Are Defined Benefit schemes insurable?

Cliff Speed
David McCarthy

What liabilities exist in the UK economy?

- Public-sector pension schemes have GBP 580 billion[3] maybe GBP 350 billion unfunded
- Occupational pension schemes have GBP 762 billion[4] in 2000; as at 2005 pension liabilities ~ GBP 1000 billion
- Occupational pension schemes have FRS17 deficits of ~ GBP 130bn[5]
- UK insurers wrote GBP 7.4 billion of new annuities in 2003[1]
- UK life insurers have GBP 70 billion[2]

1) Association of British Insurers, 2003 (figures exclude bulk annuities)

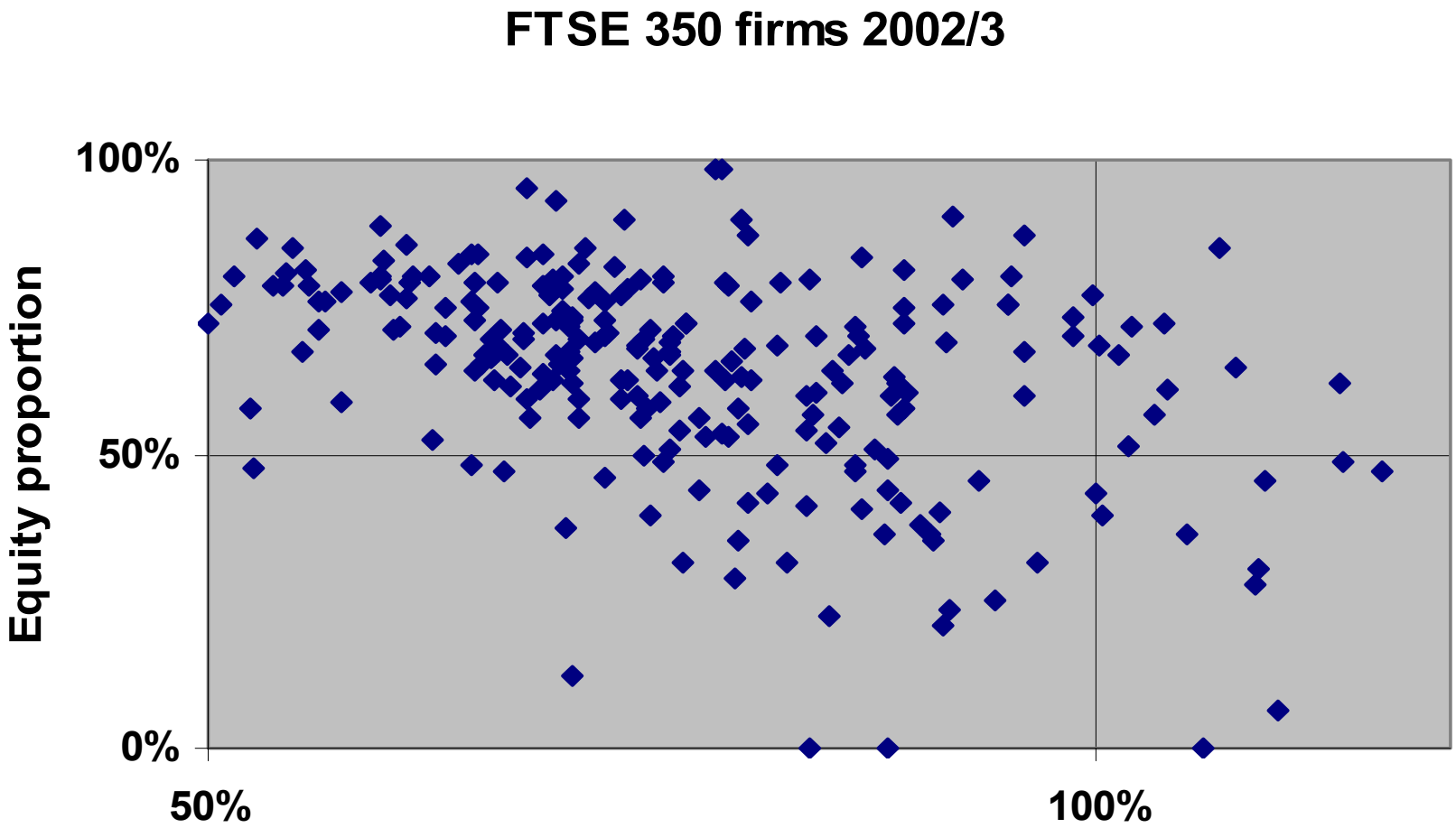
2) Richards and Jones, *Financial aspects of longevity risk*, Staple Inn Actuarial Society, 2004

3) Watson Wyatt press release, August 2004

4) Government Actuary's Department, *Eleventh Survey of Occupational pension Schemes*, 2000

5) Mercer press release February 2005, see http://www.mercerhr.co.uk/pressrelease/details.jhtml/dynamic/idContent/1169880

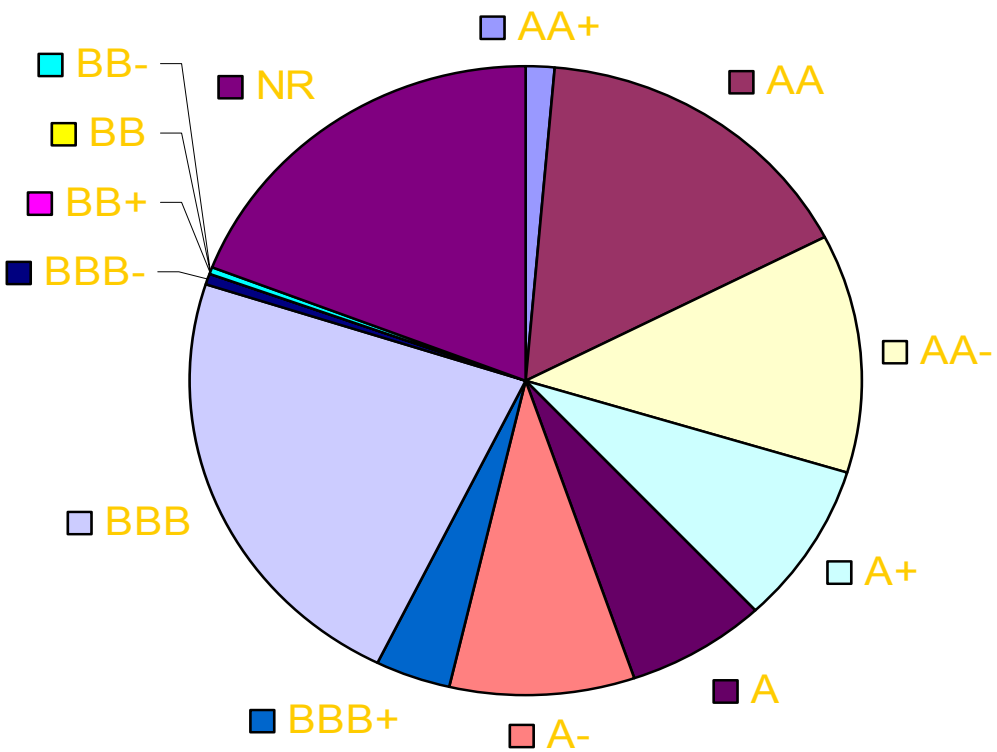
UK Pensions Environment (II)
Funds heavily exposed to equities



Source: Watson-Wyatt

UK Pensions Environment (III)

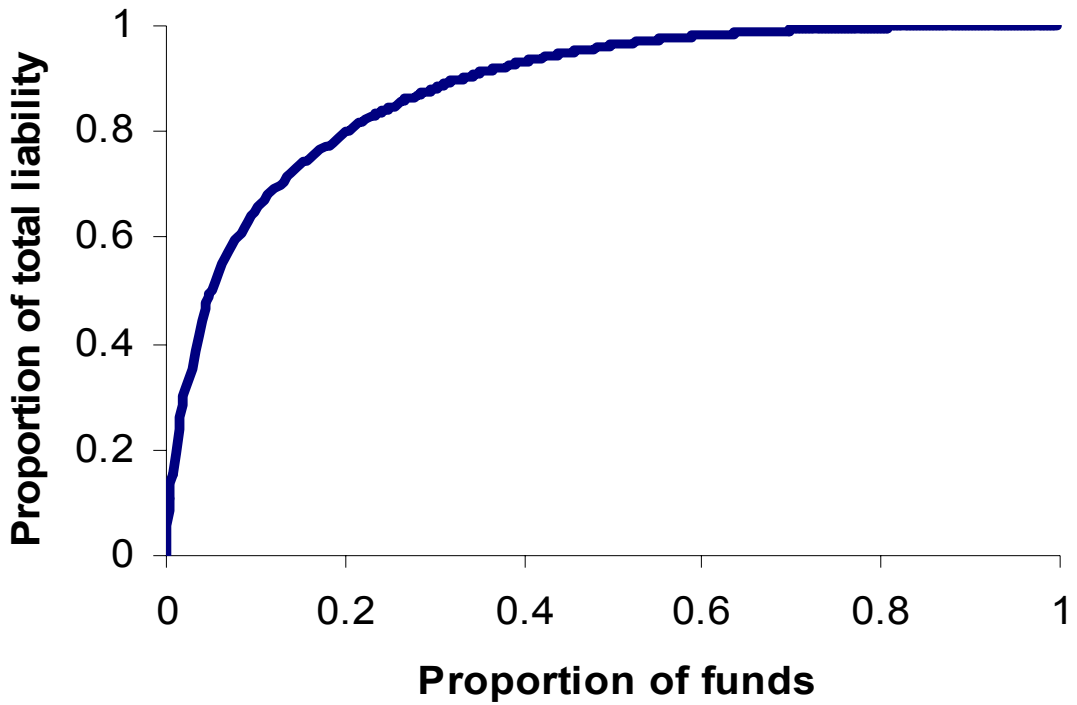
- Chart shows unfunded liability by Standard & Poors credit rating (2004) of sponsoring company



UK Pensions Environment (IV)

Pension fund size distribution is highly skewed

Largest 20% of FTSE350 funds have ~80% of total liability



UK's Pension Protection fund

Starts on 6th April 2005

- Provides a safety net for DB pensions,
- no Government backing hence a mutual insurance arrangement

Level of protection

- 10[illegible] benefits for pensioners
- 90[illegible]

Prot[illegible]

- Pension increases at LPI(2½%) post-97 accrual
- No pension increases for pre-97 accrual
- Revaluation in deferment LPI(5%)
- For "non-pensioners" cap on benefits (~ £25k pa including tax free cash increasing with NAE)

How will PPF protection be paid for?

Levy comes in two parts

- risk factors – deficits, insolvency risk, other factors (asset allocation?)
- scheme factors – scheme liabilities and other factors (#members, pensionable pay, etc)

Principles for setting the levy

- predominantly risk-related (80:20), but …phased in "in a way that suits schemes best"
- aim for consistent costs over time, regardless of economic cycle.
- Annual amount raised estimated at £300m pa, but £150m in first year.

How will PPF protection be paid for?

Other features

- Restrictions on levies
- Ability to reduce level of benefits (revaluation, increases, and then protection percentage)

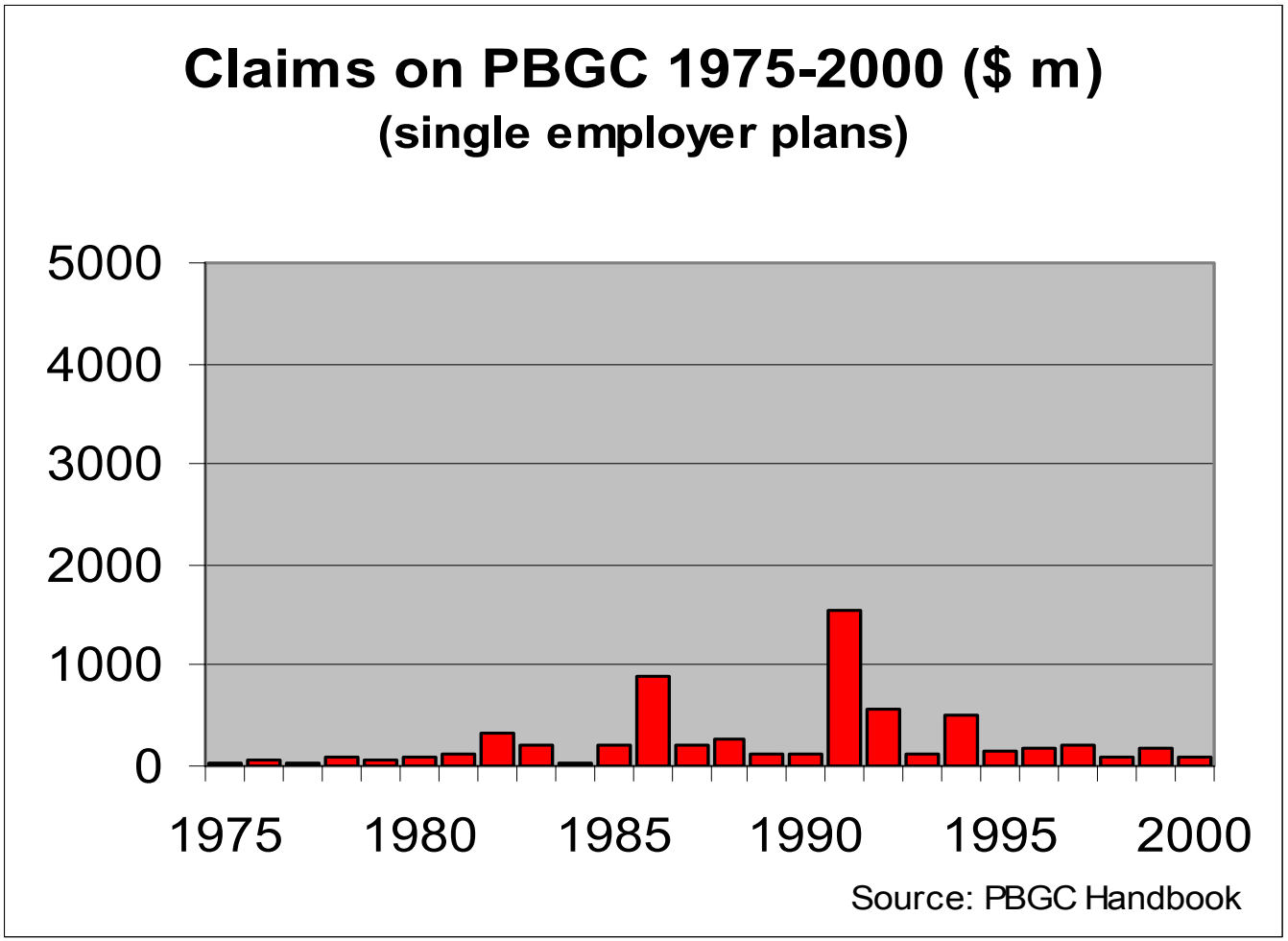
Pension Benefit Guaranty Corporation

- $20 billion loss in 2000-2004, driving cumulative PBGC deficit to $23.3 billion in Sept 2004
  - *cf:* premium income $1billion/year

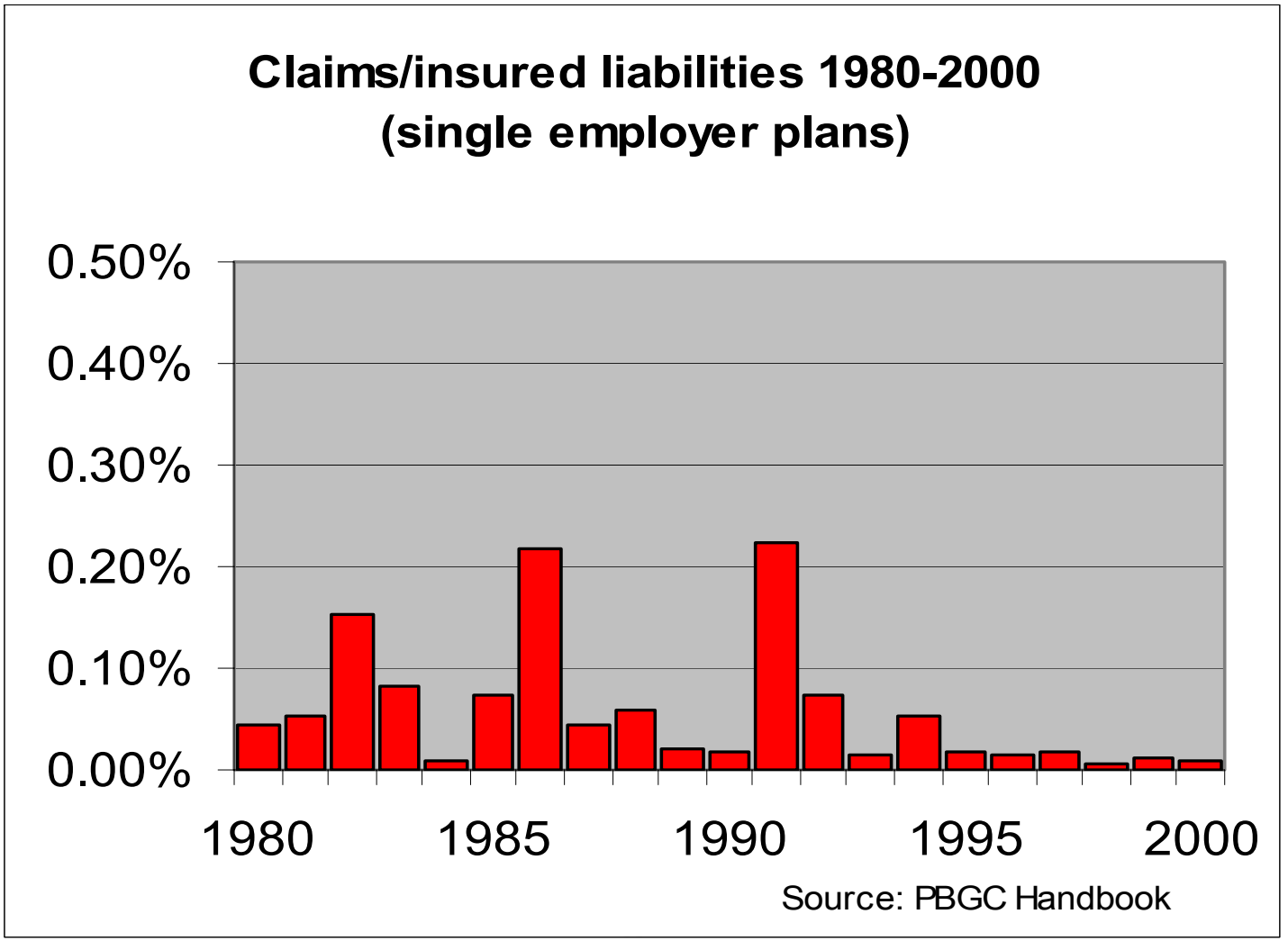
"While PBGC is not in crisis … it is clear that the financial integrity of the federal pension insurance system is at risk."

Elaine Chao, Secretary of Labour

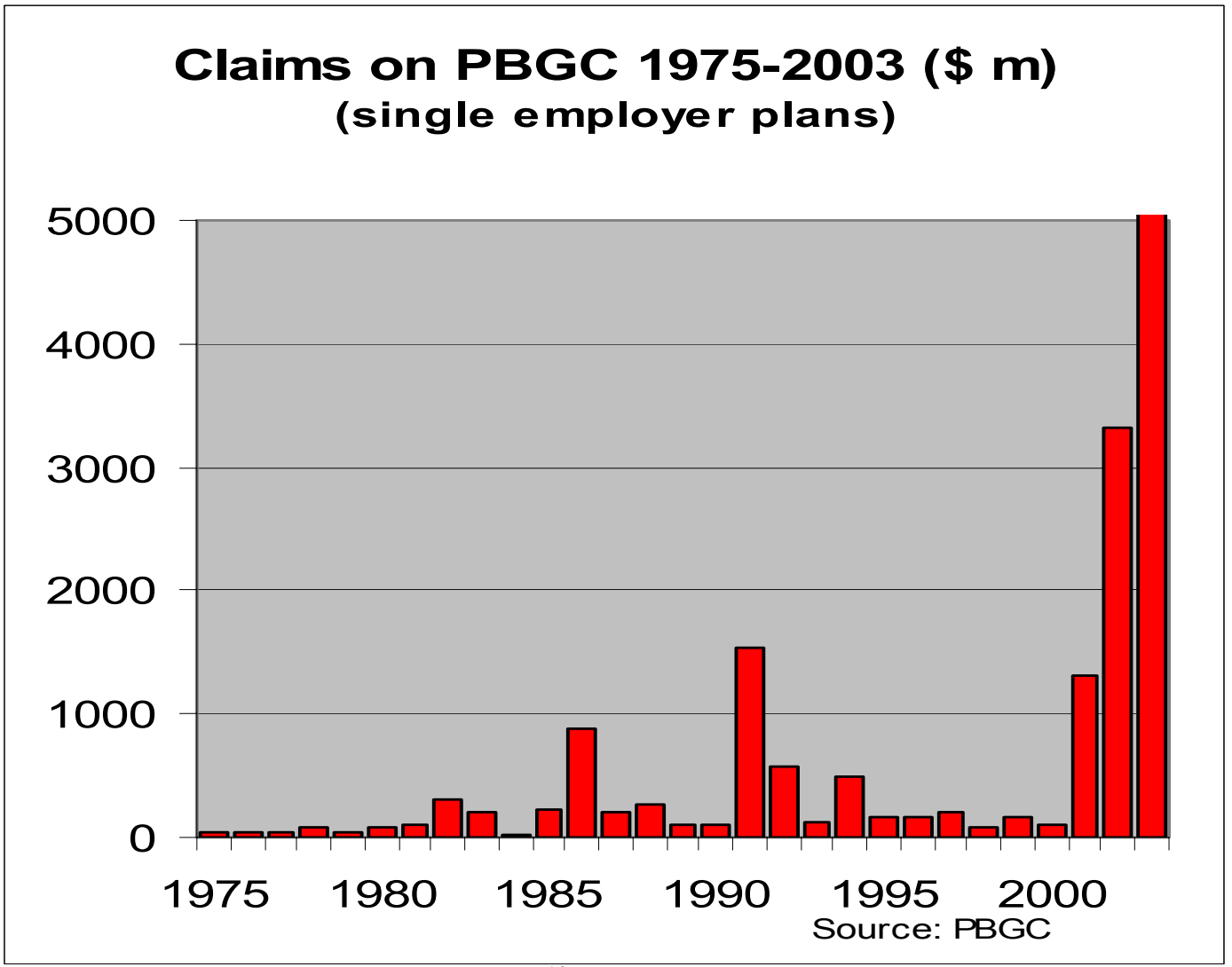
It all looked so nice …



… and not just because of inflation



… and then we get 2001/3



What are the risks?

Two major risks in providing a pension/annuity

1. Interest rate risk
2. Mortality risk

In addition need to make allowance for expenses.

When insuring a sponsored DB scheme these risks are contingent on:

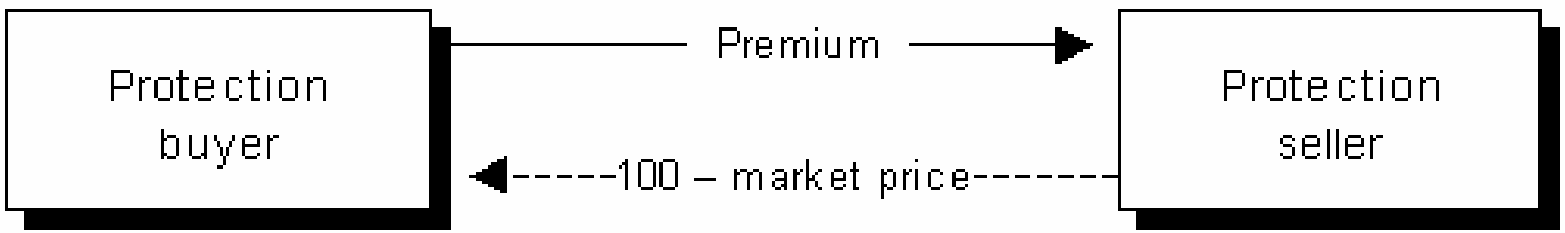
1. Employer failing to meet the promises, (credit risk) and
2. The level of funding in the scheme at default

DB insurance and credit risk

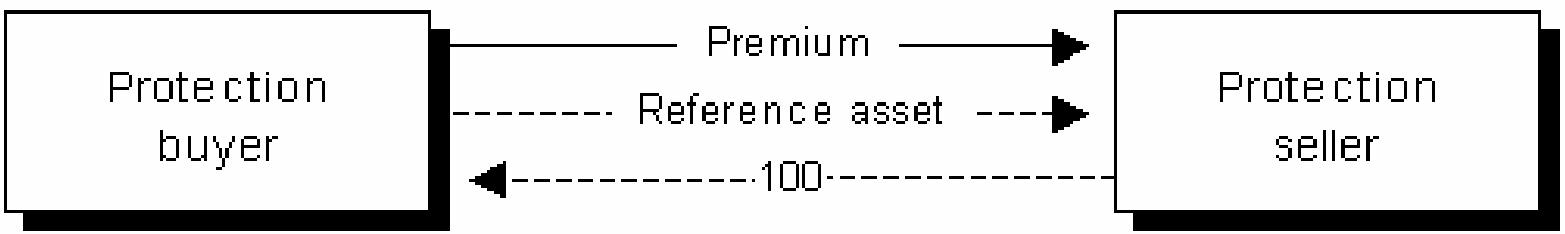
Insuring DB schemes is equivalent to issuing credit derivatives where the payout is dependent on the pension deficit at the point of default.

Credit derivatives (CDS) allow investors to buy protection against the risk of default.

Example of Cash Settlement



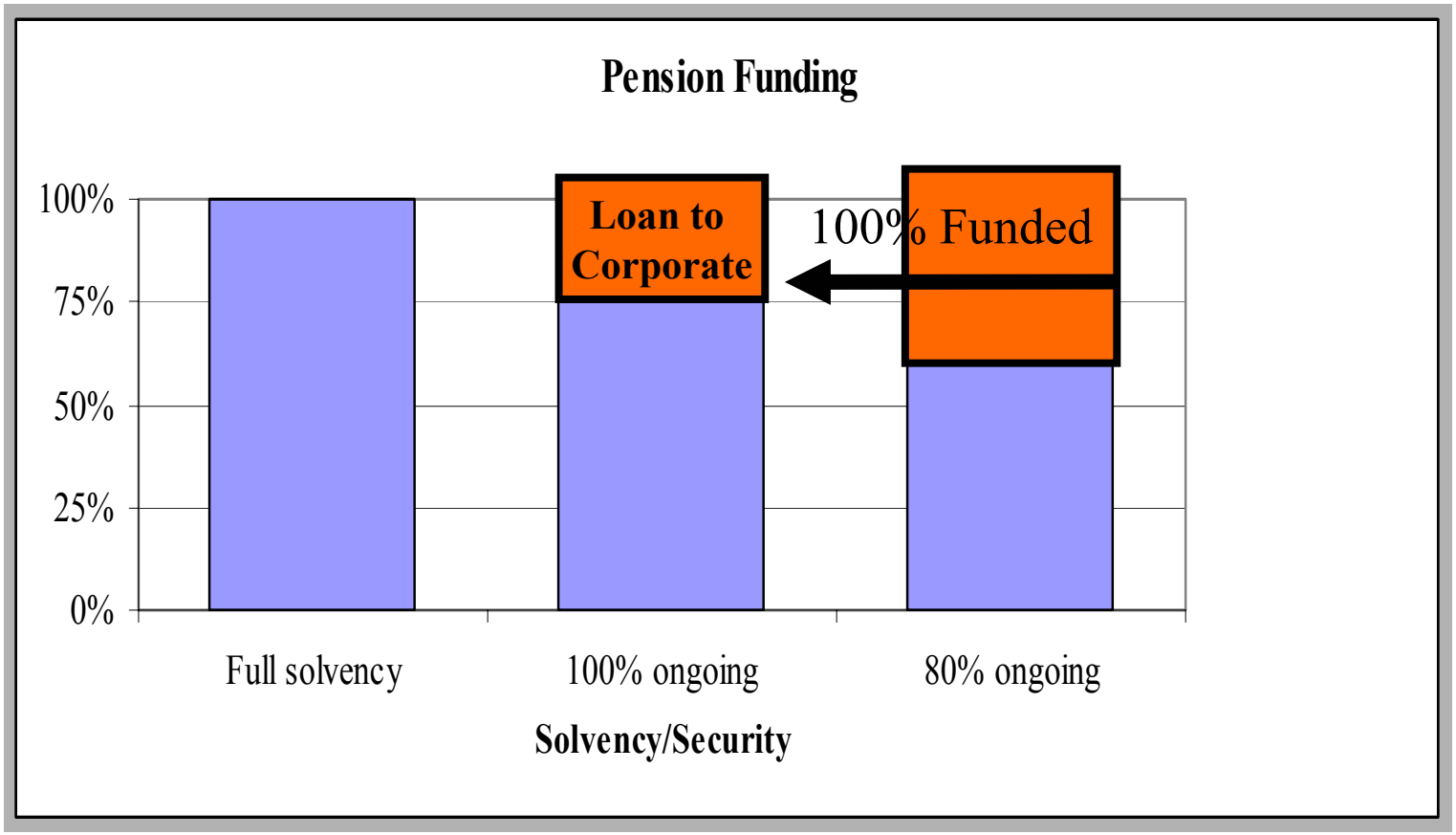
Example of Physical Settlement



Issues around amount of protection and the recovery rate.

Why would you need CDSs?

If the aim is for pension schemes to be insolvent then there is little surprise that when sponsors fail their pension schemes are insolvent.



How *could* the premium be set?

- If an insurer offered this protection how would it be priced?
- Claim = Deficit at insolvency
  - δ is the default rate
  - A the assets and L the liabilities guaranteed by the Fund
  - p is the premium

$$p = E^{Q}[\delta(1 - A/L)]^{+}$$

- If we assume insolvency independent of capital markets

$$p = E^{Q}[\delta] \times E^{Q}[(1 - A/L)]^{+}$$

- Need data on
  - Risk-neutral probability of insolvency
  - Asset allocation
  - Deficit

Data collection

- Information on asset allocation and (to a lesser extent) the deficit is readily available
- Insolvency risk is harder to quantify
- Preferred approach uses market credit data
- For a credit instrument we write

  Credit Spread = PD * (1 – recovery rate)
- Collect spread data:
  - CDS quotes
  - Corporate bonds

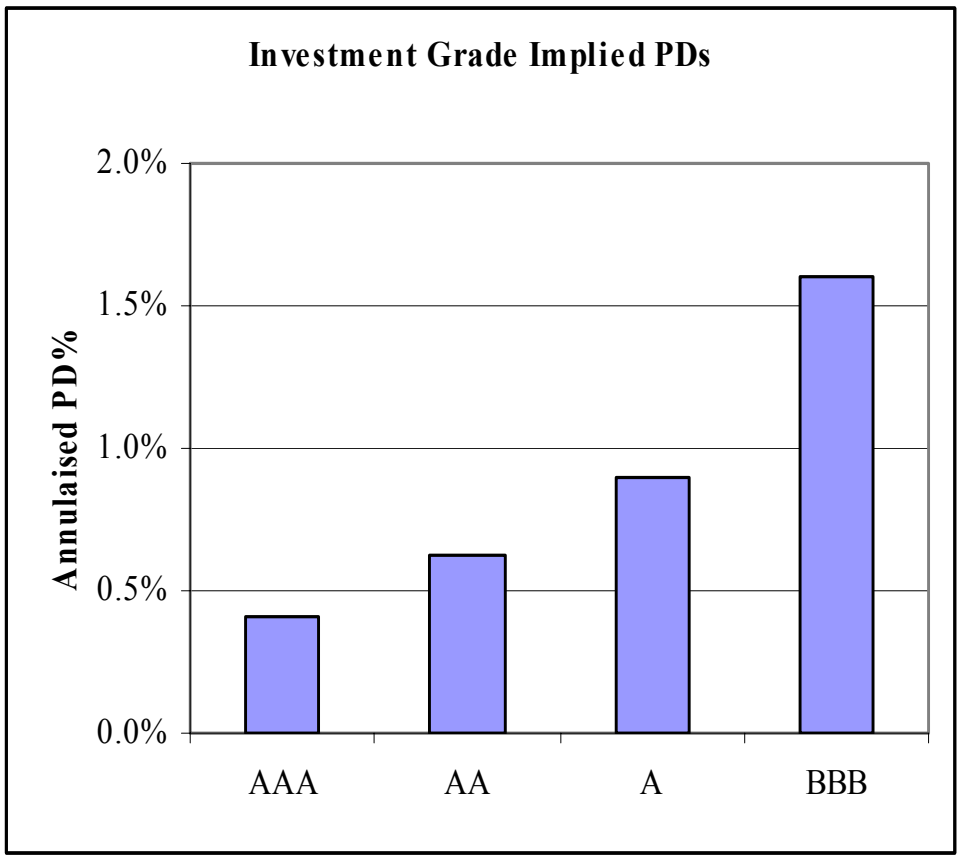
Charging for the risk of insolvency

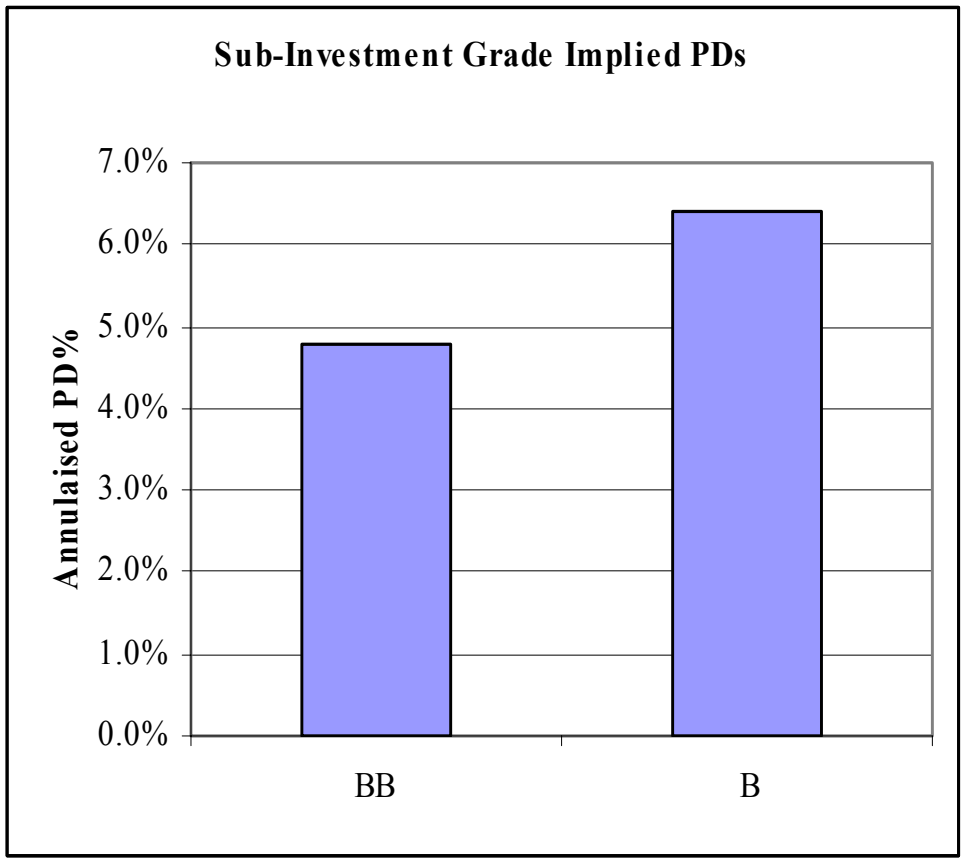
Compare to a flat 1% of deficit levy
Assume a £5bn deficit for each scheme

Sponsor	Credit rating	Pr[insolv]	Fair Levy £m	Overpayment / Subsidy £m
A	AAA	0.2%	10	£40
B	AA	0.2%	10	£40
C	A	0.5%	25	£25
D	BBB	0.6%	30	£20
E	BBB	3.7%	185	£135
F	BB	6.0%	300	£250

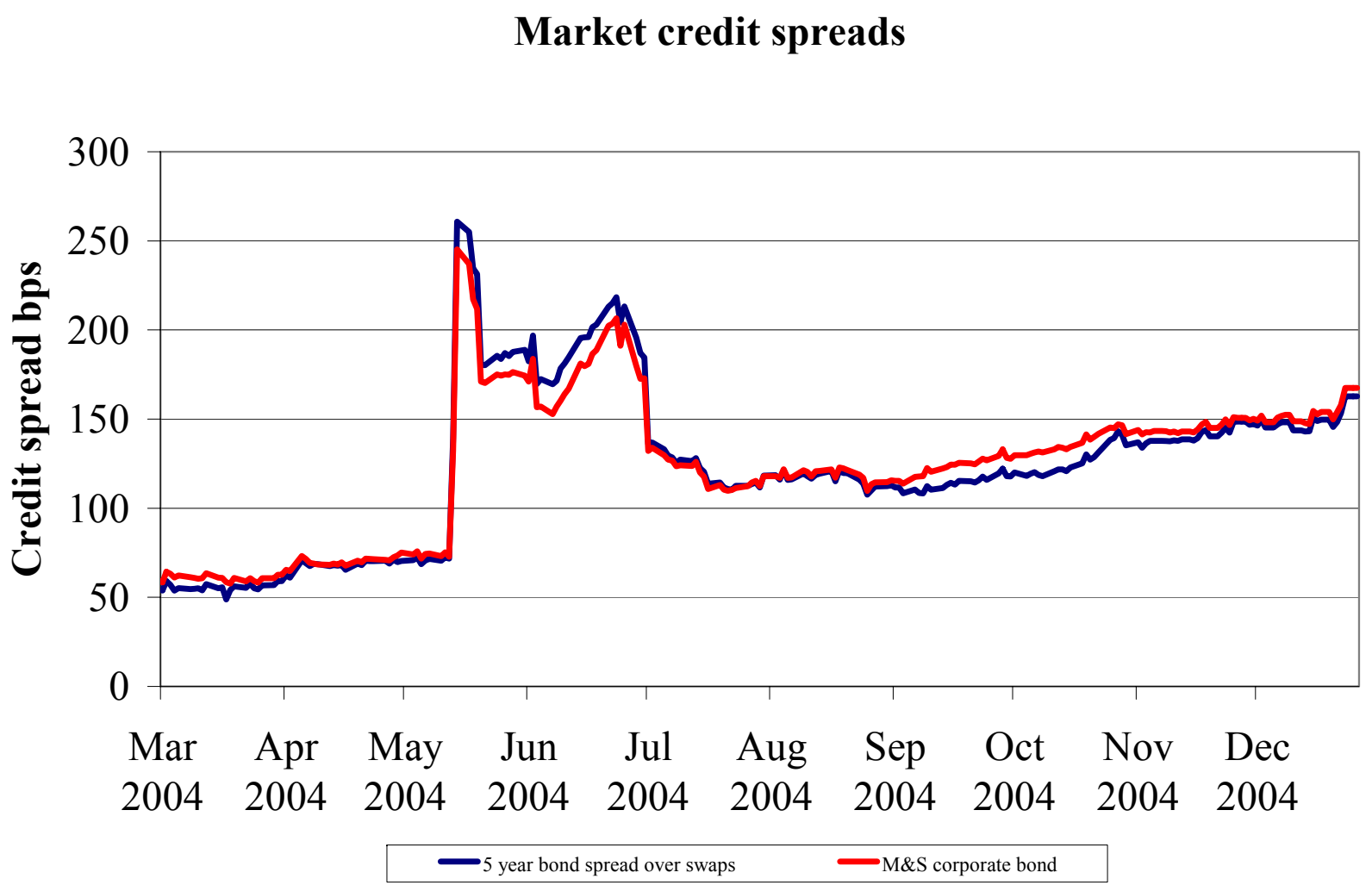
Analysis by company or credit rating?

Broad approach to categorise by credit rating - Bloomberg





How to measure the proby of insolvency?



How practical is the approach?

- Considered the 111"large" private schemes
  - Large = assets above £800m (PFTA)
- How many have market credit instruments?
  - No. of sponsors with CDS quotes 79
  - + No. sponsors with corporate bds 17
  - + No. credit ratings 0
  - Total sponsors with mkt credit data 96 (86%)
- This covers 95% of the liabilities of "large" schemes and over 50% of the liabilities of all schemes

What about where no coverage exists?

- Use credit scoring approaches
  - For example Bank models or S&P's credit tracker
- Need an assumption for insolvency rates
  - cf PBGC's 0.9% of deficit assumption
- The average credit rating is "A" (see iBoxx,)

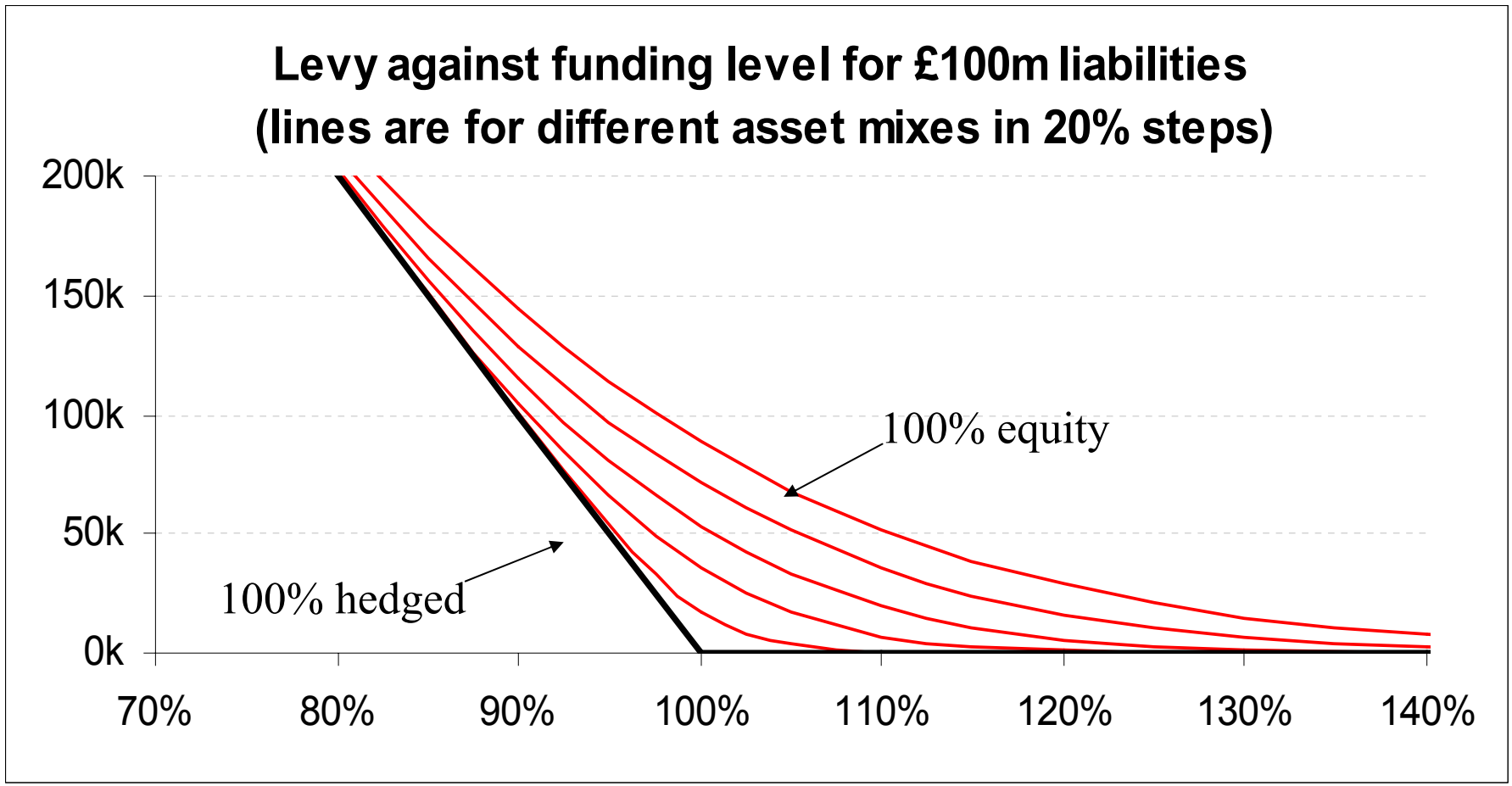
  "A"-rated credit currently has a spread ≈ 0.6%

  =>Market-implied PD = 1%,
  - Default stats handle with care
- ONS –rates of corporate insolvencies ≈ 1%
  - also see "r3" web-site
- Suggests that an assumption around 1%
- Assume a high rate of default

Measuring the deficit

- Liabilities use buy-out basis for valuing benefits
  - How much would you have to pay an insurer to take on liabilities?
  - Discount rates: gilts – 0.5%
    (ie as per GN9)
- Assets – allow for contingent assets
  - encourages risk management
- Could use a Margrabe option
  - deficit measures the extent that the put option the PPF has written is in-the-money

How to implicitly allow for asset allocation change to margrabe put



Setting the risk based levy

Combine the probability of default with the Margrabe option

$$p = E^{Q}[\delta] \times E^{Q}[(1 - A/L)]^{+}$$

Probability of sponsor insolvency

Margrabe option

No allowance for asset allocation

- Omitting a risk factor
- Danger to PPF where schemes are in aggregate solvent on PPF basis but heavily invested in mis-matching assets
- Could make an approximate allowance by measuring deficit against a target above 100% of PPF solvency level
- Could use a reduced value compared with market value for mis-matched assets ("haircut")
- S&P's "Analysis of largest 500 UK DB Schemes" found no relation
  - between asset allocation and funding level, or
  - between sponsor credit strength and asset allocation

Summary so far

- Credit data exists for setting the risk based levy on the sponsor's risk of default for large schemes
- Not doing this would lead to large cross subsidies
- Setting levy at the correct level without taking account of all the risk factors is difficult

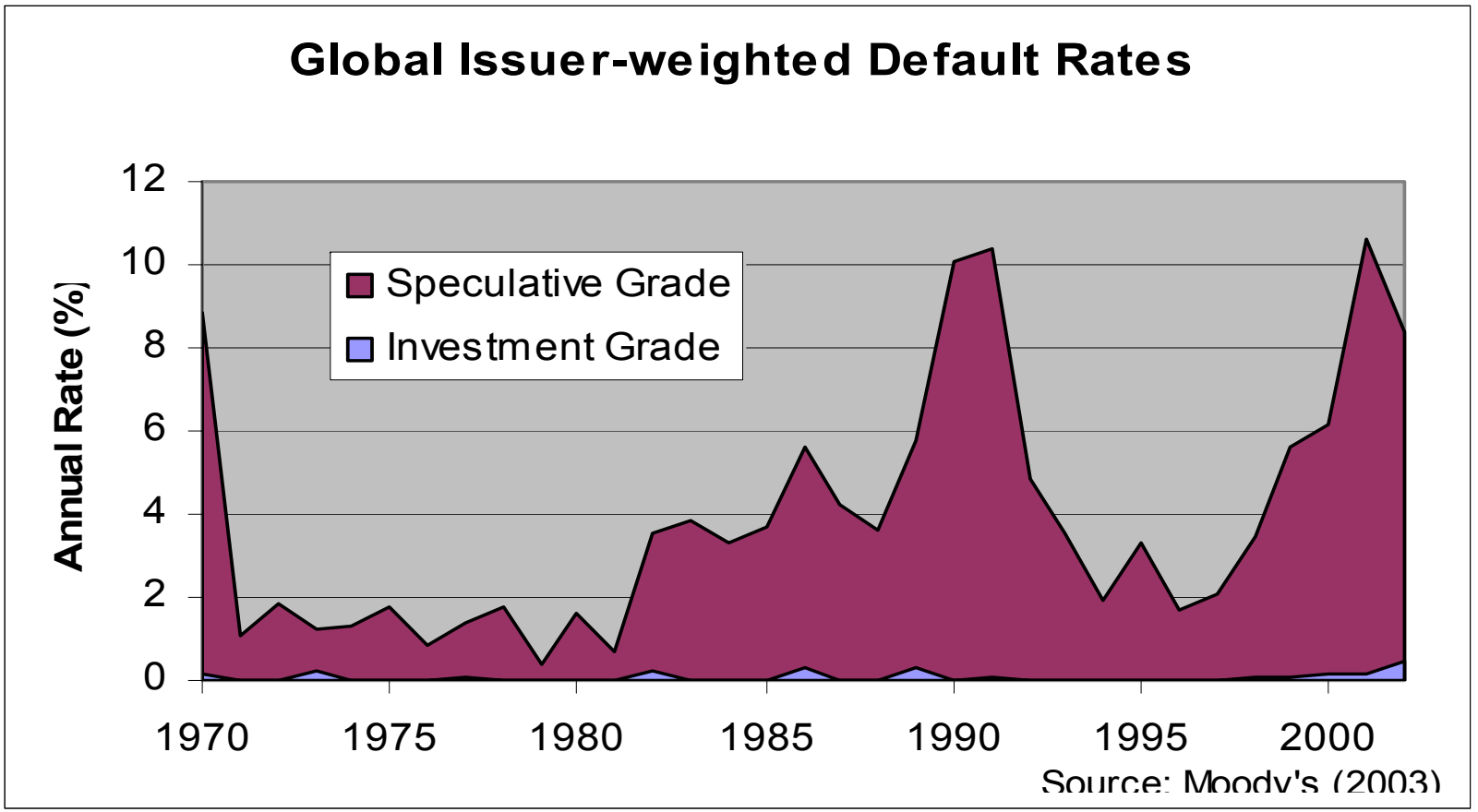
Issues remaining

- Do credit instruments exist for the sponsor?
- What assumptions are needed to calculate a probability of default?
- How to set input parameters for Margrabe option
- Assumed independence of insolvency and capital markets
- Levy pricing approach based on principles of hedging; can this be done?

Variable default rates are important

- Falling equity market increases both the probability of firms declaring insolvency and the size of pension plan deficits
- Correlation between default risk and equity market risk means that default risk is priced, raising the cost of the hedging strategy
- Correlation of default risk across firms increases the skewness of the claims process

Insolvencies are very cyclical



Model: pension fund

Solvency, not funding

Has a stock of liabilities L_t

- May change over time
- Non-stochastic
- Represents cost of buying out PPF liabilities on the market

and a stock of assets A_t

- Represents market value of pension assets
- Asset mix fixed and exogenous

Rather like UK pension plans

- Invested in stocks and bonds

Market portfolio

Riskless rate of *r*

Model: Contribution Policy

Assets:

$$dA = \left[\left(r + x\alpha \right) A + \left(\kappa_t - \pi_t \right) \right] dt + x\sigma A dz_1,$$

Proportion in equity

ERP

Equity risk

Asset return

Contributions

Payments to pensioners

Contributions:

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

ERP assumed in setting contributions

Keeps solvency ratio constant as liabilities change

Amortisation of deficit over *T* years

Model: Contribution Policy

Letting $a_t = A_t / L_t$ **gives:**

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

Limit on over-funding: $a \leq a^*$

Assumptions imply a steady-state distribution of a, independent of initial conditions

Pension Protection Fund

- The present value of premiums less the present value of claims equals 0 for fairly priced insurance:

$$E^{Q}\left[\int_{t}^{\infty}\left(P_{u}I_{u}du+\left[L_{u}-A_{u}\right]^{+}dI_{u}\right)e^{-r(u-t)}\right]=0$$

Risk-neutral density

Premiums collected while firm solvent

Amount paid by PPF when firm defaults

Indicator variable = 1 if firm is solvent

Premium process

- Many different ways of collecting premium are possible
- In this paper we assume $P_t = pL_t$.
- Abstracting from initial conditions gives

$$p = E^{Q}\left[\delta\left(1 - a_u\right)\right]^{+}.$$

Default rate

Steady state distribution of a

Possible approach I

- Fitting corporate bond spreads
  - Correlated across firms
  - Negative correlation between spreads and equity markets
  - High quality data
- Credit risk only accounts for a part of the credit spread
  - Elton, Gruber and Martin (2001)
  - Huang and Huang (2003) say ¼ of the spread is due to default risk

Possible approach II

- Structural model of the firm
  - Don't model credit spreads too well
  - Do a good job of predicting default (Huang and Huang (2003))
- Other strengths
  - Correlation between equity market and default probability arises naturally
  - Correlation between different firm defaults arise naturally because of correlation between firm assets
- Need a stationary model of firm default

Structural model of firm default

- Based on Collin-Dufresne & Goldstein (2001)
  - Debt is a claim on firm assets ← Merton (1974)
  - Assets follow diffusion process and firm's leverage ratio varies
  - Firm adjusts leverage ratio through their financing strategy, causing mean reversion to some level

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

Log leverage ratio

Mean reversion parameter

Long-run mean value

Innovation in firm's assets

Constant correlation with pension fund assets

Structural model of firm default

- We assume that each firm's idiosyncratic risk is independently and identically distributed and that all idiosyncratic risk is unpriced
- We now have a steady-state distribution of a and l
  - a varies over time but is the same across firms
  - l disperses because of firm idiosyncratic risk

Calibrating the model

- We follow Huang and Huang (2003) for an A-rated issuer
  - Equity risk premium is 6%
  - Equity market volatility is 18%
  - Assume $\kappa = 0.2$
  - Need average leverage ratio of 31.7% to get long-run average default probability to equal 0.25%
- Iterate forward on a binomial tree until we get a steady state of a and l

Annual premium: structural default rate

Figures in £/year per £1000 of liabilities	Equity Proportion			
	2/3		**1**	
	Premium	**Claim**	**Premium**	**Claim**
Poisson default	**0.72**	**0.32**	**0.96**	**0.48**
Structural default				
Base case	**4.95**	**0.93**	**6.28**	**1.25**
Stricter solvency: T = 4yrs (10)	**3.38**	**0.67**	**4.54**	**0.94**

Source: Authors' calculations. The Poisson default case is from Table 3. 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 (0.245%). The first variant on the base case have only 90% of liabilities guaranteed by the PPF, and the second has an amortisation period for pension fund deficits of 4 years rather than 10. The other parameters of the models are: a^* = 120%, sm = 18%, sv = 24.5%, =-1.15, k = 0.2, and r = 0.6.

Variation in claims rate

Claims/£1000 in worst period in thirty years

	Structural default		Poisson Default	
Fair premium	**4.95**		**0.72**	
Average claim	**0.93**		**0.32**	
	1 year	5 years	1 year	5 years
Median	**5.7**	**9.7**	**0.9**	**3.4**
Top quartile	**14.0**	**25.0**	**1.0**	**4.3**
Top decile	**28.9**	**50.7**	**1.1**	**5.8**

Source: Authors' calculations. The table is based on 1000 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 thirty year period. The parameter values for the base case are: $a^* = 120\%$, $T = 10$, $\beta = 1$, $sm = 18\%$, $sv = 24.5\%$, $=-1.15$, $k = 0.2$, and $r = 0.6$. The Poisson default case is identical except that $r = 0$.

Moral hazard

- Tables illustrate degree of cross-subsidies and hence size of incentives facing firms to maximise value of insurance
- Risk-rating premia may reduce this problem
  - Required risk premium on underfunding for a weak firm would be extremely large
  - Collecting premiums from weakest firms may actually increase recourse to public funds
- More direct methods (e.g. strong MFR) required
- Limit generosity of benefits?

Conclusions

- Existing market data can be used to determine appropriate risk-based levies for majority of potential PPF liabilities
  - Although pure hedging is likely to be impractical
- PPF claims likely to be very lumpy (witness: PBGC)
- PPF will need reserves equal to a large multiple of expected annual claims to avoid deficit
- Real chance of deficit in PPF
  - Implicit Government guarantee looks inevitable
- Risk-rated premia unlikely to control moral hazard without strong minimum solvency requirements
- Strong MSR will reduce cost of PPF

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