Feedback effects of default insurance for defined benefit schemes

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Abstract

Two scheme default insurance frameworks, based on the current and new frameworks of the Pension Protection Fund in the U.K., are investigated to determine their impact on the optimal asset allocation and spread period for deficits and surpluses of a model defined benefit pension scheme. The optimal spread period is unaffected by scheme insurance, whilst the current scheme insurance framework encourages an increase in the allocation to growth assets as the riskiness of the employer-sponsor increases, creating a negative feedback effect of increased deficits. The new framework reverses the feedback effect in most cases to a reduction in the allocation to growth assets thus reducing deficits. Results for a variety of investment strategies are tested and not found to significantly impact the effect of scheme insurance.

Key words: Defined benefit pensions, Scheme default insurance, Investment strategy, Monte Carlo methods

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1 Introduction

Underfunding of defined benefit pension schemes is a significant risk to members of these schemes. The Organisation for Economic Co-operation and Development (OECD, 2009) reports that across member nations the average scheme had a funding level of less than 80% relative to accounting liabilities at the end of 2007, with this result expected to be broadly similar in 2010[1]. Scheme default insurance (known hereafter as "scheme insurance"), such as the Pension Protection Fund (PPF) in the U.K. and the Pension Benefit Guaranty Corporation (PBGC) in the U.S., is designed to provide some protection to members of underfunded pension schemes where the sponsoring employer becomes insolvent. However, the sliding levy scales based on funding levels and, for the PPF, the perceived risk of the employer-sponsor becoming insolvent, may affect investment and contribution decisions made by stakeholders of the scheme in order to reduce the amount of levy paid. In addition, the PPF has recently announced its decision to introduce an allowance for investment risk into levy calculations. Hence, scheme insurance also has a separate indirect effect on the members of the scheme due to the effect of the insurance on these investment and contribution decisions.

In this paper a comprehensive stochastic asset and liability model is developed to investigate the effect that a scheme insurance system (based on the PPF) has on investment and contribution decisions of the stakeholders of a model scheme, and the resultant indirect effect on the scheme members. Three stakeholder objectives are allowed for in making decisions; the desire to reduce average contributions, the desire to reduce unexpected excess contributions and the desire to reduce funding deficits. Whilst there is significant previous literature on the use of

[1] For example, Table 4.2 of the purple book (The Pensions Regulator and Pension Protection Fund, 2010) shows funding levels in the U.K. to be broadly similar in 2007 and 2010, with significant dips in 2008 and 2009 due to equity market reductions offset by improvements in the equity market in 2010.

stochastic models for pension decision making[2], there is little literature on the effect of scheme insurance on these decisions. McCarthy and Miles (2007) consider the effect of adjusting the funding level to account for any deficit covered by insurance on investment decisions of trustees, although do not make any allowance for employer-sponsor contribution desires nor the cost of scheme insurance. The investment decision is set using a utility function approach on adjusted funding level. This paper takes a different approach; it is assumed that the funding level objective is not affected by scheme insurance – but that objectives are affected by the cost of scheme insurance. Sutcliffe (2004) argues from a theoretical perspective that until 1987, when PBGC levies first allowed for underfunding, the PBGC created an incentive for U.S. schemes to invest in equities due to the upside of scheme surpluses obtained by employer (through reduced contributions) and employees (through increased benefits) that were not offset by the downside of deficits to employer-sponsors (through increased levies).

Section 2 of this paper outlines the methodology used in the analysis, whilst Section 3 provides the results. Conclusions are presented in Section 4.

2 Methodology

2.1 Simulation model

Assets and liabilities of a model scheme are projected for 30 years over 1,000 simulations using stochastic economic and demographic models. The economic model is based on the Wilkie (1995) structure, parameterised using Australian data over the period 30 June 1983 to 30 June 2009. Underlying withdrawal and mortality rates are also based on Australian experience, with

[2] See Shapiro (2005) for a history of pension funding, including the use of stochastic models.

mortality improvement also being allowed for. Uniform random numbers are compared to underlying withdrawal and mortality rates each year in simulating movements between membership statuses of individual members, as per the approach of Chang (1999).

The projection of assets and liabilities of the model scheme is similar in approach to that taken by the Stochastic Valuation Working Party of the U.K. Pensions Board (see Haberman et al., 2003), with the exception that in this paper the normal contribution rate is fixed on a projected unit credit basis and not treated as a free variable like in Haberman et al. (2003).

Further information about the simulation model (including the economic and demographic sub-models) can be found in Section 3 and Appendix B & C of Butt (2011a).

2.2 The model scheme

The model scheme has 5,000 active members, 1,680 deferred members and 1,920 pensioner members at the commencement of projections and is closed to new entrants[3]. It has initial assets exactly equal to the value of the liabilities. Benefits are generally paid in the form of a price-inflation indexed pension (deferred until age 65 with indexation subject to a minimum of 0% and a maximum of 10% each year), except when a member leaves with less than 7 years of service in which case a lump sum is paid.

The liabilities targeted for funding purposes are discounted on a risk-free[4] basis using best estimate assumptions. Hence the discount rate is determined with reference to long-term

[3] The purple book (The Pensions Regulator and Pension Protection Fund, 2010) states that 60% of defined benefit scheme members in the U.K. are in schemes which are closed to new entrants.

[4] This choice is made on a somewhat pragmatic basis. Allowing the discount rate to take into account the expected return on plan assets (like the Technical Provisions, which are used for funding purposes in the U.K.) would mean the discount rate differs for each asset allocation tested, increasing the simulation time to unreasonable lengths. Using a risk-free rather than a corporate bond discount rate (as required by

government bond yields and inflation-linked bond yields and demographic assumptions are the underlying rates obtained from the relevant stochastic demographic model. Normal contributions are calculated annually on a projected unit credit basis using the liability assumptions[5], with no delay between the effective date of contribution calculations and their application.

In most cases tax on contributions and investment earnings is assumed to 15%, as per the Australian superannuation system. No tax is applied to investment earnings backing pensions in payment[6]. The liability discount rate for pre-pensioner liabilities is also reduced by 15%.

Surplus levels are not capped in any way, although after 30 years surplus assets are distributed as additional benefits to members. Should a deficit occur after 30 years, it is immediately removed by the employer-sponsor making the net of tax contribution required to fund the deficit. The employer-sponsor covenant with the scheme is assumed to be strong enough to ensure the payment of contributions required at all times. Thus the employer-sponsor is assumed to be exposed to all underfunding risk but not benefit from any overfunding[7].

Further information about the model scheme can be found in Appendix A of Butt (2011a).

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international accounting standards in incorporating pension information into sponsoring employers' financial accounts) is consistent with the funding requirements of U.S. schemes, the assumptions required by the PPF and also the valuing of bond portfolios in the economic model. This allows the comparison of highly cash flow matched asset portfolios in the results.

[5] No allowance is made in contribution calculations for the difference between expected investment returns and the discount rate.

[6] Exceptions are that Australian Equity prices have a reduced tax rate of 10% and Australian Equity dividends have an effective tax rate of -12% (-32% for pension assets) to offset company tax already paid before dividend distribution (known as dividend imputation in Australia).

[7] The exception to this is that that surplus may be used to reduce contributions for future benefit accruals.

2.3 Optimisation decision metrics

Employers generally desire low and predictable contributions and a minimal balance sheet effect from their sponsoring of defined benefit schemes[8]. Trustees desire the funding level to be maintained at an appropriate level to ensure there are sufficient assets to meet liabilities at all times. Hence, trustee desires are roughly equivalent to the desire of employer-sponsors to maintain minimal balance sheet effect[9]. However, these desires are generally not internally consistent; for example a desire for low contributions is at odds with a desire for minimal balance sheet effect.

Given the inconsistent desires of employer-sponsors and trustees, they must be balanced against each other in some way. Individual components similar to Haberman et al. (2003)[10] are weighted in a fashion simplified from Taylor (2002)[11], giving the following objective function V:

$$V = \overline{c} + \alpha \times \overline{c}_{exc} + \beta \times \overline{Dfct};$$

[8] For the purposes of this paper, employer-sponsor desires for the defined benefit scheme are considered in isolation to the performance of the company. Some argue that scheme investment in equities promotes inconsistencies with the operations of the rest of the company and the investment of shareholders. See Ralfe et al. (2004), Gold (2005) and Chapter 3 of Blake (2006) for further discussion.

[9] This assumes that any deficit in the scheme is required to be reflected fully in the sponsoring employer's financial statements (which is the case for the U.K. standard FRS17 and U.S. standard FAS158 and has recently been updated under international standard IAS19). The use of a risk-free rather than corporate bond discount rate means the funding target applied in this paper is more stringent than that which would be applied in employer-sponsors' financial statements. However, for simplicity and consistency with the PPF calculations it is appropriate to use a risk-free funding target here.

[10] Haberman et al. (2003) consider individual objectives of excess contributions and deficit levels. They consider the normal contribution rate to be a free variable, hence why this is not a component of the objectives they measured.

[11] Taylor (2002) allowed weightings to be strictly increasing or decreasing (as appropriate) functions of the components of the objective function. In this paper, the weightings are simply linear functions of the components.

where $\bar{c}$ is the average contribution rate as a percentage of salaries over 30 years, $\bar{c}_{exc}$ is the average contribution rate in excess of normal contributions over 30 years and $\overline{Dfct}$ is the mean level of deficit of assets to liabilities (treating surpluses as zero deficits) over 30 years, divided by the initial asset level for scaling. The value of the objective function V is calculated for each simulation of the model scheme, with an optimal strategy being one that minimises the average value of V across 1,000 simulations of the model scheme. See Butt (2011a) for further details of the calculation of the component parts of the objective function.

Contributions in excess of expectations are assumed to have double the effect on the objective function compared to contributions up to expectations, therefore giving $\alpha = 1$. The total contribution effects $\bar{c}$ and $\bar{c}_{exc}$ are assumed to make up two thirds of the total objective, since deficits may be removed through experience or contributions whilst contributions are an unreturnable cash expense of the employer-sponsor. To set a value for β, in the base scenario one third of V is made up by $\beta \times \overline{Dfct}$ at a growth asset allocation of 50% and a spread period of 5 years[12], giving $\beta = 10.699$. The coefficients α and β are fixed at these values to allow for consistent scenario comparison.

[12] This is consistent with the allocation to growth assets by U.K. pension schemes (see Table 7.1 of the purple book, The Pensions Regulator and Pension Protection Fund, 2010) and the smoothing period of the new insurance framework (see Section 2.5.2).

2.4 Scenarios

2.4.1 Base scenario

It is assumed that trustees and employer-sponsors have two tools available to them in meeting the desires described in Section 2.3. The first is the choice of investment strategy[13] and the second is the speed at which scheme deficits and surpluses are removed.

The investment strategy is allowed to vary between “growth” (equities) and “defensive” (all other) asset classes. The split within these classifications is based on the typical split of Australian schemes as follows:

Growth assets

Australian equities	$58^1/_3$%
International equities	$41^2/_3$%

Defensive assets

Australian bonds	$37^1/_2$%
International bonds	25%
Inflation-linked bonds	25%
Australian cash	$12^1/_2$%

For example, the asset allocation of the scheme for a 60/40 split between growth and defensive assets is as follows:

[13] Although investment decisions are the domain of trustees of the scheme, who are required to act in the best interests of members, the fact that the employer-sponsor is financially responsible for the scheme means it is reasonable to consider both trustee and employer-sponsor desires when making investment decisions.

Australian equities	35%
International equities	25%
Australian bonds	15%
International bonds	10%
Inflation-linked bonds	10%
Australian cash	5%

The split between growth and defensive asset classes is allowed to vary from 0% - 100% in the results[14]. Asset allocations are rebalanced at the end of each year.

Any surplus or deficit is spread (using the approach described by Owadally and Haberman, 1999) using a range of integer spread periods from 1 – 20 years in the results. The spread is undertaken on a fixed dollar per annum basis due to the reducing salaries in a closed scheme.

2.4.2 Cash flow matching of defensive investment (CF)

Instead of investing defensive assets as per the strategy described in Section 2.4.1, defensive assets are invested to cash flow match the liabilities of the scheme. The methodology for calculating returns on cash flow matched assets can be found in the Appendix of Butt (2011b). The assets available for cash flow matched investment are invested in proportion with the liabilities to be cash flow matched; in other words each expected cash flow is matched to the same percentage depending on the defensive assets available.

2.4.3 Dynamic investment strategy (DI)

It is found by Haberman et al. (2003) and Butt (2011a) that reducing investment risk as the funding level increases can improve objectives. Hence, each year the proportion allocated to growth assets is reduced by 1% from the initial asset allocation for every 1% that the funding

[14] For plots the split is allowed to vary in 5% increments. However, when identifying optimal strategies the nearest 1% is used.

level is greater than 100% at the start of the year. The initial growth asset allocation is still allowed to vary from 0% - 100%, with a minimum growth asset allocation of 0%.

2.5 Scheme insurance frameworks considered

2.5.1 Scheme insurance current (IC)

The current PPF model is used as a starting point. Note that only the risk-based portion of the levy is included as the scheme-based portion is similar to other expenses of the scheme which have been ignored. The risk-based levy, *Lvy(t)*, paid during year *t*, based on liabilities, $L(t-1)$, and Scheme assets, $N(t-1)$, at time $t-1$ is:

$$Lvy(t) = \min\left[0.0075 \times L(t-1), U \times P \times 0.8 \times 2.07\right];$$

where P is the employer-specific insolvency probability and U is the underfunding of the scheme and is calculated as:

$$U = \begin{cases} 1.36 \times L(t-1) - N(t-1) & \text{if} \quad N(t-1) \le 1.35 \times L(t-1) \\ 0.0100 \times L(t-1) & \text{if} \quad 1.35 \times L(t-1) \le N(t-1) < 1.40 \times L(t-1) \\ 0.0075 \times L(t-1) & \text{if} \quad 1.40 \times L(t-1) \le N(t-1) < 1.45 \times L(t-1) \\ 0.0050 \times L(t-1) & \text{if} \quad 1.45 \times L(t-1) \le N(t-1) < 1.50 \times L(t-1) \\ 0.0025 \times L(t-1) & \text{if} \quad 1.50 \times L(t-1) \le N(t-1) < 1.55 \times L(t-1) \\ 0 & \text{if} \quad 1.55 \times L(t-1) \le N(t-1) \end{cases}$$

These formulae are consistent with the PPF levy for the period 1 April 2011 – 31 March 2012. The probability of insolvency P is assumed to be fixed across the 30 year projection period[15]

[15] A scenario where the insolvency probability was allowed to vary was considered; however data from recent years from the PPF and The Pensions Regulator (see the Chart titled "Average insolvency probability by s179 liability level (schemes in deficit and schemes in surplus)" in the purple book) shows

with a range of P values tested corresponding to the current P values equivalent to the mid-points of the new levy bands to be used by the PPF in new framework (see Section 2.5.2).

Although a separate liability is required to be calculated for this measure (based on Section 179 of the Pensions Act 2004), for reasons of simplicity in computation the funding liability of the scheme is used[16]. Additionally, even though a Section 179 valuation is only required to be performed on a triennial basis, it is assumed that the levy calculation is based on the annually calculated liability. The levy amount is assumed to be paid by the employer-sponsor as excess contributions, except where surplus is large enough that no contributions are required and the levy can be paid from surplus.

2.5.2 Scheme insurance new (IN)

The PPF confirmed on 16 May 2011 that it will be pursuing a new levy framework from 1 April 2012. Details of this framework can be found in a Policy Statement (PPF, 2011). This section describes adjustments to the scheme insurance introduced in Section 2.5.1 to follow the requirements of the new PPF framework. The most significant change to the risk-based portion of the levy is that the underfunding risk U will allow for smoothing of assets and liabilities over a 5 year period and for riskiness of the scheme's investment strategy (through a separate stress test on liabilities and different asset classes). Annex D of the Policy Statement provides an example of how the smoothing and riskiness of the scheme's investment strategy will be allowed for.

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the relationship between employer-sponsor insolvency and scheme funding levels is not clear, particularly for larger schemes.

[16] It is expected that the liability upon which scheme insurance calculations are based in this paper would be significantly higher than what would be the case under Section 179 (s179) of the Pensions Act 2004, due to caps and limitations applied to the benefit to be paid to members under s179 calculations. However, it is expected that not using s179 calculations will not affect the direction of the results in this paper, but just the scale.

Firstly, smoothing is applied to liability and asset values[17]. The smoothed liability value at time t – 1, $L^{sm}(t-1)$, is calculated the same way as $L(t-1)$ but using the average discount rate applying over the previous 5 years. The smoothed value of bonds are calculated assuming yields are equal to the average yield over the previous 5 years. No smoothing adjustment is made to cash. The smoothed value of equities are calculated by adjusting equity values to reflect the average dividend yield over the previous 5 years. See the Appendix for further information on how these calculations are performed.

Secondly, stress tests are applied to smoothed liability and asset values to give adjusted liability and asset values $L^{adj}(t-1)$ and $N^{adj}(t-1)$. The stress tests are designed to allow for a one standard deviation movement[18] in the funding level. The Appendix provides information on how these stress tests are performed.

Thirdly, the formula for the risk-based levy is updated to:

$$Lvy(t) = \min\left[0.0075 \times L(t-1), U \times P \times K\right];$$

where $L(t-1)$ is unchanged from Section 2.5.1 and $U = \max\left[0, L^{adj}(t-1) - N^{adj}(t-1)\right]$. A range of P values are tested, corresponding to the new levy bands to be implemented (see Table

[17] The approach used in this paper is consistent with that described in Annex D of the Policy Statement, with the exception that the PPF uses smoothed asset values at the mid-point of the five year averaging period and thus requires smoothed liability values to be "rolled back/forward" to this point (at a discount rate which has not yet been clarified by the PPF). The approach used in this paper calculates smoothed asset values at the date of the valuation using yields; hence there is no requirement to adjust the smoothed liability value. The PPF approach is pragmatic in nature, since they receive valuation data on a triennial rather than annual basis. In any case the differences in approaches are not significant and will not materially affect the results of the paper.

[18] The PPF (2011) has indicated this is the targeted level of the stress test.

A5, PPF, 2011). $K = 3.21$ is set so that the levy for a company in PPF Levy Band 5 in the first year is equal in the new and current framework for a growth asset allocation of 50%[19].

3 Results

Results and discussion are split as per the scenarios outlined in Section 2.4. All scenarios consider a situation where no scheme insurance exists as well as the two scheme insurance frameworks outlined in Section 2.5.

3.1 Base scenario

Contour plots of the objective function for the Base scenario (with no scheme insurance and Band 5 insurance under the current and new frameworks) are presented in Figure 3.1 for various growth asset allocations and spread periods. A triangle is placed at the optimal growth asset allocation and spread period. Note that these plots are of the same form presented in Butt (2011a).

[19] For a scheme with a "High" funding level (see Table A6 of PPF, 2011 – this is equivalent to the starting funding level of 100% for the model scheme), Figure A10 of PPF (2011) suggests a 4% levy increase for PPF Levy Band 5, with decreases of 15% and 10% for Levy Bands 4 and 6 respectively. This suggests an equivalent levy calculation in the current and new framework is reasonable for PPF Levy Band 5. Band 5 is the middle band for the probability of insolvency.

Figure 3.1 – Objective function for Base

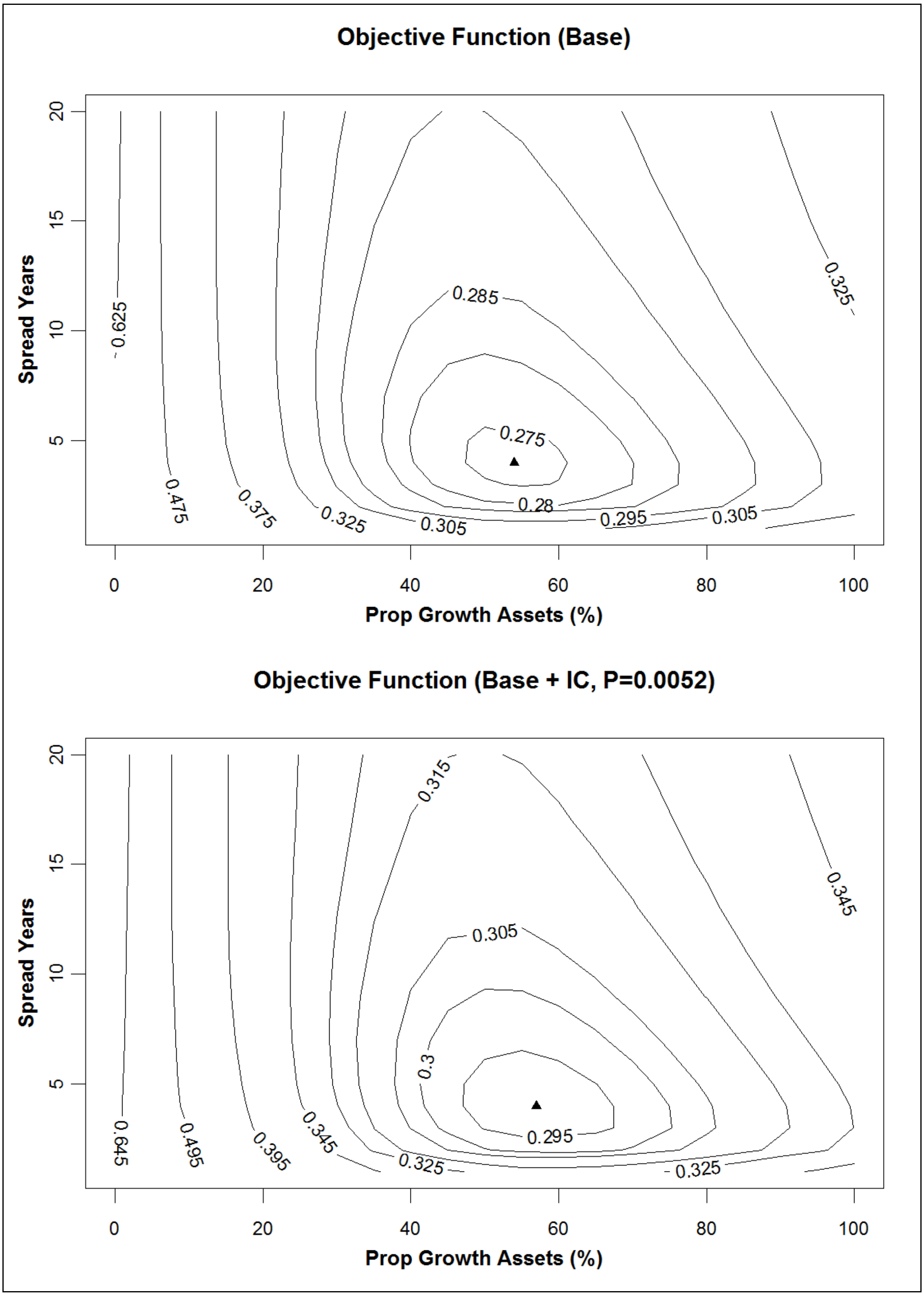
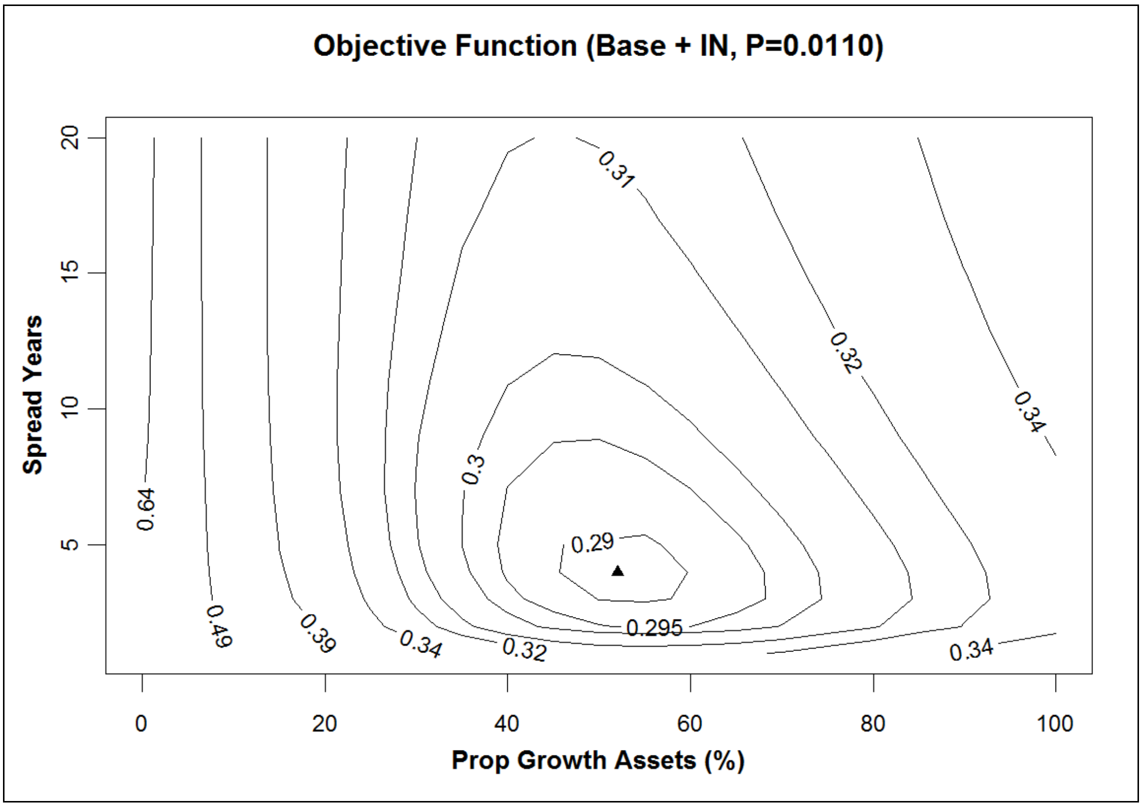


Figure 3.1 – Objective function for Base (continued)



The minimum value for the Base objective function of 0.2735 occurs at a growth asset allocation of 54% and a spread period of 4 years[20]. This is the optimal strategy to balance the contribution and funding level objectives set out in Section 2.3, giving an average contribution rate $\bar{c}$ of 14.82%, an average excess contribution rate $\bar{c}_{exc}$ of 3.69% and a mean deficit $\overline{Dfct}$ of 0.8265%. Growth asset exposures smaller than 54% reduce excess contributions and funding deficits, but are more than offset by the higher payment of normal contributions due to the smaller probability of being in surplus. A shorter spread period also reduces funding deficits, but at too much of a cost to excess contribution levels. Moving towards the top right corner of

[20] It might appear that the methodology for selection of the β coefficient in Section 2.3 biases the results towards a 50% growth asset allocation and 5 year spread period. Whilst there is some element of truth to this, using alternative approaches to selecting β shows this is only partially true. For example, using a 0% growth asset allocation and a 1 year spread period to set a β of 24.286 gives optimal strategies of 53% growth assets and a 2 year spread period. Alternatively, using a 100% growth asset allocation and a 20 year spread period to set a β of 5.290 gives optimal strategies of 58% growth assets and a 7 year spread period. In any case the purpose of this paper is to investigate the effect of scheme insurance, so the selection of a base scenario is somewhat arbitrary.

the plot by increasing growth assets and spread period affects the objective function in a smaller way, although lower average contribution rates are not significant enough a compensation for larger excess contributions and funding deficits.

The current scheme insurance framework (IC), with a Band 5 *P* value of 0.0052, causes an increase in the optimal growth asset allocation from 54% to 57%. The spread period is unchanged at 4 years. The increase in the optimal growth asset allocation is due to the desire to increase the surplus in the scheme to avoid levy payments. The minimum objective function has increased by 6.7% from 0.2735 to 0.2918 indicating the significant impact of both the additional contributions for the levy and the increase in mean deficit (see Figure 3.2).

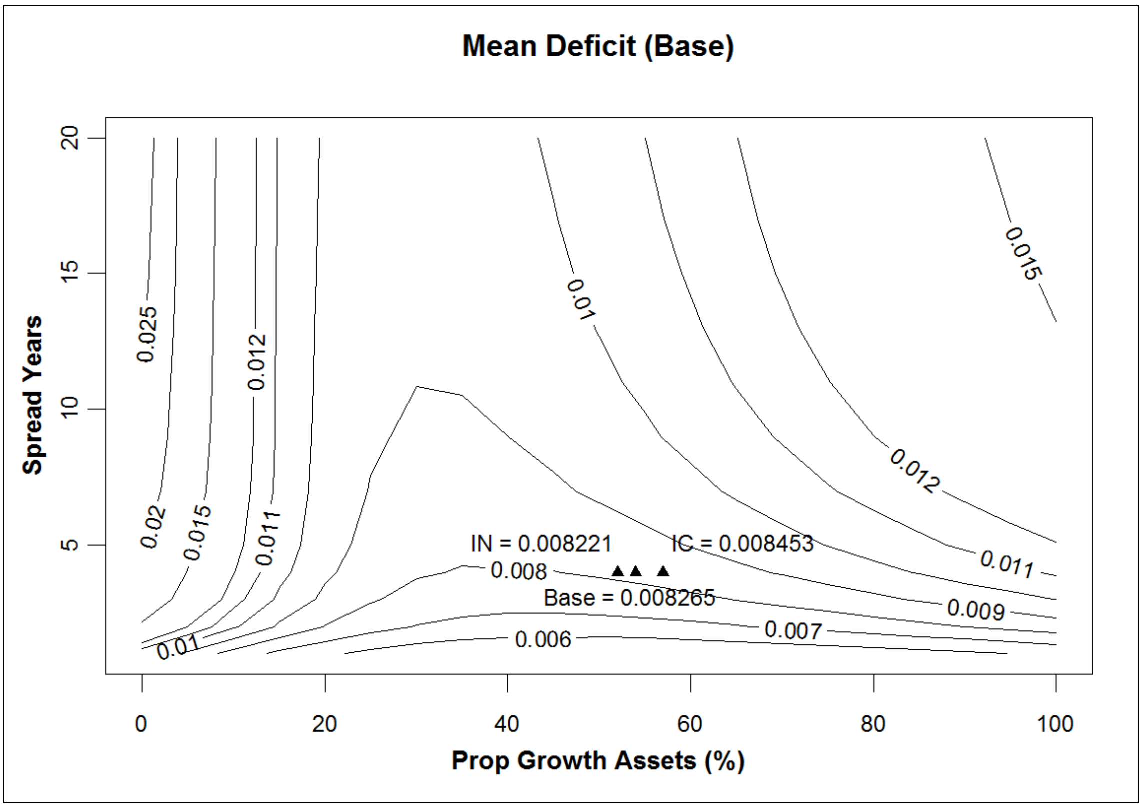
Conversely, the new scheme insurance framework (IN), with a Band 5 *P* value of 0.0110, causes a decrease in the optimal growth asset allocation from 54% to 52%, with the spread period again unchanged at 4 years. There is hence a total reduction in optimal growth asset allocation between IC and IN of 5%, from 57% to 52%. The minimum objective function has increased by 5.5% from 0.2735 to 0.2885.

Given these results, it is now of interest to investigate what impact the change in optimal investment strategy has on the risks faced by members of the scheme. The mean deficit, $\overline{Dfct}$, is the component of the objective function that most reflects this risk, as it reflects the size and likelihood of a deficit event that may result in a claim[21] to the scheme insurer and subsequent lower level of benefit payment to members from the scheme insurer[22]. Since the employer-

[21] It could be argued that a better measure of this risk might be simply the probability of a deficit, however the size of a deficit is likely to have some influence on the likelihood of it being removed; hence the mean deficit is maintained as the appropriate measure of the risk to members.
[22] In the PPF, all members are exposed to this risk in varying degrees. Those who are not currently receiving a pension are most at risk, in particular those who have an accrued pension over the compensation cap, as they receive only up to a 90% level of compensation capped at a certain maximum amount. Those who are receiving a pension may have their pension increased at a lower rate than it would have been in the scheme.

sponsor pays the levy directly each year (it is treated as an excess contribution in the objective function) or from scheme surplus if the scheme does not require contributions in that year (in which case the levy is likely to be small or even zero), scheme insurance has little impact on the mean deficit for a given growth asset allocation[23]. Hence a single mean deficit contour plot is presented for Base in Figure 3.2. The triangles (and associated numbers) on the plot represent the mean deficits using the optimal strategies in Figure 3.1.

Figure 3.2 – Mean deficit for Base



The mean deficit for Base is 0.8265% of initial assets. This increases by a percentage of 2.3% to 0.8453% under the current insurance framework (IC) but decreases by a percentage of 0.5% to 0.8221% under the new insurance framework (IN). These changes occur for two reasons,

[23] Scheme insurance will impact the mean deficit if a scheme that was previously in enough surplus to pay the levy from surplus then goes into deficit. However, this has minimal impact on the shape and scale of the contours in Figure 3.2.

firstly the change in optimal growth asset allocation, and secondly the increase in deficits due to levy payments from schemes in surplus. For example, under Base at a growth asset allocation of 57% and a spread period of 4 years, the mean deficit is 0.8388%. This indicates that 0.0123% of the 0.0188% absolute increase in mean deficit for IC is due to the growth asset allocation changes, whilst 0.0065% is due to the levy payments increasing deficits. Similarly, the mean deficit under Base at a growth asset allocation of 52% and a spread period of 4 years is 0.8190%, indicating a decrease in mean deficit for IN of 0.0075% due to growth asset allocation changes, and an increase of 0.0033% due to the levy payment increasing deficits, giving a total reduction to mean deficit of 0.0034%.

The most important factor to note is the clear negative feedback effect for members of the current framework, with the 2.3% percentage increase in mean deficit representing an increased risk to members of the employer-sponsor defaulting on its obligations whilst the scheme is in deficit. However a positive feedback effect exists for members in the new framework, with a 0.5% decrease in mean deficit.

One other point of interest about Figure 3.2 is that, despite the scheme being fully funded on a risk-free basis at the commencement of projections, the minimum mean deficit does not occur at a zero growth asset allocation. Defensive asset values, whilst being correlated with movements in liability values, are not cash flow matched; hence deficits can still occur using 100% defensive assets. Butt (2011a) comments on a strong trend towards surplus in the simulations, with the trend being stronger the larger the amount of growth assets used[24]. This trend reduces the probability of a simulation being in deficit dramatically over time, thus reducing the mean deficit. For this reason the mean deficit does not occur at a zero growth asset allocation.

[24] This trend exists due to expected investment returns being greater than the discount rate and because of the Base scenario requirement of the employer-sponsor to fund all deficits without the corresponding ability of the employer-sponsor to retrieve surplus. Further discussion is found in Butt (2011a).

Minimum objective function values, optimal strategies and associated mean deficit values for the range of *P* values tested for IC and IN are presented in Table 3.1.

Table 3.1 – Objective function, optimal strategies and mean deficits for Base

IC					**IN**				
***P* Value**	Objective Function	Growth Assets (%)	Spread Period (Years)	Mean Deficit (%)	***P* Value**	Objective Function	Growth Assets (%)	Spread Period (Years)	Mean Deficit (%)
0.0000	0.2735	54	4	0.8265	**0.0000**	0.2735	54	4	0.8265
0.0006	0.2756	54	4	0.8273	**0.0018**	0.2760	54	4	0.8271
0.0013	0.2781	55	4	0.8322	**0.0028**	0.2775	54	4	0.8274
0.0021	0.2809	55	4	0.8332	**0.0044**	0.2797	53	4	0.8241
0.0030	0.2841	56	4	0.8384	**0.0069**	0.2835	52	4	0.8210
0.0052	0.2918	57	4	0.8453	**0.0110**	0.2885	52	4	0.8221
0.0078	0.3010	58	4	0.8527	**0.0160**	0.2936	52	4	0.8234
0.0117	0.3116	61	4	0.8705	**0.0201**	0.2969	53	4	0.8281
0.0162	0.3159	62	4	0.8800	**0.0260**	0.3004	55	4	0.8369
0.0199	0.3174	62	4	0.8834	**0.0306**	0.3015	56	4	0.8415
0.0300	0.3191	62	4	0.8885	**0.0400**	0.3029	56	4	0.8422

Note: a P value of 0.0000 is equivalent to the Base scenario.

The results in Table 3.1 are broadly consistent with those in Figures 3.1 and 3.2. The optimal spread period is 4 years for all frameworks and *P* values. Movements in the growth asset allocation are designed to reduce levy payments, whilst not sacrificing other elements of the objective function. This can be achieved in two ways for the current scheme insurance framework (IC). Firstly, levy payment reduction can be achieved by reducing growth asset exposure leading to a reduced probability of severe deficits. Secondly, levy payment reduction can be achieved by increasing the growth asset exposure and aiming to increase the funding level. For IC, the second factor is more significant than the first, with the allocation to growth assets compared to the Base scenario increasing as the risk of employer-sponsor insolvency increases (i.e. the *P* value increases). This is due to the greater levy paid by schemes with a higher employer-sponsor insolvency risk encouraging a greater investment in risky assets in aiming to increase funding level and thus reduce levy contributions. This is a particular concern as it means that schemes with a less stable employer-sponsor are exposed to greater risk of deficit, which increases by an absolute value of 0.0620% or a percentage of 7.5% from 0.8265% with no levy to 0.8885% for schemes with the least stable employer-sponsor. The increased allocation to growth assets slows as the *P* value increases due to the 0.75% liability cap on levy payments applying even when schemes are in surplus[25], which reduces the ability of the scheme to quickly reduce levy payments by moving the scheme into surplus.

Incorporating investment risk into the new scheme insurance framework (IN) leads to a new way in which levy payments can be reduced. Reducing growth asset exposure reduces the effect of the stress testing on levy payments. Where levy payments are typically below the 0.75% liability cap (for *P* values up to 0.0160), this leads to a slightly reducing allocation to growth assets as *P* values increase, keeping deficit levels relatively steady as *P* values increase. However, as the *P* value increases towards 0.0400, the levy cap of 0.75% of liabilities is much more likely to be applied; hence the extra stress test effect associated with a greater growth asset allocation does not lead to additional levy payments and achieving surplus is the most significant driver of reducing levy payments. This results in an increased mean deficit of an absolute value of 0.0157% or a percentage of 1.9% from 0.8265% with no levy to 0.8422% for schemes with the least stable employer-sponsor. Thus, even in the new framework there is an incentive for schemes with the most extreme employer-sponsor risks to increase growth asset allocation, which again is a concern for members. One way to mitigate this risk is to increase the liability cap for levy payments; however this may not be a realistic option as it may lead to insolvency in any case for employers most at risk.

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[25] For example, consider a scheme with a *P* value of 0.0199 and a funding level of 110%. The IC levy calculation in this case would be $\left[1.36L(t-1)-1.10L(t-1)\right]\times 0.0199\times 0.8\times 2.07 = 0.0086L(t-1)$, which is greater than $0.0075L(t-1)$, meaning the levy cap would apply. In this case the levy cap applies for funding levels up to 113.2%.

3.2 Cash flow matching for defensive investment

When introducing cash flow matching for defensive investment (CF), contour plots of the objective function and mean deficit have the same basic shape (albeit with different optimal allocations to growth assets) as the Base scenario in Figures 3.1 and 3.2. Hence, the contour plots for the CF scenario are not presented, with Table 3.2 providing minimum objective function values, optimal strategies and associated mean deficit values for CF for the range of *P* values tested for the current scheme insurance framework (IC) and new scheme insurance framework (IN).

Table 3.2 – Objective function, optimal strategies and mean deficits for CF

IC					**IN**				
***P* Value**	Objective Function	Growth Assets (%)	Spread Period (Years)	Mean Deficit (%)	***P* Value**	Objective Function	Growth Assets (%)	Spread Period (Years)	Mean Deficit (%)
0.0000	0.2338	34	4	0.5090	**0.0000**	0.2338	34	4	0.5090
0.0006	0.2362	35	4	0.5186	**0.0018**	0.2353	34	4	0.5091
0.0013	0.2390	35	4	0.5194	**0.0028**	0.2361	34	4	0.5091
0.0021	0.2423	36	4	0.5292	**0.0044**	0.2384	34	4	0.5092
0.0030	0.2459	36	4	0.5303	**0.0069**	0.2394	33	4	0.5004
0.0052	0.2549	38	4	0.5506	**0.0110**	0.2428	32	4	0.4917
0.0078	0.2654	40	4	0.5711	**0.0160**	0.2465	32	4	0.4918
0.0117	0.2793	43	4	0.6015	**0.0201**	0.2492	32	4	0.4919
0.0162	0.2852	44	4	0.6147	**0.0260**	0.2526	32	4	0.4921
0.0199	0.2868	45	4	0.6264	**0.0306**	0.2549	32	4	0.4921
0.0300	0.2882	45	4	0.6299	**0.0400**	0.2586	32	4	0.4923

Note: a P value of 0.0000 is equivalent to the CF scenario.

Looking first at the situation where no scheme insurance exists, using a cash flow matching strategy (CF) for defensive investment results in a large improvement in the minimum objective function compared to Base, by 0.0397 or 14.5% from 0.2735 to 0.2338. A significant reduction in the allocation to growth assets from 54% to 34% is also noted. Members benefit specifically from a large decrease in the mean deficit by an absolute value of 0.3165% or a percentage of

38.4% from 0.8265% to 0.5090%. Breaking the improvement in objective function down into its three components, the average contribution rate $\bar{c}$ is increased from 14.82% in Base to 15.65% in CF, increasing the objective function by 0.0083. The average excess contribution rate $\bar{c}_{exc}$ is reduced from 3.69% in Base to 2.28% in CF, reducing the objective function by 0.0141. The reduction in mean deficit $\overline{Dfct}$ described above reduces the objective function by 0.0340. This gives the total reduction in objective function of 0.0397 (after allowing for rounding) shown above.

These improvements also exist where scheme insurance is introduced. Interestingly, the magnitude of the decrease in objective function compared to Base reduces with *P* value for IC (from 0.0397 for *P* = 0.0000 to 0.3191 – 0.2882 = 0.0309 for *P* = 0.0300) but increases with *P* value for IN (from 0.0397 for *P* = 0.0000 to 0.3029 – 0.2586 = 0.0443 for *P* = 0.0400). Thus an even stronger incentive exists for at-risk employer-sponsors to switch to cash flow matched defensive investment under IN. The impact of scheme insurance on optimal growth asset allocation and mean deficit is broadly similar for CF and Base, with IC resulting in an increasing allocation to growth assets as employer-sponsor risk increases, and a resultant negative feedback effect on members through increased deficit levels. IN again has an opposite effect with a decreasing allocation to growth assets as employer-sponsor risk increases, and a resultant positive feedback effect on members through reduced deficit levels. The levy cap effect which increased growth asset allocation as *P* values got very large in Base is not present in CF, due to the reduced effect of the stress tests in CF compared to Base (due to both the reduction in growth asset allocation and the matching of defensive assets and liabilities). Again the spread period is consistent at four years for all frameworks and *P* values.

3.3 Dynamic investment strategies (plus cash flow matching)

The results of Section 3.2 indicate that using cash flow matching for defensive investment brings considerable reductions to the objective function. Hence, it is appropriate that this section consider the use of both dynamic investment strategies and cash flow matching for defensive investment (DI&CF). Again, contour plots for the DI&CF scenario are not presented, with Table 3.3 providing minimum objective function values, optimal strategies and associated mean deficit values for DI&CF for the range of *P* values tested for the current scheme insurance framework (IC) and new scheme insurance framework (IN).

Table 3.3 – Objective function, optimal strategies and mean deficits for DI&CF

IC					**IN**				
***P* Value**	Objective Function	Growth Assets (%)	Spread Period (Years)	Mean Deficit (%)	***P* Value**	Objective Function	Growth Assets (%)	Spread Period (Years)	Mean Deficit (%)
0.0000	0.2316	43	4	0.5648	**0.0000**	0.2316	43	4	0.5648
0.0006	0.2338	44	4	0.5729	**0.0018**	0.2332	43	4	0.5649
0.0013	0.2365	44	4	0.5740	**0.0028**	0.2341	43	4	0.5649
0.0021	0.2395	45	4	0.5823	**0.0044**	0.2356	42	4	0.5578
0.0030	0.2428	46	4	0.5908	**0.0069**	0.2379	42	4	0.5579
0.0052	0.2510	48	4	0.6081	**0.0110**	0.2415	41	4	0.5508
0.0078	0.2606	51	4	0.6323	**0.0160**	0.2452	41	4	0.5509
0.0117	0.2726	55	4	0.6643	**0.0201**	0.2478	41	4	0.5509
0.0162	0.2779	57	4	0.6830	**0.0260**	0.2509	41	4	0.5510
0.0199	0.2798	57	4	0.6868	**0.0306**	0.2529	41	4	0.5510
0.0300	0.2818	58	4	0.6992	**0.0400**	0.2560	44	4	0.5726

Note: a P value of 0.0000 is equivalent to the DI&CF scenario.

Again looking first at the situation where no scheme insurance exists, using a dynamic investment strategy in addition to a cash flow matching strategy for defensive investment (DI&CF) results in a slight improvement in the minimum objective function compared to a cash flow matching strategy for defensive investment only (CF), by 0.0022 or 0.9% from 0.2338 to 0.2316. An increase occurs in the initial allocation to growth assets from 34% to 43%, although the 43% is not fixed and is reduced if the scheme moves into surplus. This initial increase in allocation to growth assets is found to detrimentally affect members through an increase in the mean deficit by an absolute value of 0.0558% or a percentage of 11.0% from 0.5090% to 0.5648%. Breaking the improvement in objective function down into its three components, the average contribution rate $\bar{c}$ is reduced from 15.65% in CF to 14.59% in DI&CF, decreasing the objective function by 0.0106. The average excess contribution rate $\bar{c}_{exc}$ is increased from 2.28% in CF to 2.53% in DI&CF, increasing the objective function by 0.0025. The increase in mean deficit $\overline{Dfct}$ described above increases the objective function by 0.0060. This gives the total reduction in objective function of 0.0022 (after allowing for rounding) shown above. Interestingly, all three objective function components, $\bar{c}$, $\bar{c}_{exc}$ and $\overline{Dfct}$, are reduced in DI&CF compared to Base.

The effect of scheme insurance (both IC and IN) is broadly similar for DI&CF as it was for CF and Base. The ability of DI to protect surpluses by reducing growth asset allocation leads to a faster increase in initial growth asset allocation as P value increases for IC, with the range of growth asset allocations being 15% for DI&CF, 11% for CF and 8% for Base. However, this protected surplus means the resultant negative feedback effect on members does not have a particularly wider range for DI&CF compared to CF, with the range of mean deficits being 0.1344% for DI&CF, 0.1209% for CF and 0.0620% for Base. Like CF, the reduced effect of the stress test in DI&CF compared to Base for IN means the reduced growth asset allocation continues across all P values until P = 0.0400, where the levy cap becomes effective and leads to an increase in the optimal growth asset allocation. The spread period is also again consistent at four years for all frameworks and P values.

4 Conclusions

This paper has considered the effect of two scheme default insurance frameworks on the optimal asset allocation and spread period for deficits and surpluses of a model defined benefit pension scheme which is closed to new entrants. The paper has then used this analysis to discuss the feedback effects of the scheme insurance frameworks on the resultant deficit levels which impact the likelihood that members will have to rely on the scheme insurer. The objective in determining optimal asset allocation and spread period considers a balance of reducing average contribution levels, average contributions levels in excess of normal contributions and the mean deficit of assets to liabilities (treating surpluses as zero deficits).

It is found that, under the objective used, the optimal spread period is 4 years in all scenarios tested. The current scheme insurance framework used by the PPF, which bases levy payments on funding level and probability of employer-sponsor insolvency, leads to an increase in the optimal allocation to growth assets as the insolvency probability increases, due to the desire to move the scheme into surplus and thus reduce levy payments[26]. This creates a negative feedback effect for members, in that the scheme insurance which is designed to protect them has the effect of increasing allocation of scheme assets to growth investments, thus increasing the deficit levels experienced by the scheme and hence increasing the risk that scheme members will have to rely on a reduced benefit from the scheme insurer should the employer-sponsor default. This feedback effect is largest for schemes with an employer-sponsor most likely to default, which exacerbates the problem.

[26] Whilst levy calculations of the PBGC in the U.S. do not incorporate probability of employer-sponsor insolvency, although they do allow for funding position; hence the results of this study infer that a PBGC-style framework will also increase the optimal allocation to growth assets on a consistent level for all schemes regardless of the strength of the employer-sponsor

The new PPF framework reverses this feedback effect, due to its consideration of investment risk in the levy calculations. Hence, under this framework it is optimal for schemes to reduce their allocation to growth assets as the probability of employer-sponsor insolvency increases, in order to reduce investment risk and thus levy payments. This creates a positive feedback effect for members due to reduced deficits. However, the cap on levy payments (based on liabilities) applied to schemes which are most at risk means the ability of schemes to reduce levy payments by reducing investment risk may be compromised. These schemes may be forced to attempt to increase surpluses by increasing investment risk, reinstating the negative feedback effect for these schemes.

These results are relatively consistent when allowing for defensive investment to be cash flow matched to liabilities (instead of being much shorter duration as per typical portfolios) and when allowing for a dynamic investment strategy that reduces allocation to growth assets as the scheme moves into surplus. Using cash flow matched defensive investment significantly improves the objective and reduces the optimal allocation to growth assets, thus reducing deficit outcomes for members. In addition, the negative feedback compromise for the new scheme insurance framework, described in the previous paragraph, does not occur. Adding the dynamic investment strategy slightly improves the objective further, although at a cost of using a higher initial growth asset allocation than cash flow matched defensive investment only and hence giving a slightly higher deficit outcome for members. Using both the cash flow matched defensive investment and the dynamic investment strategy reduces all three components of the objective compared to using neither.

The results of this study are dependent and limited by the range of assumptions made in Section 2. In particular, future research could consider the following extensions:

- The effect of alternative stochastic models;

- Testing the outcomes on schemes which are open to new entrants and closed to all future accruals[27];
- The effect of alternative objective functions[28];
- Allowing insolvency probability to vary stochastically; and
- Separating the liability calculations for funding and scheme insurance. This may allow modelling of the actual losses experienced by members due to the difference between benefits promised by the scheme and those provided by scheme insurance[29].

Scheme insurance provides clear benefits to members of defined benefit pension schemes; however the design of the levy structure can lead to unintended feedback effects that negatively impact on members. This study has shown that the introduction of investment risk into levy calculations is a positive move for members in removing some, but not all of, the negative feedback effects associated with frameworks that treat risk by considering funding level and employer-sponsor insolvency risk only.

[27] Intuitively, it would be expected that the allocation to growth assets would increase in a scheme which is open to new entrants (as in this study surplus can only be used by the employer-sponsor to reduce future contributions and thus the incentive to surplus is greater when the future benefits of the scheme are greater as they are in a scheme which is open to new entrants). For the same reason, it would be expected that that allocation to growth assets would decrease in a scheme that was closed to all future accruals. Since scheme insurance is focused on the current liabilities of the scheme it is unlikely that the effect of scheme insurance frameworks on open or closed to all future accrual schemes would be significantly different.

[28] Taylor (2002) provides significant discussion of the literature and of a generalized form of objective function. In addition, assumptions about the use of surplus could be revised and incorporated into the objective function. Sutcliffe (2004) theoretically discusses the relative attractiveness of equity investment from an employer-sponsor point of view depending on the responsibility for deficit and access to surplus of the employer-sponsor. It is argued that when the employer-sponsor has relatively high responsibility for deficit but little access to surplus then equity investment is not attractive to the employer due to the risk of deficit.

[29] This is not a trivial task as it involves not only calculating a s179 liability for levy calculations, but also a liability calculation under Section 143 of the Pensions Act 2004 in order to determine if a scheme with an insolvent employer-sponsor is to be supported by the PPF or is to be bought out by an insurance company.

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Appendix – Calculation of asset values for scenario IN

To calculate the smoothed bond values, the actual bond yields used in the calculation of bond returns for the year to time t – 1 are replaced with the average bond yields over the previous 5 years. For example, the average long-term interest rate over the previous 5 years to time t – 1, $\overline{il'(t-1)}$, is calculated as follows:

$$\overline{il'(t-1)} = \frac{il'(t-6) + 2\times il'(t-5) + 2\times il'(t-4) + 2\times il'(t-3) + 2\times il'(t-2) + il'(t-1)}{10};$$[30]

where $il'(t)$ is the long-term interest rate at time t. This calculation is performed separately for long-term interest rates and inflation-linked bond yields, which feed into the calculation of the smoothed values for Australian bonds, international bonds and inflation-linked bonds. Similarly, Australian equity market values are smoothed by adjusting the dividend yield to be equal to the average dividend yield over the previous 5 years. A consistent adjustment is made to international equity market values as the dividend yield is only calculated for Australian equities in the economic model.

Stress testing is then applied to the smoothed liability and asset values in a way consistent with the indicative stress approach of the PPF (2011)[31]. The following approach is taken:

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[30] Where less than 5 years of projection have been completed, values of $il'(t-i)$ where t – i is negative are set to $il'(0)$.

[31] The PPF engaged Redington to provide advice on taking investment risk into account in calculating the risk-based levy. Option B of Redington (2010) provides details on the standard methodology for stress testing of liabilities and assets to be applied to by the PPF in taking investment risk into account.

- The average and standard deviation of funding level of the 1,000 simulations at time 1 is obtained, using the Base scenario and a 50% growth asset allocation. This gives a funding level, at one standard deviation away from the average, of 94.0%.
- Price inflation, long-term interest rates, inflation-linked bond yields and returns on equities are identified as the most significant drivers of movement in funding level. Simulations of the first year are re-run allowing the error terms of these drivers to vary in proportion to their standard error in the economic model. All other error terms are held at zero[32]. The error terms that achieve an average funding level of 94.0% are identified in this process[33].
- Based on the results on the previous point, the following stresses[34] are applied to smoothed liability and asset values. Bond values are calculated using the same process described for smoothing, but using stressed yields. Price inflation is incorporated into both liability calculations and inflation-linked bond values. Cash values are unadjusted.

Price inflation	**Long-term interest rates**	**Inflation-linked bond yields**	**Equity values**
+0.99%	-14 bp	-38 bp	-10.18%

Making these adjustments provides the final adjusted liability and asset values, $L^{adj}(t-1)$ and $N^{adj}(t-1)$, to be used in the levy calculations. Stress tested assets for cash flow matched defensive investment are assumed to have the same value as the stress tested liabilities, as unhedged liability factors such as salary increases and mortality rates are not allowed for in the stress testing.

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[32] However, other factors are indirectly influenced by the stresses applied. For example long-term interest rates and inflation-linked bond yields influence both the liability level and the value of bond investments.
[33] Error terms are set to 0.60 of a standard deviation. Using Table B.2 in Butt (2011a), ε_q and ε_y are positive and ε_d, ε_{il}, and ε_{qy} are negative. The stresses applied to international equity returns are set equal to Australian equity returns so that there is no difference in risk characteristics between them.
[34] Note that these are different to the indicative stresses described by the PPF (2011) as the investment model used in this paper would differ in output to the information used by the PPF in generating its stresses.