ECONOMICS AND FINANCE OF PENSIONS

Lecture 14

PENSIONS AS COLLATERALISED DEBT (WITH AN APPLICATION TO PENSION INSURANCE)

Dr David McCarthy

Lecture outline

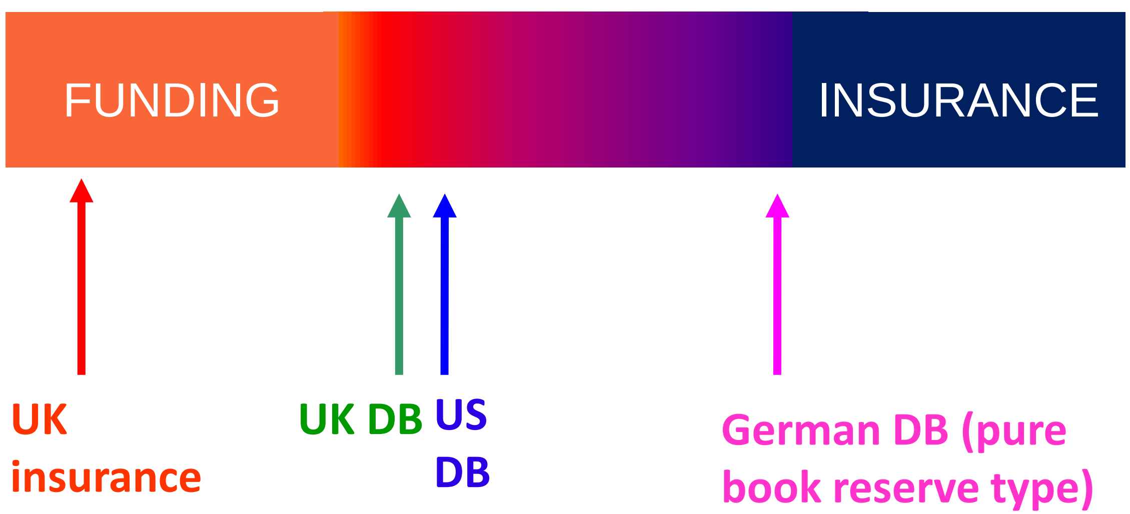
- Why insure pensions?
  - History of pension insurance in the US and UK
- A model of pension insurance
  - Pricing pension insurance
  - Systemic risk
  - When to collect premiums?
- Moral hazard
- Other possible models
- Conclusion

Why insure pensions?

- Individuals cannot insure themselves against the collapse of their pension plans
  - (markets are incomplete)
  - (they do not have the knowledge/skills)
  - (expertise is expensive relative to the size of their individual claims)
  - (solvency crisis can precede a liquidity crisis)
  - And yet they are very vulnerable to the collapse of their pension fund, either through outright fraud (Maxwell) or because the pension plan relies on a sponsor who subsequently defaults
- For a long time, the introduction of a pension insurance scheme in the UK was resisted, because of fears it might encourage moral hazard

Funding vs. insurance

- When sponsors make promises which are vulnerable to default risk, to protect members, promises can either be funded, or insured (or a combination)



- What do you think are the advantages/disadvantages of each approach?

History of pension insurance

- In the US, pension plans were started by large railroad companies (including American Express, a parcel company) in the late 19th century
- The growth of these plans was especially large during WWII (when there were price controls) and the 1950's and 1960's (when income tax rates were very high)
- In the late 1950's there was concern about the lack of transparency in company pensions, and congress passed laws requiring full disclosure
- Then, in 1963, the Studebaker company closed its plant in South Bend, Indiana

Studebaker

- The company laid off about 5000 workers and terminated the pension plan, which had been negotiated with the United Auto Workers Union
- Plan created in 1950
- Granted prior service benefits, so there was an immediate unfunded vested liability of $18m, which was amortised over 30 years
- Benefits improved in 1953, 1955, 1959, and 1961, each time creating past service credits the costs of which in every case were amortised over 30 years

Studebaker pension plan

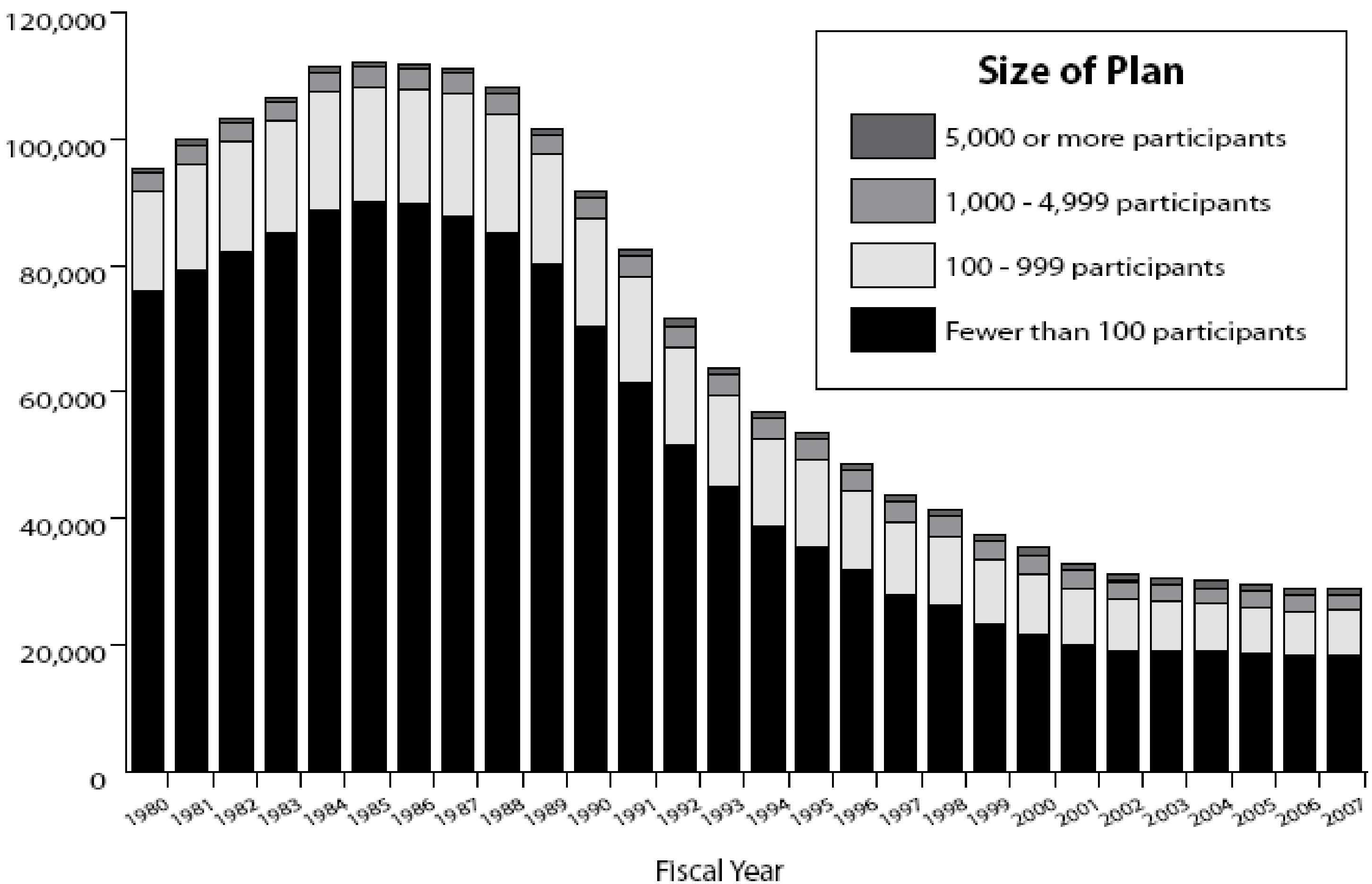
- There was $24m in the pension plan when it was terminated
- In terms of the termination, workers divided into three groups
  - 3,600 retireds and actives over the age of 59
  - 4,000 members with vested benefits (over the age of 40, > 10 years service) [average age 52, 23 years service]
  - 2,900 others
- Priority order was implemented, so the assets in the plan were first used to pay the first group, then the second, and finally the third
- First group took $21.5m, the second $1.5m (~15% of liabilities) and the third got nothing

Studebaker plan termination….

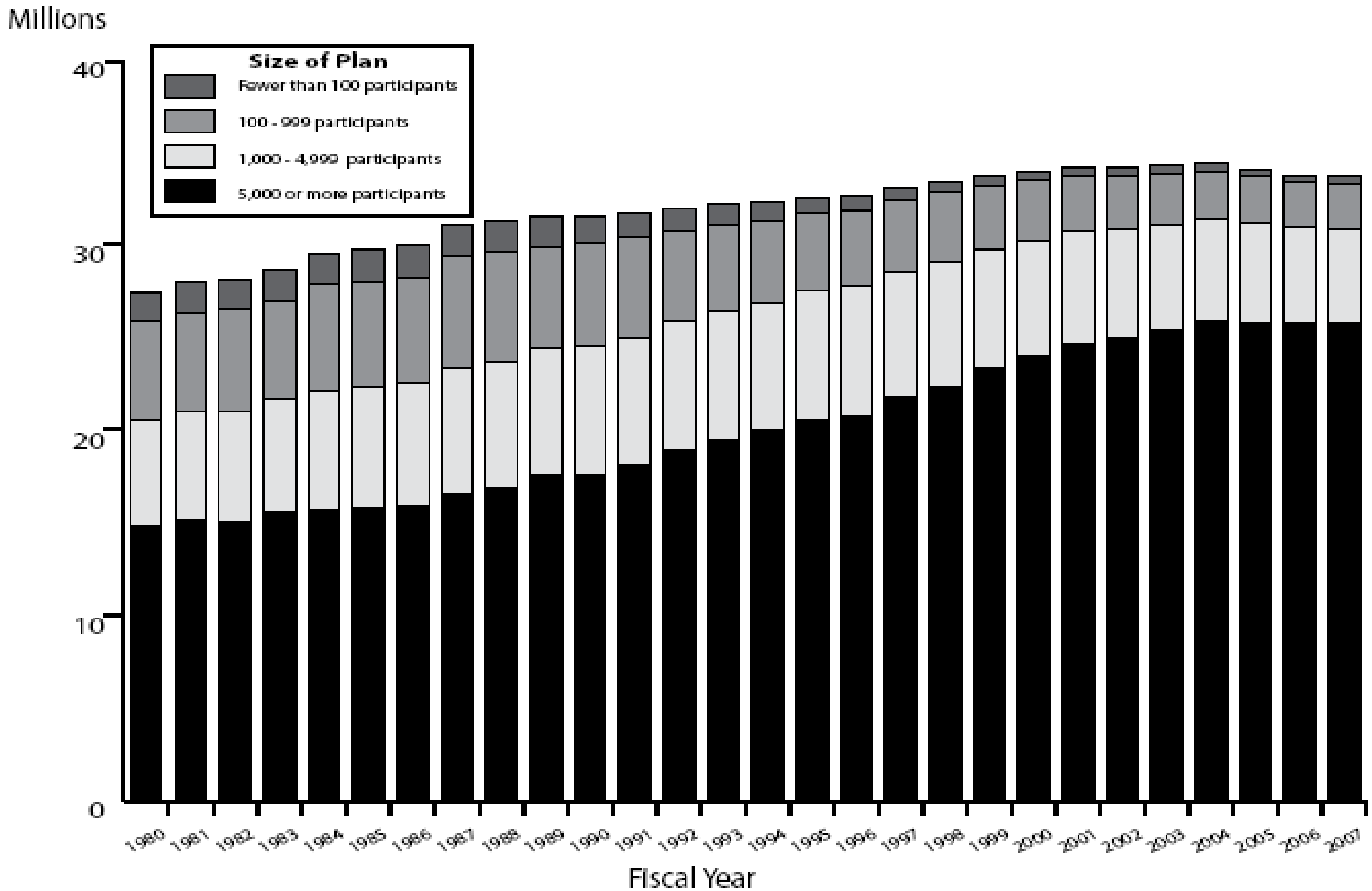
…. was completely legal, and gave rise to no litigation, ….

- …. but caused such a furore that in 1974 the US Congress passed the Employee Retirement Income Security Act (ERISA), which:
  - created a legislative framework for occupational pensions in the US and
  - created the Pension Benefit Guaranty Corporation, which was mandated to insure the DB pension liabilities of US companies

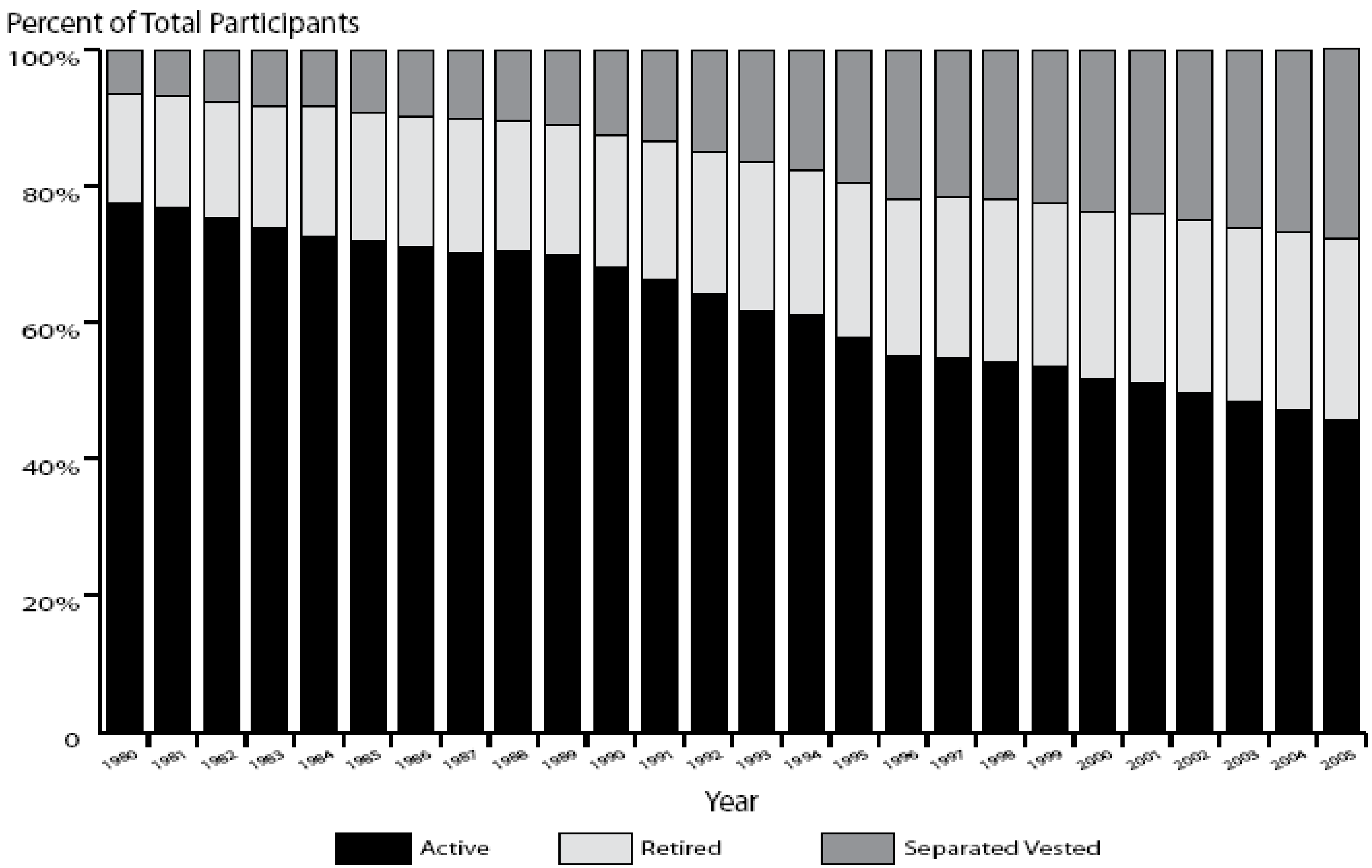
Number of PBGC-covered plans



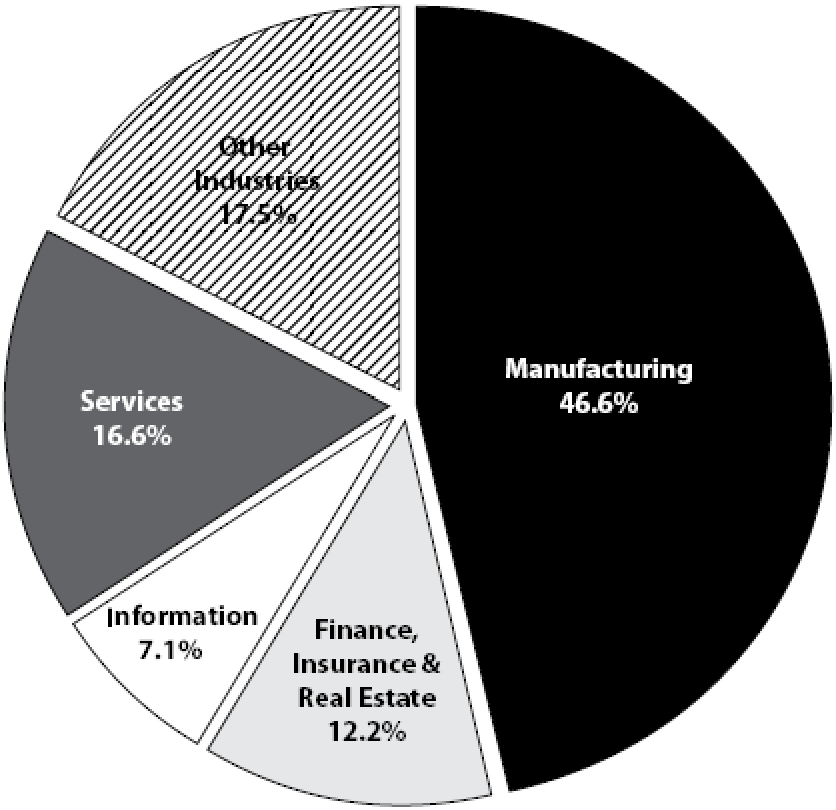
Covered members



Covered members split by type



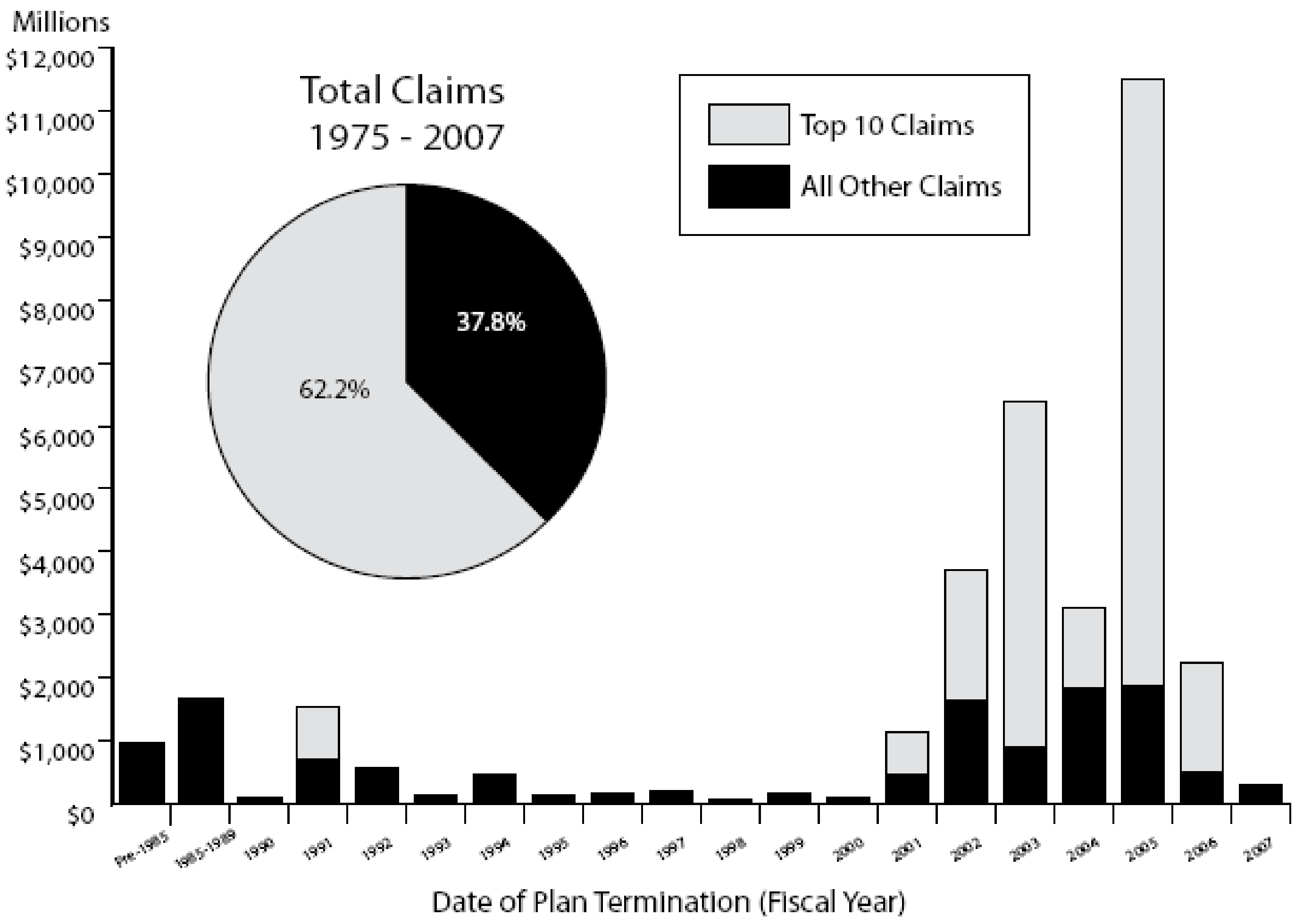
Liabilities by industry



Major Manufacturing Groups:

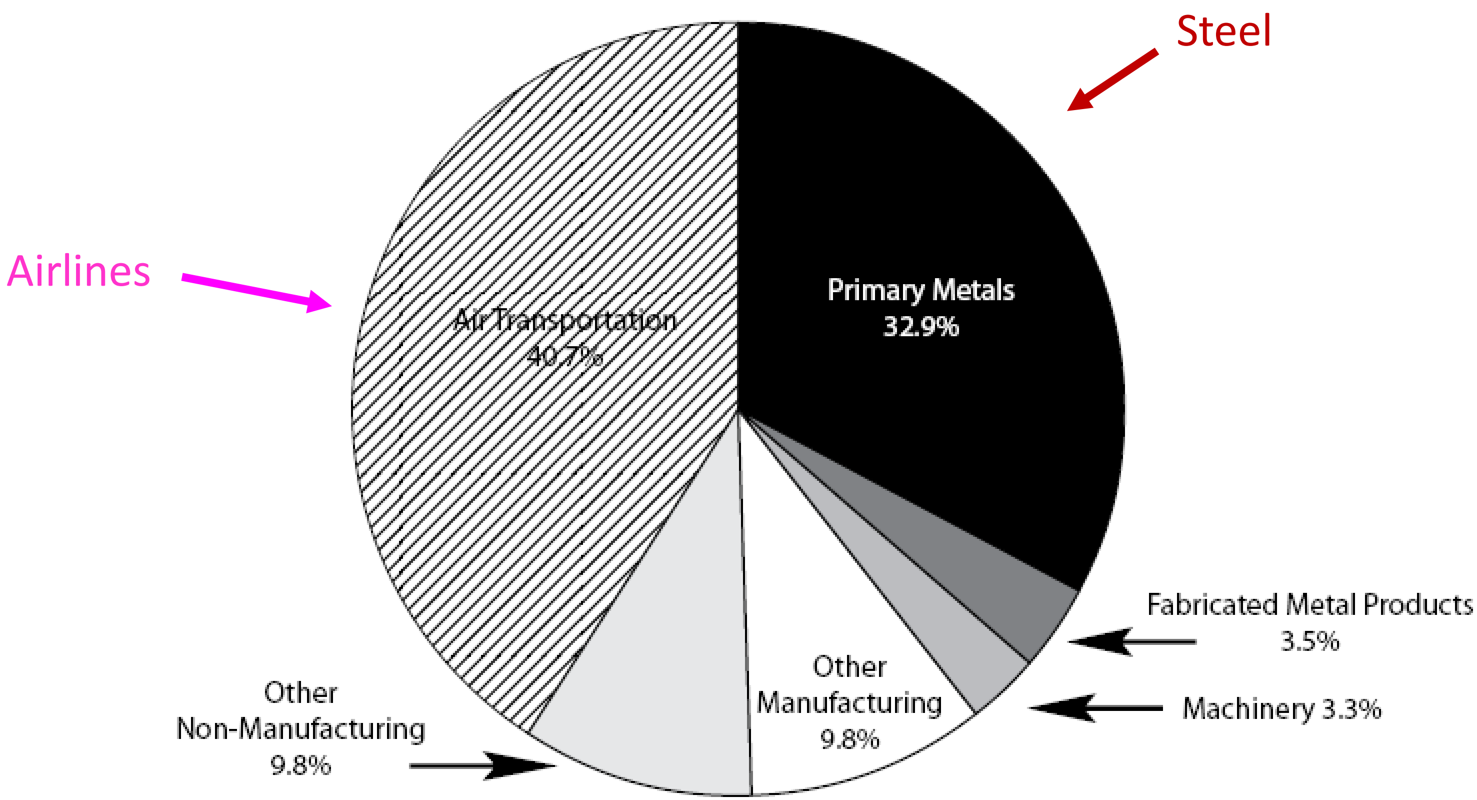
Motor Vehicles	6.1%
Chemical & Allied Products	5.1%
Food & Tobacco	3.8%
Machinery	2.5%
Primary Metals	1.7%

Claims are heavily skewed

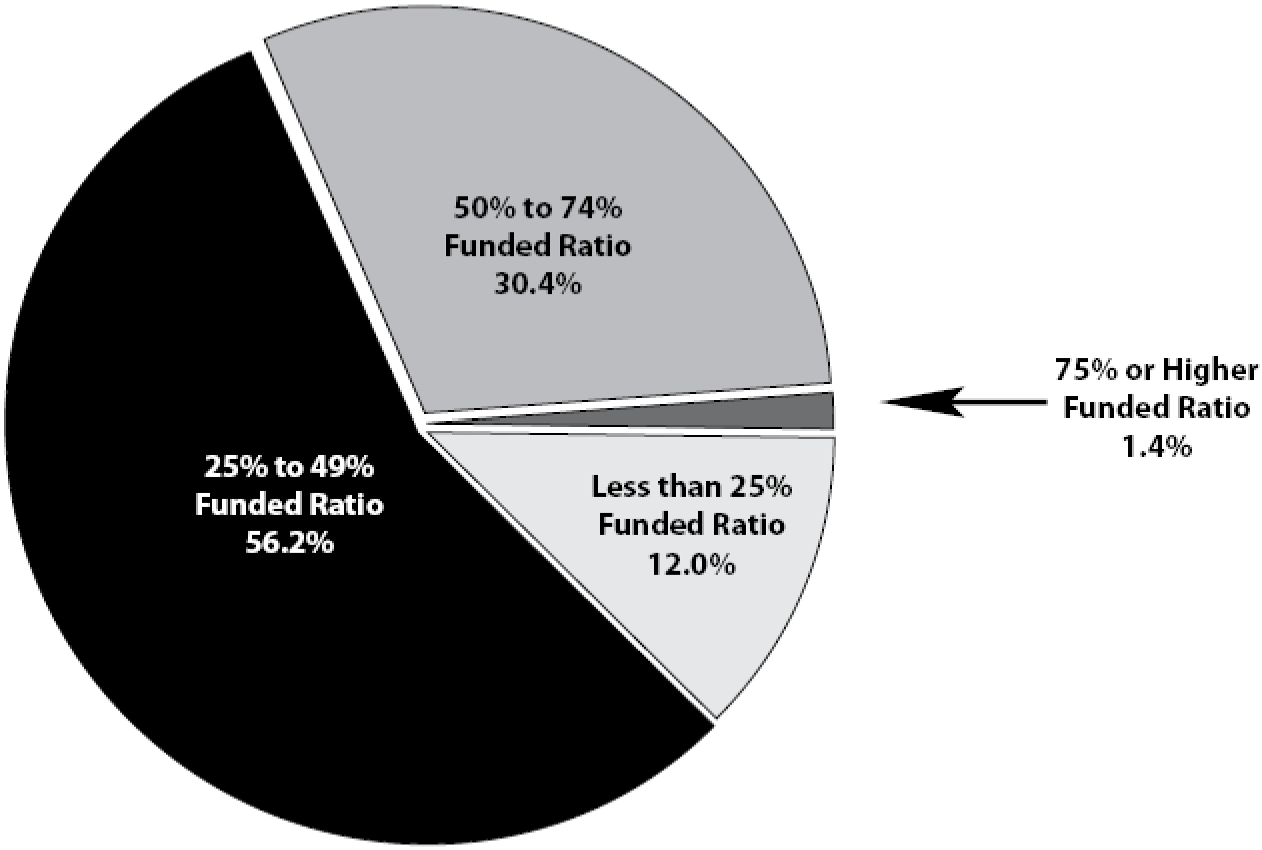


PBGC net claims (after plan recoveries), nominal $M

Claims concentrated by industry....



…and driven by poor plan funding



Why is this?

- Is it an endemic feature of a pension insurance system?
- If not, how can it be avoided?
- Prof Anthony Neuberger and I built a model of pension insurance to answer these questions
- (The model we chose was intended to illustrate broad principles, turns out it is quite difficult to calibrate in practice to credit spreads)

Model: pension fund

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
- Invested in stocks and bonds

Model: contribution policy

Proportion in equity

ERP

Assets:

$$dA = \Big[\underbrace{(r + x\alpha)A}_{\text{Asset return}} + (\kappa_t - \pi_t)\Big]dt + \overbrace{x\sigma A dz_1}^{\text{Equity risk}},$$

Contributions

Payments to pensioners

ERP assumed in setting contributions

Contributions:

$$\kappa_t = \left(\pi_t + \underbrace{\frac{dL_t}{dt}\frac{A_t}{L_t}}_{\text{Keeps solvency ratio constant as liabilities change}} - (r + x\hat{\alpha})A_t\right) + \underbrace{\left(\frac{L_t - A_t}{T}\right)}_{\text{Amortisation of deficit over } T \text{ years}}.$$

Model: contribution policy

Letting $a_t = A_t / L_t$ gives:

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

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:

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

Premiums collected while firm solvent

Indicator variable = 1 if firm is solvent

Amount paid by PPF when firm defaults

Risk-neutral density

Premium process

- Many different ways of collecting premium are possible
- So 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

Default rate

- Initially we assume that the default rate is a Poisson process with constant intensity δ

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

- We calculate the steady state distribution of a and evaluate the expectation numerically

Annual premium: fixed default rate (0.25%)

Premium in £/year per £1000 of liabilities	Equity Proportion		
	1/3	2/3	1
Base Case	0.418	0.722	0.956
Higher solvency cap: a^* = 200% (120%)	0.417	0.716	0.943
Stricter solvency: T=4 yrs (10)	0.199	0.378	0.540
No risk premium: a = 0% (6%)	0.140	0.319	0.484

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 annum, equities have an expected return of 6% in excess of the risk-free rate, deficits in the fund are made up over 10 years, and the fund value is not permitted to exceed 120% of guaranteed liabilities. The premium is shown as a percentage of liabilities for different investment strategies. The other lines of the table show how the cost varies as each of the input parameters is varied. Base case values are shown in parentheses.

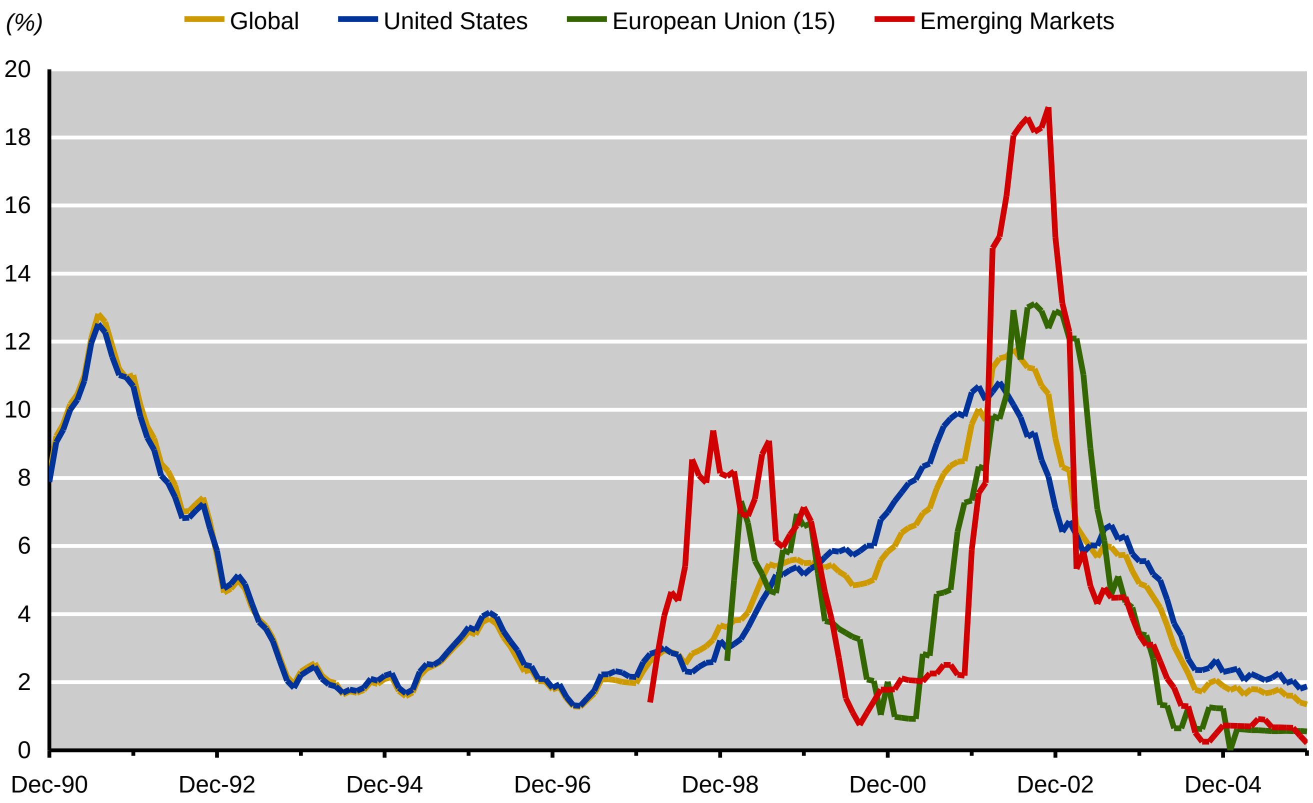
Variable default rates are important

- 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

Possible approach I

- Fitting empirical evidence on default directly
- But few defaults (esp investment-grade) and high autocorrelation

Chart 7. **Trailing 12 Month Speculative Grade Default Rate**



Source: Standard & Poor's Global Fixed Income Research; Standard & Poor's CreditPro® 7.02.

Possible approach II

- 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 III

- 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

- Extension of Merton's model, with firm altering leverage ratio to match changes in its solvency
- Based on Collin-Dufresne & Goldstein (2001)
  - Debt is a claim on firm assets
  - Assets follow diffusion process
  - Firm adjusts leverage ratio through their financing strategy, causing mean reversion to some level

Merton (1974)

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

Constant correlation with pension fund assets

Log leverage ratio

Mean reversion parameter

Long-run mean value

Innovation in firm's 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
- Consistent with Poisson default model
  - 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

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

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, β = 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.

Conclusions

- Claims are caused by the investment of pension plans in equity and the correlation between firm default and equity prices
- Pension insurers need reserves equal to a large multiple of annual premium to avoid deficit
- Risk can be reduced by imposing strong funding requirements

Pension Protection Fund

- Was introduced in 2004
- Two parts to the levy
  - Scheme-based levy
  - Risk-based levy
    - Based on amount of underfunding (on a bond basis) and sponsor’s credit score
- PPF modelling confirms NM’s prediction of highly skew claims distribution (95% VaR £4.3bn over 5 years, expected 5-year claim > £4.3bn is £7.4bn)
- Risk-based levy aims to control moral hazard (which variables missing?)

Keys to PPF success

- To the extent that scheme PPF levies simply reduce scheme funding, the PPF is ineffective
  - E.g. schemes with very poor credit ratings cannot simultaneously pay levies and fund their schemes, so the PPF effectively becomes a funding vehicle for these schemes
- PPF needs to collect money from schemes *before* their credit ratings decline to these levels, and increase total sponsor funding to pensions
- If we start off in a situation where there are some firms with pensions that are so underfunded that they cannot possibly pay the fair value of their insurance, some degree of cross-subsidisation is inevitable

Premium smoothness

- The PPF can mandate firms to buy insurance from it
- Therefore, it should insure firms over their whole lives rather than on a one-year basis
- Think of the analogy with whole life insurance
- The PPF must collect money from firms while they can still pay it (effectively use the PPF insurance as a way of advancing the claims of pension funds in bankruptcy by reducing the payment that other stakeholders receive in bankruptcy)
- Arguably, much more effective to ensure that pensions are fully funded relative to the PPF benefits (i.e. to keep the funding within the plan rather than inside the PPF)

The “absolutely fair” premium is not smooth

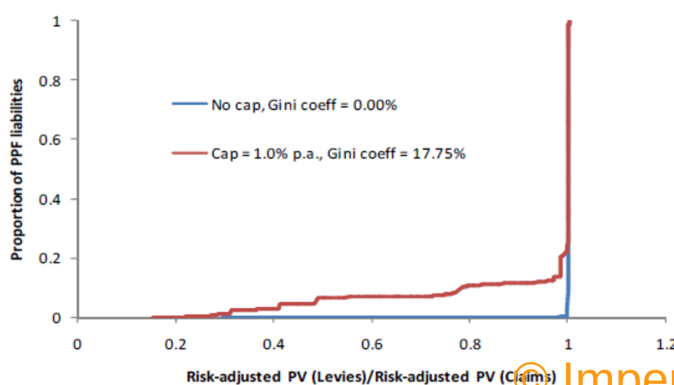
- A levy design that is constrained to be absolutely fair will have safe schemes paying very little, and risky schemes paying a lot
- But risky schemes cannot afford to pay without reducing scheme funding, defeating the object of insurance in the first place
- (Levy fairness and levy smoothness conflict)

Risk-neutral calibration

No cap	Funding ratio						
Rating	0.7	0.8	0.9	1	1.1	1.2	1.3
Aaa and Aa	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
A	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%
Baa	0.4%	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%
Ba	1.2%	0.9%	0.6%	0.4%	0.2%	0.1%	0.1%
B	1.8%	1.4%	1.0%	0.7%	0.4%	0.2%	0.1%
Caa and below	5.2%	4.2%	3.1%	2.0%	1.1%	0.4%	0.0%

Cap = 1% p.a.	Funding ratio						
Rating	0.7	0.8	0.9	1	1.1	1.2	1.3
Aaa and Aa	0.3%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%
A	0.7%	0.5%	0.3%	0.2%	0.1%	0.1%	0.0%
Baa	1.0%	1.0%	1.0%	0.8%	0.5%	0.3%	0.2%
Ba	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
B	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.8%
Caa and below	1.0%	1.0%	1.0%	1.0%	1.0%	0.9%	0.4%

Cap = 0.5% p.a.	Funding ratio						
Rating	0.7	0.8	0.9	1	1.1	1.2	1.3
Aaa and Aa	0.5%	0.3%	0.2%	0.1%	0.1%	0.1%	0.0%
A	0.5%	0.5%	0.5%	0.5%	0.4%	0.3%	0.2%
Baa	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Ba	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
B	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%

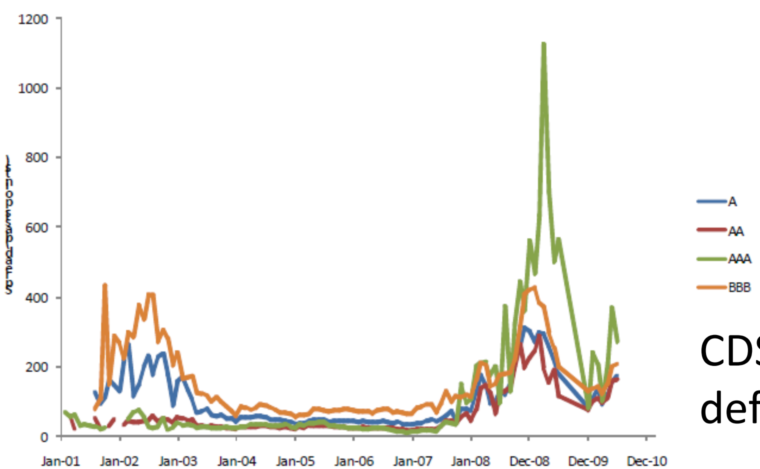


The model we used for this analysis

- Used a jump-diffusion model for firm leverage ratios (to try and get adequate risk premiums for higher-rated bonds)
- And was calibrated directly to risk-neutral default probabilities measured off CDS rates (because the theoretical risk premium was unable to match observed spreads on corporate bonds)

$$ds = [\mu_s + \kappa(\bar{s} - s)]dt + \sigma_s dz_s - Jdw$$

Exponentially-distributed jump following a Poisson process



CDS-implied one-year RN default probabilities

Sharpe (1976)

- We learned from Sharpe (1976) that if the PBGC did not charge companies fairly for the protection it offered, then this created a "PBGC put" which gave companies an incentive to maximise the difference between the value of the insurance they received and the value of the premiums they paid
  - When the PBGC was created, companies had the right to pass liabilities onto the PBGC without defaulting
  - This is no longer the case, but Chapter 11 bankruptcies in the US often involve negotiations with the PBGC about how much they will cover (and termination premiums)

Empirical work on the PGBC put

- The PBGC has never really charged “fair” premiums
  - Started off with a fixed fee per member, to which was subsequently added a variable premium based on scheme underfunding
  - No allowance for investment mix or sponsor credit quality
  - Therefore there was potentially large scope for companies to maximise the value of their PBGC insurance by underfunding their schemes and by investing the scheme assets in risky ways
  - Part of risk-shifting more boradly

Little actual evidence

- However, economists have failed to find convincing empirical evidence that this is actually happening
  - Bodie et al (1985, 1987)
  - Petersen (1996)
  - Hsieh et al (1997)
  - Coronado and Liang (2005)
- All these studies find conflicting evidence that firms systematically alter their behaviour in order to increase the value of the PBGC put

Rauh (2006a)

- Shows that firms in financial distress actually have motivation to *reduce* the risk they take in their pension plans
  - This is because they wish to avoid unanticipated pension-related cash flows which may constrain their investment options in the rest of their businesses
  - They demonstrate that DB pension contributions have depressed capital investment at the firm level
  - This is in line with a whole literature on risk management in firms, which is based on the idea that internal capital is cheaper than external, financial distress costs, concave tax schedules, dynamic investment opportunities

Rauh (2006b)

- Examines the extent of risk shifting in US pension plans
- Finds that, in the US,
  - Underfunded plans invest more in bonds and less in equities
  - Plans of firms which have higher probabilities of default are invested more in bond and less in equities

Maximum upper bound

- Moral hazard => plans which ended up at the PBGC should have taken more risk than plans that did not
  – BUT plans that took more risk are more likely to land up at the PBGC
- Hence, the difference between the risk taken by plans that landed up at the PBGC and other plans is an upper bound of the total risk shifting that could have occurred
  – Effect is small, and more consistent with reverse causality than with risk shifting (issue of with controls or without)
- Plans which terminated did not have more volatile asset returns than plans which did not, either

Conclusion

- PBGC / PPF put does not appear to exert much influence on firm behaviour
- It must be smaller than other incentives firms have to reduce risk as they approach bankruptcy
  - Mandatory ERISA contributions
  - Bankruptcy costs
  - Forgoing profitable investment opportunities
  - “Wedge” between cost of internal capital and cost of external capital

Other models

- German model is that firms can fund pensions internally (*Direktzusagen*) by creating book reserves of assets on the balance sheet of the company
  - Sometimes, pension assets are segregated from company assets using CTA’s (contractual trust agreements), but legally treated as book reserves
- These book reserves are insured against the bankruptcy of the sponsor by the *Pensions-Sicherungs-Verein auf Gegenseitigkeit (PSVaG)*
- There are also externally funded pensions
  - *Pensionskassen*
  - *Direktversicherung*
  - *Unterstützungskassen*
- Majority of German occupational pensions are *Direktzusagen*

Pension insurance in Germany

- PSVaG used to operate on a pay-as-you-go basis
- Levies were charged each year on the sum total of *Direktzusagen* (calculated on an entry-age basis) which varied from 0.15% to, in 1982, 0.69%) so that the outgoings matched the incoming liabilities, which are farmed out to a consortium of German life insurance companies
- All firms, regardless of bankruptcy probabilities, pay the same premium, so there is more potential for moral hazard than in the UK system (but roughly the same as the US)
- In 2006, they commenced pre-funding liability out of concern for the long-term solvency of the PSVaG
- PSVaG benefits limited to 3xSS contribution ceiling in Germany

Comparison of different systems

- *Ex ante* vs *ex post* cross subsidies
  - Which type leads to potential for moral hazard?
- Importance of funding regulation
- Limitations on benefits
- UK system is effectively part book-reserved
- Declining industries & changing composition of insured funds
- Extent of systemic risk similar between US and UK, but arguably lower in Germany
- Pesando discusses pension insurance in different countries

Conclusion

- Why insure pensions?
  - History of pension insurance in the US and UK
- A model of pension insurance
  - Pricing pension insurance
  - Systemic risk
  - When to collect premiums?
- Moral hazard
- Other possible models
- Conclusion