Mortality improvement select birth cohorts and their effect on pricing of survival bonds

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Pricing mortality improvement

- Increased interest in mortality improvement (or, more accurately: longevity improvement) related to pensions/retirement policy.

- Unprecedented improvements in the twentieth century. Lack of market instruments to hedge the risk

- *Survivor bond:* market instrument, can help in pricing and development of the annuities market. Coupon proportional to the number of survivors in a chosen population cohort.

Risks resulting from mortality improvement

- The standard market risk of interest rates, related to extension in maturities of payments. We'll call this *market risk of interest rates.*

- The uncertainty of the magnitude of mortality improvement. We will call this *mortality improvement trend risk.*

- The uncertainty of the fluctuations in the process of mortality improvement. We will call this the *cohort effect risk.*
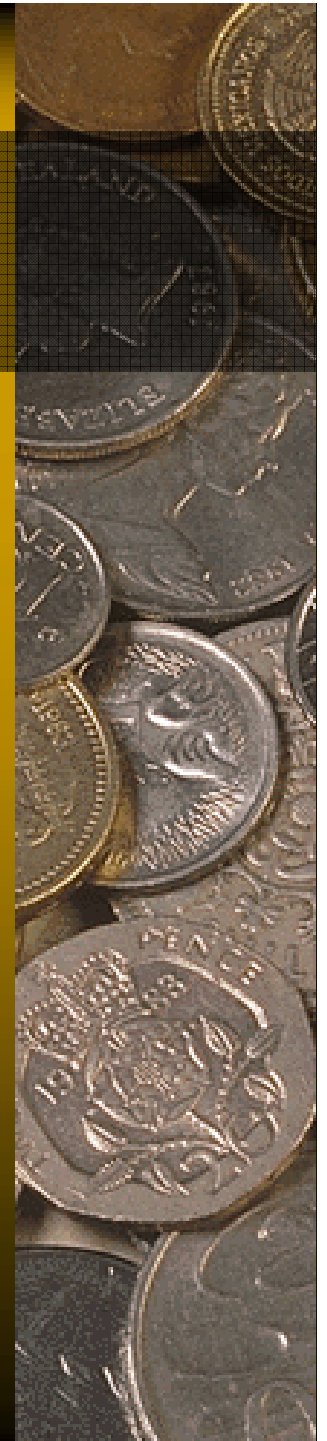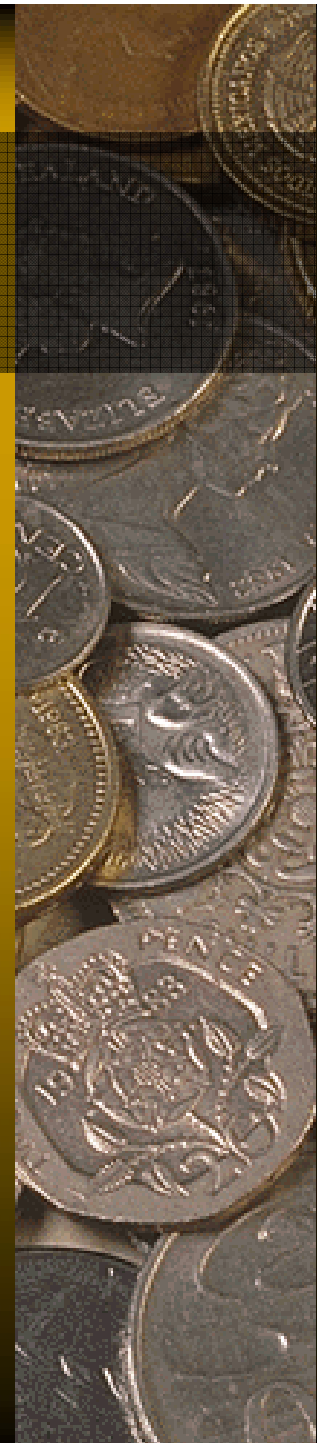
Select birth cohort

- Age cohort or generation characterized by greater rates of mortality improvement than previous and subsequent generations.

- Willets (1999) calls this the *cohort effect*, describing it as a "wave of rapid improvements, rippling upwards through mortality rates in the United Kingdom."
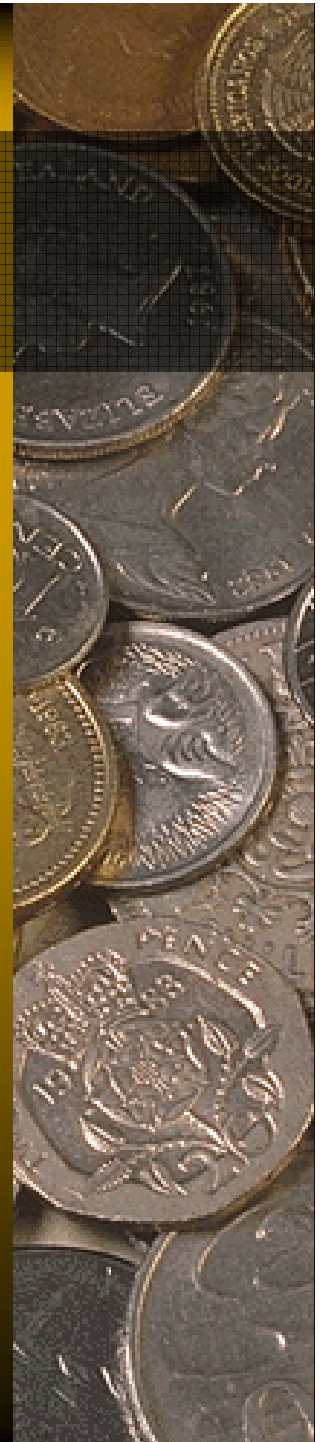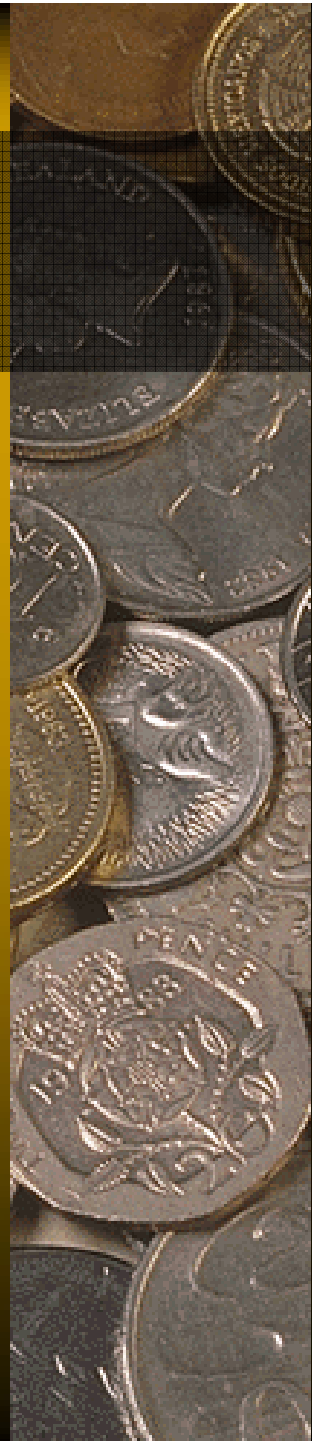
Mortality improvement defined

$$^{z}i_x = -\left(\frac{^{z}m_x - ^{z-1}m_x}{^{z-1}m_x} \right) = 1 - \frac{^{z}m_x}{^{z-1}m_x},$$

Defining a select birth cohort

- A *select birth cohort* with respect to *longevity improvement* is a birth cohort, whose relative longevity improvement exceeds that of the birth cohort just before it and just after it at the majority of individual ages.

- Alternative approach considers relative mortality improvement at each age for each birth cohort. Such specific value can be compared to a percentile (e.g., 90th percentile) of all values for the same age for the period studied. Used by Willets (1999).

Our purpose in this work

- Investigate the effect of select birth cohorts on the pricing of survivor bonds (and, by implication, life annuities and all retirement products), in comparison to the interest rate risk and mortality improvement trend risk.

- Estimate the effect of the cohort effect risk on the development of retirement products markets.
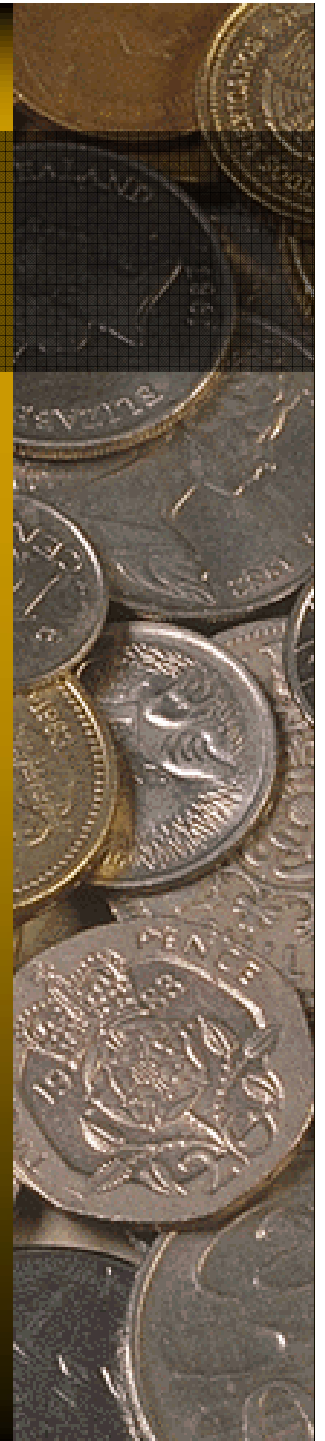
Mortality duration

$$_M D = - \frac{dP}{d\mu} \cdot \frac{1}{P} \cdot$$

An alternative measure of sensitivity to changes in rates of mortality. Of limited use, because it assumes constant force of mortality for all ages.
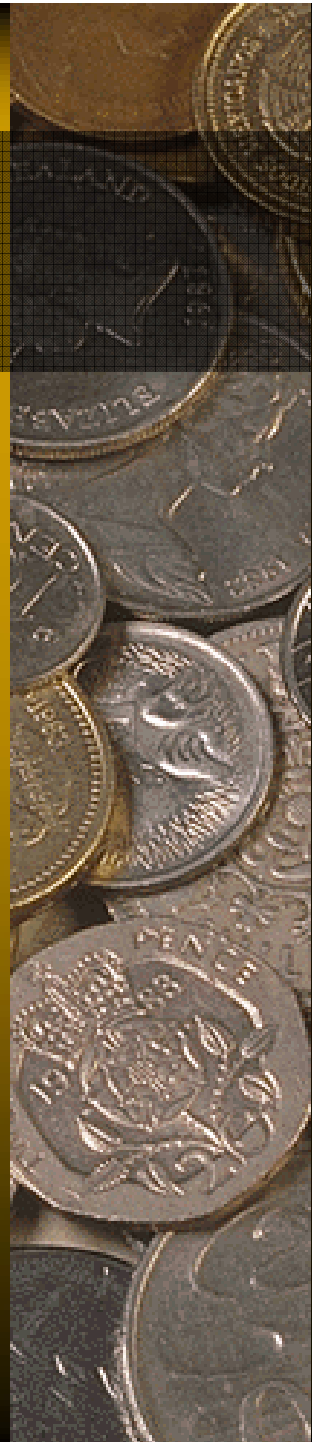
Effect of change in mortality

$$P\left(\mu^z\right) - P\left(^{z-1}\mu\right) \approx\ _M D(P) \cdot\ ^z i_x \cdot\ ^{z-1}\mu \cdot\ ^z \mu.$$

Illustration of possible use of mortality duration for estimation of the effect of mortality improvement on pricing of a financial instrument.

Comparing effects of interest rates and mortality improvement on life annuity prices

- Mortality improvement perceived as a substantial risk by most companies due to the trend risk uncertainty.
- Are the oscillations between birth cohorts also a substantial risk?
- What's the biggest risk: interest rates, improvement trend, or oscillations?
- No market instruments to hedge mortality risk …
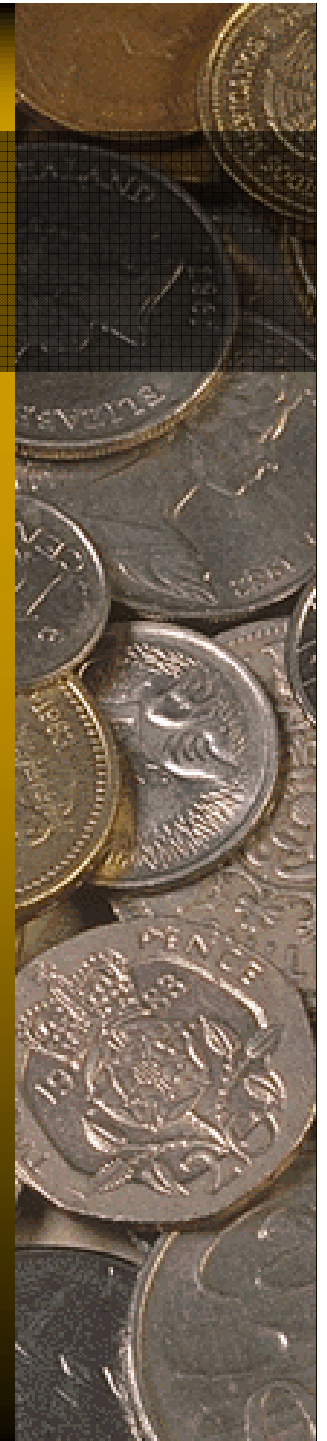
Effective duration of retirement annuity, age 65 to 100, England by year of birth
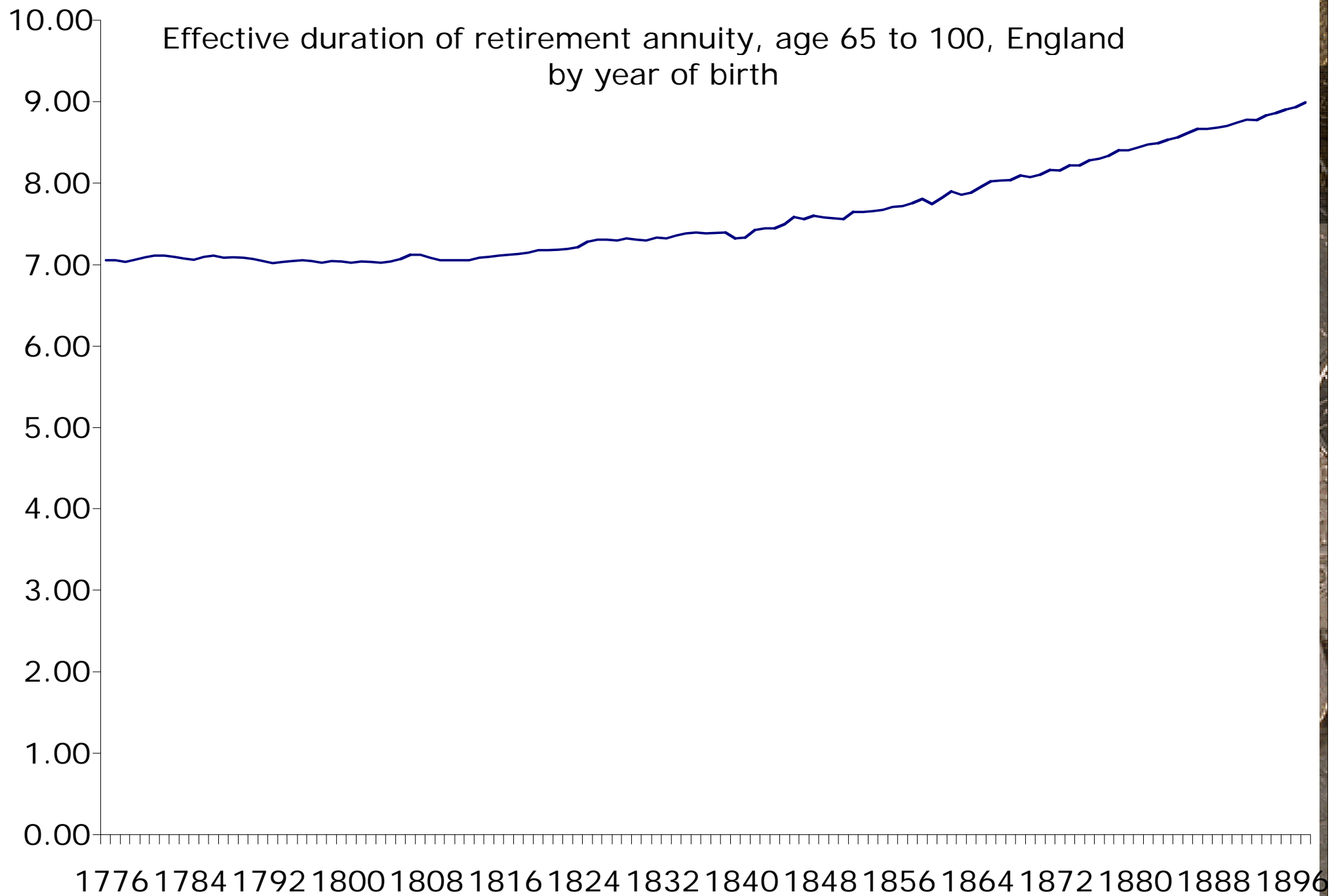
Effective convexity of retirement annuity, age 65 to 100, England by year of birth
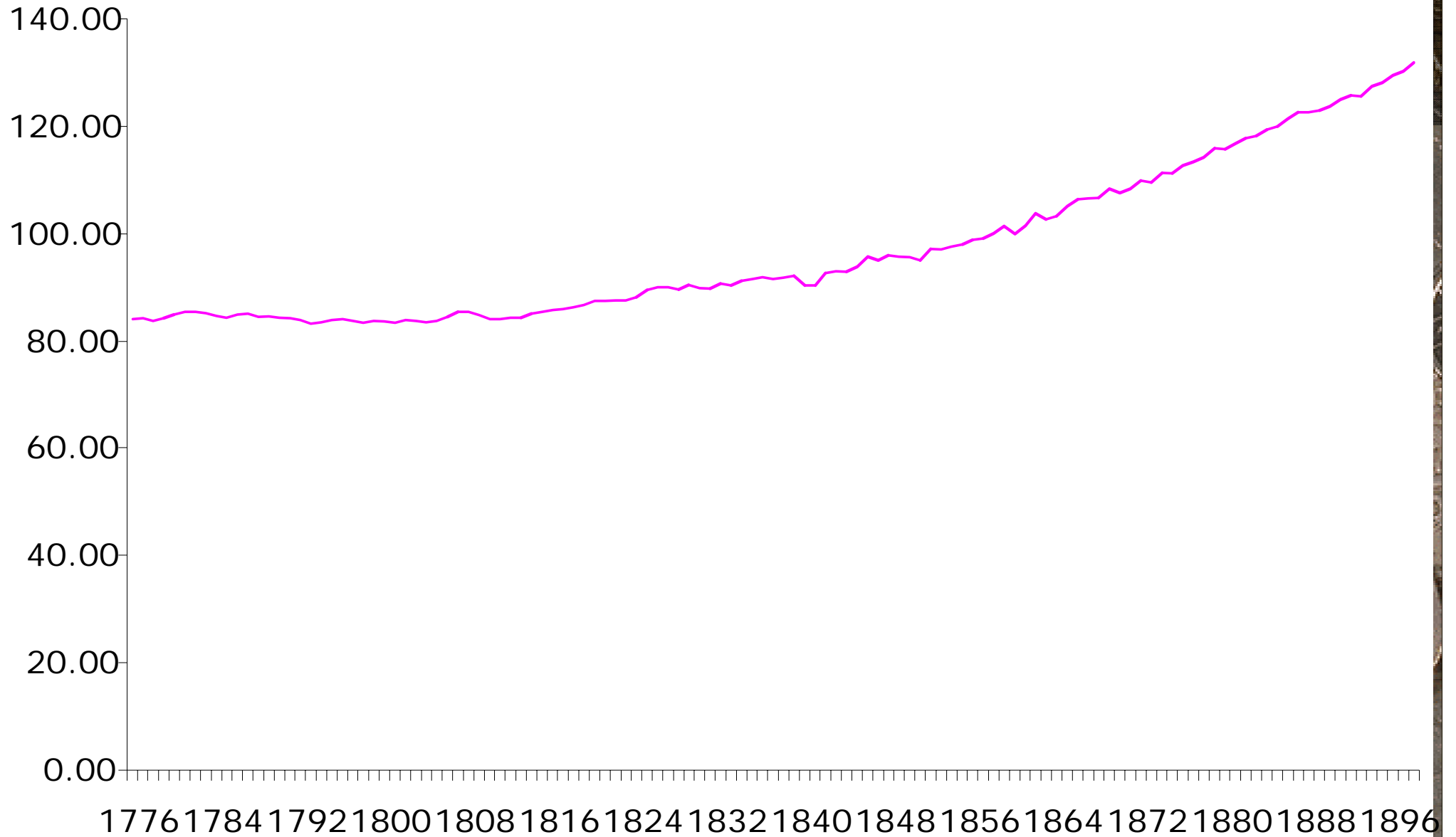
Annual oscillations in life annuity price from age 65 till 100, UK

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

The risk of select birth cohorts

- We estimate the upper range of risk to be about 1.3% of life annuity price for UK.

- Based on the upper range of estimates of duration and convexity for UK, this is equivalent to a little over 15 bps change in interest rates.

- 15 bps does not sound like much, but it is large in relation to profit margins of life annuity providers.

	CA	CH	FI	FR	IT	JP	NL	NO	SE	UK	US
Mean	35.9 bps	51.2 bps	283 bps	47 bps	114 bps	103 bps	29.7 bps	17.8 bps	31.7 bps	20.8 bps	71.4 bps
StDev	75.5 bps	235 bps	277 bps	84.7 bps	223 bps	124 bps	103 bps	71 bps	109 bps	60.7 bps	93.6 bps
n	40	91	89	68	94	14	121	121	116	122	5
Minimum	-170 bps	-1300 bps	470 bps	210 bps	-1300 bps	-90 bps	-320 bps	-210 bps	-380 bps	-140 bps	-23 bps
Median	44.6 bps	58.21 bps	485 bps	44.5 bps	176.33 bps	97.5 bps	30.7 bps	23.7 bps	35.5 bps	21.7 bps	51.6 bps
Maximum	175 bps	1098.98 bps	499 bps	234 bps	877.22 bps	312 bps	598 bps	187 bps	526 bps	215 bps	226 bps

1.3% (130 bps) change in value of life annuity from age 65 to age 100 is within one standard deviation from the mean for Switzerland, Finland, France, Italy, Japan, The Netherlands, Sweden, and the United States.

Debate about the nature of future mortality improvements

- Possibility of much better mortality improvement (Oeppen, Vaupel).
- But increasing obesity levels may reverse the trend (Olshansky).
- Can we end up with increased longevity of the retired population and increased obesity) with resulting higher mortality) of the working population?
- No market and no market price for this risk.
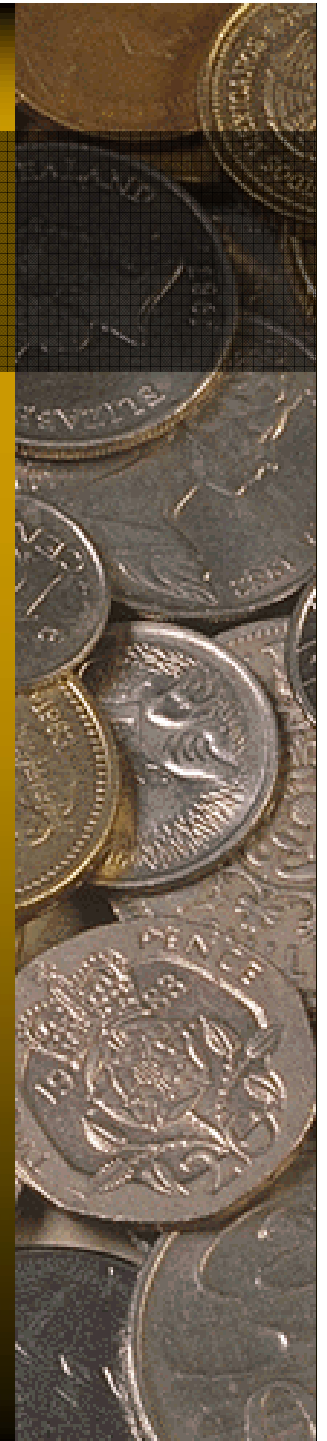
Market instruments for mortality risk

- Survivor bonds and other survivor instruments can help hedge the risk.
- But who will take the short side? Actually … governments have the short side of this position, and possibly view the risk as already excessive.
- Can Social Security Administration issue survivor bonds, as they are doing so anyway?
- On the other hand; Social Security already owns bonds issued by the Federal Government.
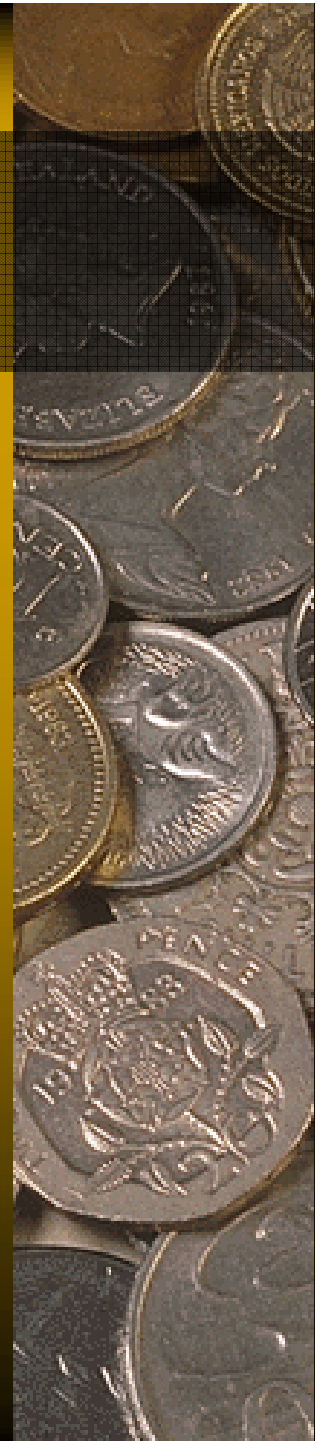
Social Security Trust Fund

- Principle 1: Non-intervention in the private economy.
- Principle 2: Security (investment assets should provide maximum degree of safety of principal and interest).
- Principle 3: Neutrality (Trust Fund investments should not be materially different than those available to other investors).
- Principle 4: Minimal management of investment.
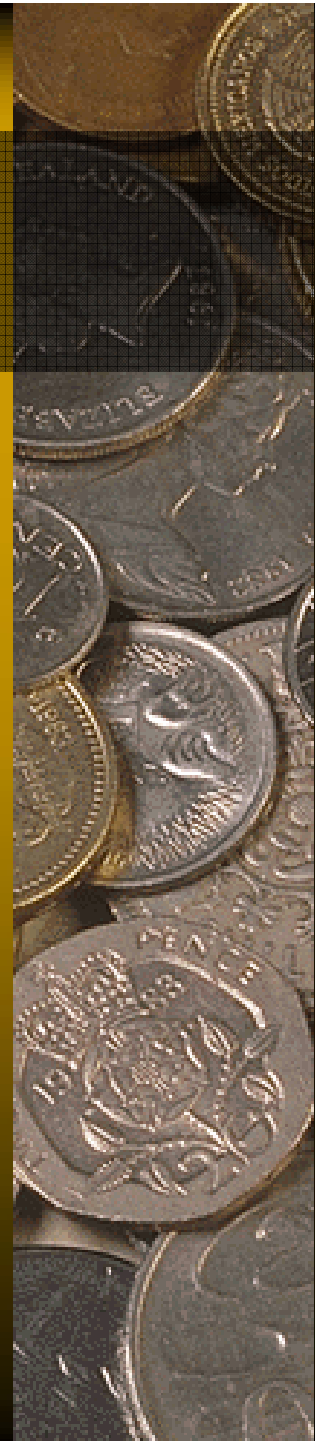
Work to do

- Applicability of this risk and use of survivor bonds for the entire global economy?

- Specifics of an investment policy for the Trust Fund?

- Individual accounts for Social Security with Trust Fund holding mortality derivatives only?