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The Funding of Closed Defined Benefit Schemes

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Abstract

This paper presents the results of a stochastic simulation projection of a model superannuation scheme which is closed to new entrants. The base scenario of the scheme uses a projected unit credit approach to funding, with investments following a balanced-type asset allocation. The scheme is defined benefit in nature and pays pensions to members upon retirement.

The most significant result found is the tendency of the scheme to develop a surplus which increases exponentially, which is a significant issue where the surplus may be unable to be recovered by the employer. The reason for this exponential surplus development is the reduction in future liabilities, leading to the assets exceeding past and future liabilities and growing at a faster rate than the liabilities.

A number of alternative scenarios are considered, specifically different contribution and investment strategies as well as changes to the structure of the model scheme. Moving to a more conservative investment strategy as the surplus increases has the effect of reducing future surplus levels as well as reducing the chance of future adverse experience wiping out the surplus. A contribution strategy which spreads deficits over a long period is the most effective for reducing future contribution and surplus levels, although at the cost of longer deficits. A scheme which pays lump sums rather than pensions is less susceptible to exponential surplus development due to higher future liabilities relative to assets.

This study presents preliminary results of a PhD thesis on this topic. As such there are a number of areas which will be developed in future research.

Keywords: closed defined benefit superannuation, pension, simulated stochastic model, funding

Contents

1 INTRODUCTION

Recent times have seen a strong trend away from defined benefit arrangements into other types of retirement benefit provisions. Campbell et al. (2006) notes a number of reasons employers may wish to reduce defined benefit exposure. Some of the reasons are as follows:

- A desire to reduce costs;
- Uncertain investment markets leading to unstable contribution requirements;
- Uncertain mortality improvement giving rise to potential asset shortfalls in future years;
- Regulatory concerns; and
- Effect of accounting standards, with scheme deficit and surplus required to be shown on the company's balance sheet.

The above reasons pertain to the UK market, some additional reasons for the trend away from defined benefit are:

- The prevalence of salary packaging and associated complications of defined benefits in this environment;
- The difficulty in allowing for switches between full-time, part-time and casual work in defined benefits; and
- A general trend in employers becoming less paternalistic toward their employees and thus taking less responsibility over retirement benefit provision.

Employers wishing to reduce their defined benefit exposure have a number of ways of achieving this. One option available to employers is to close the defined benefit scheme to new entrants and open up an alternative scheme for all new employees (sometimes known as a "soft freeze" of benefits). A more extreme example is to cease the accrual of future benefits entirely for all members (sometimes known as a "hard freeze" of benefits). This is usually done with the expectation that the defined benefit scheme will be wound up at some stage in the future with the liabilities of the scheme transferred to an insurance company (who will pay benefits as per the old scheme) or in lump sum form to a defined contribution arrangement.

This trend towards defined contribution benefits has been stronger in Australia than most countries. Australia is one of the only countries in the world to compulsorily require employers to provide retirement benefits for employees. Since this introduction, in 1986, superannuation legislation has been written with defined contribution schemes in mind, whilst making the provision of defined benefits more complicated, hastening the movement away from defined benefits. In 1995, defined benefit assets made up 22% of all superannuation assets in Australia, whereas this figure had reduced to 8% by 2007 (APRA, 2008). At 30 June 2007, defined benefit memberships made up only 2% of the 29.7 million separate scheme memberships (APRA, 2008). Whilst 38% of memberships were in hybrid schemes, anecdotal evidence suggests the vast majority of these are defined contribution members in schemes with a defined benefit section which is closed to new entrants. The majority of defined benefit members in Australia are in public sector schemes, which are more likely than private sector schemes to have little to no funding and pay benefits as pensions rather than lump sums (the introduction of the Future Fund in the 2005 Budget is designed to fully fund Australian Government superannuation liabilities by 2020).

The trend in other developed countries is not as far progressed as in Australia. For example, in the UK, most employer-provided retirement benefits are still defined benefit in nature, with 8.5 million of the 9.6 million active members in pension schemes in 2006 accruing a defined benefit (ONS, 2007). This is mainly due to public sector schemes; in open private sector schemes the proportion of active members with defined benefits has decreased from 83% in 1995 to 62% in 2006. Considering schemes which had more than 1,000 members in 2006, only 36% were open to new entrants, 54% were closed to new entrants and 10% were closed to all future accrual of benefits or were in the process of winding up. Based on this information, it would appear that UK sponsors of large schemes who wish to reduce their defined benefit exposure generally do so by a soft freeze rather than a hard freeze. Information regarding the US is not so easy to come by, due to schemes not being required to report if they have closed to new entrants. Anecdotal evidence suggests hard freezing of defined benefit schemes may be more common than in the UK, where closing schemes to new entrants is more popular. In any case, there is still a clear trend away from traditional defined benefit schemes towards alternative arrangements.

The trend towards closing or freezing of defined benefit schemes has a clear impact on the demographics, and hence the appropriate actuarial management of these schemes. The focus of this paper is on situations where a scheme has been closed to new entrants but not to future accruals of current members.

Australia is unusual in that the majority of the benefits paid from schemes are in the form of a lump sum, whereas in almost all other countries it is compulsory to take all or the majority of the benefit in the form of an income stream. The reason for this is that historically lump sum benefits have been taxed far more favourably than income streams, although this trend has reduced in recent years due to taxation changes. For the year to 30 June 1998 lump sums made up 80% of superannuation benefits paid (APRA, 2007), whilst this figure reduced to 55% for the year to 30 June 2007 (APRA, 2008). Private sector schemes are much more likely to pay benefits as a lump sum on retirement - for the year to 30 June 2007, lump sums made up 74% of all benefit payments from corporate schemes, whilst from public sector schemes this figure was 32% (APRA, 2008).

This paper presents an analysis of the stochastic simulation projections of a closed defined benefit pension superannuation scheme. This paper presents some preliminary results on a PhD thesis in this area – as such there are many extensions to the work of this paper that will be considered in the thesis, but are not described in this paper in order to keep it to a manageable length.

2 TRUSTEE & EMPLOYER OBJECTIVES

Although the primary statutory reporting role of a superannuation actuary is to the trustees, the actuary must also consider the objectives of the employer of the scheme in recommendations made to the trustees, as the employer is the entity which ultimately bears the financial risks within the scheme. The actuary's role is to make appropriate recommendations to satisfy any legislative requirements, whilst taking into account the sometimes separate objectives of the trustees and the employer.

2.1 Meeting trustee objectives

Section 52 of the SIS Act (1993) sets out the covenants that trustees must follow in the management of a scheme. In particular Section 52(2)(c) states that trustees must act "in the best interest of the beneficiaries". This clearly means trustees must act to ensure that the benefits under the rules of the scheme are able to be paid out to all members when they fall due.

Trustees are therefore particularly concerned that the scheme has an appropriate level of assets available to pay scheme liabilities, otherwise known as the funding level. This is generally defined as the level of assets divided by the liabilities of the scheme, with a scheme which is fully funded having a funding level of 100% and a scheme which is underfunded have a funding level below 100%. Liabilities are generally based on current membership and determined according to an actuarial funding method. The appropriate funding level to target is dependent on a number of factors such as regulatory requirements, strength and commitment of the employer and the investment mix of the scheme, although for the purposes of this paper it is assumed that these factors do not affect the trustees' objectives directly, just the funding level outcomes. In this thesis the funding level for two separate liabilities is considered, an actuarial liability based on unbiased assumptions, and a wind-up liability based on wind-up assumptions.

In Australia, trustees are also concerned about the level of assets relative to vested benefits and minimum requisite benefits, however since the sample scheme pays pensions these measures aren't considered. An alternative scenario, where the sample scheme pays only lump sums, is considered. In this case, the lump sum is designed to be almost identical to the actuarial liability, therefore ensuring that a funding level compared to an actuarial liability or a vested benefit is very similar.

2.2 Meeting employer objectives

The objectives of employers can be seen in the reasons that defined benefit schemes are being closed to new entrants or to all future benefit accruals, as discussed in Section 1. They are summarised as follows:

- Low contributions;
- Predictable contributions; and
- Minimal balance sheet effect.

In some cases these objectives are consistent with the objectives of the trustees. For example, accounting standards require pension deficits and surpluses to be recognised on the sponsoring employer's balance sheet. The Australian standard, AASB 119, which is based on the international standard, IAS 19, allows but does not require immediate recognition of the full deficit or surplus, whilst the UK standard, FRS 17, requires full recognition on the balance sheet. The US standard, FAS 87, has recently been updated by FAS 158 to also require full recognition. It is expected that global standards are likely to trend towards full recognition in future. Although the liability measure used in the accounting standards may differ from that used for funding purposes, this requirement means employers may be driven by the desire to avoid large deficits appearing on their balance sheet, which is consistent with the objective of the trustees to ensure an adequate level of assets.

However, the objective for low contributions may not be consistent with the trustees' objective to secure benefits, particularly if the scheme is in deficit or the employer is in financial difficulty. In addition, the objective for low, predictable contributions with minimal effect on the balance sheet may not be consistent. The lowest contributions are generated by ensuring the maximum possible return the investment of scheme assets, which may not be possible without investing in assets which jeopardise the stability of the funding level and thus predictability of the contributions and the balance sheet effect.

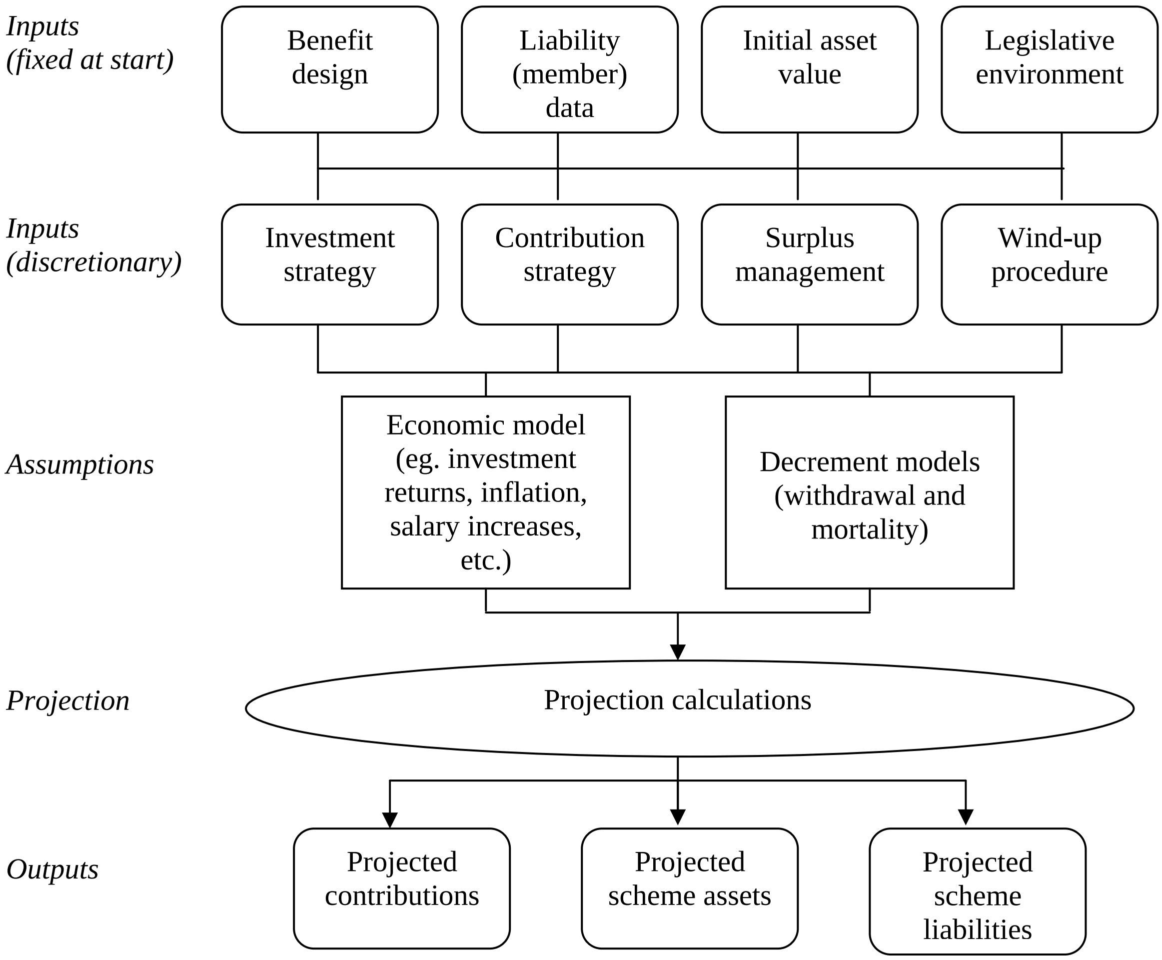
3 METHODOLOGY

3.1 Stochastic modelling approach

In this paper a stochastic approach is used to simulate the future assets and liabilities of a model scheme, in order to identify outcomes of the trustee and employer objectives discussed in Section 2. A number of assumptions must be made about the distribution of the factors which affect the assets and the liabilities of the scheme to perform the analysis. A graphic description of the projection process and the relevant assumptions is shown in Figure 3.1.

A stochastic approach, assumes that some or all of the assumptions affecting the projection of a scheme are random variables. The remainder of Section 3 discusses the development of the stochastic assumptions given in Figure 3.1. The application of the assumptions in the projection calculations is outlined in Appendix A.

Figure 3.1 – The general projection process



3.2 Economic model

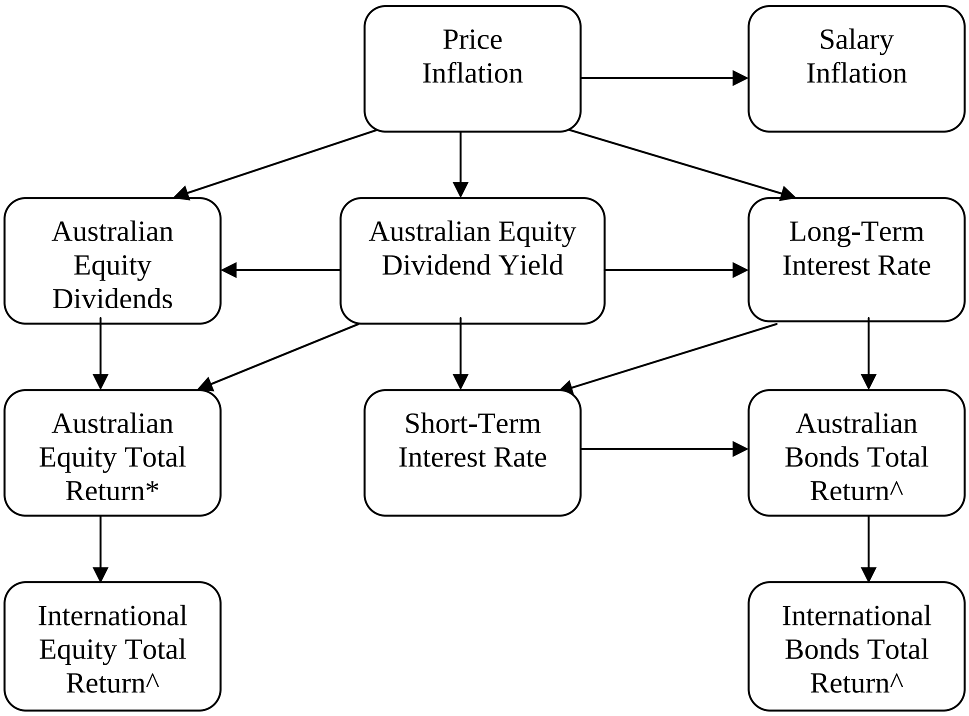
The Wilkie (1995) model is used as the starting point for the economic model. Wilkie (1995) is an update of Wilkie (1986), which considered only price inflation, share dividends, share dividend yields and long-term interest rates. Modelling share dividends and share dividend yields implicitly models share price returns, as seen in Table B.2 in Appendix B. Wilkie (1995) extends Wilkie (1986) to incorporate wage inflation, short-term interest rates, property rentals, property yields, yields on inflation-linked bonds and currency markets.

Wilkie (1995) states clearly that the purpose of the model is not to provide the best statistical fit of past or future data in the short or medium term, but to produce relationships between the economic variables which hold over the longer term. Since the projections are undertaken over an approximately 30 year period, it is felt that the long-term properties of the Wilkie model are appropriate in this case also.

Property variables are not used in this paper, due to the relatively low allocation to property of most superannuation schemes, and the paucity of Australian data available to fit such models. All allocation to "risky" assets is assumed to be made through domestic or international equities. Inflation-linked bonds are not a major component of the Australian investment market, mainly because the Reserve Bank of Australia ceased issuing these securities in 2003.

The Wilkie model is, in fact, not a single model at all, but involves the use of various types of processes, fit by past economic data and/or judgement about future expectations. The constant in the model is the linking of the variables through a "cascade" structure, where the variables are modelled individually in a hierarchical fashion. In Wilkie's structure, price inflation sits at the top of the hierarchy, with all other variables affected directly or indirectly by the price inflation process. A flowchart of the relationships between the economic variables of interest in the Wilkie model is given in Figure 3.2. An arrow from Variable X to Variable Y indicates that the calculation of Variable Y is dependent on Variable X, but not vice-versa. Hence the term "cascade" structure, where price inflation is modelled independently, directly affecting those variables to which an arrow flows from price inflation and indirectly affecting all other variables.

Figure 3.2 – The Wilkie model cascade structure



* Not calculated directly by the Wilkie model, but can be obtained indirectly via Australian equity dividends and dividend yield.
^ Not part of the Wilkie structure but included in addition to the original structure.

The returns on Australian Bonds, International Equity and International Bonds are not part of the Wilkie model and therefore it is necessary to introduce additional relationships at the foot of the Wilkie framework to model these variables. The return on Australian Bonds is determined by levels of long and short term interest rates in both the current and previous periods, in order to take into account the effect movements in interest rates have on the capital value of bonds.

Before considering the return on international investments it is necessary to decide on the hedging strategy which will be used for these investments. Convention suggests that currency is a diversifying factor for international equity investment, however recent evidence is not particularly strong either way as it reduces the correlation between Australian and International equity investment. However, currency does introduce unwanted volatility into the more stable international bond returns, ensuring these investments tend to be hedged. Therefore for the purposes of this paper, international equities are assumed to be unhedged, whilst international bonds are assumed to be hedged.

The Wilkie model considers individual currency relationships, based on the inflation rates of the countries in question. In theory, it might be possible to apply the Wilkie model in all countries under which investment is undertaken, allowing for exchange rate movements when expressing returns in domestic currency. However, international investment is generally undertaken in a wide variety of countries, and thus an approach where modelling inflation rates and equity returns of these countries is required is prohibitively time consuming. Therefore the Wilkie model for currency movements is not used in this paper. Global equity markets show significant correlation, therefore it is reasonable to model international equity returns as a function of Australian equity returns (although the causality is most likely in reverse). Currency movements have the effect of reducing the correlation between Australian and international equity returns, however since currency movements are not particularly correlated with any other factor in the economic model, it is reasonable to assume this simply adds additional volatility to the difference in return between Australian and international equities. Similarly to equities, returns on bond markets tend to be correlated worldwide, thus a similar equation to that for international equities is used, however volatility in this relationship is linked to the level of current short-term interest rates.

A description of the fitting of the Wilkie model is provided in Appendix B.

3.3 Withdrawal rates

Kilpatrick and Felmingham (1996) find that age and length of current job are both significant predictors in the probability of leaving a job for the years ended February 1989 and February 1992 from the ABS Labour Mobility report. Labour turnover decreases as both age and current job length increase.

There is much debate in the literature regarding the effect and significance of economic factors on labour turnover. There are two established arguments linking labour turnover to economic activity. The “chilling” hypothesis (Osberg, 1991), states that in times of economic downturn and high unemployment workers will not seek alternative employment. The “structural adjustment” hypothesis (Lillen, 1982), states that differences in hiring rates between industries in an economic downturn encourage labour turnover between industries.

Part of this inconsistency may be due to differences between voluntary and involuntary job movements across the economic cycle. Wooden (1999) presents information on the percentage of Australians who voluntarily or involuntarily left a job for biennial periods from February 1988 to February 1998. The data source for this table is the ABS Labour Mobility report, Table 3.1 below presents the information from Wooden (1999) extended to February 2008:

Table 3.1 – Job ceasing statistics 1988 - 2008

12 months ended February	Voluntary (%)	Involuntary (%)	Total (%)
1988	12.3	8.2	20.5
1990	13.8	8.0	21.8
1992	8.5	9.5	18.0
1994	9.9	8.8	18.7
1996	11.5	8.0	19.5
1998	10.5	7.6	18.1
2000	11.7	7.2	18.9
2002	13.3	8.1	21.4
2004	14.3	6.5	20.8
2006	12.6	6.0	18.6
2008	12.7	5.4	18.1

The periods in Table 3.1 are characterised by strong economic growth in all periods except the early 1990’s. The voluntary and involuntary columns show a clear opposing trend, with individuals more likely to leave a job voluntarily during times of boom, supporting the “chilling” hypothesis, but more likely to lose a job involuntarily in recession, supporting the “structural adjustment” hypothesis. However, the trend is not so clear in total. Therefore it can be difficult to identify a total trend in labour mobility, although trends do exist depending on the reasons for leaving.

Resignation and retirement rates are set after considering the February 2004 Labour Mobility survey by the Australian Bureau of Statistics and the additional analysis of the February 2002 survey by Shah and Burke (2003). These rates can be found in Appendix C. They are identical for males and females and are not impacted by economic factors. However, the rates do decrease as members get older and increase their length of membership.

3.4 Mortality rates

Like the withdrawal model, it is necessary to establish what factors have an influence on mortality. There is no doubt that age and gender have a significant impact on mortality rates, a cursory glance at the Australian Life Tables, 2000-2002 by the Australian Government Actuary shows this.

There is a wide body of literature linking income inequality with increases mortality, a summary of the link of income, among other factors, to mortality can be found in Brown and McDaid (2003). Knox and Tomlin (1997) find that, for pensioners in the Public Sector and Commonwealth Superannuation Schemes, mortality is significantly lower for males with higher pre-retirement income, with this relationship decreasing as pensioners get older. Knox and Nelson (2007) find a similar relationship, but using pension size instead of income. Sorlie (1995) finds that income is negatively correlated with mortality for individuals from age 25 upwards.

The link between economic factors and mortality is very complicated, with the literature providing many contradictions. Ruhm (2004) provides a summary of recent literature and its contradictions. An important early paper, Brenner (1979), hypothesised that an economic downturn, characterised by an increase in unemployment, causes a deterioration in health and an increase in mortality. This is due to the psychological impacts of unemployment, including lack of resources to meet health requirements, increased stress and turning to unhealthy habits such as tobacco, alcohol and drugs.

A number of later papers criticise these results for statistical reasons. Laporte (2004) and Ruhm (2000), using US data, and Gerdtham and Ruhm (2006), using data from 23 OECD countries, all find the reverse; that economic upturns lead to increases in mortality rates. This may be due to lifestyle factors such as longer working hours and less leisure time during upturns, meaning a reduction in health and an increase in mortality. In addition, economic upturns may increase the probability of work-related accidents.

Clearly there is debate in the literature as to the exact effect of the economy on mortality and there is no obvious answer to the effect it has. It is quite possible that psychological and lifestyle effects of the economy both impact mortality rates, but in combination the overall effect is unclear. In any case, given the competing and other unknown effects, such as technology, health services, etc. (which it could be argued, are also influenced by the economy), it is difficult to establish a firm causality relationship between economic factors and mortality. Therefore, any link is ignored for the purposes of this paper.

Whilst a consensus seems to have been reached on a negative relationship between income and mortality, ALT00-02 does not provide any information on differences in mortality dependent on income factors. In order to quantify the effect of income-dependent mortality, it would be necessary to run a full analysis of a mortality dataset which included income for the individual exposures, which has not currently been done. As a consequence no explicit allowance is made for the effect of income on mortality rates.

The starting point in generating mortality rate assumptions is q_x, the probability of a person aged exactly x dying before reaching age (x + 1), from the Australian Life Tables 2000-02 (ALT00-02). The mortality rates are split by age and gender, for the purposes of this paper a life reaching age 104 is assumed to die in the next year.

It must now be considered if any adjustments should be made to ALT00-02 in determining mortality rates to use in this paper. Premium rates for death insurance offered by large public-offer retirement benefit schemes indicate that that ALT00-02 mortality rates may be too high. However, this death insurance is usually offered with total and permanent disablement (TPD) insurance, therefore it can be surmised that many individuals who become seriously ill or injured may be offered a TPD benefit, taking them out of the scheme. These individuals would have a much higher probability of death than others of the same age and gender, thus reducing the mortality rate for members of the scheme compared to the general population. The scheme modelled in this paper does not have a separate TPD benefit, therefore it is likely that individuals who are seriously ill or injured may stay on some sort of external compensation plan and remain members of the scheme, making ALT00-02 a more reasonable measure of mortality rates.

Knox and Nelson (2007) note that the mortality experience of pensioners from a number of public sector schemes was lower than that of ALT00-02 until age 85 after which it was higher. Knox and Nelson argue the reduction in mortality is due to the fact that in these schemes the pension is fully commutable, meaning those who select the pension are in better health than those who don’t. In the scheme used in this paper the pension is not commutable, therefore removing this selection process. Knox and Nelson are surprised by the increased mortality after age 85, surmising that perhaps ALT00-02 rates are too low at higher ages.

Given no further information about the members of the scheme, it seems reasonable to assume that ALT00-02 is a sufficient measure of the mortality experience.

ALT00-02 notes that mortality rates have been in decline for over 100 years, with the most recent 25 years showing the steepest decline. Unfortunately, computer resources preclude the direct inclusion of improvements in the underlying mortality rates, due to significant increases in run time when calculating contributions and liabilities using changing expectations of mortality. However, the most important factor to consider in this case is differences between mortality assumptions and experience. Even taking into account expectations for mortality improvement, future mortality rates are affected by factors that are currently unknown, such as the level of technology improvement and epidemic outbreak. This can be proxied in a mortality model without improvements by random shocks to the underlying rates. Although the expected underlying rates remain constant, each period a random shock with expected effect zero is applied to the actual experienced rates, $z_{dth}(t)$, such that:

$$z_{dth}(t) = q_x\left(1+\varepsilon(t)\right);$$

where $\varepsilon(t)$ is a normally distributed random variable with mean zero and variance σ^2. Although it might be possible to model the relationship of the random shock $\varepsilon(t)$ between ages and genders, for simplicity purposes it is assumed that $\varepsilon(t)$ affects all ages and both genders equally, which also ensures the shape of the ALT00-02 mortality rates is maintained. It is also assumed that the random shocks are uncorrelated from year to year, as any prolonged shock is likely to result in a change to underlying rates, which is not allowed for in this paper.

It is necessary to estimate σ in order to incorporate these random shocks into the mortality model. To do this the actual mortality rates from ALT00-02, ALT95-97 and ALT90-92 were compared with the expected mortality rates assuming the previous 25 year average improvement factors, obtaining the appropriate ε for each gender and age. It is noted that this

ε uses mortality rates over successive three year periods to estimate mortality rates five years away, whereas in this paper mortality rates are estimated from year to year. The three year averaging reduces mortality variability whilst the five year estimation period increases variability; these two factors are assumed to offset each other making the above process reasonable in determining the variability of mortality from year to year. Table 3.2 gives the average ε for a variety of combinations of age and gender from the above analysis:

Table 3.2 – Mortality variability average error terms

Years	Male (17 – 100)	Male (65 – 90)	Female (17 – 100)	Female (65 – 90)
2000-2002	-0.0507	-0.0929	-0.0068	-0.0591
1995-1997	-0.0044	-0.0124	0.0194	0.0066
1990-1992	-0.0416	-0.0556	-0.0358	-0.0187

The prevalence of negative signs in Table 3.2 indicates that recent years have seen acceleration in mortality improvement, particularly for males. The reason for having a separate column for ages 65 – 90 is that the mortality rates at these ages have the most influence on the financial position of the scheme. Based on the above results, a value of σ = 0.035 is selected.

It should be noted that incorporating ε into the mortality model does not change the fact that expected and actual mortality rates are identical. However, of great concern is that assumed mortality rates might be higher than the actual rates experienced in future, leading to assets being insufficient. A scenario where this is the case is considered in this paper.

Finally, the scheme takes out insurance to cover the future liability for those who die whilst active members. It is therefore necessary to determine the premium rate which applies for this cover. Anecdotal evidence suggests that around 30% – 50% of the premium for a life insurance contract is taken up by profit loadings, expenses and commissions, with the remainder being the risk premium. Group insurance contracts of the type that would be taken up by the scheme generally have lower expenses and commissions, therefore making a lower percentage possible. Therefore the insurance premium applied for an individual is equal to the sum insured multiplied by the death rate q_x multiplied by 1.5, which indicates a percentage of 33% from above. It is assumed that the insurer does not make a separate allowance for mortality shocks as discussed above.

The q_x rates used in this paper are provided in Appendix C.

3.5 Other decrement assumptions

The withdrawal and mortality rates described in Sections 3.3 and 3.4 represent the parameters of a Bernoulli trial which is applied to each member of the scheme each year (see Appendix A). This assumes that the incidence of withdrawal/death is independent between all members. This assumption seems reasonable for mortality, with the exception of risky jobs, in that the risk between individuals is likely to be relatively independent. The assumption is not so reasonable for withdrawal, with economic conditions potentially leading to mass retrenchments or general working conditions affecting the likelihood of all members leaving.

The withdrawal and mortality models also assume that each individual of a certain age and gender has exactly the same probability of withdrawal/death, in other words that all individuals are homogeneous with withdrawal and death rates only affected by the factors outlined in Sections 3.2 and 3.3. Although random shocks might affect the underlying rates, it is assumed these affect all individuals equally. This assumption is clearly not true, individuals of the same age and gender have different health and lifestyle issues making them heterogeneous, giving them different underlying probabilities of withdrawal and death. The decrements represent an average, given the factors outlined in Sections 3.2 and 3.3. However, it is assumed that this heterogeneity does not impact the variability of withdrawal and mortality experience, therefore the heterogeneity assumption is maintained.

4 SCENARIOS TESTED

4.1 Base scenario

The projections in this paper are undertaken on a model scheme which was closed to new entrants at the commencement of projections. Full details of the scheme are provided in Appendix D. As a brief summary, the scheme pays pension benefits to members upon retirement, with those who withdraw from the scheme after more than 5 years of membership receiving a deferred pension. Members who die or leave before 5 years of membership receive a lump sum.

The investment strategy is balanced between defensive and growth assets, with funding levels and contributions calculated on a projected unit credit basis, with deficits and surpluses spread over 3 years. A new contribution rate is calculated every year. All actuarial assumptions are unbiased relative to their expected values (using the models in Section 3), including the discount rate which is based on the expected return on assets. The scheme is assumed to be exactly 100% funded at the commencement of projections. Surplus is kept within the scheme at all times – it is not used for refund to the employer or to increase benefits, except at wind-up where any additional assets are paid to members and not returned to the employer. The scheme is assumed to wind up the year after the active membership decreases below 50, with benefits thereafter provided by the purchase of annuities from an external provider.

Whilst it is recognised that the arguments from financial economics may suggest that the discount rate on any liability should be a risk-free rate, and whilst this may be appropriate for financial reporting purposes, it is not necessarily appropriate for calculating funding level calculations. One of the changes to the contribution strategy outlines a scenario where the wind-up liability is targeted funding level, which could be considered to be analogous to a risk-free funding level.

4.2 Changes to investment strategy

There is a wide variety of literature discussing the most appropriate investment strategy for schemes, with much debate on the role of various asset classes in these strategies. This debate can generally be reduced to one of two views. The first is that the assets backing liabilities should be matched as closely as possible to the liabilities, using either a duration-matching strategy with appropriate bonds or matching projected cash flows exactly. The second view is that equity investment is a reasonable hedge for the profile of the liabilities and that the additional return generated by equities in comparison to bonds is enough incentive to invest in equities. For the purposes of this paper, the matching strategy is not explored.

With the use of stochastic modelling techniques, Boulier et al. (1995) state that schemes should invest a lower proportion of assets in risky investments as the funding level increases. This is due to the diminishing upside gain as the funding level increases. Similar results are found by Haberman et al. (2003). These papers aim to minimise the present value of future contributions. This result is refuted by Taylor (2002) due to the use of a different objective function, combining contributions and funding level.

As a starting point, four alternative asset allocations are tested. The asset allocations are given in Table 4.1 below:

Table 4.1 – Alternative asset allocations

Asset Class	Base	Growth	Defensive	Low-risk
Australian Equities	35%	50%	15%	0%
International Equities (Unhedged)	25%	35%	10%	0%
Australian Bonds	20%	8%	35%	25%
International Bonds (Hedged)	15%	5%	25%	25%
Australian Cash	5%	2%	15%	50%

Given the above discussion, these asset allocations are tested in different combinations depending on the funding level, as outlined in Table 4.2.

Table 4.2 – Asset allocations for scenarios IS1 – IS4

Scenario	Funding Level (%)				
	< 80	80 - 90	90 - 110	110 - 125	> 125
IS1	Growth	Growth	Growth	Growth	Growth
IS2	Defensive	Defensive	Defensive	Defensive	Defensive
IS3	Growth	Growth	Base	Defensive	Low-risk
IS4	Low-risk	Defensive	Base	Growth	Growth

Changes to asset allocations in IS1 and IS2 affect the discount rate, due to changes in the expected return on investments, which in turn affects the value of the liabilities. Unless otherwise stated, the initial asset value remains unchanged, as it is desired to compare the effect of different asset allocations from a fixed asset base. For example, this means that the Growth asset allocation gives an initial surplus whilst the Defensive asset allocation gives an initial deficit. Note that the discount rate is not changed for IS3 and IS4, since the contribution strategy aims to return the scheme to 100% funding and thus the long-term expected return on assets still uses the Base asset allocation.

4.3 Changes to contribution strategy

Traditional funding methods generally fall into two broad categories, projected methods and accrued methods. Under projected methods, such as Attained Age and Aggregate, all future liabilities of the scheme are considered in setting a contribution rate. Under accrued methods, such as Projected Unit Credit (PUC) and Unit Credit (UC), the contribution rate targets the projected liability at some time in future, usually one to three years. Therefore, for a scheme which is closed to new entrants, projected methods give a level contribution rate over the life of the scheme, while accrued methods give a contribution rate which changes year to year as the liability develops. This usually gives a lower contribution in earlier years, but a larger contribution as the liability matures. For a scheme with a stationary population (i.e. new entrants keep the duration of the liability constant), accrued methods give a stable contribution over the life of the scheme, whilst projected methods tend to overfund as they are based on a level contribution rate for the future liabilities of current members only (assuming new entrants are not allowed for as in Entry Age Normal).

McLeish and Stewart (1987) argue an accrued approach is the most appropriate, and that the liability targeted should be the liability due if the scheme was to wind up, an approach validated by Cowling et al. (2004). This may give a different funding target to that generated if the scheme is assumed to be valued on an ongoing basis (as the liability is likely to be based on different assumptions – see Appendix D). Colbran (1982) states this approach is not appropriate as it may not target the actual liability the scheme has to pay out. He states that projected or accrued methods may both be appropriate, although projected methods could be criticised due to generating a higher contribution rate than is required to meet the liability in the short term.

Accrued methods have generally become more popular than projected methods in recent years, particularly outside Australia, partly because of legislation favouring this approach.

For example the US requires an accrued benefits approach for funding levels and minimum contribution calculations, whilst accounting standards worldwide also require accrued benefits approaches for liability and expense calculations.

There is much debate about whether future salary increases should be allowed for in calculating the liabilities of a scheme. Using US accounting terms, the Projected Benefit Obligation (PBO) uses a Projected Unit Credit (PUC) funding method and allows for future salary increases in calculating scheme liabilities and contributions. This approach is used in all major accounting standards to determine the scheme liability and expenses. The Accrued Benefit Obligation (ABO) uses a Unit Credit (UC) funding method and does not allow for future salary increases. This approach is used in the US to determine the funding liability and the minimum contribution rate. An ABO approach tends to lead to very low contributions for younger members, increasing significantly as the membership ages, whilst a PBO approach does not give such a significant increase as the member ages, as noted by Kopcke (2006). Kopcke also states that using an ABO target allows schemes to hedge liabilities more effectively, as the real wages risk is removed, whilst a PBO target may encourage investment in riskier assets with appropriate asset margins held to manage the risk.

Bulow (1982) argues that salaries should not be projected when calculating the economic value of scheme liabilities, as this approach is closer in structure to the way a defined contribution scheme is valued and allows for the fact that the scheme could be terminated at any time. It is also stated that from a funding perspective this is not particularly relevant, an employer may use whatever method to calculate contributions they feel is most appropriate. Lazear (1979) describes an implicit promise between the employer and employees for salary increases and pensions, in which case a liability measure including future salary increases is appropriate.

The simplest approach to removing deficit or surplus can be found in the aggregate method, a projected method where the future contribution rate is simply the amount required to meet the difference between current assets and total liabilities of the scheme (allowing for past and future service), with no assumption for new entrants. In this case, deficit or surplus is spread over the lifetime of the current membership. Other approaches allow a choice as to the appropriate period.

Cairns (1994) provides a summary of stochastic modelling results in a discrete-time framework and finds that there is generally a mathematical optimum range for the spread period in balancing the variance of the funding level and contribution level. More frequent valuations and quicker implementation of contribution changes lower the variability of contributions for short spread periods, but increase the variability for longer spread periods. Positive autocorrelation in investment returns increases the optimal spread period and vice-versa. Owadally and Haberman (2004) use a simulation model to estimate that deficits and surpluses should be spread over a period of 7 – 13 years to minimise funding level and contribution volatility. This result holds for models with little to no investment return autocorrelation.

The base scenario uses a PUC approach to calculating scheme liabilities and contribution rates. The following alternative contribution strategies are considered:

- CS1. Attained Age Normal;
- CS2. PUC, with deficits and surpluses removed over a period of 7 years rather than 3 years;
- CS3. Aggregate;
- CS4. Unit Credit (UC); and
- CS5. PUC, but targeting the wind-up liability and adjusting contributions accordingly.

One further scenario is described below.

CS6. Underestimating future mortality improvements
Future mortality rates are a difficult to predict, although past history shows mortality rates decreasing significantly, it is difficult to predict at what rate this will continue. It is unlikely that future mortality rates will match the assumed rates exactly. As discussed in Section 3.3, it is not possible to incorporate mortality improvements into the actuarial valuation assumptions, therefore expected mortality improvements cannot be modelled directly in the funding calculations. However it is possible to incorporate differences between the assumed mortality rates and the actual rates experienced, which can be used as a proxy to future mortality improvements being faster than expected. To achieve this, an alternative scenario is considered where the assumed mortality rates are 20% higher than the actual mortality rates experienced.

As with investment strategy, although changes to the contribution strategy may affect the initial funding level, no adjustment is made to the initial asset level to reflect this.

4.4 Changes to the structure of the scheme

The following alterations to the benefit design are considered:

- BD1. A much smaller scheme is investigated by removing 90% of all members of the scheme at random – for consistency the scheme is wound up when there are less than 5 active members;
- BD2. New entrants are allowed for – each member who leaves active membership of the scheme is replaced by a new entrant whose age is 30% less than the previous member's years of age over 20. The salary and gender of the new entrant is assumed to be identical to the leaving member; and
- BD3. All benefits are paid as a lump sum according to the rules of the withdrawal benefit. In this case the wind-up liability is assumed to be equal to the lump sum payable.

BD3 can be considered similar to the case where a scheme offering pension benefits discharges its liability through the purchase of an immediate or deferred annuity, although in this case the lump sum is known in an advance, whereas the purchase price of the annuity may change over time with changes in interest rates and other factors.

For the purposes of these alterations, the initial asset value is changed to reflect full funding under the revised benefit design.

5 ANALYSIS

The process described in Appendix A is performed for 1,000 simulations, with the following analysis undertaken across the simulations. The results of this analysis are presented in Section 6, although not all analysis is presented for all scenarios for reasons of space.

5.1 Confidence intervals

The first analysis performed is to calculate and plot the median and 95% confidence intervals for the contribution rate (as a percentage of salaries) and funding level (assets divided by actuarial liability) for each future year of projection. The median and 95% confidence interval are calculated by simply using the appropriate 2.5%, 50% and 97.5% percentile observations in each projection year, as per standard bootstrap methods (see Efron (1979)). Note that the 70% and 90% percentile observations for contribution rates are also included, due to the tendency for contributions to move towards zero for many simulations. This analysis, similar to that performed by Wright (1998, p879,889) in a 25 year stochastic analysis of funding levels, does not help to numerically identify the effect of different scenarios on the trustee and employer objectives, but does provide a broad overview of the movement in contribution rates and funding levels over time.

5.2 Trustee and employer objectives

It is also necessary to provide some sort of measure of the outcomes of the trustee and employer objectives discussed in Section 2. In order to do this single figure measures across individual simulations are derived for analysis. Frequency plots of these single figure measures over the 1,000 simulations are then presented.

Low contributions – present value

In general an employer desires contributions which are as low as possible over the life of the scheme. It is possible that a specific employer may be more comfortable paying contributions at certain times compared to others, given the vagaries of the economic cycle and its effects on different industries and companies. However this affects different employers in different ways and thus is difficult to measure effectively. In more general terms, the employer is likely to desire low contributions over the life of the scheme, also allowing for the fact that future contributions should be discounted to reflect the lower value they have relative to today's terms.

A present value approach is appropriate in valuing future contributions made over the life of the scheme. In each simulation the value of the contributions is reduced to a single figure by discounting future contributions at the cash rates applicable to that simulation. This reflects the effective cost to the employer of paying contributions to the scheme, without allowing for any specific credit profile of the company. Haberman (1997) also measures contribution rate risk using a present value approach, although in this work the valuation rate of interest is used to discount contributions.

Predictable contributions – standard deviation of contribution rate

Contribution predictability can be expressed in terms of the volatility (or standard deviation) of the contributions from year to year, weighted by the salary base upon which the contribution rate is paid.

Funding level effects – mean deficit and excess surplus

Haberman et al. (2003), in measuring solvency risk, advocate a single figure measure by calculating the mean deficit of assets to liabilities, treating surpluses as zero deficits. This is considered a superior measure to simply calculating the variance of funding levels, as it specifically allows for the probability of risk as well as the size of the deficit.

A similar measure is used in this paper, with deficits being discounted to the date of commencement of the simulation as was done for contributions. The other difference between the Haberman et al. (2003) measure and that used in this paper, is that Haberman et al. (2003) take the mean deficit at a given time across all simulations, whilst this paper takes the mean deficit across a single simulation to generate 1,000 mean deficits for a given scenario, which are then analysed. This allows deficits to be compared across the whole simulation rather than just at a particular point in time.

It is also necessary to create a related measure of surplus, although in this case the employer is not concerned by small levels of surplus, as this can be used to offset future contributions. The employer is concerned where the dollar amount of the surplus exceeds the present value of future service benefits of active members, which means the full surplus is not usable by the employer to fund future contributions under the current assumptions. Therefore an appropriate measure is mean surplus of assets to total liabilities (both past and future service), with deficits to total liabilities being treated as zero surpluses. Surpluses are also discounted to the date of commencement of the simulation.

5.3 Drivers of funding level

Section 5.2 relates to the results from each simulation being reduced to single figures for the purpose of analysis. However, it is also of interest to look at the factors which drive the development of the trustee and employer objectives from year to year.

The headline result of interest to both the trustee and employer is the funding level and therefore this will be the focus of this section. Leibowitz et al. (1994) introduce a measure for identifying movements in the funding level called the "Funding Ratio Return", which could also be called the "Funding Level Return" (*FLR*) based on the terminology used in this paper. It is a simple measure of the percentage movement in the funding level from year to year. For example, a movement in the funding level from 95% to 105% represents an *FLR* of 105/95 – 1 = 10.5%.

The *FLR* can be used to estimate the factors which most affect the scheme's performance. In general, movements in the funding level from time $t - 1$ to time t are caused by differences between actuarial assumptions at time $t - 1$ and actual experience from time $t - 1$ to time t. They can also be caused by changes to actuarial assumptions between time $t - 1$ and time t; for the purpose of this paper this only occurs to the discount rate when analysing movements in the wind-up funding level, as the discount rate is based on long-term interest rate yields and changes from year to year.

The factors to be considered are:

- Actual investment return less discount rate; (i_{diff})
- Actual less expected salary increases; (w_{diff})
- Actual less expected pension increases; (q_{diff})
- Actual less expected mortality rate; (m_{diff})
- Actual less expected withdrawal rate (lump sum only); (r_{diff})
- (Liability discount rate in year t less discount rate in year $t - 1$) / Discount rate in year $t - 1$. (i_{chng})

A basic, linear regression model is fit to the *FLR* in order to identify the factors which have the greatest impact on the *FLR*. An additional factor to those listed above, the difference between the previous funding level and 100%, $FL_{diff} = FL(t - 1) - 1$, is included. It is expected that FL_{diff} will be negatively correlated with *FLR*, due to lower contributions reducing the funding level when $FL(t - 1)$ is above one, and vice versa. However, it is noted that when funding levels get very high the interest on surplus offsets any contribution reduction. Therefore a quadratic term FL^2_{diff} multiplied by a dummy variable, $I = 1$ if $FL_{diff} > 0$ and $I = 0$ if $FL_{diff} < 0$, is included. The regression model is defined as follows:

$$FLR = \beta_0 + \beta_1 i_{diff} + \beta_2 w_{diff} + \beta_3 q_{diff} + \beta_4 m_{diff} + \beta_5 r_{diff}$$
$$+ \beta_6 i_{chng} + \beta_7 FL_{diff} + \beta_8 I \times FL^2_{diff} + \varepsilon \,;$$

where $\beta_0 - \beta_8$ are parameters to be estimated in the model.

It would be possible to fit the above model to the *FLR* for each year for all 1,000 simulations for a given scenario, generating approximately 30,000 observations. However, this would ignore potential differences in the effect of factors on *FLR* due to time. It might be possible to incorporate time into the regression model, however the interactive relationships between time and the factors in the equation are likely to be complex. An alternative used in this paper is to perform the regression on 1,000 observations from one year only and compare this to the results of another 1,000 simulations from another year. This process allows the comparison of the model effects between two time periods without having to directly estimate the effect of time. In this paper, two time periods after the start of the projection are compared, year 1 to year 2 (t = 2) and year 20 to year 21 (t = 21). The major difference between these time periods is the proportion of active members in the scheme. Year 1 to year 2 is selected in preference to the first year in order to allow differences in the starting funding level, whilst year 20 to year 21 is selected as a year where all simulations have less than 10% of their membership actively accruing benefits.

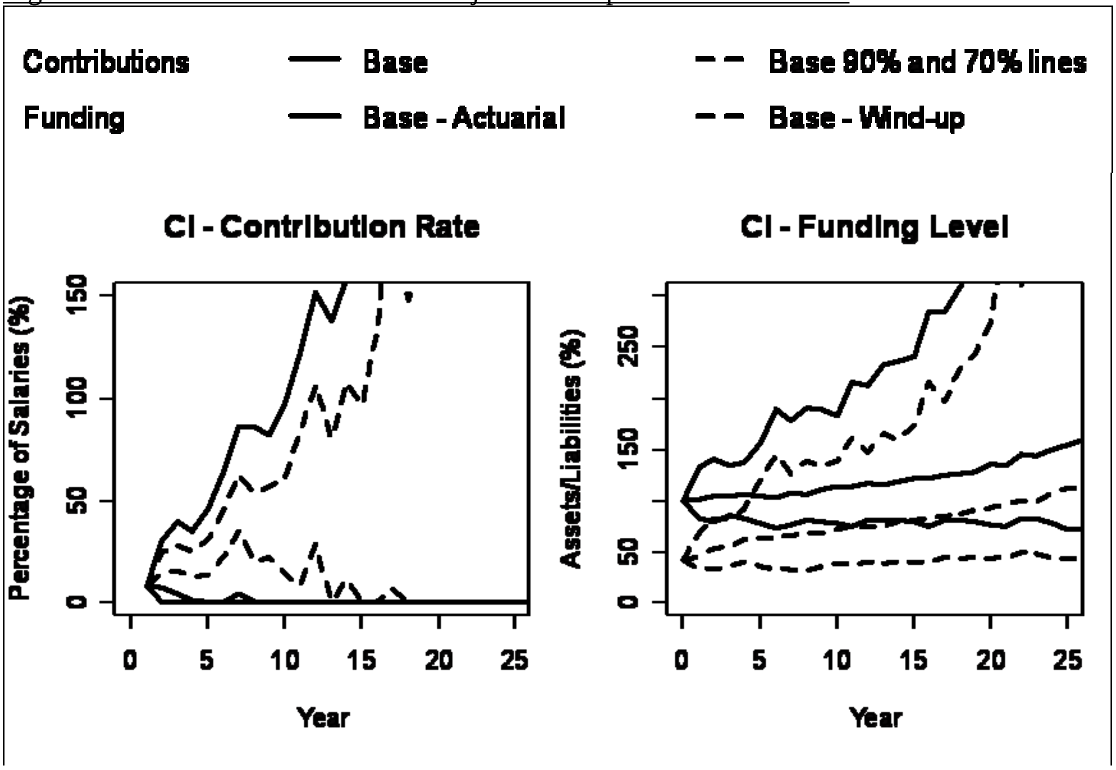
Summary statistics from the regression model are presented in Section 6, including the β estimates (Coef), the standard error of the β estimates (S.E.) and the percentage of variance explained by each predictor (SS), which is calculated by fitting the predictors in the sequential order which gives the greatest reduction in the residual sum of squares.

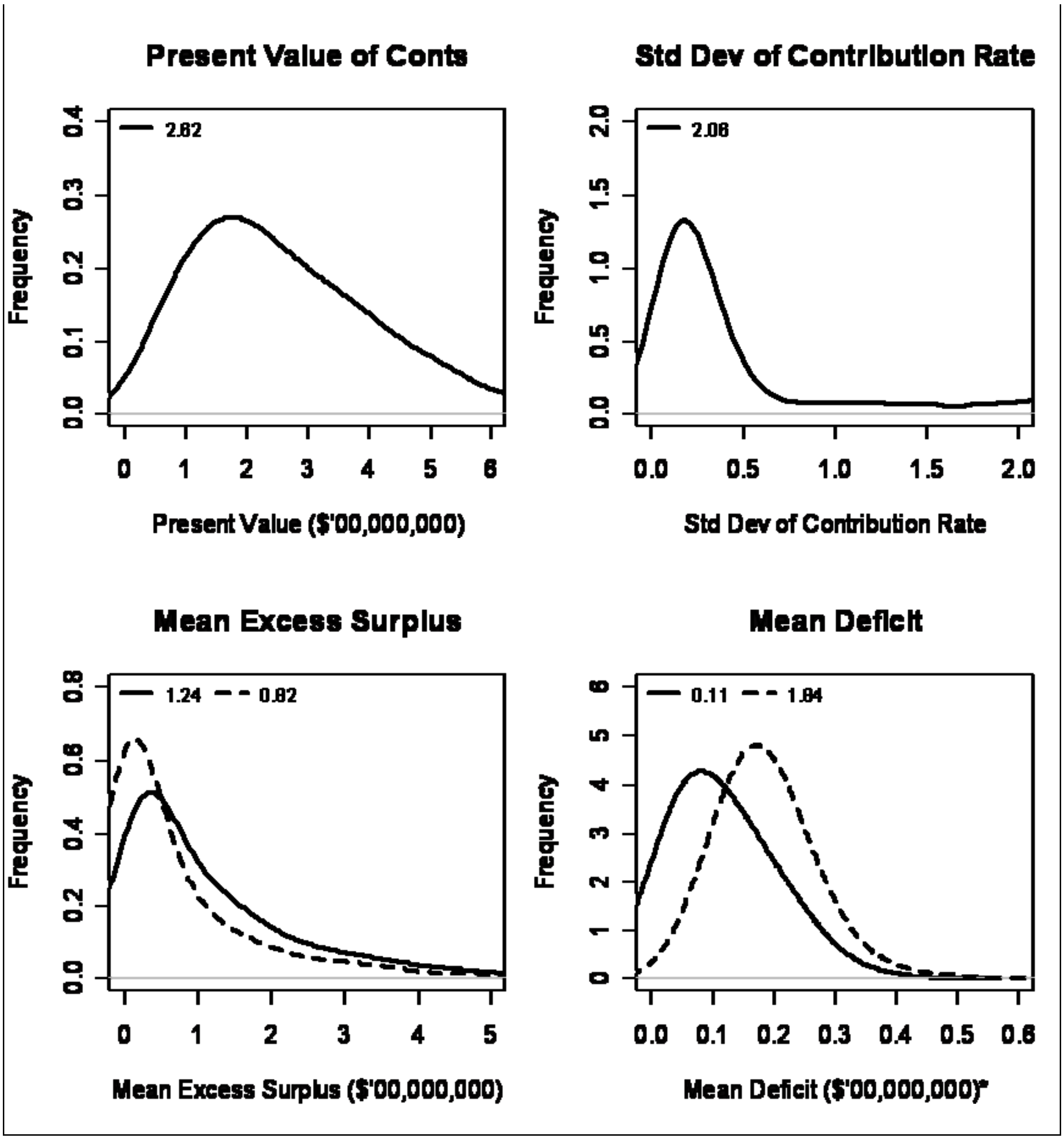
6 RESULTS

See Section 5 for a description of the analysis presented in this section and the notation used. Note that the figures below each start with a legend describing the meaning of the lines. The line types have separate meanings depending on if the plot is describing a contribution or a funding level output.

6.1 Base scenario

Figure 6.1 – Confidence interval and objectives output for base scenario





** Figures in frequency plots are means. The Mean Deficit (Wind-up) line has been scaled down by a power of 10 to fit the plot – although the mean is correct.*

The funding level confidence interval shows a clear upward trend, indicating that the base scenario results in an increasing funding level over time. The median actuarial funding level moves from 100% to 156% over 25 years, whilst the median wind-up funding level moves from 41% to 113% over the same period. This seems initially to be a strange result given the lack of bias in the actuarial assumptions. However the one bias implicit in the base scenario which has not been removed is the treatment of deficits and surpluses. Any deficit must be removed by additional employer contributions, however there is no option to refund the surplus if it reaches a size greater than the present value of future benefits. Therefore, all deficits tend to be removed over time, giving the relatively stable lower confidence interval of the funding level, but surplus can tend to grow exponentially, as seen in the median and upper confidence intervals.

This trend is consistent with the contribution rate confidence interval results. The median contribution rate moves to zero within 10 years, with even the 70% line moving to zero within 20 years. However, volatile rates are observed for higher lines, the increasing rate due mainly to the decreasing salary base across which contributions are paid.

The present value of contributions includes the contribution required to fund any difference between assets and the liability when the scheme winds up. What is interesting here is that the average present value of contributions of $262 million is considerably less than the deficit of assets to wind-up liability of $770 million at the start of the projections. Part of this is due to the initial long-term interest rate of 6.5% being lower than the average long-term interest rate of 9.0% (under which the deficit would be $361 million), however this also indicates the potential higher costs when aiming to fund the wind-up liability instead of the actuarial liability.

The standard deviation of contribution rate shows extreme right skewness, even after being weighted by salary base. The hump indicates the majority of simulations where no further contributions are required after 5 – 10 years, whist the skewness is due to the large contributions required to fund deficits in later years and on wind-up for some simulations.

The mean excess surplus and deficit plots provide further evidence of the trend to surplus over time. From an actuarial point of view the mean excess surplus is more than ten times larger than the mean deficit. The mean excess surplus is significantly right skewed indicating the extremely large value the surplus can attain in some simulations. The wind-up mean deficit is greater than the mean excess surplus due mainly to the significant deficits in early years.

Table 6.1 provides a summary of the results of the funding level regressions. See Section 5.3 for further information.

Table 6.1 – Funding level regression results for base scenario

	Actuarial						Wind-up					
	t = 2			t = 21			t = 2			t = 21		
	Coef	S.E.	SS	Coef	S.E.	SS	Coef	S.E.	SS	Coef	S.E.	SS
B_0	0.007	0.000	NA	0.038	0.001	NA	-0.108	0.009	NA	***0.002***	0.002	NA
i_{diff}	0.914	0.002	0.922	0.970	0.007	0.926	1.036	0.011	0.357	0.930	0.015	0.428
w_{diff}	-0.305	0.016	0.002	***0.009***	0.042	0.000	***-0.136***	0.079	0.000	***0.068***	0.095	0.000
q_{diff}	-0.671	0.016	0.028	-0.870	0.045	0.034	-0.224	0.088	0.001	***-0.135***	0.113	0.000
m_{diff}	1.009	0.263	0.000	***0.635***	0.329	0.000	***1.694***	1.323	0.000	***0.478***	0.728	0.000
r_{diff}	***0.115***	0.147	0.000	NA	NA	NA	***0.419***	0.743	0.000	NA	NA	NA
i_{chng}	NA	NA	NA	NA	NA	NA	1.030	0.010	0.602	0.603	0.009	0.478
FL_{diff}	-0.375	0.004	0.031	***0.003***	0.002	0.000	-0.127	0.018	0.004	0.035	0.004	0.007
FL^2_{diff}	0.927	0.016	0.014	0.002	0.001	0.004	NA	NA	NA	-0.004	0.002	0.000
		Total	0.996		Total	0.964		Total	0.964		Total	0.914

*Coefficients in **bold italics** are **insignificant** at the 5% level.*

The regression results provide information on what factors have the greatest influence on funding level. When holding the discount rate constant, as in the actuarial funding level, the difference between actual and assumed investment return explains more than 92% of the movement in funding level in both year 2 and year 21. A 1% increase in investment return relative to funding level gives almost a 1% increase in the funding level. The coefficient trend for salary increases and price inflation indicates the shift of members from active to deferred or pensioner status from years 2 to 21. Whereas a 1% increase in salary increases leads to a 0.3% decline in the funding level in year 2, this reduces to insignificance in year 21. Conversely, the effect of price inflation increases rises between year 2 and year 21. As expected, the total effect of salary increases and price inflation is broadly similar to that of investment returns in coefficient terms, although the greater volatility of investment returns ensures this explains a far greater proportion of the funding level variance. Interestingly, differences between actual and assumed mortality have little impact on the funding level – the positive coefficient indicates an increase in observed mortality rates increases the funding level as expected, but this explains virtually no variance in the funding level. Similarly withdrawal rates have virtually no impact on the funding level. As anticipated, year 2 shows two effects for the previous funding level, the first being the trend of funding levels moving towards 100% due to contribution strategy, and a second effect where extremely high funding levels do not move back to 100% due to exponential surplus increase. The previous funding level coefficients are not significant in year 21, this seems to be due to the increase in the intercept coefficient – it seems that due to most simulations being in significant surplus by year 21, the exponential funding level increase is reflected in the intercept rather than the funding level effects.

Results for the wind-up funding level reflect the impact of the changing discount rate with the long-term interest rate. This change now represents the majority impact of movements in the funding level. The reduction in variance explained from year 2 (60%) to year 21 (48%) is due to the additional volatility created by the long-term interest rate moving upwards towards its average rate during year 2. The large negative intercept in year 2 represents an apparent inadequacy in the regression model for dealing with a discount rate change which has a trend. In this case the trend is upwards, for the reasons discussed above, the coefficient in this year is much larger than year 21, however it is offset by the negative intercept. In year 21, a 1% relative increase in the discount rate leads to a 0.6% increase in the funding level, with no intercept effect. Again, investment return is the other significant predictor of funding level variability; its coefficients are broadly similar to that for the actuarial funding level. The presence of the change in discount rates also renders the effect of salary increases and price inflation virtually irrelevant – in the case of price inflation this is because price inflation is linked directly to long-term interest rates in the Wilkie model, therefore the coefficient estimate is unreliable given the presence of long-term interest rates.

6.2 Changes to investment strategy

In the interests of keeping this paper to a reasonable size, not all of the results presented under the base scenario are presented here. Appendix E provides the confidence interval plots for these scenarios, whilst the means equivalent to Figure 6.1 are provided in Table 6.2 below.

Table 6.2 – Means for investment strategy scenarios

	Base	**IS1**	**IS2**	**IS3**	**IS4**
Present Value of Contributions	2.62	2.08	4.23	2.68	3.13
Std Dev of Contribution Rate	2.06	2.26	1.35	2.72	2.24
Mean Excess Surplus (Actuarial)	1.24	2.28	0.45	0.36	1.65
Mean Excess Surplus (Wind-up)	0.82	1.70	0.22	0.06	1.31
Mean Deficit (Actuarial)	0.11	0.10	0.15	0.11	0.14
Mean Deficit (Wind-up)	1.84	1.81	1.59	2.05	1.90

Means are expressed in the same scale as Figure 6.1

Using a Growth strategy (IS1) clearly reduces the present value of future contributions, partly because the initial contribution rate is zero (given the reduction in the liability for the increased discount rate) and partly because the Growth strategy exacerbates the exponential surplus increase, thus minimising the chance of having to make additional contributions to fund the higher liability upon wind-up of the scheme. Since much of the standard deviation of contribution rate is dependent on the final contribution required on wind-up, the standard deviation of contribution rate for the Growth strategy is only marginally higher than the base scenario.

A Defensive strategy (IS2) has the advantage of reducing the excess surplus and volatility of contributions, but at the significant cost of higher present value of contributions. The higher actuarial mean deficit is due to the initial deficit (given the increase in the liability for the reduced discount rate).

Reducing investment risk with surplus increase (IS3) significantly reduces the surplus build up, without significantly increasing the present value of contributions. In fact the average contribution rate under IS3 tends to be lower than the base scenario except upon wind-up, which explains the higher standard deviation of contribution rate. This scenario appears to be attractive to trustees and employers who wish to avoid a significant surplus build up. On the other hand, increasing investment risk with surplus increase (IS4) does not seem particularly attractive, given it increases all values relative to the base scenario.

Indeed, the above contribution results are heavily dependent on the treatment of the scheme upon wind-up. For the base scenario, $21m of the $262m in present value of contributions is made up of the additional wind-up contributions (over and above the actuarial liability), whilst for IS1 the figures are $21m from $208m and IS3 $32m from $268m. This indicates that reducing investment risk with surplus increase reduces the present value of contributions before taking the wind-up into account.

The regression results for each scenario are not presented. The coefficients are very similar to those found in Table 6.1 for each scenario, although the variance explained by the investment return increases/decreases as the volatility of the investment strategy selected increases/decreases.

6.3 Changes to contribution strategy

Similar to the investment strategies, not all of the results presented under the base scenario are presented here. Appendix E provides the confidence interval plots for these scenarios, whilst the means equivalent to Figure 6.1 are provided in Table 6.3 below.

Table 6.3 – Means for contribution strategy scenarios

	Base	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**
Present Value of Contributions	2.62	2.64	2.52	2.51	2.51	7.81	2.48
Std Dev of Contribution Rate	2.06	2.04	2.43	2.57	2.24	0.68	2.03
Mean Excess Surplus (Actuarial)	1.24	1.27	1.09	1.07	1.11	7.96	1.13
Mean Excess Surplus (Wind-up)	0.82	0.84	0.71	0.69	0.67	6.50	0.75
Mean Deficit (Actuarial)	0.11	0.11	0.16	0.17	0.13	0.00	0.11
Mean Deficit (Wind-up)	1.84	1.82	1.95	1.96	2.01	0.23	1.68

Means are expressed in the same scale as Figure 6.1

The attained age funding method (CS1) provides almost identical results to the base scenario, with the small increase in contribution rate under CS1 being swamped by the variation in scheme experience.

The seven year spread of deficits and surplus (CS2) and aggregate funding method (CS3) both result in deficits being removed more slowly than under the base scenario, whilst the unit credit funding method (CS4) is a slower pace of funding than the base scenario. All three of these approaches provide similar results; they slightly reduce the excess surplus whilst also slightly reducing the present value of future contributions. The lower funding level ensures the final contribution on wind-up is higher than the base scenario, giving a higher standard deviation of contribution rate. In fact, given the above results, an attractive strategy might be to spread deficits over a long period, but remove surpluses quickly, although this is unlikely to be a popular strategy with the Regulator.

Targeting the wind-up liability (CS5) has a massive impact, the present value of contributions increase threefold, with extremely large surpluses generated. In fact, the contribution in the first year under CS5 is greater than 150% of the present value of all contributions in the base scenario. Clearly, combining an investment strategy including equities and a funding level target of the wind-up liability produces unreasonable results.

Using mortality rate assumptions which are 20% higher than experience (CS6) has little impact on the results, in fact the present value of contributions decreases. This is because the higher assumed mortality rates result in a slower pace of funding and therefore a smaller excess surplus. However, it should be noted that the CS6 scenario is a result of the assumptions being changed; the liability experience is identical to the base and all other contribution strategy scenarios. Schemes in significant surplus are not likely to be affected by members living slightly longer than expected, although increasing the size by which the assumptions are wrong may have a greater impact. Also of interest, but not performed as yet, is the effect on contributions of the experienced mortality rates being lower than expected.

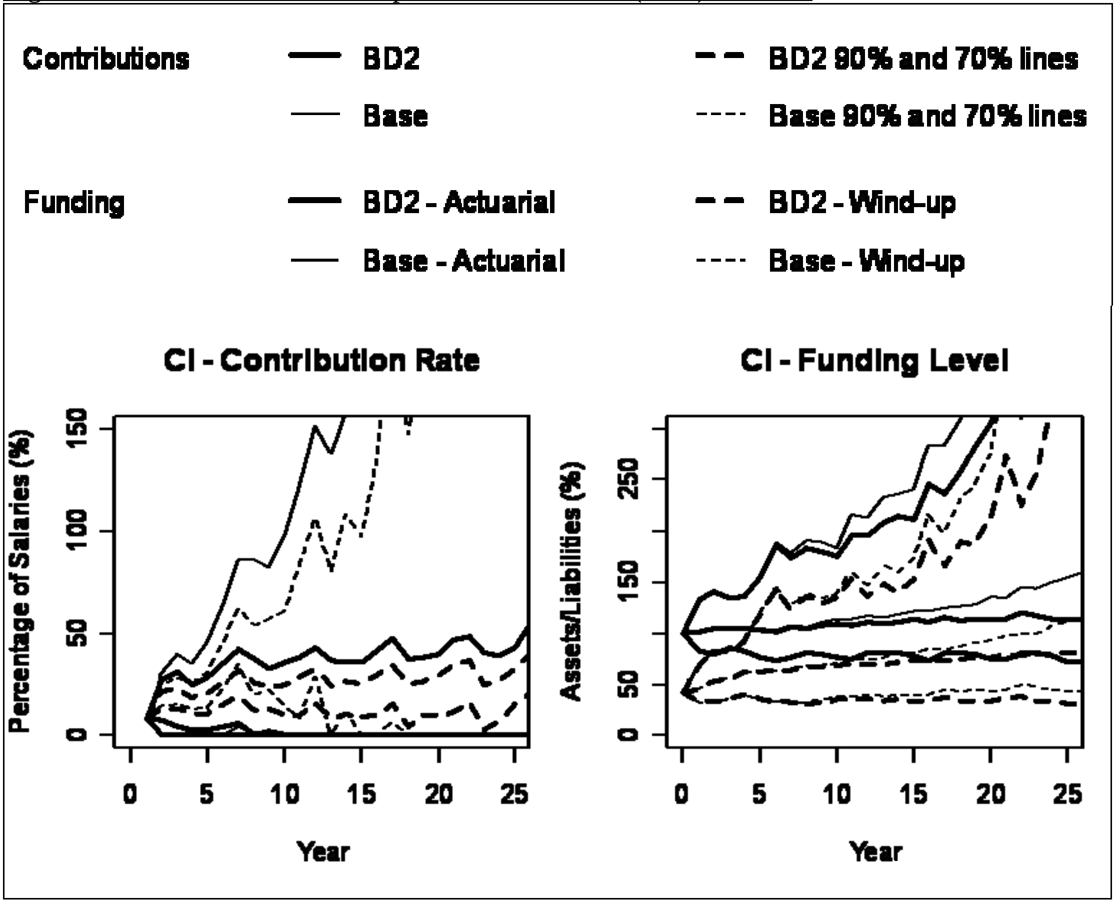
The regression results for each scenario are once again not presented. In most cases the coefficients are very similar to those found in Table 6.1 for each scenario, although increasing the spread period of deficits and surpluses (as in CS2 and CS3) reduces the size of the previous funding level coefficients due to the speed of movement to full funding being reduced. The FL_{diff} coefficient for the wind-up liability during year 2 when the wind-up liability is the funding target (CS5) is a much larger negative than under the base scenario, reflecting the significant contributions being made to move the scheme to full wind-up liability funding. Surprisingly, the incorrect mortality rate assumptions (CS6) have virtually no impact on the mortality rate coefficient. It appears that the assumptions have to be far more significantly wrong to have an impact.

6.4 Changes to the structure of the scheme

Reducing the size of the scheme by 90% (BD1) has virtually no impact on the output results, which are not presented here. The main reason for testing a smaller scheme is to identify if the decrement factors have more of an influence in a smaller scheme. The regression coefficients are very similar to those presented in Table 6.1, which is not surprising, however the percentage of funding level movement explained by death and withdrawal is still very low. For year 2/year 21 there is 0.0%/0.2% explained by mortality and 0.0%/NA explained by withdrawal. It appears that variation around a known mean mortality rate will only have an effect on funding levels for extremely small schemes, whereas differences between the expected and actual mortality rates should have the same effect irrespective of the size of the scheme. Appendix E provides the confidence interval plots for this scenario.

In most cases it is not possible to directly compare the results of a scheme which is open to new entrants (BD2) with the base scenario, due to the extremely different liability structures in future years. Figure 6.2 below compares the confidence interval plots for BD2 with the base scenario.

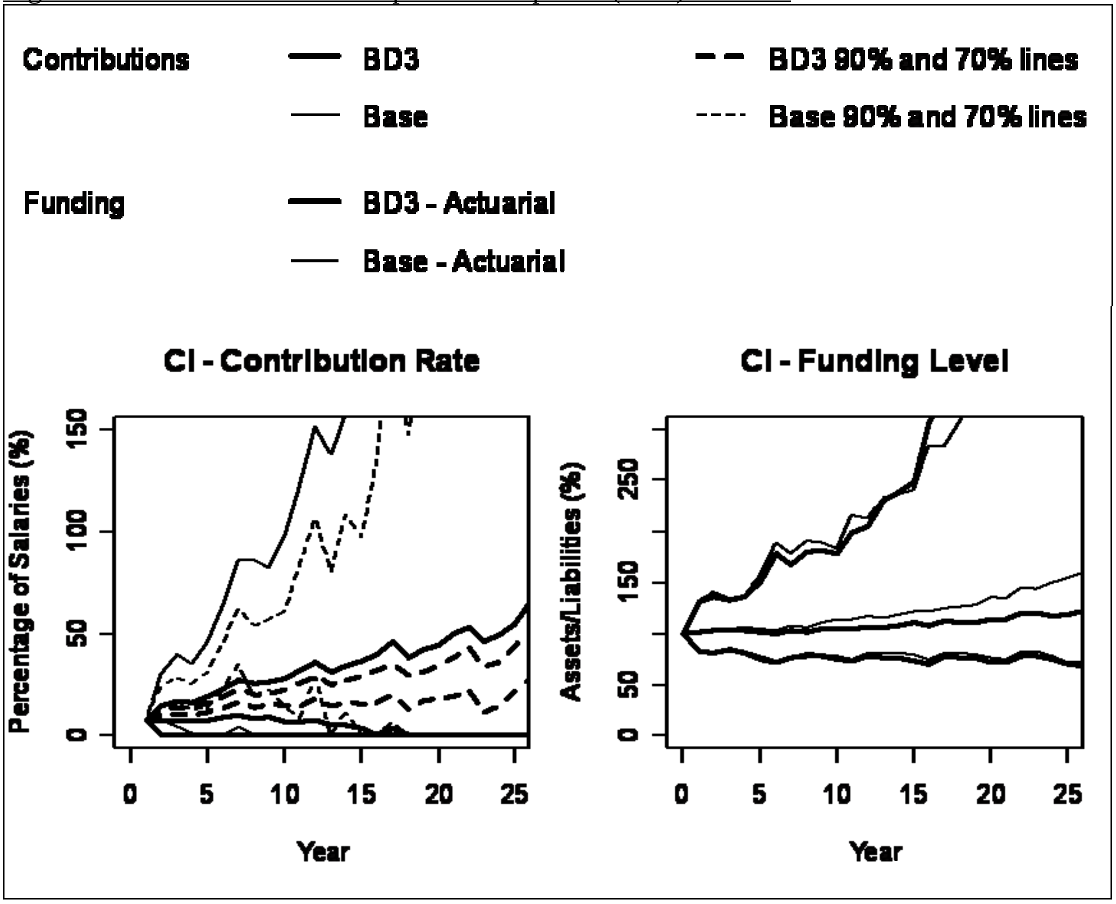
Figure 6.2 – Confidence interval plot for new entrant (BD2) scenario



The first point to note about Figure 6.2 is the relative flatness of the median actuarial funding level around 100%. This indicates the funding method and actuarial assumptions chosen generally lead to approximately 100% funding. However the upper confidence interval again shows exponential increase. In Section 6.1, it was noted for a closed scheme that this occurs when the surplus exceeds the present value of future benefits. For a scheme which is open to new entrants, the present value of future benefits is much larger due to the presence of members with low membership. In addition, new entrants each year generate additional future benefits. However, it is still possible for the surplus to exceed the present value of future benefits (including the new future benefits for new entrants) in a given year. When this occurs, the surplus will tend to increase exponentially as per the upper bound above. Note also that the lower bound for the actuarial funding level is the same for the closed and open schemes, which is to be expected given the requirements to contribute to fund deficits. The upper bound for contribution rates is far more stable when new entrants are allowed for, due to the larger salary base. Regression results are broadly similar to Table 6.1 and are therefore not presented.

Figure 6.3 below compares the confidence interval plots for BD3 with the base scenario. Note that the wind-up intervals are irrelevant as the wind-up liability is not significantly different as it was under the other scenarios.

Figure 6.3 – Confidence interval plot for lump sum (BD3) scenario



The two most obvious differences between BD3 and the base scenario are the flatter median funding level and the lower extreme contribution rates for BD3. The flatter funding level is due to the initial deferred and pensioner members not being present in BD3, making the future liabilities much higher compared to the asset level. This means the funding level has to grow much higher before the surplus can exceed the value of future liabilities. However, it can be seen from the upper confidence interval that once the surplus exceeds the future liabilities the surplus does grow exponentially.

The upper confidence intervals for contribution rates are lower for BD3 than the base scenario for similar reasons. Since the initial deferred and pensioner members are not present in BD3, the salary base compared to any deficit or surplus level is significantly higher, meaning the contribution rate is lower. In fact the salary base is always directly related to the level of deficit or surplus, as there are no members present who are not being paid a salary. This is also reflected in the median contribution rate being paid for much longer under BD3, as the higher future service benefit relative to the surplus means a contribution holiday requires a much higher funding level than under the base scenario, therefore it takes more time for schemes to reach a point where a contribution holiday is possible.

Comparison against the other plots from Figure 6.1 is not done due to the significant difference in liability structure discussed above. Suffice to say, all factors are significantly lower than the base scenario due to the lack of presence of the deferred and pensioner members. Of particular interest is the fact that the present value of contributions is significantly lower under BD3 ($139m) than the base scenario ($262m). Part of this is because the future service benefit of the active members is slightly lower under BD3 than the base scenario, but the majority is due to the employer not being required to fund future deficits for deferred and pensioner members who are fully funded at the start of the projection period.

Regression results are presented in Table 6.4 below, only the actuarial results are presented due to the irrelevancy of the wind-up result for BD3.

Table 6.4 – Funding level regression results for lump sum (BD3) compared to base scenario

	Lump Sum - BD3						**Base**					
	t = 2			**t = 21**			**t = 2**			**t = 21**		
	Coef	**S.E.**	**SS**	**Coef**	**S.E.**	**SS**	**Coef**	**S.E.**	**SS**	**Coef**	**S.E.**	**SS**
B_0	0.004	0.000	NA	0.020	0.004	NA	0.007	0.000	NA	0.038	0.001	NA
i_{diff}	0.940	0.001	0.898	1.030	0.012	0.838	0.914	0.002	0.922	0.970	0.007	0.926
w_{diff}	-0.993	0.008	0.046	-1.012	0.072	0.031	-0.305	0.016	0.002	***0.009***	0.042	0.000
q_{diff}	***0.015***	0.009	0.000	0.176	0.077	0.000	-0.671	0.016	0.028	-0.870	0.045	0.034
m_{diff}	-1.278	0.220	0.000	***-0.235***	0.319	0.000	1.009	0.263	0.000	***0.635***	0.329	0.000
r_{diff}	***0.015***	0.028	0.000	0.274	0.064	0.001	***0.115***	0.147	0.000	NA	NA	NA
i_{chng}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FL_{diff}	-0.418	0.002	0.047	0.047	0.002	0.042	-0.375	0.004	0.031	***0.003***	0.002	0.000
FL^2_{diff}	0.711	0.009	0.008	-0.003	0.000	0.008	0.927	0.016	0.014	0.002	0.001	0.004
		Total	0.999		Total	0.921		Total	0.996		Total	0.964

The most obvious differences between the BD3 and base scenarios in Table 6.4 relate to the changing impacts of price and salary inflation. Since price inflation does not directly affect the liability, it is not a significant predictor of movements in funding level, although salary increases now affect the entire liability and thus have an absolute increase in coefficient value. However the proportion of funding level variability explained by salary increases is still very small compared to investment returns. The mortality effect is now reversed, reflecting the fact that the insurance in BD3 does not fully cover the additional death benefit (see Appendix D), meaning additional mortality has a negative impact on the funding level. For year 21, the exponential surplus effect is seen more in the FL_{diff} coefficient than the intercept for BD3 compared to the base scenario. This may be due to less simulations in BD3 having an excess surplus than the base scenario.

7 CONCLUSIONS & FURTHER RESEARCH

This paper presents the results of a stochastic simulation projection of a model superannuation scheme which is closed to new entrants. The most significant result is the tendency of the scheme to develop a surplus which increases exponentially, which is a significant issue where the surplus is unable to be recovered by the employer. The reason for this surplus development is the reduction in future liabilities, leading to the assets exceeding total liabilities (past and future) and then growing at a faster rate than the liabilities.

A number of different scenarios were tested, generating the obvious result that increasing the aggressiveness of the investment structure will tend to decrease the contributions required into the scheme, although without significantly impacting the potential for future deficits. Moving to a more conservative investment structure as the surplus increases has the effect of reducing future surplus levels without increasing the need for future contributions. A contribution strategy which spreads deficits over a long period is effective in reducing future contribution and surplus levels, although at the cost of longer deficits. A scheme which pays lump sums rather than pensions is less susceptible to exponential surplus development due to higher future liabilities relative to assets.

The above results make the assumption that the trustee and employer is indifferent to the timing of any deficit or surplus, and that the employer is able to increase contributions to fund a deficit at all times necessary. This assumption is not true; in addition the timely removal of a deficit may be heavily influenced by the Regulator. However, the results of this study clearly indicate that the quick removal of deficits comes at a risk of generating significant surpluses which may be of no use to the employer.

This study presents preliminary results of a PhD thesis on this topic. As such there are a number of areas which will be developed in future research. Some of these areas are discussed briefly below. This effect may also be different between genders.

Effect of the economic model on withdrawal rates
Although Table 3.1 shows job leaving rates are relatively stable over the economic cycle, this is only when combining voluntary and involuntary leaving. An economic downturn is likely to lead to an increased variation in the leaving rates between firms/industries, which could be incorporated into the withdrawal model.

Effect of income on mortality rates
The current mortality model does not include any allowance for the effect of income, despite the literature indicating that higher incomes lead to lower mortality rates (see Section 3.3).

Additional investment strategies
A number of studies contend that scheme assets should be matched a closely as possible to the liabilities they are backing, if not through exact cash flow matching, at least through duration matching. Blake (2001) claims scheme investments should be split into two components – a cash flow matching strategy for projected benefit payments over a short time frame (5 – 10 years) and a long-term strategy for liabilities in the growth phase, investing in equities and property. This strategy ensures sufficient assets are held to meet current liabilities whilst taking advantage of the long-run outperformance of equities and property. Bodie (1990) states that scheme assets backing liabilities should be invested in bonds, with equity investment only used for any additional assets owned by the scheme. Wilcox (2006) takes a similar view and contends that scheme benefits should be essentially risk-free for members, so as to avoid the correlation with firm risk. The way of achieving this is to invest an amount equal to current liabilities in high quality debt. However, scheme liabilities contain a number of components which may be difficult to hedge effectively, such as salary and price inflation increases and mortality risk. Future research will investigate the ability of a scheme to undertake such an investment strategy and the effect this might have on the model outputs.

Use of scheme surplus
One of the key assumptions of this study is that the employer is not able to organise a refund of surplus from the scheme. In any case, legal, industrial and tax requirements mean that only a fraction of any surplus may be available to an employer for refund. It should be noted that in practice it may be possible to use surplus to fund contributions in a separate defined contribution arrangement, but this is generally only possible if the defined contribution arrangement is within the same scheme as the defined benefit arrangement. An alternative use for scheme surplus might be to increase the benefits of current members. Future research will explore how much of the surplus may be delivered to members without requiring the employer to make additional contributions.

Wind-up and transfer of liabilities
This study assumes that a scheme winds up at a fixed time based on the number of active members. However, it may not be in the trustee or employer’s best interest to wind-up at this time, depending on interest rates and the financial position of the scheme at that point. It may be advantageous for a scheme to consider winding up at a different stage.

REFERENCES

Australian Bureau of Statistics. (Various issues). *Employee Earnings, Benefits and Trade Union Membership*. Cat No. 6310.0.

Australian Bureau of Statistics. (Various issues). *Labour Mobility Australia*. Cat No. 6209.0.

Australian Government Actuary. (Various issues). *Australian Life Tables*.

Australian Prudential Regulation Authority. (2007). *APRA Insight*. Issue 2.

Australian Prudential Regulation Authority. (2008). *Statistics: Annual Superannuation Bulletin June 2007*. Issued 26 March 2008.

Australian Taxation Office. (2008). Company tax and imputation: average franking credit and rebate yields. Downloaded from www.ato.gov.au on 20 November 2008.

Blake, D. (2001). UK Pension Fund Management: How is Asset Allocation Influenced by the Valuation of Liabilities? *Pensions Institute Discussion Paper*, PI-0104, February.

Bodie, Z. (1990). The ABO, the PBO and Pension Investment Policy. *Financial Analysts Journal*, **46**(5), 27-34.

Boulier, J-F., Trussant, E. and Florens, D. (1995). A dynamic model for pension funds management. *Proceedings of the 5th AFIR International Colloquium*, 361-384.

Brenner, M.H. (1979). Mortality and the national economy: a review, and the experience of England and Wales 1936-1976. *The Lancet*, **314**, 568-572.

Brown, R.L. and McDaid, J. (2003). Factors Affecting Retirement Mortality. *North American Actuarial Journal*. **7**(2), 24-43.

Bulow, J.I. and Scholes, M.S. (1982). *Who owns the assets in a defined benefit pension plan*. Working Paper No. 924, National Bureau of Economic Research.

Cairns, A.J.G. (1994). *An introduction to stochastic pension plan modelling*. Presented to the Workshop on Interest Rate Risk. Simon Fraser University, Vancouver.

Campbell, A.C., Grimley D.C., Pallister, J.K., Stoker, A.M., Walton, A.R. and Yiasoumi, C.A. (2006). Lessons from closure: An analysis and comparison of the issues facing closed life funds and closed pension schemes. *British Actuarial Journal*, **12**(3), 639-727.

Colbran, R.B. (1982). Valuation of Final-Salary Pension Schemes. *Journal of the Institute of Actuaries*, **109**, 359-385.

Cowling, C.A., Gordon, T.J. and Speed, C.A. (2004). *Funding Defined Benefit Pension Schemes*. Institute of Actuaries and Faculty of Actuaries.

Efron, B. (1979). Bootstrap Methods: Another Look at the Jackknife. *The Annals of Statistics*, **7**(1), 1-26.

Gerdtham, U-G. and Ruhm, C.J. (2006). Deaths rise in good economic times: Evidence from the OECD. *Economics and Human Biology*, **4**, 298-316.

Haberman, S. (1997). Stochastic investment returns and contribution rate risk in a defined benefit pension scheme. *Insurance: Mathematics and Economics*, **19**, 127-139.

Haberman, S., Day, C., Fogarty, D., Khorasanee, M.Z., McWhirter, M., Nash, N., Ngwira, B., Wright, I.D. and Yakoubov, Y. (2003). A stochastic approach to risk management and decision making in defined benefit pension schemes. *British Actuarial Journal*, **9**(3), 493-618.

Kilpatrick, S. and Felmingham, B. (1996). Labour Mobility in the Australian Regions. *The Economic Record*, **72**, 214-223.

Knox, D. and Tomlin, A. (1997). An Analysis of Pensioner Mortality by Pre-retirement Income. Working Paper Series No. 44. Centre for Actuarial Studies, University of Melbourne, Australia.

Knox, D. and Nelson, M. (2007). The mortality experience of Australian superannuation pensioners: Some surprising results. Presented at the *2nd PBSS Colloquium*, Helsinki.

Kopcke, R.W. (2006). Managing the risk in Pension Plans and Recent Pension Reforms. *Public Policy Discussion Papers*, Federal Reserve Bank of Boston, 06-7.

Laporte, A. (2004). Do economic cycles have a permanent effect on population health? Revisiting the Brenner hypothesis. *Health Economics*, **13**, 767-779.

Lazear, E.P. (1979). Why is There Mandatory Retirement? *Journal of Political Economy*, **87**(6), 1261-1284.

Leibowitz, M.L., Kogelman, S. and Bader, L.N. (1994). Funding Ratio Return. *Journal of Portfolio Management*, **21**(1), 39-47.

Lillen, D. (1982). Sectoral Shifts and Cyclical Unemployment. *Journal of Political Economy*, **90**, 777-793.

McLeish, D.J.D. and Stewart, C.M. (1987). Objectives and Methods of Funding Defined Benefit Pension Schemes. *Journal of the Institute of Actuaries*, **114**, 155-199.

Office for National Statistics (2007). *Occupational Pension Schemes Annual Report*. No 14, 2006 edition, Editor: Chris Daffin.

Osberg, L. (1991). Unemployment and Inter-industry Labour Mobility in Canada in the 1980's. *Applied Economics*, **23**, 1707-1717.

Owadally, M.I. and Haberman, S. (2004). Efficient Gain and Loss Amortization and Optimal Funding in Pension Plans. *North American Actuarial Journal*, **8**(1), 21-36.

Ruhm, C.J. (2000). Are recessions good for your health? *Quarterly Journal of Economics*, **115**, 617-650.

Ruhm, C.J. (2004). Macroeconomic conditions, Health and Mortality. Working Paper 11007, National Bureau of Economic Research.

Shah, C. and Burke, G. (2003). *Labour mobility: demographic, labour force and education effects and implications for VET*. Report to Australian National Training Authority, Monash University – ACER, Centre for the Economics of Education and Training.

Sorlie, P.D., Backlund, E. and Keller, J.B. (1995). US Mortality by Economic, Demographic, and Social Characteristics: The National Longitudinal Mortality Study. *American Journal of Public Health*, **85**(7), 949-956.

Taylor, G. (2002). Stochastic Control of Funding Systems. *Insurance: Mathematics and Economics*, **30**, 323-350.

Wilcox, D.W. (2006). Reforming the Defined-Benefit Pension System. *Brookings Papers on Economic Activity*, 1:2006.

Wilkie, A. D. (1986). A stochastic investment model for actuarial use. *Transactions of the Faculty of Actuaries*, **39**, 341-403.

Wilkie, A. D. (1995). More on a stochastic investment model for actuarial use. *British Actuarial Journal*, **1**(5), 777-964.

Wooden, M. (1999). Job insecurity and job instability: Getting the facts straight. *Business Council of Australia Papers*, **1**(1), 14-18.

Wright, I.D. (1998). Traditional Pension Fund Valuation in a Stochastic Asset and Liability Environment. *British Actuarial Journal*, **4**(4), 865-901.

Appendix A – Projection Methodology

All modelling is performed on a discrete basis, with the results of the scheme being projected from year to year. Each simulation commences with the inputs and the membership data as described in Appendix D. A sample of the projection model for a year from 30 June 20X1 to 30 June 20X2 is shown below:

a) Valuation calculations are performed including a new employer contribution rate. Although it tends to take 6-12 months to complete an actuarial valuation, it is assumed that any change to the contribution rate is backdated by the employer to commence from 1 July 20X1.

b) The economic factors affecting the scheme, as outlined in Appendix B, are calculated for the 20X1/X2 year. Investment returns are based on the asset allocation of the scheme, as discussed in Appendix D.

c) For each member of the scheme at 30 June 20X1, a random variable is generated that decides if the member experiences a transition of membership status during the 20X1/X2 year. The three non-absorbing statuses are Active, Deferred and Pensioner, whilst dying or having a benefit paid as a lump sum results in that member being removed from the remainder of the simulation. The effects of a membership status change are:
   - Active or Deferred members who die or withdraw with a lump sum benefit during the 20X1/X2 year have their lump sum calculated as at 31 December 20X1, the date the benefit is assumed to be paid, and are removed from the projections. The insurance receipt for active members is also calculated as at this date. No projection of salaries is necessary as there has been no increase in salary since 30 June 20X1. For Active members, employer contributions and insurance premiums for half a year are also calculated. These are based on the contribution rates, insured amounts and insurance premium rates which applied at 30 June 20X1.
   - Active members who withdraw with a deferred pension or retire have their accrued pension calculated as at 31 December 20X1 and are transferred to Deferred or Pensioner status as appropriate. The above rules for salaries, employer contributions and insurance premiums also apply.
   - Deferred members who reach the retirement age are transferred to Pensioner status.
   - Pensioner members who die during the 20X1/X2 year are removed from the projections. No pension is assumed to be paid to these members. Those who die before age 75 are paid a lump sum at 31 December 20X1 as per the benefit design.

d) For those members who remain Active through the whole 20X1/X2 year, their membership details are projected to 30 June 20X2 using the economic factors calculated in (b). Pension and deferred benefit increases due to price inflation for the previous year are calculated. Pension payments, employer contributions and insurance premiums are calculated for the full year, based on membership details at 30 June 20X1 and membership status at 31 December 20X1.

e) Assets of the scheme are projected to 30 June 20X2 according to the following formula:

$$N^{X2} = N^{X1} \times (1+e) + \left(0.85 \times (C_E - I_P) - B + I_R\right)(1 + e/2)$$

where;

$$e = \frac{L_{pens} \times e_{pens} + \left(L - L_{pens}\right) \times e_{np}}{L}$$

- N is the assets of the scheme;
- e is the average percentage return on assets;
- C_E is the total employer contributions received over the year;
- I_P is the total insurance premiums paid over the year;
- B is the total paid out in benefits over the year;
- I_R is the total insurance receipts over the year;
- L_{pens} is the scheme liability for pensioner members only (see Appendix B.2 for calculation);
- e_{pens} is the percentage return on assets backing pensions in payment (untaxed);
- L is the total scheme liability (see Appendix B.2 for calculation);
- e_{np} is the percentage return on assets not backing pensions in payment (taxed); and
- the superscript $X1$ or $X2$ refers to the year in which the factor was valued.

This formula makes the following assumptions:

- A contribution tax rate of 15% applies, with contribution limits having no impact.
- A full tax deduction can be claimed for insurance premiums each year. Tax is payable immediately it is incurred.
- All cash flows received during the year receive investment earnings at exactly half of the investment return calculated in (b).

While these assumptions may not be entirely realistic, any differences to reality are likely to be small in scale relative to the results of the projection.

Once the process above is completed, the scheme has complete information as at 30 June 20X2 and the simulation can be continued for the year 30 June 20X2 to 30 June 20X3. The projection model continues until it is decided to wind up the scheme and transfer all existing entitlements to an alternative entity which will take on the liabilities. The wind-up procedure is discussed in Appendix D. This marks the end of one simulation. The outputs in this paper are based on 1,000 simulations of the model scheme.

Appendix B – The Wilkie (1995) model

In order to obtain the economic model for use in the simulations of this paper, it is necessary to estimate the parameters underlying the Wilkie model. The model parameters are estimated based on historical data with no adjustments made to allow for future expectations. This is done in order to keep the model fitting as objective as possible.

Table B.1 gives the indices and data sources for the variables fitted in the economic model.

Table B.1 – Indices and data sources

Variable	**Index**	**Data Source**
Price Inflation	Consumer Price Index (all groups)	Reserve Bank of Australia
Salary Inflation	Average Weekly Ordinary Time Earnings (all employees)	Reserve Bank of Australia
Short-Term Interest Rate	90 Day Bank Accepted Bills	Reserve Bank of Australia
Long-Term Interest Rate	10-Year Australian Government Bond Yield	Reserve Bank of Australia
Australian Equity Dividend Yield	S&P/ASX200 Total Return and Price Index*	Reserve Bank of Australia
Australian Equity Dividends	S&P/ASX200 Total Return and Price Index*	Reserve Bank of Australia
Australian Equity Prices	S&P/ASX200 Price Index	Reserve Bank of Australia
International Equities (Total Return – Unhedged)	MSCI World ex-Australia Net Index converted to $A using the $A/$US exchange rate	MSCI, Datastream
Australian Bonds (Total Return)	UBS Warburg Australia Composite Bond Accumulation Index	Mercer
International Bonds (Total Return – Hedged into $A)	Citigroup World Government Bond Index – Hedged into $A	Datastream

**NB – Dividend Yield and Dividends obtained by calculating the difference in return between the S&P/ASX200 Price and Total Return Indices.*

Data from 30 June 1982 to 30 June 2008 is used, with the exception of International Bonds, for which the index is only available from 30 June 1985. The reasons for this start date are as follows:

- Both 30 June 1982 and 30 June 2008 reflect a recent significant fall in equity prices;
- Both dates experienced significant reductions in interest rates shortly after;
- The Australian/US dollar exchange rate is similar at both dates and decreases shortly after (although the floating of the Australian dollar was still to take place in December 1983);
- The 26 year period between 30 June 1982 and 30 June 2008 is very similar to the period being projected in this paper; and
- Using an integer number of years allows economic models to be fitted with annual data as well as quarterly data if it is so desired.

However, there are certain factors which make the selection of this period somewhat problematic for forecasting future returns. There is a fundamental difference in the use of monetary policy in Australia between 1982 and 2008. In 1982, the Treasurer maintained control of short-term interest rates and used them to target a certain monetary level in the economy. A major change occurred in the late 1980's and early 1990's to a system where the Reserve Bank of Australia now controls monetary policy with an objective to keep price inflation between 2 – 3% per annum. This has reduced inflation significantly over the period 1982 – 2008, such that the estimated parameters generated by fitting a model over the period 1982 – 2008 may not adequately reflect current monetary policy.

In addition, household debt levels have increased dramatically with decreases in interest rates over the past 26 years. This means small movements in interest rates have a much more significant impact than they did during the 1980's and therefore that a return to the high interest rates of the 1980's is highly unlikely. Thus the interest rates projected by a model fit over the period 1982 – 2008 may be higher than likely in future.

For the reasons above, model parameters may not accurately represent expectations of future economic values, although this does not necessarily mean the parameters should automatically be adjusted to reflect this. The modelling performed in this paper is measuring changes in assets and liabilities of a superannuation scheme. The economic factors most affecting the liabilities are price inflation, salary inflation and long-term interest rates, whilst asset returns most affect the value of assets. The most important factor in analysing the financial results of the scheme is the difference between the factors affecting the assets and the liabilities. The reduction in price inflation between the 1980's and 1990's brought with it a reduction in salary inflation, interest rates and average equity returns.

On this basis, no adjustment is made to the estimated parameter values to reflect the issues discussed above. Although future expectations of the economic factors may be lower than those generated by the economic models, this is expected to have equal effect on the assets and liabilities of the scheme and thus not bias the comparison of the two.

Wilkie (1995) considered both annual and monthly data and showed that seasonal effects can impact economic series which are considered more frequently than annually. Since there are a number of parameters that must be estimated in fitting the economic models, it is desirable to use as many observations as possible in the estimation process. Hence, as a starting point, modelling is undertaken on a quarterly basis, the most frequent period the data allows. It is therefore necessary to investigate if any seasonal effects are evident in the economic variables. Significant seasonal effects were noted in the dividends and dividend yields. This is due to the timing of dividend payments not being equally spread over a year. To alleviate this issue, calculations of dividends for each quarter are calculated on an annual basis. This removes the seasonal effects from the dividends and leaves most of the variation in share prices to changes in yield rather than changes in dividends, which is observed by Wilkie (1995). It is also consistent with the way yields are quoted in practice. The quarterly yield (continuously compounded) is calculated by taking the annual yield modelled and dividing by four.

After fitting the model using both quarterly and annual data, it was found that annual data better reflects the model assumptions of normality and non-correlation of residuals. Thus the model is fit using annual data. The model equations and parameters are found in Tables B.2 and B.3 below. All interest rates and returns are modelled on a continuously compounding basis. Unless stated, all error terms $\varepsilon(t)$ are independently and identically distributed normally with mean zero and variance σ^2. Summary statistics for the output of the model over 30 years of projections and 1,000 simulations are provided in Table B.4, average returns are geometric.

Table B.2 – Wilkie model – summary of equations used

Variable	**Notation**	**Equation**
Price Inflation	$q(t)$	$q(t) = \mu_q(1-\phi_q) + \phi_q q(t-1) + \varepsilon_q(t)$
Salary Inflation	$w(t)$	$w(t) = \varphi_{w,1} q(t) + \varphi_{w,2} q(t-1) + \mu_w + \varepsilon_w(t)$
Short-Term Interest Rate	$is(t)$	$\ln[is(t)] = \ln[il(t)] - N_{is}(t)$ $N_{is}(t) = \mu_{is}(1-\phi_{is}) + \phi_{is} N_{is}(t-1) + \varepsilon_{is}(t)$
Cash	$c(t)$	$c(t) = \big(is(t) + is(t-1)\big)/2$
Long-Term Interest Rate*	$il(t)$	$il(t) = \varphi_{il}\left[\sum_{j=0}^{4} q(t-j)/5\right] + \mu_{il}\exp\big(N_{il}(t)\big)$ $N_{il}(t) = \phi_{il,1} N_{il}(t-1) + \varepsilon_{il}(t)$

Variable	**Notation**	**Equation**
Australian Equity Dividend Yield	*y(t)*	$\ln\left[y(t)\right] = \ln\mu_y + N_y(t)$ $N_y(t) = \phi_y N_y(t-1) + \varepsilon_y(t)$
Australian Equity Dividends	*d(t)*	$d(t) = \mu_d + \tau_d \varepsilon_y(t-1) +$ $\varepsilon_d(t) + \theta_d \varepsilon_d(t-1)$
Australian Equities Price Return^	*p(t)*	$p(t) = \ln\left(D(t)/\ln\left(1+y(t)\right)\right) -$ $\ln\left(P(t-1)\right)$
Australian Equities Total Return	*ae(t)*	$ae(t) = p(t) + \ln\begin{pmatrix} 1+\ln\left(1+y(t)\right) \\ \times\left(\exp(p(t))\right)^{0.5} \end{pmatrix}$
International Equities (Total Return)	*ie(t)*	$ie(t) = \mu_{ie} + ae(t) + \varepsilon_{ie}(t)$
Australian Bonds (Total Return)	*b(t)*	$b(t) = \varphi_{b,1} il(t) + \varphi_{b,2} il(t-1) +$ $\varphi_{b,3} is(t) + \varphi_{b,4} is(t-1) + \varepsilon_y(t)$
International Bonds (Total Return)	*ib(t)*	$ib(t) = \mu_{ib} + \varphi_{ib} b(t) + \varepsilon_{ib}(t)$ $\sigma_{ib}(t) = \delta_{ib} is(t)$

* $\left[\sum_{j=0}^{4} q(t-j)/5\right]$ assumed to be a minimum of 0.001 in order to ensure the long-term interest rate cannot be negative.

^ Notation in capitals (e.g. $D_t = D_{t-1}\exp\left(d(t)\right)$ refers to the index value of that variable.)

<u>Table B.3 – Wilkie model – fitted parameter values and standard errors</u>

Notation	**Parameter**	**Fitted Value**	**Standard Error**
q(t)	μ_q ϕ_q	0.0457 0.6737	0.0121 0.1618
w(t)	$\varphi_{w,1}$ $\varphi_{w,2}$ μ_w	0.4111 0.6392 0.0071	0.1748 0.1610 0.0032
is(t)	μ_{is} ϕ_{is}	0.0491 0.5932	0.0491 0.0701
il(t)	φ_{il} μ_{il} ϕ_{il}	1.0950 0.0354 0.6471	0.0942 0.0049 0.1411
y(t)	μ_y ϕ_y	0.0381 0.4504	0.0354 0.1752
d(t)	μ_d τ_d θ_d	0.0820 -0.4029 0.5358	0.0282 0.1337 0.1631
ie(t)	μ_{ie}	-0.0202	0.0290
b(t)	$\varphi_{b,1}$ $\varphi_{b,2}$ $\varphi_{b,3}$ $\varphi_{b,4}$	-3.5324 4.4037 -0.2665 0.4005	0.2317 0.2107 0.1256 0.1254
ib(t)	μ_{ib} φ_{ib} δ_{ib}	0.0381 0.6996 0.3555	0.0149 0.1363 0.0470

Table B.4 – Results generated by the Wilkie model

Factor	Average Return (p.a.)	Standard Deviation (p.a.)	Yearly Autocorrelation (Average)
	(pre-tax)		
Price Inflation	4.7%	2.8%	58%
Salary Inflation	5.7%	3.2%	51%
Long-Term Interest Rate	9.0%	2.7%	77%
Australian Equities Total Return	13.6%	23.7%	1%
International Equities (Total Return)	11.5%	29.2%	2%
Australian Bonds (Total Return)	8.6%	7.6%	18%
International Bonds (Total Return)	10.0%	6.4%	15%
Cash	8.8%	3.0%	82%
Asset Allocation	*(non-pension assets – post-tax)*		
Base	10.9%	13.1%	2%
Growth	11.8%	18.4%	1%
Defensive	9.3%	6.5%	10%
Low-risk	7.8%	3.4%	34%
Asset Allocation	*(pension assets – post-tax)*		
Base	12.6%	15.1%	2%
Growth	13.5%	21.1%	1%
Defensive	10.8%	7.5%	10%
Low-risk	9.1%	4.0%	34%

As discussed, the results outlined in Table B.4 give a much higher average return for all factors than future expectations, at least in the short-term, might produce. In addition, the difference between the non-pension base asset allocation return and the salary inflation is 5.2%, whereas a typical actuarial assumption for this gap might be 2-3%. However, in order to keep the study as objective as possible no adjustment is made to the model parameters to allow for this.

A promotional salary inflation scale is introduced in order that salary increases might be dependent on age. The scale can be found in Appendix C and is based on the Employee Earnings, Benefits and Trade Union Membership report (ABS, various issues). These values were tested across a variety of years from 1999 – 2007 and found to be relatively consistent across years and gender. Thus a single promotional salary scale is used for males and females and is assumed to be consistent over the life of the projections. A reduction of 1% is made from the salary inflation calculated in the economic model to offset the effect of promotional salary increases. Therefore, the total salary increase for an individual is equal to the salary inflation calculated in the economic model less 1% plus the age-based promotional salary inflation found in Table C.1.

The above modelling is all performed on a pre-tax basis. Tax on dividend income is reduced or eliminated due to imputation. Australian Tax Office statistics (2008) reveal that approximately 75% of dividends have been franked over the past 7 years to 30 June 2008. Tax on assets backing pensions in payment is nil, with a full franking credit of 32% paid on Australian Equities Dividends (equal to 30% / 70% x 75% assuming a company tax rate of 30% and that 75% of dividends are franked).

Both employer contribution and non-pension backing investment income received by superannuation schemes is generally taxed at a rate of 15% in Australia, although capital gains tax on assets held for more than one year is 10%. The tax reimbursement for Australian dividend income due to imputation is around 12% (equal to (1+32%) x 15% – 32%). It is assumed that capital gains tax is typically 10%, with the vast majority of capital gain realised on assets which have been held for 12 months and capital losses offsetting capital gains on assets held for less than 12 months. The overall tax rates applied to the asset classes is outlined in Table B.5 below.

Table B.5 – Tax rates applied to non-pension backing asset classes

Asset Class	Tax Rate
Australian Equities Dividends	-12%
Australian Equities Price	10%
International Equities	15%
Australian Bonds	15%
International Bonds	15%
Australian Cash	15%

Appendix C - Other tables

The promotional salary increase and decrements which affect the scheme each year are outlined in Tables C.1 – C.2 below. Death rates are based on q_x from ALT00-02.

Table C.1 – Pre-retirement decrement table

Age	Promotional Salary Increase	Withdrawal^	Death^	
			Male	Female
17	9.5%	350	0.730	0.295
18	8.5%	350	0.938	0.329
19	7.5%	340	0.958	0.348
20	6.5%	340	0.956	0.359
21	5.5%	330	0.977	0.363
22	4.5%	330	1.014	0.365
23	4.0%	320	1.059	0.368
24	3.5%	320	1.104	0.372
25	3.0%	310	1.142	0.377
26	2.6%	310	1.167	0.386
27	2.3%	300	1.181	0.396
28	2.0%	300	1.187	0.410
29	1.7%	290	1.189	0.427
30	1.5%	290	1.191	0.448
31	1.3%	280	1.195	0.472
32	1.1%	280	1.206	0.500
33	0.9%	270	1.225	0.533
34	0.7%	270	1.250	0.569
35	0.5%	260	1.284	0.610
36	0.4%	260	1.327	0.654
37	0.3%	250	1.379	0.704
38	0.2%	250	1.440	0.757
39	0.1%	250	1.511	0.816
40	0.0%	250	1.593	0.879
41	0.0%	250	1.686	0.947
42	0.0%	250	1.790	1.021
43	0.0%	250	1.907	1.103
44	0.0%	250	2.035	1.194
45	0.0%	250	2.177	1.296
46	0.0%	250	2.332	1.410
47	0.0%	250	2.501	1.537

Age	Promotional Salary Increase	Withdrawal^	Death^	
			Male	Female
48	0.0%	250	2.690	0.680
49	0.0%	250	2.904	1.839
50	0.0%	250	3.148	2.016
51	0.0%	250	3.429	2.213
52	0.0%	250	3.751	2.430
53	0.0%	250	4.120	2.670
54	0.0%	250	4.541	2.933
55	0.0%	250	5.021	3.222
56	0.0%	250	5.564	3.538
57	0.0%	250	6.177	3.881
58	0.0%	250	6.863	4.254
59	0.0%	250	7.630	4.658
60	0.0%	250	8.482	5.095
61	0.0%	250	9.424	5.566
62	0.0%	250	10.462	6.071
63	0.0%	250	11.602	6.617
64	0.0%	All remaining	12.847	7.218

^ *Per 1,000 members*

Table C.2 – Post-retirement mortality^

Age	Male	Female	Age	Male	Female	Age	Male	Female
65	14.204	7.895	79	58.826	35.435	93	184.432	162.048
66	15.681	8.668	80	63.990	40.359	94	193.093	173.366
67	17.306	9.552	81	69.693	45.992	95	202.055	184.364
68	19.108	10.571	82	76.872	52.315	96	210.694	195.404
69	21.120	11.742	83	85.453	59.321	97	219.294	206.355
70	23.369	13.084	84	95.119	66.983	98	227.845	217.213
71	25.887	14.615	85	105.563	75.284	99	236.343	227.974
72	28.703	16.371	86	116.484	84.204	100	244.785	238.633
73	31.844	18.412	87	127.597	93.721	101	253.169	249.184
74	35.338	20.565	88	138.628	103.812	102	261.492	259.623
75	39.213	22.692	89	149.317	114.453	103	269.749	269.945
76	43.495	24.998	90	159.337	125.786	104	277.940	280.144
77	48.208	27.767	91	168.279	137.835	105	1000.000	1000.000
78	53.377	31.233	92	176.379	150.115			

^ *Per 1,000 members*

The withdrawal decrement is based on a new member to the scheme. The decrement is reduced by 2% (or 20 per 1,000 members) per year of service, subject to a minimum value of 10% (or 100 per 1,000 members). The decrements above are assumed to be dependent, thus a member is certain to withdraw (and hence become a pensioner) or die during the year in after they turn 64.

The post-retirement mortality rates in Table C.2 are significantly higher than those found by Knox and Nelson (2007), for the reasons discussed in Section 3.4.

Appendix D – Model scheme base scenario

Benefit design
The scheme has only one category of defined benefit membership and was closed to new entrants at the commencement of projections.

The benefit design of the scheme is as follows:

Member Contributions	Nil.
Membership	Calculated in years, with any completed months of membership counting as one twelfth of a year.
Retirement Benefit	Annual pension of 1/60th of final salary per year of membership payable until death. The value of current salary multiplied by current membership at any time is known as the accrued pension.
Retirement Age	All retirement pensions commence payment at age 65.
Pension Increases	Pensions are increased on an annual basis at the price inflation rate of the previous year, subject to a maximum increase of 10% and a minimum increase of 0%.
Withdrawal Benefit	A deferred pension payable from age 65 until death, based on salary and membership at withdrawal. The deferred pension is increased annually as per pension increases.
	For members who leave before completing 5 years of service a lump sum benefit is payable, which is equal to the accrued pension multiplied by 9.5 discounted by 5% per annum compound for each year the member is below age 65.
Death Benefit (active)	A lump sum benefit equal to 9.5 multiplied by the annual pension which would have been paid had the member remained in the scheme until retirement age with an unchanged salary.
Death Benefit (deferred)	A lump sum benefit equal to the accrued pension multiplied by 9.5.
Death Benefit (pensioner)	For pensioners who die before age 75, a lump sum benefit equal to the pension in payment multiplied by 9.5 x (75 – Age at death) / 10.
Insured part of Death Benefit (active only)	Equal to the death benefit less the accrued pension multiplied by 9.5.

Member data
A summary of the membership of the scheme at the start of the projections is provided below in Table D.1:

Table D.1 – Summary of membership

Member Status	Active	Deferred	Pensioner
Number of Members	5,000	2,080	1,920
Average Age	38.0	53.7	72.7
Average Membership	6.7	N/A	N/A
Total Accrued Pension	$39,002,167	$22,516,277	$27,274,008
Average Accrued Pension	$7,800	$10,825	$14,205
Total Salary	$293,630,500	N/A	N/A
Average Salary	$58,726	N/A	N/A

Initial asset value

The scheme is exactly 100% funded at the start of the projection period. This gives an initial asset value of $535,524,065.

Investment strategy

The asset allocation of the scheme is as follows:

Australian Equities	35%
International Equities (Unhedged)	25%
Australian Bonds	20%
International Bonds (Hedged)	15%
Australian Cash	5%

The asset allocation used to model the overall investment return is rebalanced at the end of each year, meaning that the asset allocation remains unchanged from year to year.

Contribution strategy

Scheme liabilities and contributions are calculated annually on a projected unit credit basis. All actuarial assumptions are unbiased relative to their expected values. In particular the rate used to discount liabilities is equivalent to the expected return on scheme assets given the scheme's investment strategy. Deficits and surpluses are spread over a period of 3 years.

Surplus management

Surplus is retained in the scheme at all times. Refund of surplus is not available to the employer and surplus is not used to increase benefits except on wind-up.

Wind-up procedure

The scheme is wound up on the valuation date after the active membership decreases below 50 members. All active members are transferred to deferred status, with immediate and deferred annuities purchased from an appropriate entity to discharge the liabilities. Annuities are purchased at a cost using the same assumptions as the actuarial liability, with two exceptions:

- the discount rate is equal to the long-term interest rate, with a downward adjustment of 0.5% p.a. to allow for the profit margins of the provider. This rate is further reduced by 15% for pensions not yet in payment; and
- the cost is then increased by 2% to allow for the costs of wind-up.

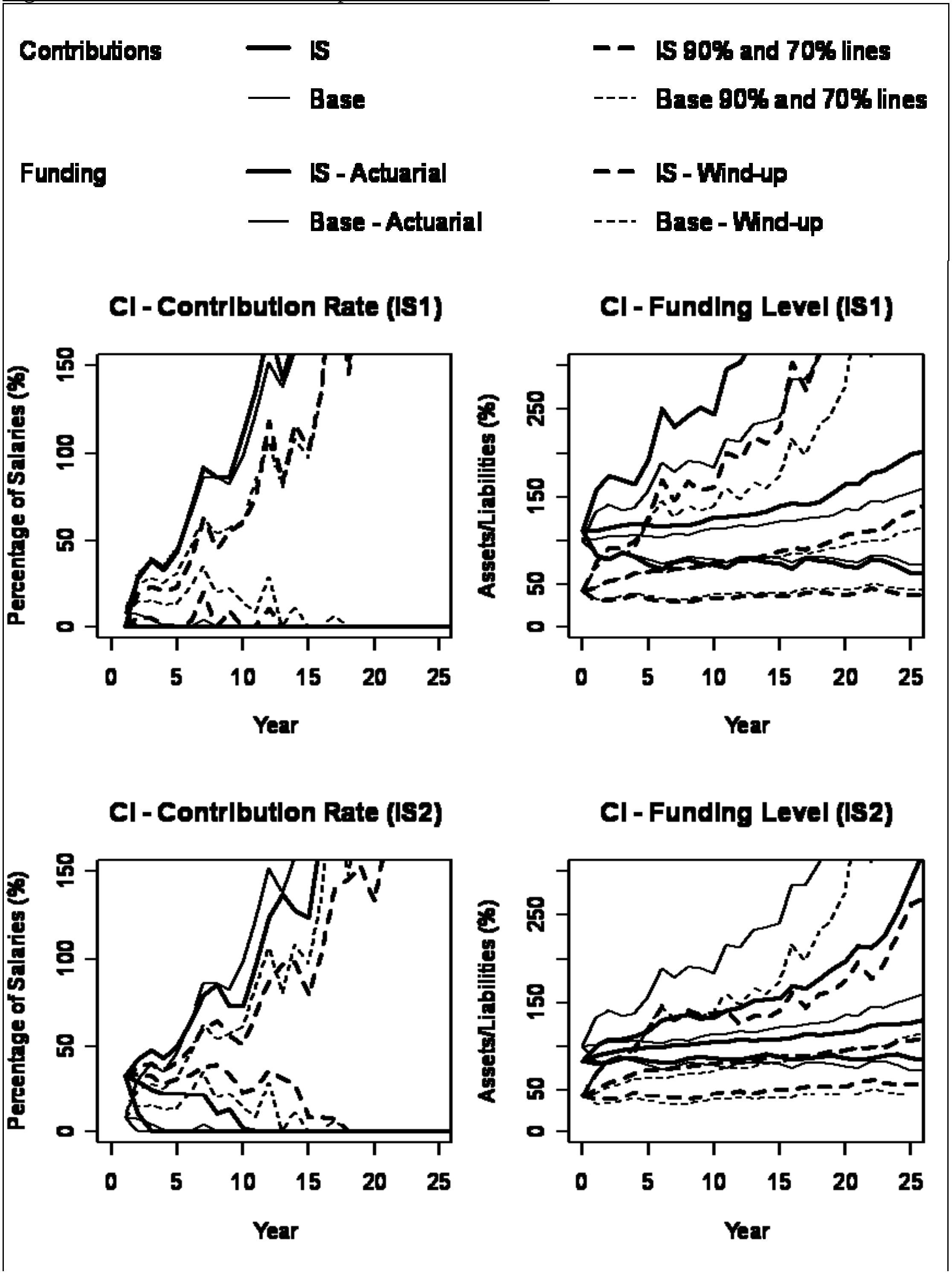
These are typical assumptions to those currently used in the UK buy-out market and this is the "solvency" liability is required to be calculated in the UK by the Pensions Act 2004.

Upon wind-up of the scheme, any surplus is paid to members as additional benefits. Should the assets be insufficient to pay for the annuities and wind-up costs, the employer will contribute the amount required to meet all liabilities after allowing for the 15% contribution tax.

Appendix E – Confidence interval plots for remaining scenarios

Note that only the plots not presented in the body of the paper are provided in this appendix.

Figure E.1 – Confidence interval plots for IS scenarios



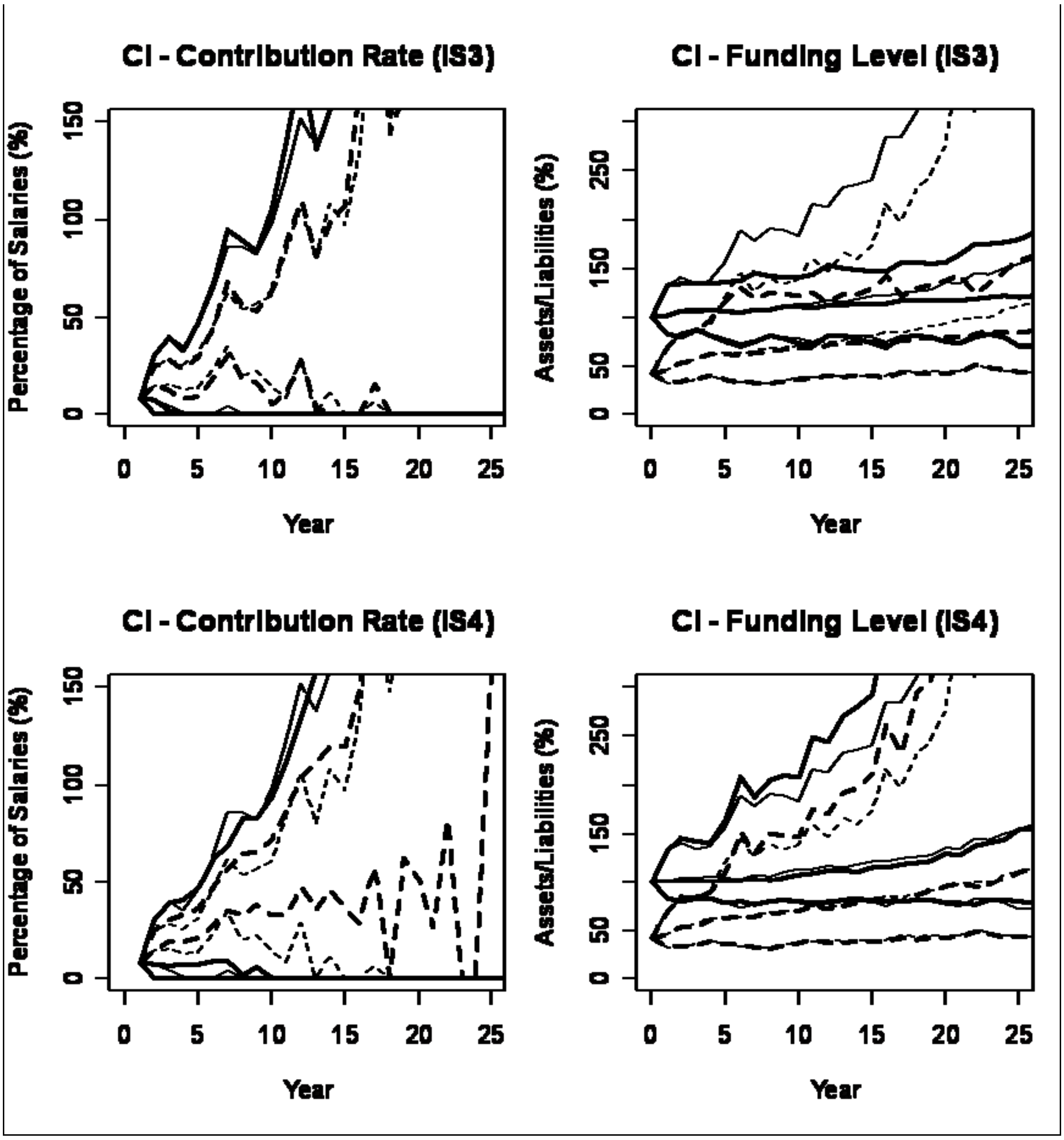
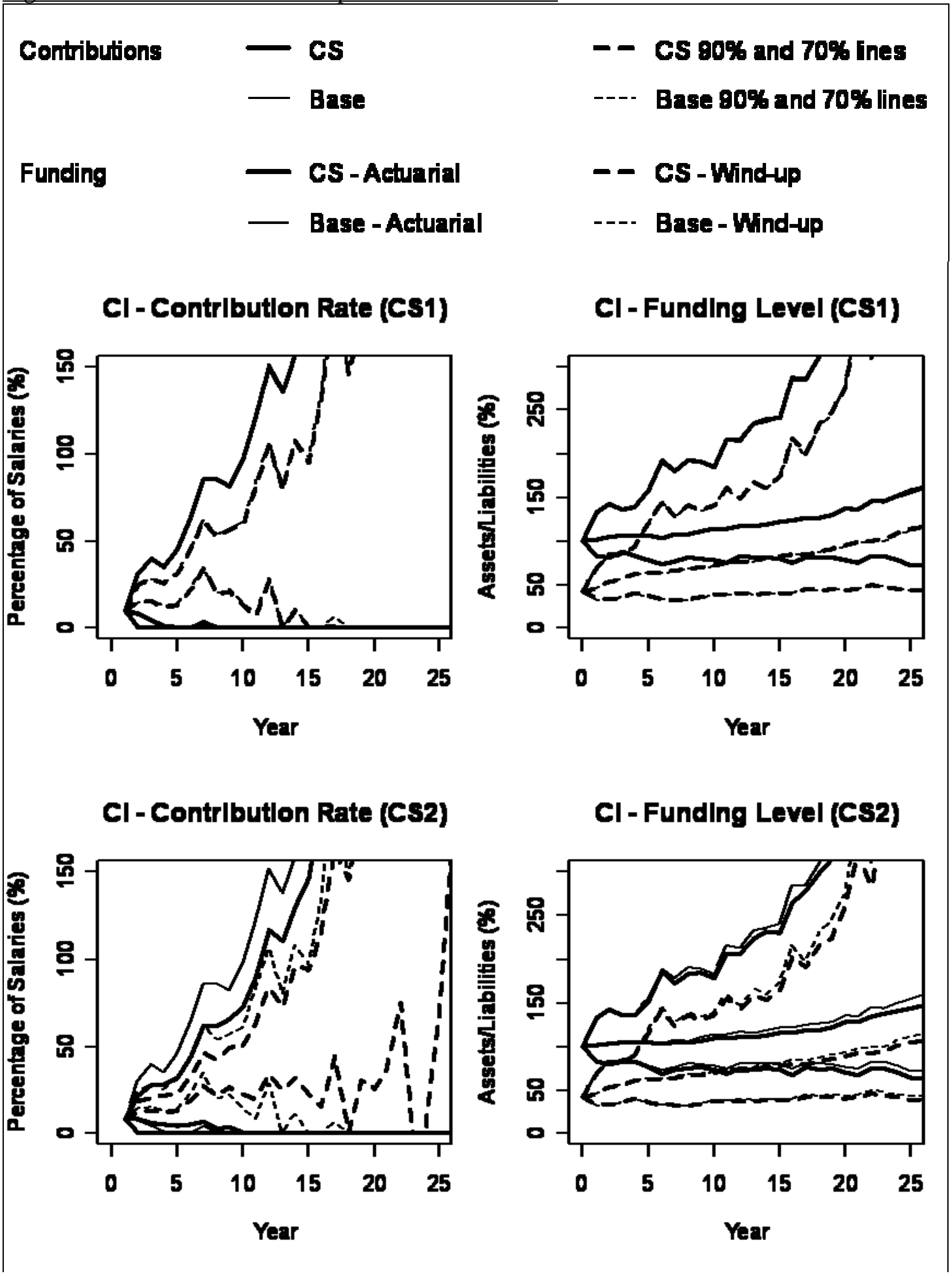
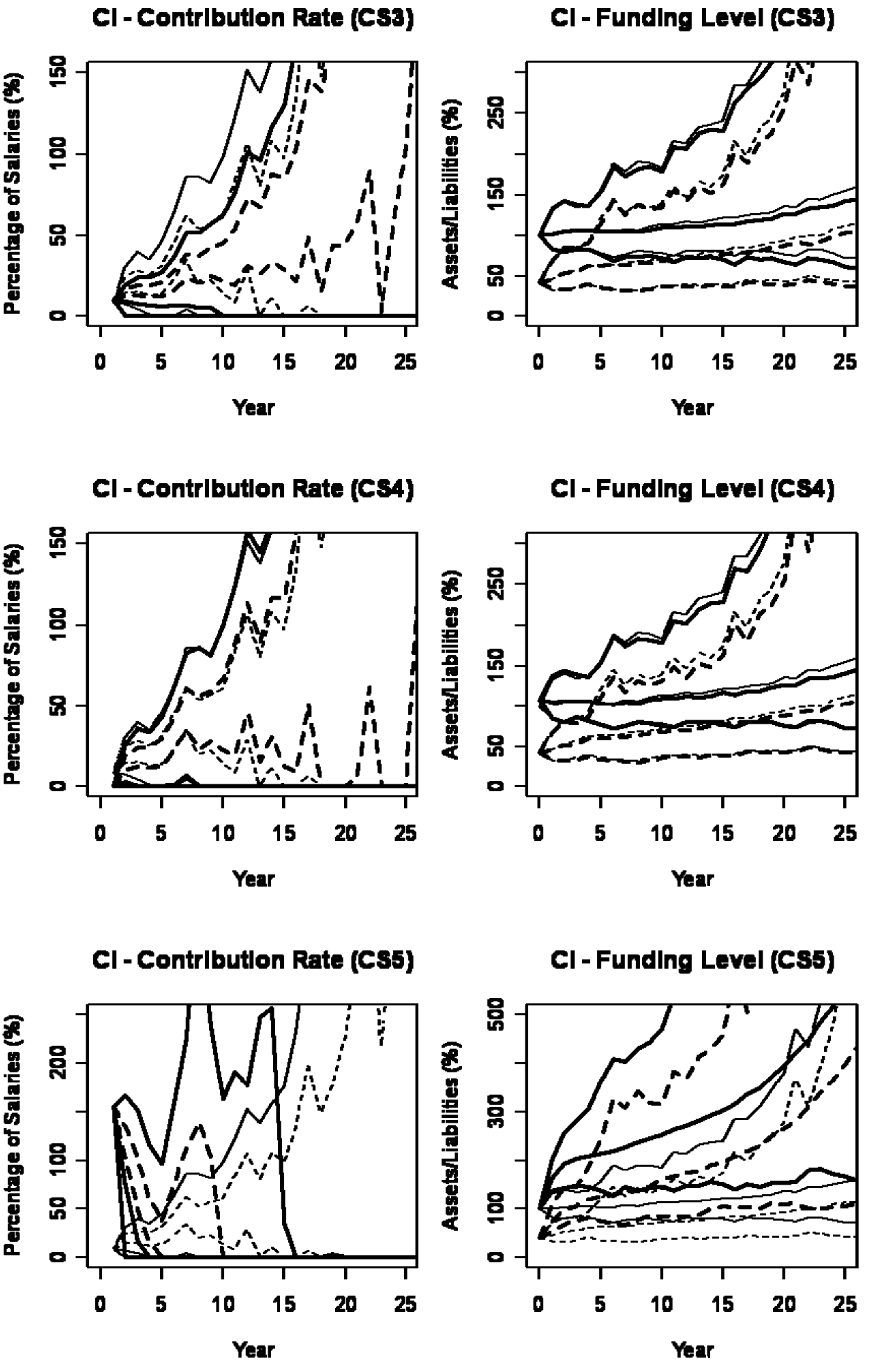

CI - Contribution Rate (IS3)
Percentage of Salaries (%)
Year
CI - Funding Level (IS3)
Assets/Liabilities (%)
Year
CI - Contribution Rate (IS4)
Percentage of Salaries (%)
Year
CI - Funding Level (IS4)
Assets/Liabilities (%)
Year

Figure E.2 – Confidence interval plots for CS scenarios




CI - Contribution Rate (CS3)
Percentage of Salaries (%)
Year
CI - Funding Level (CS3)
Assets/Liabilities (%)
Year
CI - Contribution Rate (CS4)
Percentage of Salaries (%)
Year
CI - Funding Level (CS4)
Assets/Liabilities (%)
Year
CI - Contribution Rate (CS5)
Percentage of Salaries (%)
Year
CI - Funding Level (CS5)
Assets/Liabilities (%)
Year

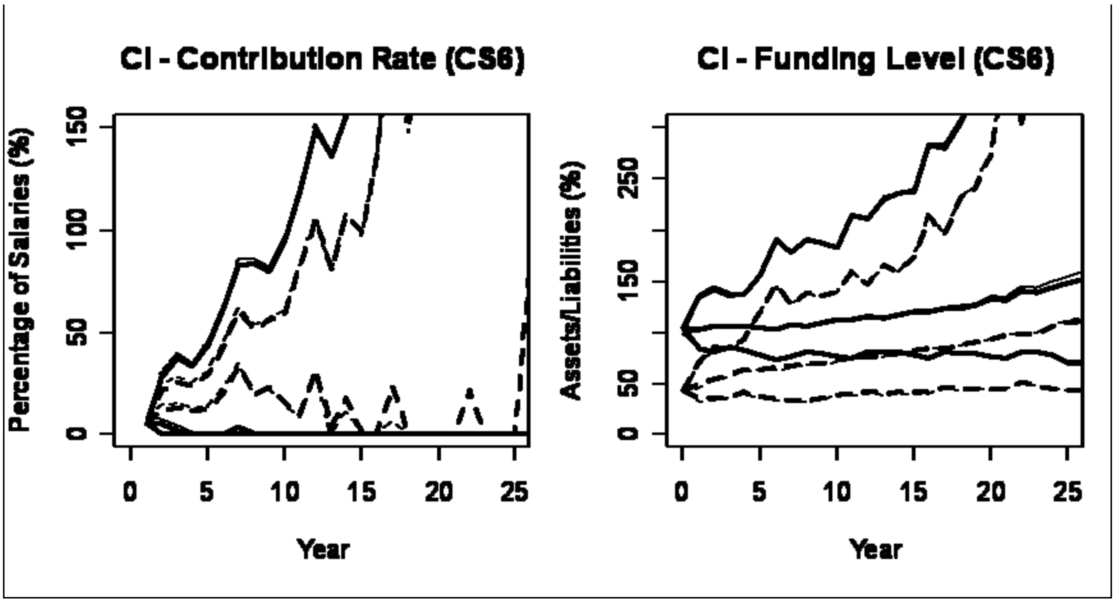


Figure E.3 – Confidence interval plots for BD scenario