

Mortality and the Economy: Is the Financial Crisis Going to Kill Us?

Genevieve Hayes*

25th November, 2008

Abstract

It is common among actuaries to assume that the mortality rates for a block of Life Insurance or Superannuation business are not influenced by economic factors (such as interest rates and inflation) and conversely. While it seems reasonable to assume that mortality rates do not affect the economy, it does not necessarily follow that the opposite is true. In this paper, we investigate the relationship between fluctuations in interest rates and unemployment on the one hand, and Australian mortality rates on the other, and find that significant relationships do exist between these variables. The implications of these results for Superannuation and Life Insurance actuaries, particularly in light of the current financial crisis, are then discussed.

1 Introduction

It is common among Superannuation and Life Insurance actuaries to assume that economic fluctuations have no impact on the mortality experience of insured lives and vice versa. While it seems reasonable to assume that mortality rates do not affect the economy, it does not necessarily follow that the opposite is true. In fact, a great number of studies have been conducted that demonstrate that statistically significant relationships do exist between economic variables (particularly unemployment rates) and mortality rates for the populations of industrialised nations, such as the US and those of Western Europe (references are given in Section 2). The nature of these relationships has been the cause of much controversy¹. Nevertheless, these studies do raise the possibility that

*Contact: Genevieve Hayes B Act S (Hons), B Comm, FIAA, GStat, Lecturer, School of Finance and Applied Statistics, ANU College of Business and Economics, Canberra ACT 0200, Australia. Email: genevieve.hayes@anu.edu.au

¹Throughout this paper and in the papers cited herein, we are referring to the relationship between economic variables and mortality for industrialised nations. It is generally accepted that sustained economic growth leads to reduced mortality for developing countries and this has been demonstrated by a number of studies, for example Pritchett and Summers (1996) and Nomba (2004).

there is a significant relationship between Australian mortality rates and fluctuations in the Australian economy.

In this paper, we test the hypothesis that significant relationships exist between fluctuations in unemployment and the short-term interest rate on the one hand and Australian mortality rates on the other, using both Australian population mortality data and mortality data pertaining only to Australian insured lives, and find that significant relationships are observed between these variables, except in the case of insured lives aged under 65. Although results differ between data sets, an increase in the unemployment rate is generally associated with either a decrease or no change in mortality rates among lives aged under 45 and an increase in mortality rates among lives aged over 45, and similar outcomes are associated with an increase in the interest rate.

Using the fitted models to forecast the impact of the current financial crisis on mortality rates, it is predicted that the economic fluctuations associated with the financial crisis will result in a decrease in mortality among lives aged under 45 and an increase in mortality among lives over 45. The implications of these projections are that financial services institutions are predicted to make a mortality profit from any life annuity business they might have on their books and may make either a mortality profit or loss on their life insurance business, depending on the composition of their sales portfolio.

2 Population Mortality and the Economy

In his seminal paper on the topic, Brenner (1979) hypothesised that recessions and other sources of economic instability are associated with higher mortality rates. A number of researchers have criticised these results on statistical grounds (a summary of these criticisms can be found in Laporte (2004)) and the majority of subsequent studies have, in fact, found evidence that economic downturns lead to reduced mortality.

Ruhm (2000), Laporte (2004) and Tapia Granados (2005) all found, using US aggregated mortality data (and differing methodologies), that mortality rates fall when the economy deteriorates (as characterised by increased unemployment rates). Gerdtham and Ruhm (2002) and Neumayer (2004) reached the same conclusion, but using aggregated mortality data for 23 OECD countries (including Australia) and Germany, respectively. Ruhm (2003) also reached the same conclusion using US unit record data (referred to as *microdata*), while Gerdtham and Johannesson (2005) used Swedish microdata and found that “recessions increase the mortality risk of men, but have no effect on the mortality of women” (p.206). This is not an exhaustive list of papers that have dealt with the relationship between the economy and mortality. For a more detailed summary of papers that have been written on this topic, see Ruhm (2004).

There are two main schools of thought as to why the economy has an impact on mortality. One focuses on the psychological reasons, while the other focuses on the eco-

conomic reasons. From a psychological point of view, downturns in the economy can place additional stress on people, particularly those in lower socioeconomic groups, which can result in a negative impact on physical and mental health. Brenner and Mooney (1983, p.1128) list three ways in which recessions (and the associated unemployment) can have a detrimental effect on health (and subsequently on mortality rates):

1. *Poverty or lack of material resources to meet the ordinary requirements and extraordinary problems of life affect many of the unemployed and others who lose financially.*
2. *Psychosocial stress associated with (the) loss (of employment or money) is potentially damaging in itself, especially if it leads to withdrawal and loss of potentially beneficially social relationships.*
3. *Attempts to alleviate psychological distress by medication with alcohol or legal and illegal drugs, by overeating or undereating, or by smoking tobacco, will tend to exacerbate existing morbidity and produce additional health problems.*

On the other hand, Ruhm (2000, pp.620–622) offers four reasons why economic upturns can have a negative effect (and recessions can have a positive effect) on health and mortality, based on an economic model of utility maximisation:

1. *The Opportunity Cost of Time: Leisure time declines during economic upturns, making it more costly to undertake health-producing activities (such as exercise) that are time intensive. Similarly, the time price of medical care will rise if individuals working more hours find it harder to schedule medical appointments for themselves or their dependents. . .*
2. *Health as an Input into Production: . . . hazardous working conditions, job-related stress, and the physical exertion of employment may have negative effects on health, particularly when job hours are extended during short-lasting economic expansions. . .*
3. *External Sources of Death: . . . work-related accidents are likely to become more common during temporary (economic) expansions. Other types of accidents will probably increase as well. Of particular importance, drinking and driving rise in good times, leading to higher motor vehicle fatality rates. . .*
4. *Migration Flows: (Migration flows have) the potential to raise death rates (in destination locations). . . through increasing crowding, because the new migrants import disease, or if they are unfamiliar with roads or medical infrastructure. . .*

These two points of view seem to contradict one another. However, as was pointed out by Neumayer (2004, p.1039), these “two perspectives and the theories associated with

them need not be inconsistent with each other. Instead, they could capture two different aspects of a complex impact of economic fluctuations on health and mortality.” So, if economic fluctuations are found to have no statistically significant effect on mortality rates, this could be because the two above described effects are of approximately equal strength and cancel each other out. Furthermore, a statistically significant positive or negative effect does not necessarily imply that one effect is non-existent, “instead, it merely means that one effect is so much stronger than the other that the overall effect goes into one direction.”

3 A GLM-Based Test for a Relationship Between Economic Fluctuations and Mortality

Each of the papers mentioned in the previous section put forward an econometric model that can be used to determine whether a statistically significant relationship exists between economic fluctuations and mortality. All of the tests proposed are very similar in nature:

- They all test for a significant relationship between an economic variable (in most cases the unemployment rate) and (the logarithm of) a standardised measure of mortality,
- after allowing, either directly or indirectly, for other, non-economic variables that are likely to have an impact on the mortality rate (for example, age and sex), and
- this is generally done through the use of linear regression models.

In this paper, we use Poisson generalised linear models (GLMs) to test for a significant relationship between Australian mortality rates and fluctuations in Australian economic variables. The models used are of the general form:

$$\ln \left(\frac{E(D_{x,t})}{E_{x,t}^c m_{x,t}^s} \right) = \eta; \quad (1)$$

where $\frac{D_{x,t}}{E_{x,t}^c m_{x,t}^s}$ is the standardised mortality ratio for lives aged x in year t and η is a linear combination of economic and non-economic covariates. $D_{x,t}$ denotes the number of deaths observed among a group of lives aged x in year t , $E_{x,t}^c$ denotes the central exposed to risk for lives aged x in year t , and $m_{x,t}^s$ denotes the central mortality rate given by a (specified) standard mortality table for lives aged x in year t .

This model is similar in form to those used by Ruhm (2000, 2003), Gerdtham and Ruhm (2002) and Neumayer (2004), except that a Poisson error structure is assumed instead of a normal error distribution. It is more appropriate to assume the number of deaths follows a Poisson distribution than a normal distribution, as the observed number

of deaths is a discrete, non-negative random variable, whereas the normal distribution would imply that it was a continuous random variable with range over the entire number line (nevertheless, in a large sample, we expect there to be little difference between the Poisson and normal models, by the Central Limit Theorem).

In all of the previous studies mentioned in Section 2, the unemployment rate was included as an economic explanatory variable in the test model (in most cases, it was the only economic explanatory variable included). From an actuarial point of view, it is also of interest to determine whether significant relationships exist between mortality rates and other economic variables that are often incorporated into actuarial models. In theory, this could be done by including all of the economic and non-economic variates under consideration in the linear predictor of the GLM given in Equation (1) and then testing to determine whether the economic variates are significant, given the presence of the non-economic variates in the model. However, many of the economic variates that are likely to be considered are highly correlated with each other, and including all of them together in the one model is likely to give rise to multicollinearity problems. For example, interest rates are highly correlated with the inflation rate, so interest rates and inflation should not be included in the same model. Furthermore, the existence of a statistically significant relationship between two variables does not necessarily imply that a causal relationship exists between them, and although it is easy to see how a causal relationship could exist between unemployment rates and mortality, it is more difficult to see how a causal relationship could exist between, for example, commercial property yields and mortality. Such variates should also be excluded from the model.

Consequently, it was decided to include only the short-term interest rate (defined as the yield on 90-day bank accepted bills) and the (all persons) unemployment rate in the linear predictor when testing for a significant relationship between mortality and economic fluctuations. To test for a relationship between the mortality rate and either of these variables, two different linear predictors were considered in fitting the GLM in Equation (1) to the mortality and economic data:

Model 1:

$$\eta = \beta_0 + \beta_1 Z; \tag{2}$$

Model 2:

$$\eta = \beta_0 + \beta_1 Z + \beta_2 U + \beta_3 STI + \beta_4 U \times I(F) + \beta_5 STI \times I(F); \tag{3}$$

where Z is a vector of the non-economic covariates, including all two-way interactions, U denotes the unemployment rate, STI denotes the short-term interest rate, $I(F)$ is an indicator variable that equals 1 if the life is female and 0 otherwise, and the β 's are model parameters to be estimated.

The indicator variable included in the model allows for differences in the results by sex to be observed. In order to observe differences by age, the models were fitted to each of the following data subsets: ages 15–24, 25–44, 45–64 and 65+, as well as to the entire data set (ages 15 and above). Children aged under 15 years were not considered in the investigations. Each of the two models was fitted to each data subset using the R statistical computer package², and then, because the two models are nested, the residual deviances of the models were used to compare them. The results are presented in Section 5.

4 The Data

Australian population mortality data for the period from 1901 to 2003 were obtained from the Australian Demographic Databank³. This data set (which is subsequently referred to as the *Australian Population Data Set*) gives deaths and central exposures to risk by age, sex, State/Territory and year. A second Australian mortality data set was also available. This data set (referred to as the *IAAust Data Set*) comprises data collected by the Institute of Actuaries of Australia Mortality Committee from a large number of Australian Life Insurers over the period from 1995 to 1999. It gives numbers of deaths and central exposures to risk for insured lives subdivided by age, sex, year, policy type and (policy) duration. The policy types represented by this data set are as follows⁴:

Type 1: Whole of life/endowment insurance, both with and without term insurance riders;

Type 2: Unbundled policies, both capital guaranteed and investment-linked, carrying significant death risk;

Type 3: Temporary insurances where premiums are fully guaranteed, and the sums insured may be level or reducing; and

Type 4: Temporary insurances where the premium rate may be reviewed.

Tests were conducted using both data sets. The second data set was used, in addition to the first, in order to determine whether the same results hold for lives that have passed through the underwriting process, as for the general population.

For the Australian Population Data Set, age, sex and State/Territory were included as non-economic covariates (with sex and State/Territory treated as a categorical covariate), while for the IAAust Data Set, age, sex, policy type and duration were included in the test models as non-economic covariates (with sex and policy type treated as categorical

²R version 2.2.1. Copyright ©2005 the R Foundation for Statistical Computing.

³Australian Demographic Databank, Version 3.2b, February 2005.

⁴IAAust Mortality Committee (2001, p. 4).

covariates). In each case the year variable was excluded, in order to avoid multicollinearity problems. In calculating the mortality ratios on the left hand side of Equation (1), the IA95-97 mortality table was used to determine $m_{x,t}^s$ for the IAAust Data Set tests, as the 1995 to 1997 portion of this data set was used by the Institute of Actuaries of Australia Mortality Committee to develop this table. ALT95-97, on the other hand, a mortality table developed by the Australian Government Actuary, based on Australian population data collected over the same time period, was used to determine $m_{x,t}^s$ for the Australian Population Data Set tests. The mortality improvement factors based on the most recent 25 years of data, given in Appendix E of AGA (1999), that is, ALT95-97, were used to allow for mortality improvements over time in each case (no mortality improvement factors are included in IA95-97). Both of these standard mortality tables give initial mortality rates, rather than central mortality rates. To adjust for this, $m_{x,t}^s$ is approximated by:

$$m_{x,t}^s = -\ln(1 - q_{x,t}^s); \quad (4)$$

where $q_{x,t}^s$ denotes the initial mortality rate given by a standard mortality table for lives aged x in year t , as suggested by Haberman and Renshaw (1996).

The unemployment rate and short-term interest rate data were obtained from the Reserve Bank of Australia (RBA) website⁵. Both time series were observed at monthly intervals. For consistency with the mortality data, it is necessary to calculate “annual” values of these time series, which is done, for each year, by calculating the arithmetic average of the twelve monthly observations for the period from January to December. The short-term interest rate data was available from June 1969 onwards, while the unemployment rates were available from February 1978. Consequently, the GLMs previously described were only fitted to the Australian Population Data Set for the period from January 1979 to December 2003. The GLMs were also fitted to this data set for the period from 1995 to 1999, for comparability with the IAAust Data Set.

Figure 1 plots the (logged) all-age, all-state mortality ratios, calculated using the Australian Population Data Set, by year and sex, over the period from 1979 to 2003. From this figure, it is clear that the male and female mortality ratios are highly correlated with each other. Tapia Granados (2005, p.1195), citing John Stuart Mill’s fifth canon, pointed out that “if two phenomena vary up and down simultaneously, one is causing the other or there is a third factor causing both of them”. It is unlikely that the male mortality ratio is causing the variation in the female ratio or vice versa, which suggests that there is a third factor causing both of these factors to vary. This could be an environmental factor, for example weather conditions or the prevalence of certain viruses from year to year, but it could also be an economic factor.

⁵www.rba.gov.au (downloaded on 24th September, 2007).

Figure 2 shows the unemployment rates and short-term interest rates, also plotted over the period from 1979 to 2003. A comparison of this graph with Figure 1 shows that the short-term interest rate, in particular, exhibits a similar downward trend to the mortality ratio. Over the period under consideration, the correlation between the short-term interest rate and the male mortality ratio is 0.801 (with a p -value of 0.000) and the correlation between the short-term interest rate and the female mortality ratio is 0.498 (p -value = 0.005). This provides preliminary evidence to suggest that economic fluctuations may have a significant effect on the mortality ratios.

Figure 1: All-Age, All-State Mortality Ratios for the Australian Population Data Set

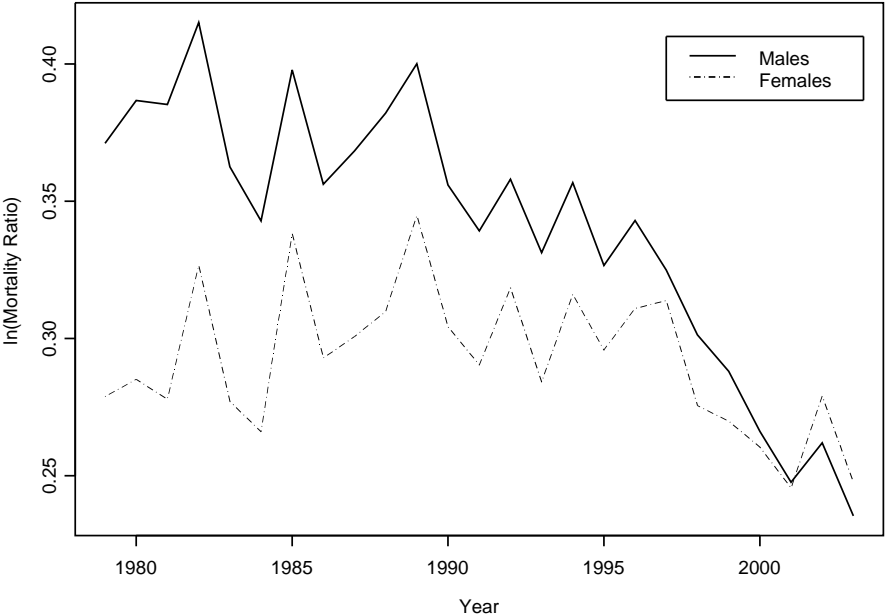


Figure 2: Short Term Interest Rate and Unemployment Rate



5 Results and Discussion

The two models described in Section 3 were fitted to the Australian Population Data Set for each of the time periods, 1979–2003 and 1995–99, and to the IAAust Data Set for the period 1995–99, for each of the age-based subsets previously mentioned. The decrease in deviance between Models 1 and 2, along with the associated change in degrees of freedom and p -value for each pair of models fitted, are presented in Table 1.

Table 1: Drop in Deviance between the Two Economic Fluctuation versus Mortality GLMs

Age Subset	Aust. Pop. (1979–2003)			Aust. Pop. (1995–99)			IAAust Data (1995–99)		
	Δ Dev.	df	p -value	Δ Dev.	df	p -value	Δ Dev.	df	p -value
All Ages	2557.00	4	0.000*	163.90	4	0.000*	61.80	4	0.000*
15–24	98.90	4	0.000*	19.67	4	0.001*	7.69	4	0.104
25–44	248.10	4	0.000*	21.60	4	0.000*	6.50	4	0.165
45–64	371.70	4	0.000*	24.70	4	0.000*	4.10	4	0.393
65+	1599.00	4	0.000*	173.00	4	0.000*	94.15	4	0.000*

Note: * indicates significance at the 5% level.

In all of the Australian Population Data Set cases, Model 2 provides a significantly

better fit to the data than Model 1, suggesting that a significant relationship exists between economic fluctuations and mortality for the general population at all ages. However, for only two of the IAAust Data Set cases, the all age case and the ages 65 and above case, does Model 2 provide a superior fit. This second result suggests that, either due to the fact that insured lives have passed through an underwriting process, or due to the fact that insured lives typically come from higher socioeconomic groups than uninsured lives, or a combination of both, a significant relationship does not exist between economic fluctuations and mortality for younger lives, that is, lives under 65, but in spite of these facts, does exist for lives aged over 65.

Table 2 gives the fitted coefficients of U , STI , $U \times I(F)$ and $STI \times I(F)$, with standard errors shown in brackets, for each of the data subsets for which Model 2 provided a significantly better fit to the data than Model 1. Note, in interpreting the coefficient values, that the unemployment rate and short-term interest rate were given in decimal (rather than percentage) form in the data sets. A number of the estimated coefficient values presented in this table are not significantly different from 0 (at the 5% significance level). In particular, most of the coefficients of $U \times I(F)$. This suggests that the effects of fluctuations in the unemployment rate typically do not vary by sex. For each of the models for which this is the case, the insignificant covariates were removed from the model (one at a time) and the model refitted. The coefficients of the economic covariates in the refitted models are given in Table 3.

Table 2: Estimated Coefficients of the Economic Covariates in Model 2, with Standard Errors Shown in Brackets

Age Subset	Covariate			
	U	STI	$U \times I(F)$	$STI \times I(F)$
Australian Population Data (1979–2003)				
All Ages	1.030* (0.057)	0.869* (0.018)	-0.532* (0.083)	-0.663* (0.027)
15–24	-0.831* (0.366)	1.015* (0.118)	0.096 (0.722)	-0.578* (0.234)
25–44	-0.899* (0.225)	-0.557* (0.073)	-1.068* (0.398)	-0.825* (0.129)
45–64	0.438* (0.124)	0.748* (0.040)	0.021 (0.209)	-0.511* (0.067)
65+	1.272* (0.068)	0.774* (0.022)	-0.717* (0.095)	-0.569* (0.031)
Australian Population Data (1995–1999)				
All Ages	2.612* (0.439)	0.494* (0.196)	0.419 (0.638)	-0.651* (0.285)
15–24	-1.423 (3.019)	-2.883* (1.338)	0.192 (5.930)	-2.198 (2.655)
25–44	-2.011 (1.704)	-0.608 (0.763)	0.567 (3.031)	-2.474 (1.363)
45–64	3.017* (1.055)	0.001 (0.465)	1.251 (1.737)	-0.640 (0.769)
65+	2.889* (0.511)	0.725* (0.228)	0.148 (0.717)	-0.665* (0.321)
IAAust Data (1995–1999)				
All Ages	2.327 (1.355)	3.585* (0.720)	3.186 (3.599)	-5.543* (1.963)
65+	3.281* (1.639)	5.596* (0.888)	3.189 (4.700)	-6.986* (2.676)

Note: * indicates significance at the 5% level.

Table 3: Estimated Coefficients of the Economic Covariates in the Refitted Models, with Standard Errors Shown in Brackets

Age Subset	Covariate			
	U	STI	$U \times I(F)$	$STI \times I(F)$
Australian Population Data (1979–2003)				
All Ages	1.030* (0.057)	0.869* (0.018)	-0.532* (0.083)	-0.663* (0.027)
15–24	-0.807* (0.315)	1.016* (0.118)	-	-0.584* (0.229)
25–44	-0.899* (0.225)	-0.557* (0.073)	-1.068* (0.398)	-0.825* (0.129)
45–64	0.446* (0.100)	0.749* (0.040)	-	-0.512* (0.066)
65+	1.272* (0.068)	0.774* (0.022)	-0.717* (0.095)	-0.569* (0.031)
Australian Population Data (1995–1999)				
All Ages	2.810* (0.319)	0.438* (0.176)	-	-0.533* (0.221)
15–24	-	-3.825* (0.897)	-	-
25–44	-	-1.178* (0.591)	-	-2.314* (1.058)
45–64	3.143* (0.650)	-	-	-
65+	2.964* (0.359)	0.704* (0.204)	-	-0.623* (0.248)
IAAust Data (1995–1999)				
All Ages	-	4.331* (0.575)	-	-4.495* (1.579)
65+	3.669* (1.536)	5.469* (0.868)	-	-5.907* (2.153)

Note: * indicates significance at the 5% level.

From Table 3, it can be seen that different results were achieved using different data sets. However, in almost every case, the signs of the coefficients are the same for a given age subset, regardless of data set, allowing conclusions to be drawn about the direction of the relationships between the two economic covariates and mortality.

Among insured lives, a significant relationship between unemployment rates and the mortality ratio only exists for lives aged 65 and above. Similarly, for lives in the general Australian population, over the period from 1995 to 1999, a significant relationship between the unemployment rate and mortality is only observed for lives aged 45–64 or over 65, and for the all age group. Thus, in many cases, fluctuations in the unemployment rate are not observed to have a significant effect on mortality. However, for all of the Australian Population cases over the period from 1979 to 2003, a significant relationship between unemployment and mortality is observed. For all of the cases (for all data sets) where such a significant relationship is observed, a negative relationship between unemployment and mortality is observed for lives aged 15–24 or 25–44, and a positive relationship is observed for lives aged 45–64 or 65+ and for the all-age group. This is further illustrated by Table 4, which shows the percentage change in the mortality ratio associated with a 1% increase in the unemployment rate, all other things being equal, by sex and age subset, as suggested by each model.

It is surprising that a significant relationship exists between the unemployment rate and mortality for the 65+ age group, since the majority of the people in this age group are

Table 4: % Change in the Mortality Ratio Associated with a 1% Change in the Unemployment Rate

Age Subset	Aust. Pop. (1979–2003)		Aust. Pop. (1995–99)		IAAust Data (1995–99)	
	Males	Females	Males	Females	Males	Females
All Ages	1.04%	0.50%	2.85%	2.85%	0.00%	0.00%
15–24	-0.80%	-0.80%	0.00%	0.00%	0.00%	0.00%
25–44	-0.89%	-1.95%	0.00%	0.00%	0.00%	0.00%
45–64	0.45%	0.45%	3.19%	3.19%	0.00%	0.00%
65+	1.28%	0.56%	3.01%	3.01%	3.74%	3.74%

retired and, therefore, not seeking employment. However, fluctuations in the unemployment rate could affect these people indirectly, through the well-being of younger family members, or the unemployment rate could be acting as a proxy for economic conditions in general, which could affect these people in some other way.

The negative (pro-cyclical) relationships between unemployment and mortality for the younger age groups are consistent with what was observed in a number of previous studies (discussed in Section 2), including Ruhm (2000) and Neumayer (2004) who performed similar investigations to ours, using US and German aggregated mortality data respectively. However, the positive (counter-cyclical) relationships observed for the older age groups and for the all age group are contrary to what was observed in these studies. Neumayer (2004) hypothesised that the reason why some studies, such as Brenner (1979), have observed counter-cyclical movements in mortality is because these studies have omitted time-invariant variables, in particular, state-specific effects. Neumayer then demonstrated, for his data set, that omitting the state covariate from his test model reversed his conclusions. Nevertheless, state was included as a covariate in each of the models we fitted to the Australian Population Data Set, and even if state is omitted completely from our models, this has only a minimal effect on the coefficients of the economic covariates and does not change any of the signs of these values.

One of the main differences between our model and many of the models used in previous studies is that, whereas in other studies it is common for only one economic covariate, usually the unemployment rate, to be included in the test model, in this study we have included two economic covariates, the unemployment rate and the short-term interest rate, in our model. It is possible that the inclusion of both of these variables together in our model is the source of the differences in our results.

Significant relationships between the short-term interest rate and mortality were observed for all of the Australian Population Data Set cases, except for the 45–64 age group in the period from 1995 to 1999, and for both of the IAAust Data Set cases for which Model 2 was found to provide a better fit to the data than Model 1. Table 5 shows the

percentage change in the mortality ratio associated with a 1% increase in the short-term interest rate, by sex and age subset, as suggested by each model.

Table 5: % Change in the Mortality Ratio Associated with a 1% Change in the Short-Term Interest Rate

Age Subset	Aust. Pop. (1979–2003)		Aust. Pop. (1995–99)		IAAust Data (1995–99)	
	Males	Females	Males	Females	Males	Females
All Ages	0.87%	0.21%	0.44%	-0.09%	4.43%	-0.16%
15–24	1.02%	0.43%	-3.75%	-3.75%	0.00%	0.00%
25–44	-0.56%	-1.37%	-1.17%	-3.43%	0.00%	0.00%
45–64	0.75%	0.24%	0.00%	0.00%	0.00%	0.00%
65+	0.78%	0.21%	0.71%	0.08%	5.62%	-0.44%

As is illustrated by Tables 3 and 5, in most cases, a positive relationship is generally observed between the short-term interest rate and mortality, although a weaker relationship is observed for females than for males and in the two IAAust cases the sum of the coefficients of STI and $STI \times I(F)$ is not significantly different from zero. Excluding the two IAAust cases, all but one of the remaining cases for which a negative relationship is observed are associated with one of the two younger age groups. These results seems unexpected, since younger people are more likely to be in debt, and thus, be adversely affected by increases in interest rates, while older people are more likely to be receiving an income from assets, and thus benefit by such an increase. One possible explanation for the negative relationship between interest rates and mortality among younger people is that low interest rates tend to drive up the price of housing, causing emotional stress to those wishing to purchase a house and the negative health impacts that are associated with that stress. This reasoning can also assist in explaining the positive relationship between interest rates and mortality among older people, since older people typically own their own homes and an increase in property values leads to an increase in the value of this asset, which is beneficial to the asset holder. However, other explanations for this phenomenon are also possible.

In practice, it is unlikely that one of the economic variables under consideration would move and not the other, since both of these variables are constantly moving in response to changes in the domestic and international economic environments. Most recently, these variables have been affected by the “global financial crisis” or “subprime mortgage crisis”. At the time of writing this paper⁶, the unemployment rate, given in ABS (2008), was at 4.3% and the short-term interest rate, as reported on the RBA’s website, was at 4.94% p.a. (which is 0.36% below the RBA’s current target cash rate of 5.25% p.a.). Recent forecasts

⁶10th November, 2008.

produced by JPMorgan predict that Australia’s unemployment rate will rise to 9% by the end of 2010 (Murdoch (2008b)), while the UBS chief economist, Scott Haslem, projected that the official cash rate will fall to 4% by the middle of 2009 (Murdoch (2008a)). The combined effect on mortality of a 4.7% increase in the unemployment rate and a 1.25% fall in the interest rate, as suggested by the fitted models, is given in Table 6.

Table 6: % Change in the Mortality Ratio Associated with a 4.7% Increase in the Unemployment Rate and a 1.25% Decrease in the Short-Term Interest Rate

Age Subset	Aust. Pop. (1979–2003)		Aust. Pop. (1995–99)		IAAust Data (1995–99)	
	Males	Females	Males	Females	Males	Females
All Ages	3.83%	2.10%	13.50%	14.25%	-5.27%	0.20%
15–24	-4.94%	-4.24%	4.90%	4.90%	0.00%	0.00%
25–44	-3.47%	-7.24%	1.48%	4.46%	0.00%	0.00%
45–64	1.17%	1.82%	15.92%	15.92%	0.00%	0.00%
65+	5.14%	2.38%	13.94%	14.83%	10.95%	19.47%

The implications of these changes vary, depending on which model is considered. However, based on the models fitted to the Australian Population Data for the period from 1979 to 2003, which are arguably the most reliable of the three sets of models, since they are fitted to 25 years of data, as opposed to only five years, it is predicted that the financial crisis will lead to a fall in mortality for younger lives and a rise in mortality for older lives.

From the point of view of a financial services institution that sells products which pay a death benefit, such as life insurance, these results suggest that the financial crisis will lead to a fall in the number of death claims among younger lives and a rise in the number of death claims among lives aged over 45. Whether this will give rise to a mortality profit or a loss will depend on the composition of the portfolio under consideration, but for portfolios for which a loss is implied, the seller may need to hold extra reserves to allow for this possibility. On the other hand, from the point of view of an institution that offers survival contingent products, such as life annuities, these changes are associated with an increase in the number of benefit payments among younger lives and a decrease among older lives. Since life annuities are primarily sold to older lives, aged 65 and over, institutions that sell such products are likely to make a mortality profit as a result of the financial crisis. Of course, many financial institutions offer both of these products, so the overall impact of the financial crisis will, again, depend on the composition of the institution’s sales portfolio, and any mortality profits made because of the financial crisis may be offset by losses arising from the fall in investment returns.

6 Conclusions and Further Research

In the past, a number of studies conducted using data from the US and Western Europe, have demonstrated that a significant relationship exists between economic fluctuations and mortality. In this paper, GLMs were used to test whether a significant relationship also exists between fluctuations in Australia's economy, specifically, in the unemployment rate and the short-term interest rate, and Australian mortality, and such a relationship was observed. We found that, although results differed depending on the data set used to fit the models, an increase in the unemployment rate was generally associated with either a decrease or no change in mortality rates among lives aged under 45 and an increase in mortality rates among lives aged over 45, and similar outcomes were associated with an increase in the interest rate. The fact that these results *do* differ depending on the data used to obtain them, however, should be emphasised. The implication of this is that repeating these tests using data relating to another period of time may lead to different results being observed and alternative conclusions reached. It would be of interest to repeat these tests again after the current financial crisis is over, using data relating to this period, to see if the results drawn using this data are consistent with those found in this paper.

Acknowledgements

The guidance and feedback of Prof. Ross Maller is gratefully acknowledged. I would also like to thank Dr. Len Smith of the Australian Centre for Population Research at the Australian National University, who provided access to the Australian Population Data Set, and Anthony Brien and Sue Clark of the Institute of Actuaries of Australia Life Risk Insurance Committee, who provided access to the IAAust Data Set.

References

- ABS (2008). *Labour Force, Australia, October 2008*. Australian Bureau of Statistics.
- AGA (1999). *Australian Life Tables 1995-97*. Australian Government Actuary.
- Brenner, M. (1979). Mortality and the national economy: a review, and the experience of England and Wales 1936–1976. *The Lancet* 314, 568–572.
- Brenner, M. and A. Mooney (1983). Unemployment and health in the context of economic change. *Social Science and Medicine* 17, 1125–1138.
- Gerdtham, U. and M. Johannesson (2005). Business cycles and mortality: Results from Swedish microdata. *Social Science and Medicine* 60, 205–218.

- Gerdtham, U. and C. Ruhm (2002). Deaths rise in good economic times: Evidence from the OECD. Discussion Paper 654, Institute for the Study of Labor, Bonn.
- Haberman, S. and A. Renshaw (1996). Generalized linear models and actuarial science. *The Statistician* 45, 407–436.
- IAAust Mortality Committee (2001). *Mortality Investigation IA 95-97 M and F: Graduated Mortality Tables*. Institute of Actuaries of Australia.
- Laporte, A. (2004). Do economic cycles have a permanent effect on population health? Revisiting the Brenner hypothesis. *Health Economics* 13, 767–779.
- Murdoch, S. (2008a, 10th November). Reserve bank gloomy outlook flags more interest rate cuts. *The Australian (Online)*.
- Murdoch, S. (2008b, 23rd October). Unemployment rate tipped to hit 9pc in two years. *The Australian (Online)*.
- Neumayer, E. (2004). Recessions lower (some) mortality rates: Evidence from Germany. *Social Science and Medicine* 58, 1037–1047.
- Noumba, I. (2004). Are wealthier nations healthier nations? A panel data approach to the determination of human development in Africa. Presented to the DPRU-TIPS-Cornell University Forum on “African Development and Poverty Reduction: The Macro-Micro Linkage”.
- Pritchett, L. and L. Summers (1996). Wealthier is healthier. *Journal of Human Resources* 31, 841–868.
- Ruhm, C. (2000). Are recessions good for your health? *Quarterly Journal of Economics* 115, 617–650.
- Ruhm, C. (2003). Good times make you sick. *Journal of Health Economics* 22, 637–658.
- Ruhm, C. (2004). Macroeconomic conditions, health and mortality. Working Paper 11007, National Bureau of Economic Research.
- Tapia Granados, J. (2005). Increasing mortality during the expansion of the US economy, 1900-1996. *International Journal of Epidemiology* 34, 1194–1233.