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The Pension Protection Fund*

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Abstract

We develop a model of the Pension Protection Fund (PPF), a defined benefit pension guarantee system for the UK, based on an analogy between pension liabilities and corporate debt obligations. We show that the PPF is likely to face many years of low claims interspersed irregularly with periods of very large claims. There is a significant chance that these claims will be so large that the PPF will default on its liabilities, leaving the government with no option but to bail it out. The cause of this problem is the double impact of a fall in equity prices on the PPF: it makes sponsor firms more likely to default and it makes defaulted plans more likely to be underfunded. We use our model to derive a fair premium for PPF insurance under different circumstances, to estimate the extent of cross-subsidies in the PPF between strong and weak sponsors, and to show that risk-rated premiums are unlikely to have a substantial effect on either the size or the lumpiness of claims. We argue that for the PPF to operate effectively, it should be introduced in tandem with strong minimum funding requirements and a lower level of benefit guarantee than at present.

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I. Introduction

The UK government has introduced legislation to establish a Pension Protection Fund (PPF) to protect members of private sector defined benefit schemes[1] whose firms become insolvent (Pensions Act, 2004). Many details of the fund have still to be finalised. The purpose of this paper is to identify and roughly quantify some of the main policy issues involved in the establishment of such a fund.

One key issue is the future solvency of the PPF and possible claims on the public purse. The largest and best-established exemplar of a protection fund is the USA's Pension Benefit Guaranty Corporation (PBGC). After a run of years of very low claims – claims over the period 1980–99 averaged $300 million a year – the PBGC has been facing very large claims in the period 2000–04, amounting to some $21 billion in total. Its 2004 accounts show a deficit of $23.3 billion, taking account of probable claims from currently insured plans. The total underfunding of US pension plans covered by the PBGC increased from less than $30 billion in 1999 to more than $450 billion in 2004, as a result of interest rate changes and poor equity market performance (Pension Benefit Guaranty Corporation, 2004). With premium income of $1.5 billion per year and strong opposition in Congress to raising premium levels substantially, it is questionable whether the PBGC will be able to meet its obligations without government support.

In this paper, we model a generic plan to help analyse the extent to which these problems are inherent to a fund to protect defined benefit pensions. Recognising that corporate pensions are similar to corporate debt obligations, we show that the PPF is likely to face many years of low claims interspersed irregularly with periods of very large claims when prolonged weakness in equity markets coincides with widespread corporate insolvencies. We argue that it will not be possible to build up sufficient surpluses in the PPF in the good years to pay for the bad years. It will also be difficult to raise premiums sufficiently after a run of bad years to bring the PPF back to solvency. The government will not be able to let the PPF default, so it will be underwritten by the government whether the guarantee is recognised formally or not.

We consider, and reject, the argument that the problem can be mitigated by levying 'risk-based' premiums.[2] They will have a limited impact on moral hazard. What they will do, however, is ensure that the burden of making good any deficit in the PPF will fall particularly on those schemes

[1]For brevity, we will use the word pension to mean specifically a private sector defined benefit occupational pension.

[2]Legislation provides that at least half the premium should be risk-based, tied to scheme solvency, sponsor credit rating, investment policy and other factors relevant to the likelihood of a claim.

least able to bear it, making it more difficult to keep the PPF solvent and increasing the likelihood of recourse to government.

We also investigate the relation between the PPF and solvency requirements. The issue of pension default was the major focus of the Goode Report in 1993, set up following the theft by Robert Maxwell of the assets of the pension fund of Mirror Group Newspapers. It considered, and rejected, the idea of a PPF. Instead, it recommended the introduction of a funding requirement to help ensure that there would be adequate assets in the pension fund to meet liabilities if the employer became insolvent or closed the fund for other reasons. This was subsequently introduced by the Pensions Act 1995 as the Minimum Funding Requirement (MFR). Following criticism of its inflexibility and its distorting effect on pension fund investment, the government decided to withdraw the MFR. We argue that far from avoiding the need for a funding requirement, the establishment of a PPF is likely to force the reintroduction of something very similar.

To address these issues, we develop a simple model of a pension plan. In its basic version, firm insolvency is a random (Poisson) event, with a constant hazard rate. If the firm becomes insolvent, any deficit in the pension plan is picked up by the PPF. The contribution of the firm to the pension plan follows a simple smoothing rule that ensures that any deficits and surpluses are amortised over a number of years. Plan solvency varies over time because of the mismatch between the assets and liabilities; the assets are partly invested in equities, while the liabilities are bond-like. The investment policy and the contribution policy are exogenous. The model shows how the premium the PPF needs to charge to remain solvent depends on key parameters such as the investment policy of the pension plan, the contribution policy and the equity risk premium. The model is also used dynamically to simulate the behaviour of claims over time.

We then develop a more sophisticated model in which the default rate is stochastic. Since a downturn in equity markets will not only increase pension fund deficits but also tend to be accompanied by an increase in insolvencies, the stochastic default model shows much greater volatility in claims on the PPF. To model the default rate, we treat the PPF insurance as a guarantee of a corporate debt obligation, the firm’s pension promise to its employees. We use a structural model of the firm, based on Collin-Dufresne and Goldstein (2001), where the firm’s assets follow a stochastic process and the firm defaults when its leverage ratio reaches a critical level. With defaults being correlated across firms (because of the positive correlation in asset values across firms), the claims process is much more volatile than with Poisson default. With default being correlated with deficits in pension plans (because the assets of the firm are positively correlated with the assets of the pension plan), the claims level also becomes much larger.

The original paper on pension insurance was by Marcus (1987). He also used an options framework to value pension guarantee insurance and in many respects our model builds on his work. While he computes the value of insurance on a fixed portfolio of risks that evolve with time in a non-stationary way, we compute the value of insurance for a steady-state population of firms. We choose to model firm funding policy in a way that ensures that firm assumptions about the equity risk premium enter into the steady-state risk-neutral density of firm solvency ratios. In common with other more recent work (see, for example, Pennacchi and Lewis (1994) and Lewis and Cooperstein (1993)), we assume that the PPF does not receive the pension surplus if a firm declares bankruptcy and that it does not have any claim on the assets of a bankrupt firm.

The models we use take the firm’s policy as exogenous. They do not allow us to explore the impact of the PPF on efficiency. We also discuss how the existence of the PPF provides incentives that may affect behaviour – the moral hazard issue. We examine the consequences of varying premiums according to the solvency of the pension fund. We show that neither policy does much to mitigate the substantial wealth transfers from high-credit firms to low-credit firms resulting from the creation of the PPF. We conclude that to minimise the level of premiums and the size of these transfers, there will need to be solvency requirements similar in form and effect to the MFR.

II. The nature of pension liabilities and claims on the PPF

In this section, we discuss the nature of the claims on the PPF in order to explain and motivate the model we will be using. Our main concerns are with the factors determining the level of the premium to be charged and with the pattern of claims over time. We model a representative firm and its pension plan. The investment policy of the plan and the contribution policy of the firm are exogenous; we consider later how they may be affected by the existence of the PPF.

Firms offering defined benefit pensions to their employees are obliged to fund their obligations. The adequacy of the pension fund is reviewed every three years by an independent actuary who recommends to the trustees the level of future contributions required to ensure that the fund is able to meet its liabilities on a continuing basis.

The actuarial valuation is not related to solvency – ensuring that the assets of the plan exceed its liabilities – but rather to funding – setting a smooth path for contributions that will over the long term allow the plan to pay the promised pensions. In deciding whether a scheme is adequately funded, the actuary will, for example, make judgements about future investment returns, which are irrelevant to solvency. So a scheme that is fully funded may well be in substantial deficit.[3] That does not mean it will not meet its obligations, but it will need ongoing support from the employer to be sure of doing so.

If the scheme is underfunded, the actuary will recommend an increased level of contributions that will, assuming reasonable investment performance, allow the scheme to become fully funded in a number of years. The relation between the firm's financial state and its contribution policy is complex. On the one hand, a firm facing financial distress may be particularly inclined to defer contributions; on the other hand, it is precisely in these cases where a rapid return to fund solvency is of greatest importance to pensioners. Recent evidence on the relationship between pension fund solvency and the financial status of sponsoring firms is difficult to find. In the USA, Bodie et al. (1985) found a negative relationship between the credit rating of a firm and the solvency of its pension plan in weaker firms. Orszag (2004), however, has found little

TABLE 1

Total UK defined benefit pension liabilities for FTSE-350 companies

S&P credit rating	*Number of companies*	*UK pension liability (FRS17, £m)*	*Unfunded UK pension liability (FRS17, £m)*	*Median plan funding ratio*
AA+	2	11,816	523	0.91
AA	5	21,184	3,349	0.87
AA–	5	14,743	3,267	0.76
A+	12	32,225	5,801	0.74
A	10	21,145	4,187	0.82
A–	12	55,230	14,539	0.78
BBB+	13	13,228	3,325	0.74
BBB	14	18,977	2,427	0.81
BBB–	7	12,760	1,730	0.84
BB+	2	3,784	453	0.85
BB	3	8,711	503	0.79
Not rated	163	63,886	14,180	0.70
Total	248	277,689	54,285	0.73

Source: Watson Wyatt Pension Risk Database. Data from published accounts for the company financial year ending between June 2002 and May 2003. Liability figures are in millions of pounds, calculated on the FRS17 basis reported in the accounts, and include only UK liabilities. Figures include only those companies in the FTSE-350 that have defined benefit plan liabilities. The credit rating is as reported by Standard and Poor's at the date of the accounts.

[3]We use the term deficit to mean the difference between the market value of assets and the cost of buying out accrued liabilities. According to a forthcoming Institute and Faculty of Actuaries working party report, of 685 actuarial valuations surveyed in 2001 and 2002, the average valuation discount rate was approximately 140 basis points above gilt rates (Institute and Faculty of Actuaries, 2004).

evidence that weaker UK firms systematically underfund their pension plans. The distribution of pension liabilities and underfunding in the UK can be seen in Table 1. It shows the median funding ratio, the total pension liability and the total unfunded pension liability for all FTSE-350 companies with defined benefit pension plans. It is derived from the FRS17 disclosures in their accounts for fiscal year 2002–03.[4] Several patterns can be noted. First, the majority of pension liabilities (68 per cent) and pension underfunding (69 per cent) is with companies rated BBB or above, even making the conservative assumption that all non-rated companies have true credit ratings below BBB. The last column shows the median funding ratio in each rating category. There is no clear trend in funding as the credit strength of the sponsoring firm declines.

In the light of this, and to keep the model simple, we take the contribution policy to be independent of the firm's financial state, and to depend only on the plan's solvency level so that, over the long term, the assets equal the liabilities, although we later make allowance for the fact that pension plans may fund to a different standard.

The potential for a large deficit when an employer becomes insolvent depends on the investment policy of the pension plan. The plan's liabilities resemble a long-dated inflation-indexed bond. The assets of UK pension plans are typically at least 50 per cent invested in equities. One might expect trustees of plans that are more precarious (larger deficits, weaker employers) to be more cautious about protecting their solvency, but the evidence does not bear this out. Table 2 shows the average equity proportion of a variety of types of fund and finds no strong relationship, except that plans that are less well funded appear to invest slightly more heavily in equities. In our model, we assume that the asset mix of the pension fund is constant.

TABLE 2

Average equity proportion in pension fund asset portfolio for different pension plan types

Plan variable	*Below median*	*Above median*
Pension plan assets / Pension plan FRS17 liabilities	0.72	0.58
Pension plan FRS17 liabilities / Company market capitalisation	0.68	0.62
Book value of company debt / Company market capitalisation	0.66	0.63
Company market capitalisation / Book value of firm assets	0.65	0.65

Source: Authors' calculations using Watson Wyatt Pension Risk Database. Each cell shows the proportion of the plan's assets invested in equities for plans below and above the median value of each plan variable. Means differ as not all data are available for every company.

[4]The numbers need to be treated with some caution since the valuations for each firm are at the balance sheet date, which varies across firms.

It is clear that the level of claims on the PPF is heavily dependent on the mismatch between the assets and liabilities of pension plans, and the speed with which any over- or under-funding is corrected. The time profile of claims on the PPF will closely reflect the performance of the equity market, with a prolonged downturn leading to widespread underfunding, and large claims when firms become insolvent.

III. Modelling the guarantee

1. The Poisson model

The PPF guarantees the pension liabilities of a set of firms. Although the PPF does not guarantee all the liabilities of a pension plan – only 90 per cent of deferred benefits are covered and only then up to a cap – for simplicity we derive the model assuming that it covers all the liabilities and we make the necessary adjustments later. In this section, we assume that there are an infinite number of small, identical firms, and focus on one representative firm. The insolvency of a firm is modelled as a Poisson process with hazard rate δ. With δ being constant and default risk uncorrelated across firms, each firm faces a constant and equal probability of default in each time period. Because we assume an infinite number of firms, the central limit theorem guarantees that a constant fraction δdt of the firms will become insolvent in each period dt. The present value of the accrued liabilities of the firm's pension plan at time t, denoted by L_t, may vary over time, but we assume that it is non-stochastic. The assets of the plan have value A_t, so if the firm becomes insolvent at time t and if the guaranteed liabilities of the plan exceed the assets, the PPF pays $L_t - A_t$.

In practice, pension plan liabilities are measured in several different ways. For the purpose of this model, L_t should be interpreted as the cost at time t of buying out the guaranteed liabilities of the pension plan at that time, and A_t is the market value of the assets of the plan, after allowing for any costs of winding up. Implicitly, we are assuming that if the firm becomes insolvent, the PPF has full access to the assets of the pension plan, at least so far as they do not exceed the guaranteed liabilities, but no access to the assets of the firm itself. By topping up the pension plan's assets to equal its liabilities, the PPF can ensure that there is no further claim on the PPF from that pension plan.

The assets of the pension plan comprise a riskless bond with constant interest rate r and an equity portfolio. We assume that each plan invests in the same market index fund, which may be assumed to be the portfolio of all available equities, weighted in proportion to their market capitalisation. We assume that the instantaneous return on the market portfolio, dS/S, follows an Ito process:

(1) $$\frac{dS}{S} = (r+\alpha)dt + \sigma_m dz_m ,$$

where z_m is a standard Brownian process, α is the market risk premium and σ_m is the volatility of the market. The first term represents the mean instantaneous return on the portfolio, which is the risk-free rate plus the equity risk premium, while the second term has zero expected value and models random variation around the mean instantaneous return.

We wish to compute the present value of future claims on the PPF. The claims will be stochastic and will depend on future stock market performance. Rather than computing the expected level of future claims and taking their present value by discounting back to the present at a suitably chosen discount rate that reflects the riskiness of the cash flows, we use the risk-neutral methodology that is standard in the finance literature. Where, as in our model, all risks are hedgeable,[5] present values can be obtained by projecting future outcomes using a pricing or risk-neutral measure Q in place of the objective probability measure, and discounting the expected claims using the risk-free interest rate. The risk-neutral probability measure is that measure under which all the assets have an expected return equal to the risk-free rate. Hence, (1) can be rewritten as

(2) $$\frac{dS}{S} = rdt + \sigma_m dz_m^Q ,$$

where z_m^Q is a standard Brownian process under measure Q. Setting the right-hand sides of (2) and (1) equal, we can derive an expression for dz_m^Q in terms of dz_m:

(3) $$dz_m^Q = \frac{\alpha}{\sigma_m}dt + dz_m .$$

The expected value of dz_m^Q under measure Q is 0, so taking expectations of both sides under the risk-neutral measure Q gives

(4) $$E^Q(dz_m) = -\frac{\alpha}{\sigma_m}dt .$$

[5]The level of liabilities faced by the PPF is perfectly correlated with the level of the equity market. This means that the PPF could in principle reduce, or even get rid of, credit risk by selling equities. While this hedging may not be desirable or even practicable, it does provide a price for the risks to which the PPF is exposed.

I_t is an indicator function that takes the value 1 if the firm is still solvent at time t and 0 otherwise. If the firm becomes insolvent, the pension plan is closed. If the firm becomes insolvent at time t (so $dI_t = -1$) and if the pension fund is in surplus at that time ($L_t \leq A_t$) then the pension plan is able to pay pensions due in full and no liability falls on the PPF.[6] If there is a deficit in the pension plan when the firm becomes insolvent, the PPF takes over both the assets and the liabilities. The cost to the PPF at the time the firm becomes insolvent is thus

$$(5) \qquad -\int_t^\infty [L_u - A_u]^+ dI_u \quad \text{where} \quad [x]^+ \equiv \text{Max}(x,0) .$$

(a) Determining the premium

The firm pays an insurance premium P_t to the PPF. From the PPF's perspective, insuring the plan has a present value equal to the expected value of the premiums paid by the firm when it is solvent, less the expected value of the payments that the PPF will have to make if a firm defaults, both discounted at the risk-free rate. We take expectations using the risk-neutral measure Q to ensure that the value obtained takes proper account of the risk in the PPF's premiums and its liabilities:

$$(6) \qquad E^Q\left(\int_t^\infty P_u I_u e^{-r(u-t)} du + \int_t^\infty [L_u - A_u]^+ e^{-r(u-t)} dI_u\right).$$

If the PPF is to be able to cover the cost of claims from its premium income then, ignoring administrative costs, the present value of premium income less claims must be zero. Hence, any premium must satisfy the condition

$$(7) \qquad E^Q\left(\int_t^\infty P_u I_u e^{-r(u-t)} du + \int_t^\infty [L_u - A_u]^+ e^{-r(u-t)} dI_u\right) = 0 .$$

In principle, there are many ways of levying the premium. The PBGC uses a combination of a charge per member covered and a charge proportional to the dollar size of any deficit in the scheme. In the UK, the PPF is required to take account of other matters, including the solvency of the scheme sponsor. We do not address the question of the optimum premium schedule directly. For the present, we assume that the premium is a constant proportion of the scheme's liabilities.

If the premium is levied at rate p,

$$(8) \qquad P_t = pL_t .$$

[6]We are implicitly assuming that the investment policy of a closed fund precludes the trustees from investing in risky assets and putting the solvency of the fund at risk.

From (7), using the Poisson default rate process and the non-stochastic nature of the liabilities, the rate p is given by

(9) $$p = \frac{\int_t^\infty E_t^Q \left[\delta \left(1 - A_u / L_u \right) \right]^+ L_u e^{-(r+\delta)(u-t)} du}{\int_t^\infty L_u e^{-(r+\delta)(u-t)} du}.$$

Modelling default as a Poisson event among a continuum of atomistic schemes with uncorrelated default rates ensures that a constant proportion δdu of plans become insolvent in each time period du. This gives rise to the δ inside the expectation term. The δ in the discount factor reflects the fact that the number of plans is declining at rate δ because of insolvencies. The premium rate is a weighted average of the expected claim rate into the future. It depends on the current solvency level of the scheme. The main focus of this paper is on the impact of different contribution schedules, investment policies and guarantee arrangements on the level of the premium. To abstract from variations caused by initial conditions, we look at processes that generate stationary distributions of insolvency rates and deficit levels, and take unconditional expectations.

With unconditional expectations, (9) simplifies to

(10) $$p = E^Q \left[\delta \left(1 - A_u / L_u \right) \right]^+ .$$

(b) The dynamics of scheme solvency

In order to evaluate the expectation in equation (10), we need to specify the dynamics of the scheme solvency ratio A_u/L_u under the risk-neutral measure Q. The dynamics of A depend on the return on the portfolio, outflows to pensioners and inflows from contributions. Again, written as an Ito process, we have

(11) $$dA = \left[\left(r + x\alpha \right) A + \left(\kappa_t - \pi_t \right) \right] dt + x\sigma_m A dz_m ,$$

where x is the (fixed) proportion of the assets held as equity, κ is the contribution rate and π is the rate of payout to pensioners. The first component of the dt term states that the expected rate of return on the assets is the risk-free rate plus the equity risk premium on the equities held by the plan. The second component shows that the assets increase at rate κ because of contributions to the fund and decrease at rate π because of payments to pensioners. As before, the dz_m term has zero expected value and models how the value of the assets changes as a result of random fluctuations in the value of the equities held by the fund.

The firm's contribution to the pension plan has two components. The first maintains the current solvency level after allowing for payments to pensioners, any change in net liabilities and the expected return on the assets of the plan. The second component is designed to eliminate any surplus or deficit in the plan over a specified period of *T* years. The lower the level of *T*, the faster any deficit is eliminated and the lower the potential claim on the PPF. The simplest formulation that achieves this is

$$\kappa_t = \left(\pi_t + \frac{dL_t}{dt}\frac{A_t}{L_t} - \left(r + x\hat{\alpha}\right) A_t \right) + \left(\frac{L_t - A_t}{T} \right), \tag{12}$$

where $\hat{\alpha}$ is the excess return on equities assumed by the firm in setting its contribution rate; it may be identical with the true α but is not necessarily so. Define the solvency ratio of the fund *a* as

$$a_t = \frac{A_t}{L_t}. \tag{13}$$

Then, using Ito's lemma, we can calculate the stochastic differential equation governing the evolution of the solvency ratio as follows:

$$\begin{aligned} da &= \frac{dA}{L} - a\frac{dL}{L} \\ &= \left(\left(r + x\alpha - \frac{dL}{Ldt} \right) a + \frac{\kappa_t - \pi_t}{L} \right) dt + x\sigma_m a dz_m \\ &= \left(\frac{1-a}{T} + x\left(\alpha - \hat{\alpha}\right) a \right) dt + x\sigma_m a dz_m \ . \end{aligned} \tag{14}$$

We can express this equation in terms of the risk-neutral probability measure *Q* by substituting equation (3) to give

$$da = \left(\frac{1-a}{T} - \hat{\alpha} a x \right) dt + x\sigma_m a dz_m^Q \ . \tag{15}$$

Given the investment policy and the contribution policy, the solvency ratio follows a stationary stochastic process that is independent of the behaviour of liabilities. We can derive the unconditional distribution of *a* at time *t* under the risk-neutral measure by stating the condition that the distribution is stationary and using equation (15) to derive a differential equation.[7] Formula (10) then gives the fair premium rate p (expressed as a proportion of the liabilities of the pension plan) as

$$(16) \qquad p = \delta \int_0^1 (1-a)\, g^Q(a)\, da \, .$$

Note that the true equity risk premium, α, does not enter into equation (15), and hence will not affect the risk-neutral density function g^Q or the premium rate p. A higher equity premium raises the expected future solvency level of pension schemes, but this is offset by the reduction in discount rates used for valuing the PPF's liabilities. However, the equity premium assumed by the scheme, $\hat{\alpha}$, does enter into the premium; the higher the assumed premium, the lower the contribution rate and the greater the expected claim on the PPF.

The premium can be compared with the unconditional objective expectation of the rate of claims as a proportion of liabilities, c, which we calculate in a similar way, using equation (14) instead of equation (15).[8]

(c) Extending the model

One element of unrealism in our model is that the solvency ratio of the pension fund is not bounded above. There are limits on the degree to which the pension fund can hold assets in excess of its liabilities, imposed largely to prevent the sponsor company using the pension fund as a tax avoidance device. We can readily impose the condition in our model that a is not permitted to exceed some limit a^*. Whenever a does exceed the limit, the contribution rate is constrained to force a below the limit. a^* acts as a reflecting barrier.

We assume that firms are able to reclaim investment surpluses from their pension plans over the same time horizon over which deficits are amortised. In practice, firms may struggle to reclaim investment surpluses because they face pressure to improve benefits or because they do not wish to be seen 'raiding' their employees' pension plan.

We have also assumed that the liabilities that are guaranteed by the PPF are *the* same as those used to determine the firm's pension contribution. In

[7]The unconditional stationary distribution is $g^Q(a)e^{-\delta t}$, where g^Q satisfies the differential equation $\frac{1}{2}\frac{d^2}{da^2}\left(x^2\sigma_m^2 a^2 g^Q(a)\right) - \frac{d}{da}\left(\left(\frac{1-a}{T} - x\hat{\alpha}a\right)g^Q(a)\right) = 0$. The equation expresses the condition that the unconditional distribution of a is stationary over time.

[8]The resulting expected cost of claims is $c = \delta\int_0^1 (1-a)\, g^P(a)\, da$, where g^P satisfies $\frac{1}{2}\frac{d^2}{da^2}\left(x^2\sigma_m^2 a^2 g^P(a)\right) - \frac{d}{da}\left(\left(\frac{1-a}{T} + x\left(\alpha-\hat{\alpha}\right)a\right)g^P(a)\right) = 0$. The differential equation expresses the condition that the distribution of the solvency ratio is stationary.

practice, these two measures of liability may well differ substantially, and in either direction. Not all accrued liabilities are guaranteed; there is a cap on the level of wages on which the pension is guaranteed; the PPF only guarantees 90 per cent of deferred pensions, and certain pension increases are not guaranteed. In addition, the definition of liabilities used by actuaries in computing funding levels generally takes account of future wage growth in computing the pension liability arising from past service. Finally, the actuarial valuation may also use a higher discount rate in valuing liabilities than the rate at which the liabilities can be bought out in the market.

The model can readily be adapted to distinguish between the liabilities used for funding requirements and those that are guaranteed by the PPF if we assume that the ratio of guaranteed liabilities to the actuary's measure of liabilities is constant. Denote this ratio by λ. Assume also that the PPF retains a prior claim on all the assets of the fund if the firm becomes insolvent. Maintain the definition of a as the ratio of plan assets to the cost of meeting the liabilities guaranteed by the PPF. Then a mean-reverts to $1/\lambda$ rather than to 1. The adjustments to the model are obvious. For example, equation (14) becomes

$$da = \left(\frac{1/\lambda - a}{T} + x\left(\alpha - \hat{\alpha}\right)a \right)dt + x\sigma_m a dz_m . \tag{17}$$

2. Estimating the model

The model expresses the fair premium per pound of guaranteed liabilities, p, as a function of seven parameters:

- $\hat{\alpha}$, the market risk premium assumed by the scheme in determining contributions;
- σ_m, the volatility of the market;
- δ, the bankruptcy hazard rate of the sponsor company;
- a^*, the maximum funding ratio;
- x, the equity proportion in the fund;
- T, the time over which fund deficits are amortised;
- λ, the proportion of liabilities that are guaranteed.

We take $\hat{\alpha}$ to be 6 per cent and σ_m to be 18 per cent. The probability of the firm becoming insolvent, δ, is hard to estimate. Moody's documents long-term default rates by rating category. Using its global database for 1983–2003 (Hamilton et al., 2004, exhibit 31) and applying it to the observed credit-rate distribution of UK pension liabilities in Table 1 suggests a 10-year cumulative default rate of 2.95 per cent, corresponding to an annual rate of 0.30 per cent. This may be too high as a long-term estimate since it takes as its base ratings in 2002–03, when the corporate sector was in a financially weak state. Also, a firm that defaults on its debt may refinance and continue without defaulting on its pension obligations. On the other hand, Moody's data apply only to rated companies; the PPF insures plans of companies that are not rated, and these are likely to have, on average, higher probability of default. In the light of this, we take δ to be 0.25 per cent per year. Consistent with the observed behaviour of pension schemes, we take as our central case a maximum funding ratio, a^*, of 120 per cent, an equity proportion, x, of $^2/_3$ and a 10-year amortisation period, T, and we assume that the PPF liabilities are 90 per cent of liabilities assumed for funding purposes (so λ = 0.9). Since these parameters will vary between schemes, we also show a sensitivity analysis.

Table 3 explores the effects of varying the investment strategy (as measured by x) and the funding strategy (as measured by T) on the size of the premium. In the base case, the premium level is £0.50 per £1,000 of liability.[9] The difficulty of estimating the mean default rate means that the absolute level of premium that we obtain from our model should be treated with great caution. But since the premium is directly proportional to the default rate, the sensitivity of the premium to varying assumptions should not be affected by the uncertainty in the default rate

TABLE 3

Premium with Poisson default

Pounds per year per £1,000 of liabilities

	Equity proportion		
	⅓	*⅔*	*100%*
Base case	0.206	0.497	0.726
Higher solvency cap: a^* = 200% (120%)	0.206	0.494	0.716
Stricter solvency: T = 4 years (10 years)	0.044	0.191	0.339
No assumed risk premium: $\hat{\alpha}$ = 0% (6%)	0.039	0.171	0.314
Lower guarantee: λ = 80% (90%)	0.062	0.297	0.510

Notes: The base case shows the unconditional fair-value premium for guaranteeing a pension fund against default when the risk of default is 0.25 per cent per annum, equities have an expected return of 6 per cent in excess of the risk-free rate, deficits in the fund are made up over 10 years, the fund value is not permitted to exceed 120 per cent of liabilities, 90 per cent of liabilities are guaranteed and the volatility of the market is 18 per cent. The premium is shown relative to liabilities for different investment strategies. The other rows in the table show the cost when one of the input parameters is varied. Base-case values are shown in parentheses.

[9]This figure looks comparable to the premium rates initially proposed for the PPF, which is expected to raise £300 million per year in revenues. While it is not easy to give a precise estimate of the insured liabilities, it is worth noting that the defined benefit liabilities of FTSE-350 companies in Table 1 amount to nearly £300 billion, and the pension liabilities of non-UK-based companies, including UK subsidiaries of overseas companies, may be of the same order.

The direction of the sensitivities is as one would expect. The higher the equity proportion, the larger the premium. Having a higher solvency cap does reduce the premium because the fund is allowed to build up large surpluses when the market does well. But the effect is small: raising the cap on assets from 120 per cent to 200 per cent of liabilities, even assuming 100 per cent equity funding, reduces the premium by less than 2 per cent.[10] Stricter solvency requirements, as modelled by amortising deficits over four rather than 10 years, have a very substantial effect, cutting the premium by over 50 per cent.

The assumed risk premium has a substantial impact, with a zero risk premium cutting the insurance premium by nearly two-thirds in the central case. This can be interpreted in two ways. The first is as a measure of the importance of funding policy: if companies, in computing their contribution rate, assume that all their assets would just earn the risk-free interest rate, they would pay higher contributions for any given level of the solvency ratio, and so would on average achieve a higher solvency ratio. The burden on the PPF would be lower because of the more conservative contribution policy, just as it would be with a more rapid amortisation policy.

A second interpretation is to see it as a measure of the importance of the price of risk in setting a fair insurance premium. The premium computed using a zero risk premium is the same as the expected rate of claims (under the objective measure) when the true and assumed risk premiums coincide. Taking the base case with $^{2}/_{3}$ equity, the table shows that while the fair premium is 0.050 per cent of liabilities each year, the (objective) expected rate of claims is about one-third of that level, at only 0.017 per cent of liabilities each year. The difference between the two arises because claims on the PPF are most likely to occur when the market declines, and the cost of insuring against bad states of the world is higher than the objective probability of those states occurring.

The bottom row of Table 3 shows that restricting the guarantee to 80 per cent rather than 90 per cent of liabilities, while retaining the PPF’s senior claim on all the pension plan’s assets, also reduces the premium significantly. This is not only because the sum guaranteed is smaller, but also because the first part of any deficit in the pension plan falls fully on the beneficiaries. With a two-thirds equity proportion, restricting the guarantee to 80 per cent of liabilities reduces the premium per pound of pension liabilities by 40 per cent.

[10]The reason that raising the cap has such a small effect is that the probability (risk-adjusted) of reaching 120 per cent solvency is rather small, so the cap does not greatly affect contribution levels.

IV. A structural model of default rates

In this section, we extend the model to include a stochastic default rate. The variability of default rates is important for pension plan guarantees. The risk of default varies substantially over time and is correlated across firms. It is also negatively correlated with the equity market. This has three important implications:

- A falling equity market increases both the probability of sponsor firms becoming insolvent and the size of pension plan deficits. So stochastic default induces a positive correlation between the probability of a claim on the PPF and the size of the claim. This increases the fair premium.
- The correlation between default risk and equity returns means that default risk is priced. This will further increase the difference between the (objective) expected rate of claims on the PPF and the fair premium.
- The correlation of default risk across firms increases the skewness of the claims process.

None of these phenomena is captured in the Poisson default model. To explore the practical significance of these issues, we need a model of default that captures correlations across firms and correlations with the equity market. We explore three possible strategies for modelling default: fitting the empirical evidence on default directly, fitting the behaviour of corporate credit spreads, and structural models of the firm. We explain why we choose to follow the structural model approach and why we choose the structural model with mean-reverting leverage of Collin-Dufresne and Goldstein (2001). We then present premium calculations and claim simulations based on this model.

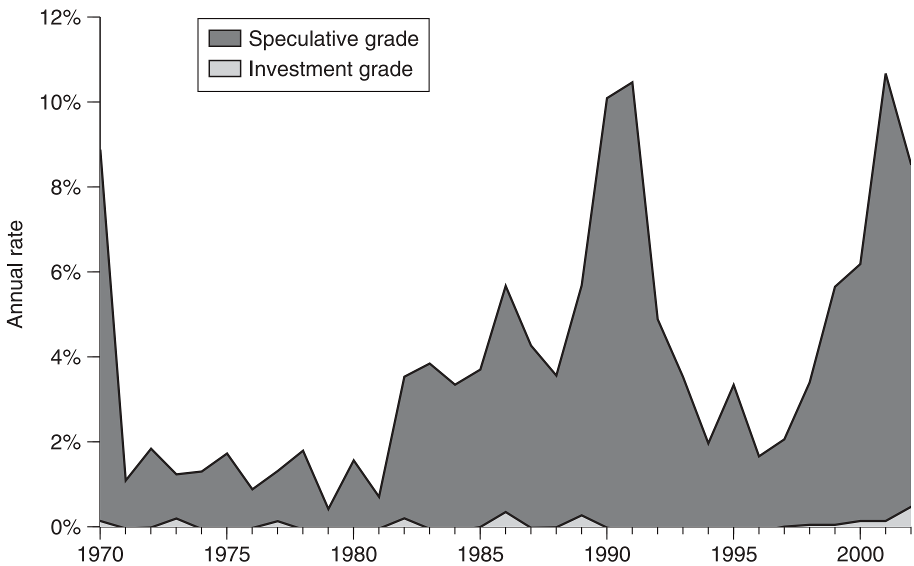
1. Choice of default model

The simplest strategy for modelling default is to take historic default rates, postulate some functional form for their time-series behaviour and estimate a relationship. The problem with this is the paucity of data. Defaults are rare – fewer than 1,500 defaulted issuers are included in Moody's database between 1970 and 2003. As shown in Figure 1, default rates are highly autocorrelated over time. This is obviously important for modelling the PPF. But basing a model purely on the limited empirical data would be hard to do with any reliability. The peaks in 1990–91 and 2000–02 would drive any analysis.

An alternative approach is to use information from the behaviour of credit spreads. The empirical evidence does strongly support correlations in

FIGURE 1

Global issuer-weighted default rates



Source: Hamilton et al., 2004.

changes in credit spread across firms and strong negative correlation between credit spreads and the equity market. Pedrosa and Roll (1998) document the existence of strong common factors in credit spreads for portfolios of credits, where the 60 portfolios in question are characterised by broad industry group, credit rating category and maturity. A more detailed analysis of the spreads on individual US industrial bonds is presented by Collin-Dufresne, Goldstein and Martin (2001). They look at weekly changes in spreads against comparable Treasury bonds on a universe of 688 straight (not callable or convertible) bonds from 261 different issuers over the period 1988–97. They regress the changes on changes in a number of factors suggested by theory, including the firm leverage ratio, the level and slope of the government yield curve, the level and slope of implied volatility on the equity market, and the level of the equity market. They find that a 1 per cent increase in the S&P500 index is associated with a credit spread decrease of about 1.6 basis points. Their regressions explain about 25 per cent of spread changes; by examining the residuals from the regression, they show that 75 per cent of the unexplained change can be ascribed to a common factor that they fail to identify with any other macroeconomic variable.

While these results are based on US data, similar results are found by Manzoni (2003) in the sterling Eurobond market where daily changes in the spread of the yield on the market index to UK Treasury yields are negatively correlated with returns on the UK stock market. Over the period 1991–99, a 1 per cent increase in the FTSE-100 index is associated with a credit spread decrease of 2.1 to 3.5 basis points depending on the specification.

Building a model of default that is calibrated to bond prices is attractive because of the large amount of high-quality data on the behaviour of bond yield spreads. But it faces a serious obstacle. There is mounting evidence (Elton et al., 2001; Huang and Huang, 2003) that credit risk accounts for only a part – according to Huang and Huang, in the case of investment grade bonds it is less than a quarter – of the yield spread. In the absence of any generally accepted explanation of why the risk-adjusted expected return on corporate bonds is higher than that on default-free bonds, the credibility of a model that incorporates the whole yield spread in valuing the pension fund guarantee would be in doubt.

The approach we follow is to model the default process from fundamentals, using a structural model of the firm. Structural models originate with Merton (1974), who models a risky bond as a portfolio consisting of a riskless bond and a short position in a put option on the assets of the firm. This simple idea has been developed by many other authors (see Duffie and Singleton (2003) for an overview), and structural models are widely used as a basis for pricing credit-sensitive instruments, though they do not appear to capture yield spreads on corporate bonds with great accuracy.

However, Huang and Huang (2003) show that structural models, when suitably calibrated, do fit the empirical data on default rather well. For our specific purpose, structural models have three other advantages: the correlation between corporate default and the behaviour of the equity market arises naturally within the model; the correlation in default rates across firms arises naturally in the model from the correlation in firms' asset values; and, unlike models based on the yield spread, the price of default risk can be computed within the model, without the need to make any assumptions about the behaviour of recovery rates.

In the previous section, we had a stationary process for pension plan deficits that allowed us to compute an unconditionally fair insurance premium that is a constant proportion of the value of insured liabilities. To retain this feature, we need a structural model of default that is also stationary. The natural candidate is that of Collin-Dufresne and Goldstein (2001, hereafter 'CDG'), who have a model with mean-reverting leverage ratios. As in other structural models based on Merton (1974), debt is a claim on the firm's assets V. The assets follow a diffusion process with constant volatility σ_v, and the firm's leverage varies accordingly. But CDG argue that firms tend to adjust their leverage over time through their financing strategy. This causes the leverage ratio to revert to some target level.

The key variable in their model is the log leverage ratio of the firm, l. The leverage ratio is defined as the ratio of the critical asset level at which default will occur to the current asset level. CDG model the dynamics of l as a first-order autoregressive process:

$$(18) \qquad dl = \kappa\left(\bar{l} - l\right)dt + \sigma_v dz_v \,.$$

If $l > \bar{l}$ then the dt term in equation (18) is negative, causing the value of l to fall in expectation, while if $l < \bar{l}$ then the opposite is true. Therefore the process reverts to the mean value, $\bar{l}$. κ determines the speed of mean reversion, and $\sigma_v dz_v$ is the random innovation in the log return on the firm's assets. The expected value of $\sigma_v dz_v$ is 0. We assume a constant correlation between changes in firm value and changes in the assets of the pension plan, so the two stochastic processes z_v and z_m have constant correlation ρ.

The log leverage ratio, l, is strictly negative so long as the firm is solvent; if it hits zero, the firm defaults. We have now fully specified the processes governing the claim on the PPF from an individual firm. The log leverage ratio, which determines firm solvency and thus when any claim is made, follows the stochastic process in (18). The pension plan solvency ratio, which determines the size of any claim that is made, is governed by the stochastic process in (14).

We need two more elements to complete the specification of the model. First, we need to specify the correlation structure of firms' asset returns. We assume that each firm's return is the market return plus a noise term that is identically and independently distributed across firms. So, given two firms i and j, we have

$$(19) \qquad dz_v^i dz_v^j = \rho^2 dt \quad \text{if} \quad i \neq j \,.$$

Second, we assume that idiosyncratic risk is unpriced, and we follow a similar argument to that which we used to derive equation (4) and find that

$$(20) \qquad E^Q\left(dz_v^i\right) = -\rho \frac{\alpha}{\sigma_m} dt \,.$$

Starting with a portfolio of firms with the same leverage and the same pension funding, the pension funding level varies over time with the equity market, but remains the same across firms, while leverage ratios disperse because of firm idiosyncratic risk.

With no new firms being born, the steady-state joint probability function of a and l is $g(a, l)e^{-\delta t}$, where δ is now the steady-state default rate driven by the condition that l = 0 is an absorbing barrier. The results would be unaltered if there were a steady entry of new firms into the portfolio, provided that their distribution in (a, l) space is the same as the steady-state distribution.

2. Estimating the model

In estimating the model, we generally follow Huang and Huang (2003); their estimates are broadly consistent with CDG. Since their estimates vary slightly according to the credit rating of the bond in question, we take their estimates for an A-rated issuer (Moody's or Standard and Poor's). In particular, we take the mean-reversion parameter, κ, to be 0.2, the asset volatility, σ_v, to be 24.5 per cent and the asset risk premium to be 4.89 per cent. Huang and Huang show this is consistent with an equity premium for the firm of 5.99 per cent. Taking the equity beta to be 1, the market risk premium is also 5.99 per cent, and the asset beta is 0.82. Using an equity market volatility, σ_m, of 18 per cent, the correlation between the change in firm asset value and the equity market return is

(21) $$\rho = \beta \frac{\sigma_m}{\sigma_v} = 0.60\ .$$

Using Huang and Huang's estimate of the long-term average leverage ratio of 38 per cent gives a long-run average default rate of 0.75 per cent per year. For the reasons already discussed, this looks very high, so we have used an average leverage ratio of 31.7 per cent, which gives a long-run default rate of 0.25 per cent per year.

We compute the steady-state joint density of the solvency ratio a and the leverage ratio l using a two-dimensional binomial tree with births and deaths, and iterate forward in time until the default rate and the rate of claims on the fund converge to their limiting values. In all the iterations, we use a time step of 0.1 years.

Table 4 shows the premium and expected claims rate for a variety of parameter values. Using the same base-case parameters as before (two-thirds of the pension fund invested in equity, 120 per cent ceiling on overfunding, 10-year deficit amortisation period, 90 per cent of liabilities guaranteed), the average rate of claims is £0.68 per £1,000 of liabilities per year. This compares with a claims rate of £0.17 per £1,000 in Table 3, where the default process is Poisson. This fourfold increase is entirely attributable to the correlation between corporate defaults and the underfunding of pension schemes in the structural model.

The impact of the structural default model on the premium is still greater. With Poisson default, the fair premium in Table 3 is £0.50 per £1,000. With

TABLE 4

Premium and average claims with structural default

Pounds per year per £1,000 of liabilities

	Equity proportion of ⅔		Equity proportion of 100%	
	Premium	*Claim*	*Premium*	*Claim*
Poisson default	0.50	0.17	0.73	0.31
Structural default:				
Base case	3.90	0.68	5.23	1.01
λ = 80% (90%)	2.86	0.45	4.19	0.77
T = 4 years (10 years)	2.34	0.43	3.50	0.70

Notes: The structural default model base case has the same dynamics for the solvency ratio as the Poisson model; the two also have the same expected default rate (0.25 per cent). The first variant on the base case has only 80 per cent of liabilities guaranteed by the PPF, and the second has an amortisation period for pension fund deficits of four years rather than 10. The other parameters of the models are: a^* = 120%, σ_m = 18%, σ_v = 24.5%, $\bar{l}$ = –1.15, κ = 0.2 and ρ = 0.6.
Source: Authors' calculations. The Poisson default case is from Table 3.

the structural default model, it is more than seven times as high, at £3.90 per £1,000. The other two rows of the table show that the level of premiums and the average rate of claim can be reduced significantly by limiting the proportion of liabilities guaranteed (with the PPF retaining first claim on all the assets of the pension fund) and by stricter pension fund solvency requirements.

These figures for the fair premium level seem to be substantially higher than those envisaged for the PPF. It is difficult to compare our calculated premiums with actual premiums charged by the US PBGC, as these depend on actual pension underfunding while our calculations assume a steady-state distribution of funding and firm leverage. However, the PBGC's annual report shows that in the fiscal year 2004, it collected $1,481 million in premiums on its single-employer programme. The guaranteed liabilities amounted to $1.35 trillion in 2001 – the latest date for which figures are available (Pension Benefit Guaranty Corporation, 2003) – a premium of $1.10 per $1,000 of liability. Our premium is thus more than three times greater than the PBGC premium and our expected claims are roughly half the PBGC premium. However, it would be wrong to attach too much importance to the absolute numbers. They are very sensitive to the parameters chosen, and in particular to the assumptions concerning the long-run average leverage ratio. Using Huang and Huang's estimate of 38 per cent rather than the value we have used of 31.7 per cent would lead to fair premiums that are more than twice as high.

3. Claims distribution

The previous subsection established the average level of claims in the long run. The premium reflects the average long-run claims experience of the

PPF, but the variation in the claims level is also a matter of considerable concern. To investigate it, we simulate the claims process and ask 'How high a claims rate can one reasonably expect over a period of, say, 30 years?'.

The simulations are carried out with the same base case as Table 4, using the structural default model and an equity proportion of $^2/_3$. As set out in Table 4, the fair premium is £3.90 per £1,000 of liabilities, while the expected level of claims is £0.68 per £1,000.

Table 5 shows the distribution of the 30-year worst case, using objective probabilities; it is based on 1,000 simulations, with a time step of 0.1 years. The simulations start with the steady-state distribution of firm leverage and pension fund solvency. A path for the equity market is then simulated. The liabilities of schemes grow at a constant rate that is equal to the average rate of insolvency, so ensuring that the level of insured liabilities is stationary.

Since the pension assets of all firms are perfectly correlated, and deficits are corrected by adjusting contribution policy, the initial dispersion in pension funding levels among firms quickly narrows. Firm asset value is subject to idiosyncratic risk, so while there is co-movement, there is also substantial dispersion.

In running the simulations, the first 70 years are used as a conditioning period, and the following 30 years are then used as the sample period. The conditioning period is needed to ensure that the start of the sample period is suitably randomised. For comparison, we also show comparable figures for the Poisson default case. The claims are expressed as a proportion of the average size of liabilities over the 30-year period. The results are shown graphically in Figure 2.

The table shows how the structural model of default not only increases the magnitude of average claims, but also greatly increases their skewness. In the Poisson model, the level of claims in the worst year in 30 is just over

TABLE 5

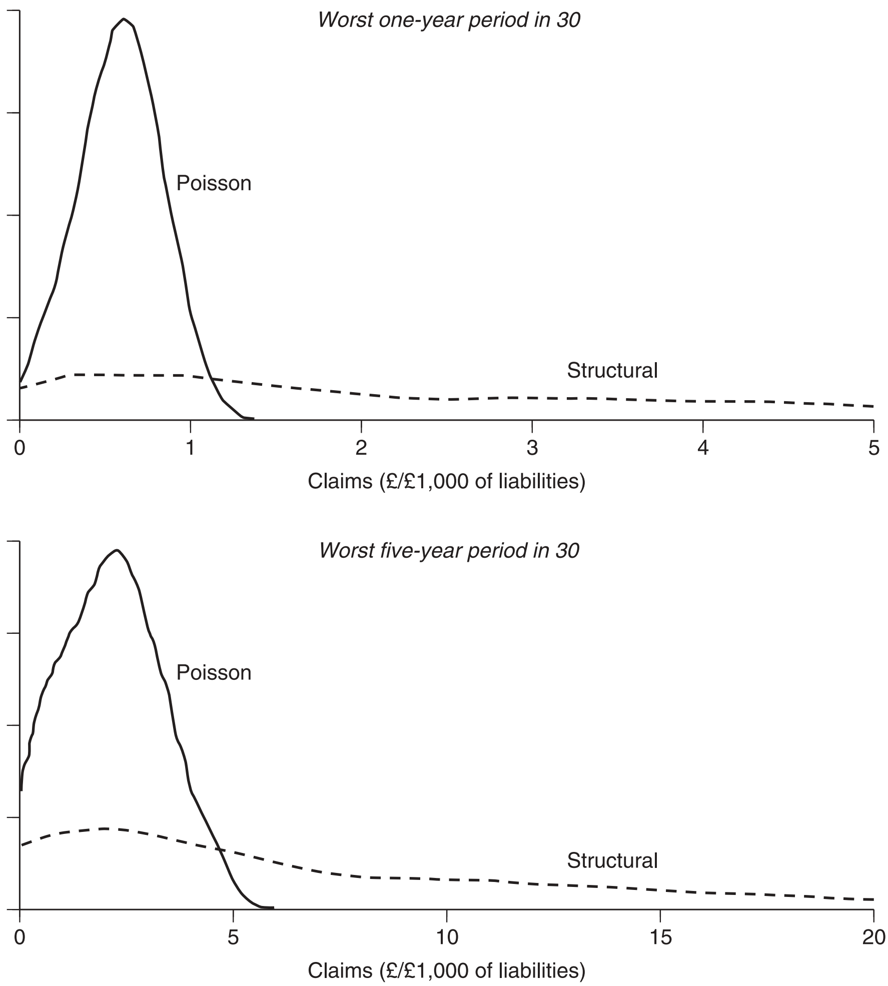
Claims per £1,000 in worst period in 30 years (simulation)

	Structural default		*Poisson default*	
Fair premium	3.90		0.50	
Average claim	0.68		0.17	
	1 year	*5 years*	*1 year*	*5 years*
Median	4.1	6.9	0.59	2.1
Top quartile	11.5	19.2	0.74	2.9
Top decile	24.1	42.8	0.87	3.6

Notes: The table is based on 1,000 simulations of the evolution of the distribution of firm leverage and solvency level for the population of insured firms, and shows the average and peak annual claim level over each 30-year period. The parameter values for the base case are: a^* = 120%, T = 10, λ = 90%, β = 1, σ_m = 18%, σ_v = 24.5%, $\bar{l}$ = –1.15, κ = 0.2 and ρ = 0.6. The Poisson default case is identical except that ρ = 0.

FIGURE 2

Probability density of claims in worst period in 30 years (simulation)



Notes: This is a pictorial representation of the simulation in Table 5. The density function is based on 1,000 simulation points, smoothed using a Gaussian kernel.

three times the average claim level in the median case; with the structural default model, the ratio is in excess of six. In the worst decile of 30-year periods, the contrast is even more stark: with Poisson default, the ratio is about five, while with structural default, the ratio is well over 30. The effect is strongly visible even looking at five-year periods, with the worst five-year period being comparable to nearly twice the worst single-year experience.

While it would be wrong to attach much precision to the numbers – we are looking at rare and extreme events – the results of the simulation do illustrate the extent to which correlated defaults across firms, and the correlation between the mean default rate and the equity market, may create considerable skewness in claims experience. This has important implications for the setting of premiums. If the PPF wants to build up reserves sufficient to meet claims in the worst year in 30 years with 90 per cent probability, Table 5 suggests it would need to have reserves in excess of 24 years of average claims, or roughly 2½ per cent of insured liabilities. It is hard to believe that agreement could be reached on setting the level of premiums necessary to build up such a high level of reserves.

In the absence of such reserves and of any support from government, the PPF would need to borrow to pay claims, using its future premium income as collateral. But this alternative looks barely more palatable, since it would require premiums to be raised very substantially. If, for example, there were claims equal to 2.5 per cent of liabilities in one year, and they were met by borrowing that had to be repaid over 10 years, then additional premiums equal to nearly four times the normal average claims level would need to be charged to repay the debt, ignoring any real interest due on the debt. This high premium would have to be charged at a time when, by assumption, the solvent firms that remain are heavily leveraged and themselves have pension funds in substantial deficit.

If the PPF cannot weather extreme events either by way of reserves or by way of borrowing backed by increased premiums, then that leaves two alternatives: default or some form of government involvement. The PPF will have powers to reduce the amount guaranteed under extreme circumstances, but this is a route that is fraught with problems. The very name of the fund, and the fact that the government has frequently stated that it has acted to restore confidence in the pensions promise,[11] mean that it will be very difficult politically for a government to allow the PPF to reduce its commitment significantly. It is hard to avoid the conclusion that the government will be left as the final guarantor of defined benefit pensions.

V. Cross-subsidy and moral hazard

In our base case, the fair insurance premium is £3.90 per £1,000 of insured liabilities per year and the expected claim level is £0.68 per year. This is not a deadweight loss to pension plans. The total cost of the premiums to all pension plans is exactly matched by the gains to pensioners in failed pension plans. But for individual firms, the costs and benefits will not match. For pensioners of firms that have high credit ratings, the probability of default is

[11]For example, 'We will make sure that in future individuals in final salary schemes will never again face the injustice of saving throughout their lives only to have their hard-earned pension slashed just before they retire. The Pension Protection Fund will allow individuals to save with confidence' (Andrew Smith, Secretary of State for Work and Pensions, 12 February 2004, quoted on Department of Work and Pensions website, www.dwp.gov.uk/lifeevent/penret/penreform/4_ppf.asp).

very small, and for them (or their employers) the PPF represents in effect a significant tax from which they derive little benefit. Since it is a tax just on defined benefit pensions, it will tend to discourage the provision of such pensions.

So far, we have assumed that the existence of the PPF and the way that premiums are set do not affect the investment strategy of pension funds or the contribution and benefit policy of firms. But there are good reasons to query these assumptions.

The difference between the costs and the benefits of the PPF insurance at the fund level creates incentives for firms to maximise the net value of their own PPF cover, with potential consequences for the solvency of the PPF as a whole. For instance, members and firms receive the benefits of a risky investment strategy, but the costs may be paid by the PPF. Therefore trustees have an incentive to follow a riskier investment strategy than they would otherwise. Weaker firms might find that an underfunded pension plan – effectively a loan from employees guaranteed by the PPF – is cheaper than a loan from the markets and has no consequence for pension fund members because it is guaranteed by the PPF. The PPF could thus become a source of subsidised financing for unscrupulous firms. Firms may also collude with employees to increase pension benefits – guaranteed by the PPF – in lieu of current wages, effectively a joint raid on the PPF. Firms may also alter the relative funding of their pension plans to take into account benefit limits on the PPF. The list of opportunities for dishonest behaviour is limited only by the imagination of firms and their advisers, as pointed out by two ex-PBGC Executive Directors (Utgoff, 1993; Kandarian, 2003).

Our model can be used to assess the size of incentives for bad behaviour if we assume that the PPF charges our constant base-case premium of £3.90 per £1,000 of liability to all firms. In our model, a firm that invested its pension assets entirely in bonds would never be underfunded and so would derive no value from the PPF insurance. It would therefore suffer a loss of £3.90 per £1,000 of liability per year. A firm that invested its assets entirely in equities, on the other hand, would receive pension insurance with a value of £5.23 per £1,000 per year, but would pay only £3.90 per £1,000, hence receiving an annual windfall of £1.33 per £1,000 of liability. Similarly, a firm that maintained full pension funding at all times would derive no value from pension insurance but would pay £3.90 per £1,000 of liability. A firm that amortised any surpluses and deficits over four years instead of 10 years – a stricter funding standard than the base case – would value the PPF insurance at only £2.34 per £1,000 per year, but would pay £3.90 per £1,000 – a loss of £1.44 per £1,000 of liability per year. Similarly, firms with an average leverage ratio of 38 per cent (these firms would be financially weaker than our base-case firms, which have an average leverage ratio of

31.7 per cent) would value insurance at £8.20 per £1,000 per year and pay £3.90 per £1,000 – and hence would pay less than half the fair premium.

One way of reducing these transfers is to set premiums for guaranteeing the pension benefits that more closely reflect their risk level. The PPF is required by law to ensure that 50 per cent of the premium is ‘risk-rated’, probably rated on the degree of pension underfunding, pension investment policy and the strength of the corporate sponsor. Although risk-rating using these factors would remove some of the moral hazards associated with the PPF, it would probably do little to control the extreme lumpiness of the claims process pointed out in the previous section. We have already seen that, in the absence of the PPF, schemes are heavily invested in equities and are often seriously underfunded. As Table 4 shows, the value of the PPF to a sponsor and the beneficiaries is greater, the more equity investment and the less strict the funding. So considerable risk-rating in setting the premium would be necessary just to offset these benefits.

The lumpiness of the claims process can only be mitigated by forcing financially weak sponsors to ensure their schemes are fully funded. But the premiums required to do this look prohibitively large, as a crude calculation demonstrates. In the absence of premium penalties, underfunding a pension scheme is similar to borrowing from the scheme at the riskless rate to fund the business. To induce a sponsor to put additional money into a scheme, the penalty on maintaining a deficit needs to be of the same order as the borrowing spread the sponsor would pay – and this may well be of the order of 2–3 per cent per annum for a borrower who is just below investment grade. Similarly, in order to induce firms to switch from equities into bonds, the penalty on equity investment would need to be of the same order as the equity risk premium – up to 6 per cent per annum of the amount invested in equities.

So risk-related premiums may improve fairness by ensuring that those schemes benefiting most from the PPF pay more towards its cost, but they will do little to reduce the probability of very high claims. Indeed, they may make it more likely that a run of bad years could force government intervention. For if, as we have argued, the PPF will be unable to build up large reserves, and if it is unlikely in practice to cut back benefits, then the only way it can react to a run of bad years is to raise premiums. But the constraint on raising premiums is the damage it does to companies and to employment. The pressure to raise premiums will be particularly acute if they bear more heavily on the highest-risk sponsors, since these are precisely the companies where raising premiums is most likely to cause financial distress.

In order for the PPF to work effectively, something other than risk-rating will be required. A strong minimum funding requirement on a transparent basis will effectively control underfunding, and hence claims on the PPF. The PPF itself will have to lay down precise rules for computing the solvency ratio, and could not allow pension funds leeway in making their own assumptions.

Further, the PPF could cut back on the level of guaranteed benefits without changing the funding process. Under current legislation, the PPF guarantees only 90 per cent of deferred pensions, there is a cap on the amount of each pension that is protected, and some pension increases are not covered by the PPF. Lowering the level of guaranteed benefits will have a significant effect on the cost of insurance to pension funds and, eventually, to the taxpayer but will not reduce the volatility of claims.

VI. Conclusions

Our analysis does not claim to be a very accurate or even a practical method of determining a premium for the Pension Protection Fund. However, it does illustrate some of the problems that may be faced by the PPF in the future, and suggests ways in which the design of the PPF could be changed to accommodate these effects. Although failures of pension plans to pay people their entitlements have been unusual in the UK, it would be dangerous and wrong to conclude that failures will be rare and small in the future. The way that pension schemes are funded and the way that funds are invested imply that a deep and prolonged decline in financial markets could readily lead to widespread failure. An inherent feature of the claims process of the PPF is likely to be that many years of small claims will be interspersed with rare and unpredictable periods of exceedingly large claims. These periods will coincide with periods when the stability of the whole of the financial sector is under maximum strain. We suggest that the magnitude of the claims in these unstable periods will be so great that it will not be politically feasible or economically sensible to build up reserves to meet them. When such a crisis does occur, it may well be impossible to meet claims by a steep increase in the levy on employers since they will simultaneously be facing heavy financial demands to rebuild their own depleted pension funds. It is hard to see any alternative to the government stepping in. The government has repeatedly made clear that it will not guarantee the PPF; in reality, it will be forced to do so, and a substantial part of the cost of the scheme will actually fall to the taxpayer.

However, the major part of the cost will be borne by employers. The PPF will necessarily involve large transfers from companies that are unlikely to default to companies that may well default. These transfers are inefficient and create opportunities for moral hazard. To minimise the cost of the insurance and to keep down the level of cross-subsidy, the PPF is to risk-rate its premiums. We argue that risk-rated premiums, unless punitive, will not largely alter the current investment and funding policy of UK pension plans, and hence will not resolve the problem. Premium risk-rating will therefore need to be implemented in tandem with a strong Minimum Funding Requirement in order to reduce the potential cost of the PPF to future UK taxpayers.

The model we have presented is necessarily simplistic, but most of the assumptions we have made tend to underplay the nature of the problem. We have modelled the liabilities as a continuum of small plans; we therefore ignore the lumpiness in claims that comes from a large plan failing. We have assumed zero correlation in the idiosyncratic risk of companies, and so take no account of whole industries facing financial distress. We have ignored any gains and losses that might occur if the PPF fails to match the assets and liabilities of the defaulted plans that it itself is managing. If it invests in equities, the volatility in the PPF's net worth would be further increased. We have assumed that the only systemic risk affecting the sector is equity market risk; other risks such as unpredicted changes in interest rates and longevity could further increase the volatility of claims on the PPF.

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