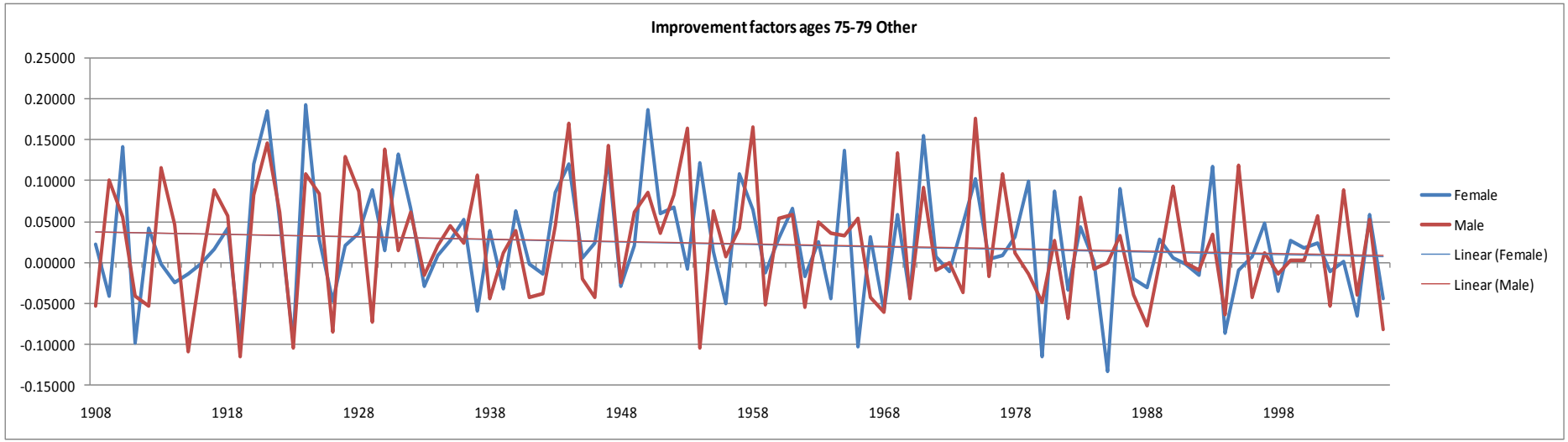

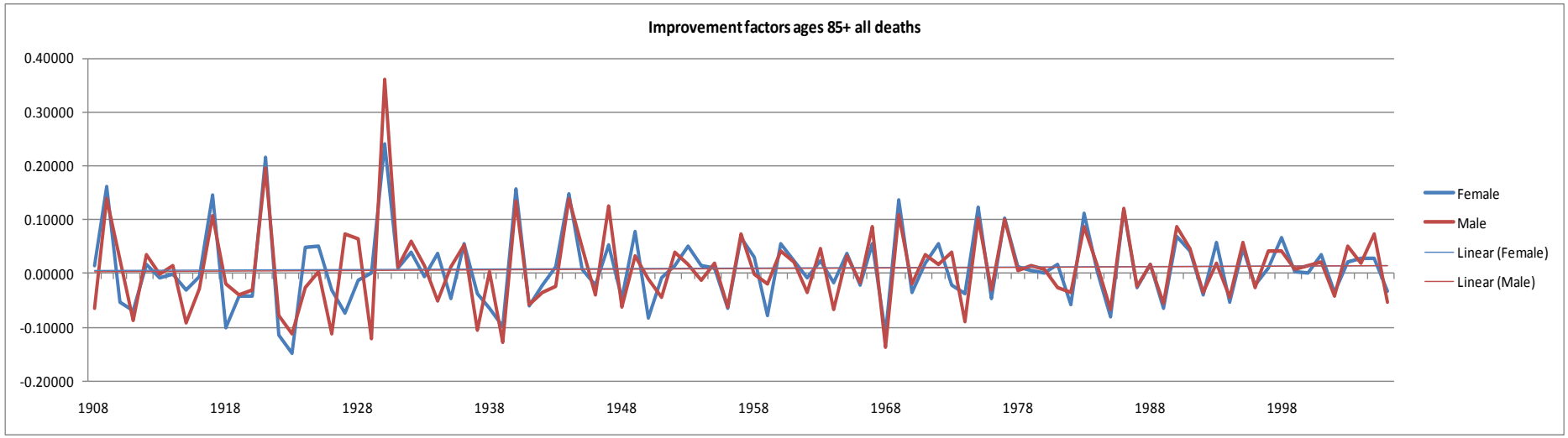

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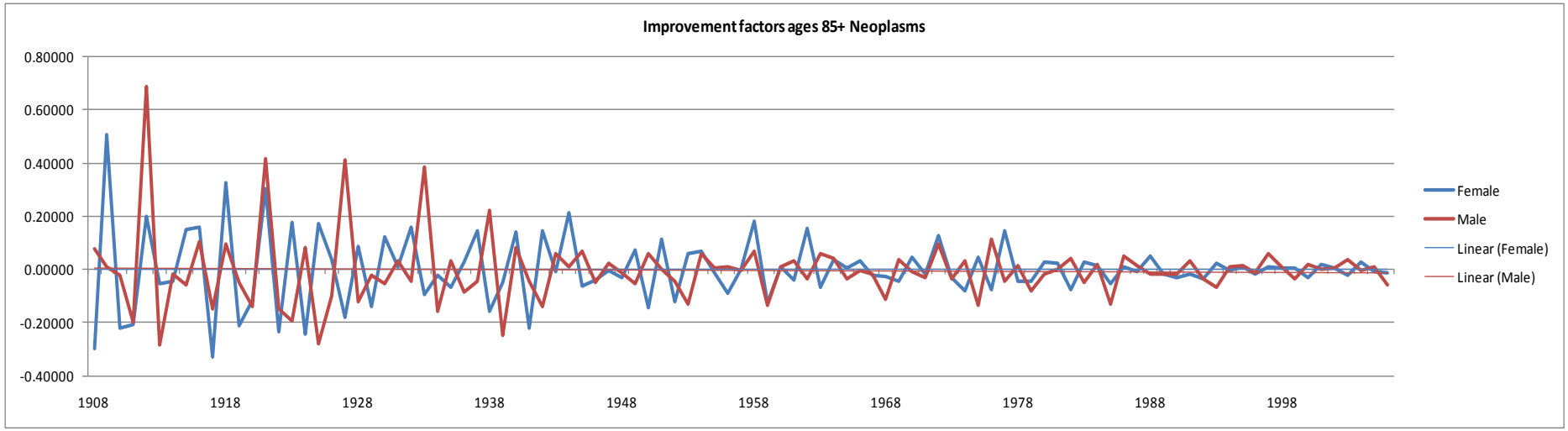

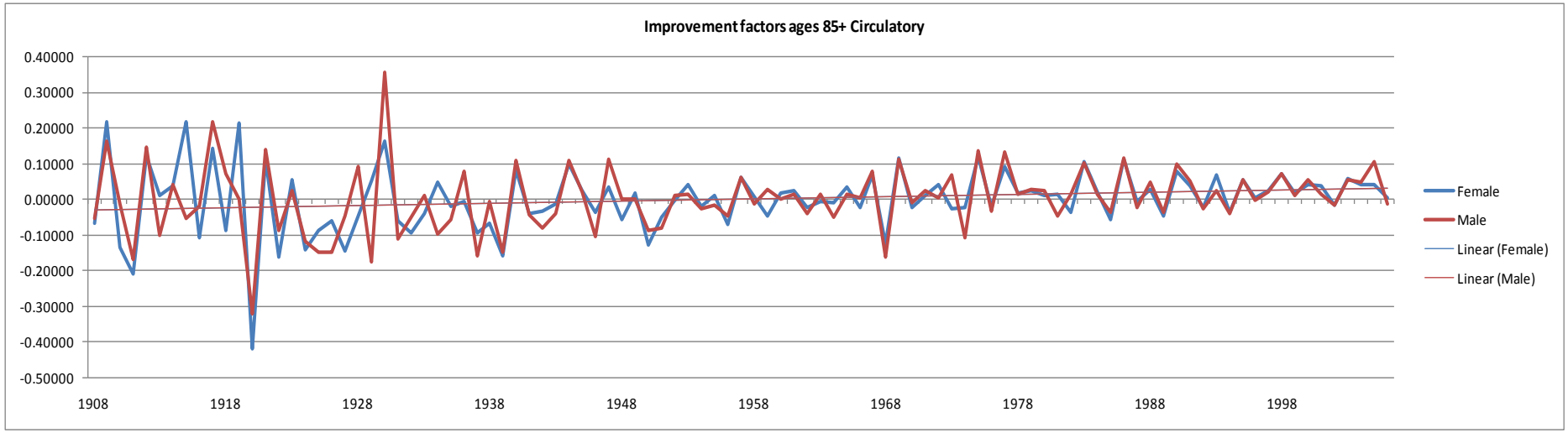

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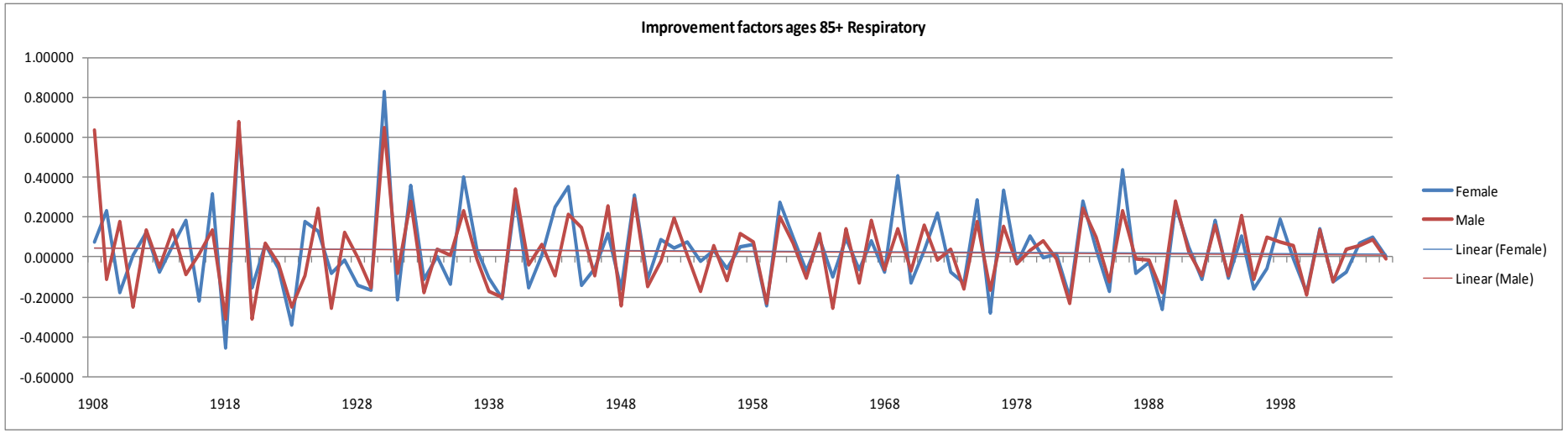

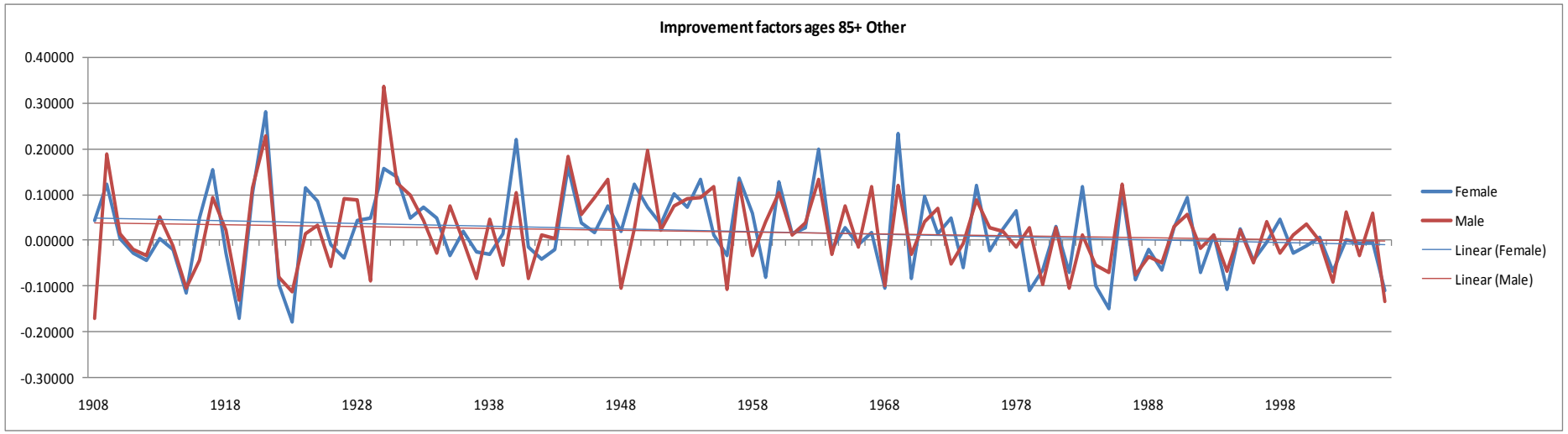

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