University of Bath
School of Management

Defined Contribution Pension Schemes Investment Options: An International Comparison

Edmund Cannon (University of Bristol)
Ian Tonks (University of Bath)

Actuarial Profession – Pensions Conference

Celtic Manor Resort, 5-7 June 2013

University of Bath
School of Management

Move to DC pension Schemes

- International demographic trends: ageing population, falling birth rate, declining support ratio; sustainability of PAYE state pensions
- Policy response to demographic trends is to shift burden of pension provision to individuals
- International phenomenon:
  - World Bank (1994),
  - EU (DG ECFIN, 2001, 2006, 2009)
- Questions:
  - How much risk do individuals bear with shift to DC schemes?
  - Are there investment options that reduce these risks

Pension Reforms: Individual DC accounts

- All OECD countries have some individual DCs
  - US (401K plans);
  - UK (personal & stakeholder pensions);
    - Auto-enrollment from 2012
  - Germany (Reister plans);
  - Australia (Superannuation Guarantee)
  - New Zealand (Kiwi saver)
- Recent EU members: Bulgaria, Estonia, Latvia, Lithuania, Hungary, Poland, Slovakia have shifted previous public pillar to mandatory funded private pillar
- Chile, Colombia, Chile, Peru, Argentina, Uruguay, Mexico, Bolivia and El Salvador all have individual DC schemes
- Notional DC's in Sweden & Italy
- Some countries have retained PAYG model but with reduced promised benefits:
  - France, Belgium, Czech Republic and Slovenia.

University of Bath
School of Management

Risks in DC Pension Schemes

- Inadequacy of pension:
  - insufficient income to *maintain* standard of living
- Appropriate metric is **"replacement ratio"**
  - size of the resulting pension income to final labour income
- Also consider **"fund ratio"**
  - size of pension fund to final labour income

$$replacement\ ratio_t = annuity\ rate_t \times fund\ ratio_t$$

80%? 5% - 10%? 8 – 16 ?

Sources of investment risk in a DC scheme?

- Fluctuations in earnings growth
- Rate of return on savings
- Type of savings scheme
  - (*eg* all equity or lifestyle)

Accumulation phase

- Annuity rate risk
- Drawdown
- Hedging
  - how are these components correlated?

Decumulation phase

University of Bath
School of Management

Measuring Hypothetical Replacement Ratios

- 10% savings rate out of earnings
- Earn average wages from age 25 to 65
- Re-invest all interest/coupons/dividends into the pension fund
- Buy a pension on retirement at 65
- Charges
  - Initial charge 5% (*so* effectively 9.5% savings rate)
  - Annual charges of 2% (equity) and 1% (bonds)

Four Asset Allocation Strategies

- Invest all in **equity**
- Invest all in **bonds**
- Invest **50:50** in equity & bonds
- **Lifestyle**:
  - All equity for 28 years, gradual move to bonds in next 9 years, all bonds last 3 years

University of Bath
School of Management

International Data on 16 countries for 106 years

Equity, bills, & bond returns

Dimson, Marsh and Staunton (2002) *Triumph of the Optimists* (updated to 2007)

Mortality tables

Human Mortality Database University of California, Berkeley and Max Planck Institute for Demographic Research

Bond yields

IMF *International Financial Statistics* supplemented by various central bank databases

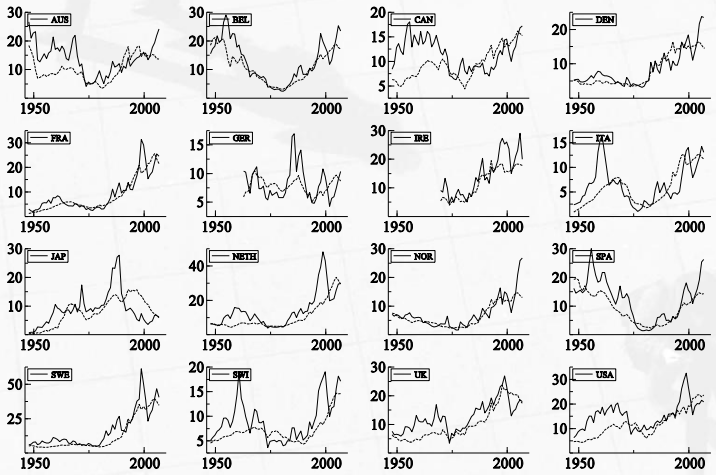
Wage growth

Mitchell (2003) *International Historical Statistics*

ILO Statistics and national statistical agencies

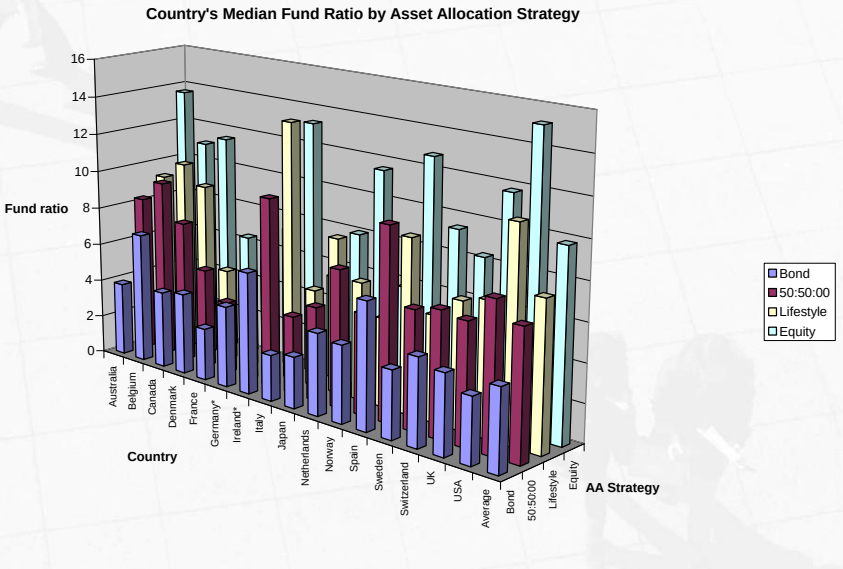
GDP growth rates from Maddison (2007) for some of the earlier years

Pension fund ratios for all-equity & lifestyle asset allocations



Country	Average equity fund ratio (%)
Australia	13.36
Belgium	6.28
Canada	11.40
Denmark	6.73
France	5.07
Germany	9.16
Ireland	12.11
Italy	5.23
Japan	6.69
Neth.	11.86
Norway	6.26
Spain	4.81
Sweden	9.62
Switz.	8.42
UK	11.88
USA	14.96

University of Bath
School of Management



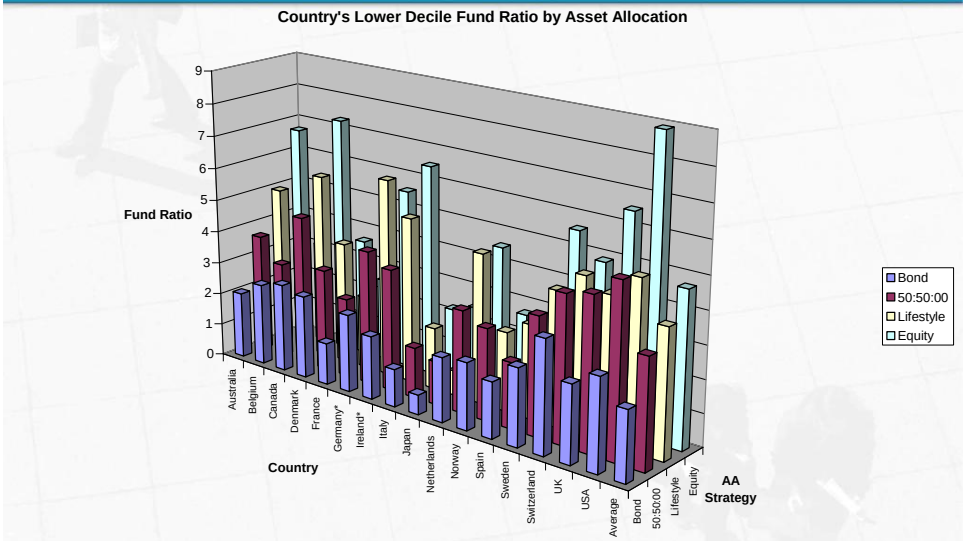
	Country's Median Fund Ratio		Country's Lower Decile Fund Ratio	
Country	**Equity**	**Lifestyle**	**Equity**	**Lifestyle**
Australia	13.36	9.29	6.26	4.83
France	5.07	4.71	2.71	2.06
Germany	9.16	8.73	6.28	7.33
Italy	5.23	4.87	2.21	1.79
Japan	6.69	6.74	1.75	0.62
Norway	6.26	4.96	2.76	2.45
Spain	4.81	3.49	1.24	2.19
Sweden	9.62	5.48	5.68	4.18
UK	11.88	7.07	6.65	4.57
USA	14.96	10.64	9.01	4.95
Average	**8.99**	**6.60**	**4.67**	**3.88**

In Germany & Spain, Life-style provides better downside protection

University of Bath
School of Management

Effect of constant 1.5% wage growth: fund ratios much higher

	Median Fund Ratio (actual wage growth)	Median Fund Ratio (1.5% wage growth)	
Country	**Equity**	**Equity**	**Lifestyle**
Australia	13.36	29.71	18.39
France	5.07	44.65	42.69
Germany*	9.16	20.42	21.52
Italy	5.23	39.67	40.88
Japan	6.69	173.38	59.61
Norway	6.26	10.55	8.99
Spain	4.81	23.07	23.24
Sweden	9.62	23.60	17.82
UK	11.88	34.02	29.20
USA	14.96	27.40	20.48
Average	**8.99**	**35.62**	**25.37**



University of Bath
School of Management

Effect of annual charges

Fund invested in equity only

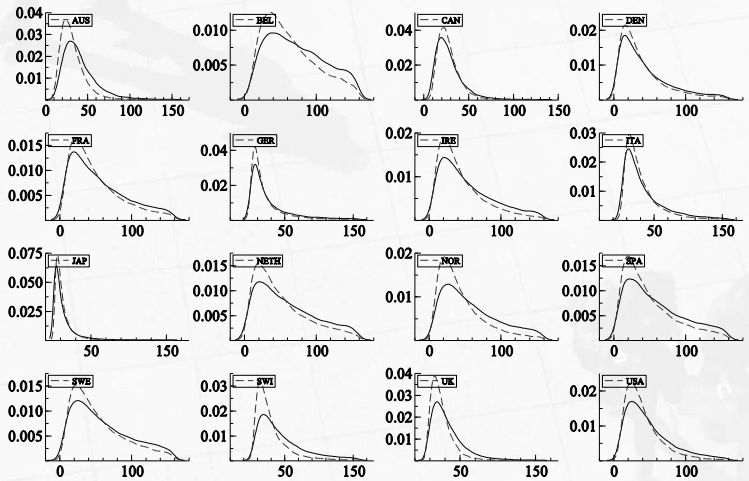
Annual Charges	2.0%	1%	0.3%
Australia	13.36	17.25	20.23
France	5.07	6.32	7.13
Germany*	9.16	10.10	10.61
Italy	5.23	6.37	7.20
Japan	6.69	9.59	10.53
Norway	6.26	7.25	8.46
Spain	4.81	16.27	19.25
Sweden	9.62	11.67	13.62
UK	11.88	14.49	16.86
USA	14.96	19.12	22.61
Average	**8.99**	12.14	14.12

Simulated Frequency Distribution of Replacement Ratios

- Initial analysis used historical data to construct pension fund ratios.
  - However observations not independent
- Simulation using VAR for equity yield, bond yield, and the growth rate of earnings
- Two lags and constant with no trend
- Simulate data from normal errors and bootstrap
- Simulate annuity rates from bond yields and country mortality tables
- Generate 20,000 replacement ratios

University of Bath
School of Management

Simulated pension fund ratios: Data post-1979



Simulated median fund ratios: data 1901-2007

	Aust	Den	Fr	Ger	Italy	Japan	Neth	Nor	Sp	Swe	Switz	UK	USA
Equity	20.4	10.3	8.0	12.3	6.8	5.8	11.8	7.7	7.1	14.2	9.3	12.5	15.4
50:50	9.3	7.3	5.1	8.4	4.4	4.0	7.3	5.9	4.9	8.2	6.7	7.1	8.6
Lifestyle	12.7	8.2	5.7	9.2	4.7	4.1	8.4	6.2	5.4	9.9	7.4	8.6	10.7

Simulated lowest decile fund ratios: data 1901-2007

	Aust	Den	Fr	Ger	Italy	Japan	Neth	Nor	Sp	Swe	Switz	UK	USA
Equity	8.4	3.3	1.9	2.9	1.7	1.7	4.0	2.6	1.9	4.3	3.6	4.9	5.9
50:50	4.5	3.0	1.6	3.9	1.5	1.2	3.5	2.5	2.1	3.8	3.6	3.3	4.7
Lifestyle	5.3	3.1	1.6	3.2	1.5	1.0	3.6	2.5	2.1	3.9	3.6	3.6	4.9

University of Bath
School of Management

Fund Ratio Simulation Results

- All-equity asset allocation dominates, average median value for all countries is 10.7
- But substantial downside risk for France, Germany Italy and Japan
  - For Germany & Spain life-style and 50:50 dominate equities at lower decile
- Considerable variation from using sub-sets of data:
  - Post-war returns result in high fund ratios and lower downside risk (except for Australia & Spain)
  - Average fund ratios higher post-1978 (except for Japan)

Simulated Pension Replacement Ratios

	Simulated Pension Replacement Ratio		With Constant Annuity Rate	Comparison of Risk
	Median	Lower Decile	Lower Decile	Ratio of St Dev
Australia	0.91	0.65	0.55	0.86
France	0.55	0.21	0.24	0.71
Germany*	0.96	0.81	0.76	0.62
Italy	0.55	0.22	0.23	0.75
Japan*	0.82	0.50	0.06	0.54
Norway*	0.42	0.27	0.26	0.87
Spain*	0.67	0.39	0.31	0.55
Sweden	0.64	0.34	0.46	0.85
UK	1.15	0.36	0.53	0.84
USA	1.22	0.32	0.49	0.97
Average	**0.79**	**0.42**	**0.43**	**0.77**

University of Bath
School of Management

Pension Replacement Ratios

- For nominal annuities average replacement ratio is 0.79
- Mean value of lowest decile is 0.42,
  - but some countries (France, Italy, Japan, Norway, Spain, Switz) have 10% prob of replacement ratios less than 0.42
- Risk in replacement ratios is less dramatic than in fund ratios because of low correlation between equities and bonds which hedge risks

Pension Guarantees

- "Defined Ambition pensions"
  - Hybrid DB/DC
- Money back guarantees
  - Cumulative sum of payments returned if fund value less than cumulative sum
- Problems:
  - Guarantees are expensive: value of put-option
  - Replacement ratio from money-back guarantee is low
  - Mis-selling?

University of Bath
School of Management

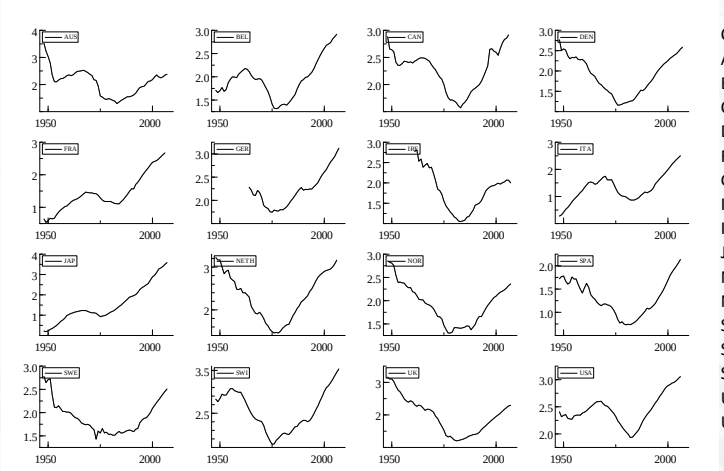
Value of Money Back Guarantee

INPUTS:	
Stock price (P)	2000
Exercise price (EX)	2000
Interest rate, percent (r)	3.5
Maturity in years (t)	40
Annual standard deviation, percent (s)	23.57
Equivalent continuously compounded rate, percent	3.56
DY	3
INTERMEDIATE CALCULATIONS:	
PV(EX)	493.1939
d1 = log[exp{-DY*t}*P/PV(EX)]/s√t + s√t/2	0.8673
d2 = d1 - s√t	-0.6234
N(d1) = delta	0.8071
N(d2)	0.2665
Black-Scholes OPTION VALUES:	
Call value = N(d1) x P - N(d2) x PV(EX)	345.99
Put value = Call value + PV(EX) - S	247.65

8% of median earnings

=248/2,248
=11%

Pension fund ratios from money-back guarantees



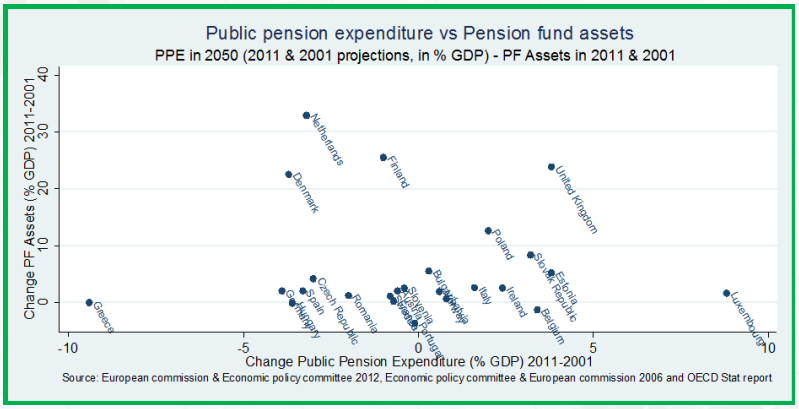
Country	Fund ratio (%)
Australia	2.08
Belgium	1.95
Canada	2.26
Denmark	1.89
France	1.43
Germany	2.22
Ireland	1.79
Italy	1.32
Japan	1.53
Neth.	2.32
Norway	1.93
Spain	1.31
Sweden	1.90
Switz.	2.56
UK	1.97
USA	2.44

University of Bath
School of Management

Solutions?

- Regular updates on DC fund value, with projected replacement ratio
  - Similar to endowment mortgage "red letters"
  - Allows:
    - Adjust contributions through working life
    - Adjust date of retirement
- Important role for basic state pension to provide "floor"

Is private savings replacing public sector pensions?



Source: Nkouchou and Tonks (2013)

University of Bath
School of Management

Conclusions

- Paper assesses risk in DC schemes using historical data on international bond & equity returns
- Actual replacement ratios vary across countries and time
- The different risks partially hedge each other
- Simulated replacement ratios do show sizeable risk
- Ambiguous optimal investment strategy