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Money's Worth of Pension Annuities

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Edmund Cannon and Ian Tonks have recently completed a book on Annuity Markets published by Oxford University Press in October 2008.

Glossary of terms

Annuity rate	The annual payment received by an annuitant divided by the purchase price. Where the annual payment is increasing over time, the annuity rate is the annual payment in the first year divided by the purchase price.
Compulsory-purchase annuity (CPA)	An annuity which is only available to individuals who have accumulated a personal pension fund, which has received tax relief. It is compulsory for the individual to use some (typically 75 per cent) of their pension fund to secure their income, usually through purchasing an annuity, but the precise details are complicated and the reader should consult the text for a full explanation (see also *Pension annuity*).
Concentration ratio	The fraction (usually expressed as a percentage) of a market which is supplied by a given number of firms. So if the five-firm concentration ratio is 70 per cent, it means the five largest firms provide 70 per cent of the sales and all of the smaller firms provide the remaining 30 per cent.
Defined-benefit pension	A pension where the amount of pension is linked to the pensioner's salary or wage. These pensions are typically provided by employers (occupational pension).

Defined contribution pension — A pension where the amount of pension received in retirement depends on the value of the pensioner's pension fund and the annuity rate at the time of retirement. These pensions can be provided by employers or can be personal pensions.

Enhanced annuities — Annuities sold to people with health problems or who have smoked. Annuity rates on such products tend to be higher, since the life expectancy of such individuals is lower.

Escalating annuity — An annuity whose annuity payments rise over time by a fixed amount in money terms every year. The most common product is for the annuity payment to rise by three per cent per year.

Fair price — The price of an annuity which ensures that the annuity provider makes zero excess profit after allowing for any load factors. If an annuity provider incurs zero load factors and prices annuities fairly then the money's worth of the annuity would be unity.

Guaranteed annuity — Any life annuity makes payments to the annuitant while the annuitant is alive (and these payments are certain). Some annuities may also make payments even after the annuitant has died (in this case the payments are made to the annuitant's estate). An annuity with a guarantee period of five years will make payments for five years or until the annuitant dies, whichever happens later. It is possible to buy annuities with guarantee periods of up to ten years, although five years is most common.

Level annuity — An annuity whose payments remain the same, in money terms, for the duration of the payments. This can be contrasted with a real (or Retail Price Index (RPI)-linked or indexed) annuity or an escalating annuity.

Life expectancy	The length of time that an individual can expect to live. In practice this is not known and must be estimated. Actuaries do this by estimating the mortality and then calculating the life expectancy using appropriate mathematical formulae.
Load factor	A measure of the extent to which the money's worth will be less than 100 per cent due to the administrative and regulatory costs and normal profits incurred by the annuity provider.
Money's worth	The expected present value of the annuity payments divided by the actual price paid. If the annuity is fairly priced then the money's worth is equal to one. Sometimes this is expressed as 100 per cent or as £1 per £1 purchase. In this report we express all money's worths as percentages.
Mortality	This is the probability of an individual dying in a short interval of time. Mortality increases with age. For a given age, mortality of men tends to be higher than mortality of women.
Normal profit	Minimum reward required by the annuity provider to remain in business.
Pension annuity	An annuity which is only available to individuals who have accumulated a personal pension fund, which has received tax relief (see also *Compulsory-purchase annuity*).
Price of an annuity	The amount of premium necessary to purchase an annuity paying £1 per year. The price is the reciprocal of the annuity rate. (Also referred to as premium or consideration.)
Purchase-life annuity (PLA)	An alternative name for an annuity purchased in the voluntary annuity market.
Real (or RPI-linked or indexed) annuity	An annuity whose payments rise over time in line with some measure of inflation.

Term structure of interest rates If money is borrowed or lent then it will be repaid at a point in the future called the term. It is common for payments in the future with different terms to have different interest rates. The term structure refers to the information on all of the different interest rates at a point in time for different terms. If these interest rates are plotted on a graph with the term on the horizontal axis, then the resulting graph is called the yield curve.

Voluntary annuity An annuity purchased freely in the purchased life market. Annuity rates for such annuities are typically lower than for annuities in the pension annuity market. The annuity payments from voluntary annuities are taxed differently from pension annuities.

Abstract

This report examines a time series of pension annuity rates in the UK for the period 1994 to 2007. The report computes the money's worth of annuities and finds that, on average, the money's worth over the sample period for 65-year old males has been 90 per cent, and for 65-year old females has been a similar but slightly larger 91 per cent. Taking into account load factors associated with annuity contracts and in comparison with other financial and insurance products this implies that annuities are fairly priced. However, the value of the money's worth is sensitive to the assumptions made about life expectancy, and we explain the assumptions made about the appropriate life tables to apply to annuitants in the pension annuity market. There is some evidence that money's worth has fallen since 2002. We discuss a number of factors that could have effected the fall in money's worth, including: changes in insurance regulation; changes in industrial concentration; an insurance cycle; pricing of mortality uncertainty and the growth in the impaired lives market.

Summary

In this report we construct a time series of United Kingdom (UK) pension annuity price quotes from 1994 to 2007 and examine whether these annuities were fairly priced over this period. The most important part of the analysis consists of looking at the changes in life expectancy for people approaching retirement and measuring whether this has been incorporated appropriately in annuity prices. This analysis is complemented by a discussion of changes in the market for annuities over the period.

The conventional methodology for valuing annuities is to calculate the 'money's worth' statistic, which should equal 100 per cent when annuity providers have no administrative costs and are making no profits: in practice the money's worth is typically less than 100 per cent due to the presence of administrative costs and the need for annuity providers to make 'normal profits' (i.e. a reasonable return for the company). The sum of the costs and normal profit is called the 'load factor'. If the money's worth plus load factors were less than 100 per cent, this would suggest either that firms were making excessive profits or that there was some other problem.

Calculations of the money's worth rely upon important assumptions about the life expectancy of individuals who are purchasing annuities and who might live for up to another 30 or 40 years. Since life expectancy is not known it has to be estimated and producing appropriate estimates has been made highly difficult in recent years by substantial increases in life expectancy. Annuity providers do not provide detailed accounts of the methods they use to calculate life expectancy and we would not expect them to do so since some of the information they use is commercially sensitive.

The period 1994 to 2007 has seen two important changes in projections of life expectancy: the first is simply that life expectancy has risen significantly. Because annuitants who live longer receive more payments, the size of each payment and hence the annuity rate must fall when life expectancy increases. This is a significant contributor to the fall in annuity rates. The second change to the life expectancy projections lies in the methodology and conceptual apparatus used by actuaries. At the beginning of the period under study, actuaries still forecasted future life

expectancy by using a deterministic projection method. This took no account of the uncertainty in the forecast. Presumably actuaries used informal methods of their own to price this uncertainty when setting annuity rates. Throughout the period actuarial science has been developing new tools for measuring the uncertainty attached to forecasts of life expectancy and it is likely that the increased awareness of uncertainty will have had an impact on annuity rates. In calculating the money's worth we have made judgements about how actuaries used these theoretical advances in practice.

Throughout our analysis of how the money's worth has changed since 1994, we have avoided using hindsight to evaluate annuity prices. Although current data might allow us to know what actual death rates and life length turned out to be in the 2000s, we only know this with the benefit of hindsight and to calculate what would have been an appropriate annuity price in 1994 means that we must use only information available in 1994.

Between 1994 and 2007 the average annuity rate that a 65-year old man could obtain fell from about 11 per cent to about seven per cent. These figures are for a particular type of annuity (not protected against inflation and with no 'guarantee period') and for a man of a particular age, but all annuity rates have shown analogous falls (illustrated in Figures 5.1 to 5.3). During this period interest rates fell from about eight per cent to just under five per cent and this explains some of the fall in annuity rates.

Our conclusions are that money's worth for the base case of a 65-year old man has averaged 90 per cent over the period, which represents a fair value after allowing for load factors, and is very good value compared with other insurance and financial products. The results for women are similar, with the money's worth for 65-year old females averaging 91 per cent. However, there is evidence that the money's worth has fallen since the year 2002. After taking into account changes in life expectancy the money's worth has fallen from 94 per cent to 88 per cent for 65-year old men (Table 6.2) and 92 per cent to 86 per cent for women (Table 6.4).

There are a number of reasons why the money's worth might have fallen. One obvious candidate is that annuity providers have become less competitive and are making larger profits. However, there are more than ten large annuity providers and there is no significant change in the number of annuity providers or the market structure, so we reject this possibility.

Other factors are much harder to quantify. Annuities are being sold at a time when life expectancy is increasing quickly and annuity providers are taking on substantial long-term liabilities. Changes in actuarial methodology and a greater awareness of the risks in forecasting life expectancy are likely to have made life insurers more likely to price annuities cautiously.

The market is also changing as 'impaired lives' annuities become increasingly important. People with recognised medical conditions or who have shorter life expectancy due to having smoked are increasingly able to get more generous bespoke annuity rates. This means that the pool of annuitants buying conventional annuities is shifting towards being more healthy, meaning that over time, the life expectancy of people buying conventional annuities is tending to increase relative to the whole population.

1 Introduction

A number of commentators have pointed out that annuity rates have fallen since the early 1990s and this fall is documented in detail in Cannon and Tonks (2004a). We report below that annuity rates have continued to fall since 2002 even though long-term bond yields, with maturities of ten years or more, have stabilised at around five per cent. If the fall in annuity rates had happened while everything else remained the same, a consequence would be that the value of annuities would have fallen. However, although bond yields have been stable over this period, there have been substantial upward revisions to projected life expectancy. As people live longer, a given sum of money paid for an annuity has to finance a longer stream of income and so income per year has to fall. This reduction in annuity rates is unavoidable: the relevant issue is whether the magnitude of the fall in annuity rates in the recent past is appropriate given the increases in life expectancy.

This report addresses whether the fall in annuity rates over the period 1994 to 2007 is larger than could be justified by the fundamental changes in longevity and bond yields. Our analysis centres on calculations of the 'money's worth' which is the conventional measure used by economists to determine whether annuities are fairly priced. To supplement our money's worth calculation we also describe the annuity market and how it has changed in this period.

Our analysis starts in Chapter 2 with a brief overview of the economics of annuities and Chapter 3 describes the UK annuity market. In Chapter 4 we define the money's worth and review existing research. Chapter 5 discusses the life expectancy projections and other data issues and Chapter 6 provides our money's worth calculations. Chapter 7 concludes.

This paper constructs a time series of UK annuity price quotes in the pension annuity market from 1994 to 2007, and examines whether annuities were fairly priced over the period. The pension annuity or compulsory-purchase annuity (CPA) market annuitises wealth accumulated in tax-efficient pension savings schemes. We undertake a fair-pricing analysis by computing the money's worth of the price quotes, meaning that we compare the present discounted value of the expected annuity payments with the purchase price of the annuity.

2 Economic theory of annuities

For the purpose of this report the most important feature of an annuity is that it is a product making a stream of income payments and the primary determinant of whether a payment is made is whether or not the annuitant is alive.[1] The simplest form of annuity consists of a single payment (sometimes called a 'premium' or 'consideration') from the annuitant to the annuity provider and thereafter the annuity provider pays a constant stream of regular payments (which could be monthly, quarterly or annually), each of which has the same money value.

More complicated products could have the stream of payments rising over time by a fixed amount (an escalating annuity) or rising in line with inflation (real annuities). It is also possible to buy an annuity where the first five years' payments are made regardless of whether the annuitant lives or dies but payments thereafter are only made if the annuitant is alive (a guaranteed annuity – if the annuitant dies before five years, the payments are made to the annuitant's estate).[2] If an annuitant dies before the total payments received sum to the purchase price, it is possible to have the difference repaid as a lump sum to the annuitant's estate (a value protected annuity). A detailed description of these various products is provided in Cannon and Tonks (2005).

It is usual for people to buy annuities when they are in their 60s or later (since the probability of dying when younger than this is sufficiently low that it can be ignored for many purposes) and the usual purpose of an annuity is to provide a pension income. The incentive for individuals to accumulate savings for a pension

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1 An older nomenclature used 'life annuity' to refer to what we refer to as an annuity. Other products, called 'term-certain annuities', paid a guaranteed stream of income regardless of whether the annuitant was alive or not. Throughout this report we use 'annuity' in the more modern sense.

2 Guarantee periods need not be for five years. Where annuities are purchased in the compulsory purchase market the maximum guarantee period allowed by Her Majesty's Revenue & Customs (HMRC) is ten years.

in a defined contribution scheme may depend partly upon access to annuities in the decumulation phase of the pension plan. Yaari (1965) demonstrated in a life-cycle model of saving that risk-averse individuals should annuitise all of their capital at retirement and hence, the existence of a well-functioning annuity market is important for pensioners' welfare.[3]

There are several reasons to believe that annuity markets may not function perfectly. Brown, Mitchell, Poterba and Warshawsky (2001) note that the private annuity market in the United States of America (USA) is small, which is inconsistent with agents getting large utility gains from purchasing annuities. Poterba (2001) and Brown (2001) suggest a number of explanations for this 'annuity puzzle'. Annuities may be expensive, either due to high administrative costs for annuity providers (referred to as 'load factors') or to mis-pricing. Elderly people may prefer to hold their wealth in more liquid assets for precautionary reasons or because they wish to bequeath their wealth to the next generation. Demand for private annuities may be low because many people receive a state pension which is itself a form of annuity. Annuity markets may suffer from a particular problem of 'adverse selection', since longer-lived individuals benefit more from an annuity than shorter-lived individuals, and shorter-lived individuals may leave the market. Finally, individuals may dislike annuities for a range of other factors (not all of which need be fully rational).

To identify which of these explanations are valid, Brown (2001) constructs a utility-based measure of annuity value, and using data from retired individuals finds that differences in annuity equivalent wealth can partly explain the probability of annuitising balances in defined contribution pension plans. These results give some support to the basic life-cycle model of savings/consumption behaviour, but still leave the annuity puzzle unresolved. At the time of writing there is no widespread agreement among economists on the relative importance of the different explanations for the annuity puzzle.

In the UK, individuals at retirement have a significant proportion of annuity equivalent wealth in state pension rights. The Pensions Commission (2004 [182]) reports that only those individuals whose labour income exceeds about £25,000 per year have a sizeable amount of their total wealth in assets other than their state pension.

We may illustrate the welfare benefits of an annuity, with recourse to a simple example which is explained in more detail in the Appendix. Consider the consumption decision of an individual i who has just retired with accumulated pension wealth W_0, and who must now allocate this wealth over two remaining periods of their life (c_0, c_1). However, there is uncertainty over whether this individual will be alive in the second period: individual i has a probability p_1 of surviving into the second period. In the absence of an annuities market, the individual chooses to

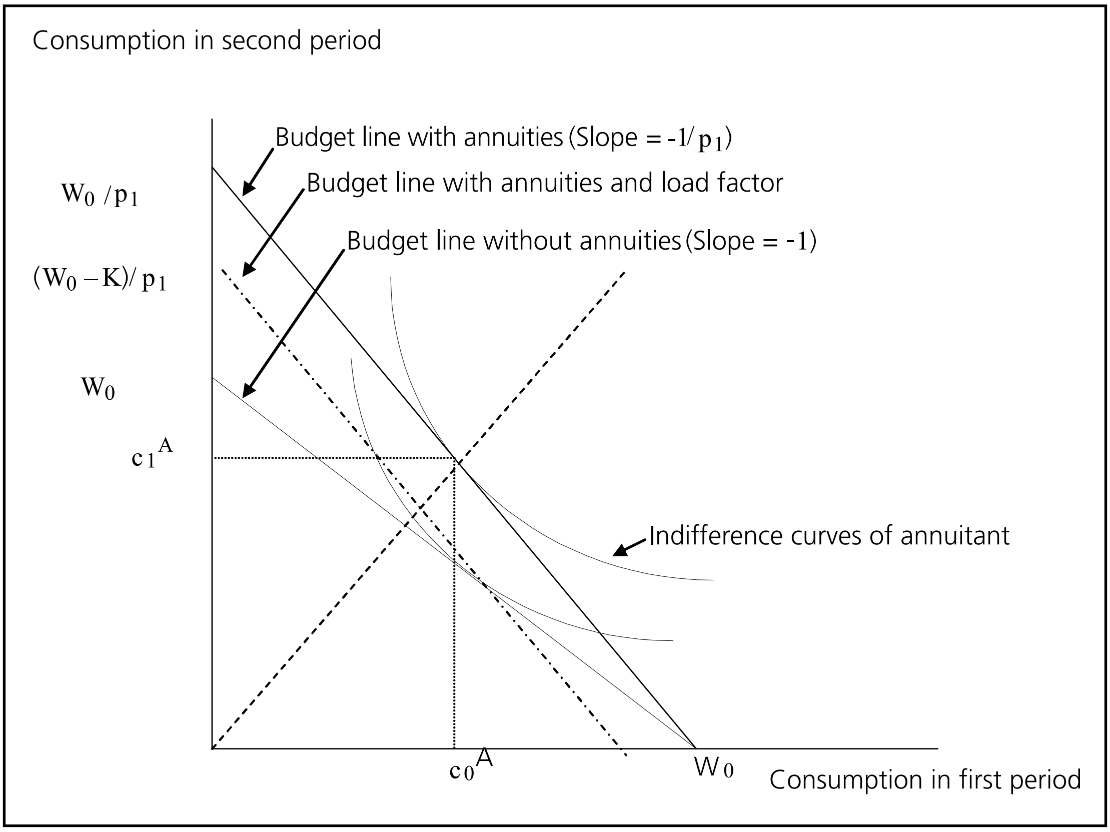
3 Yaari's results concern the investment of wealth more generally, but are most applicable to consumption in retirement.

allocate their consumption across the two periods according to the inter-temporal budget constraint:

$$c_1 = (W_0 - c_0)(1 + r) \qquad (1)$$

where r is the rate of return on savings. Figure 2.1 illustrates the budget line in the special case of $r=0$, with the horizontal axis representing an individual's consumption in the first period, and the vertical axis showing second period consumption. Any combination of consumption in each period, on the budget line W_0W_0, is feasible. It is likely that a risk-averse individual, concerned about the probability of surviving in each period will probably consume more heavily in the first period. However, this solution is inefficient for two reasons: firstly, consumption is not the same in each period, for those individuals that survive; and secondly consumption in the second period is left unconsumed for those individuals that die.

Figure 2.1 Impact of an annuities market on a consumer's budget constraint



Now, suppose that an annuities market with fair priced annuities exists. Under this annuity contract, the individual pays an annuity premium (annuity price) (W_0 - c_0^A) to an insurance company and in return, the insurance company will pay out an income c_1^A in the second period if the individual survives but will pay out nothing if the individual dies. This contract is fair priced if the insurance company breaks even, so that the price of the annuity contract equals the discounted expected annuity payment, $(W_0 - c_0^A) = p_1 c_1^A/(1+r)$. Then the budget constraint facing the individual becomes:

$$p_1 c_1^A = (W_0 - c_0^A)\,(1+r) \qquad (2)$$

and the individual uses the promised annuity payment to fund second period consumption. Comparing equations (1) and (2), the term $p_t/(1+r)^t$ can be thought of as the price of second period consumption, and since $p_1/(1+r) < 1/(1+r)$, then the existence of an annuities market is equivalent to no annuities market but with lower prices of future consumption.

As can be seen in Figure 2.1, access to an annuities market increases utility by expanding the budget frontier, which pivots to the right and hence, a consumer is always better off by participating in the annuities market. This is because there is a cross-subsidy between the annuitants that die early and those that survive into the second period, allowing consumption for those that survive to be higher in both periods. However, suppose the insurance company sells annuities but with a load factor K, to reflect its costs – the price of the annuity contract will be greater than the discounted expected annuity payments, $(W_0 - c_0^A) = K + p_1 c_1^A/(1+r)$. The budget constraint facing the individual with a load factor becomes:

$$p_1 c_1^A = -K + (W_0 - c_0^A)\,(1+r) \qquad (3)$$

The introduction of the load factor will shift the budget constraint-with-annuities in the diagram back towards the origin. For small load factors, the gain in utility from accessing the annuities market will outweigh the load factor. However, for a sufficiently large load factor, the consumer will not want to annuitise.

In less technical language, the existence of an annuities market allows more consumption in both periods – in this simplified two-period model – due to the cross-subsidy from those that die to those that survive. The introduction of a load factor representing the annuity provider's costs reduces the benefits of the cross-subsidy; for sufficiently high load factors the costs to providers of providing annuities may more than outweigh the benefits to individuals.

The costs incurred by an annuity provider and thus included in the load factor are: the administration costs of sale and delivery of the annuity contracts, including the payments system; the transaction costs of purchasing assets, to match the liability incurred by the insurance company when it sets up the annuity contract, and all of the on-going costs of managing these assets; and the costs arising from the remaining risks faced by the annuity provider. The most obvious risk faced by an annuity provider is that it has underestimated life expectancy and hence, has higher liabilities (in the form of annuity payments) than initially realised. This risk can be partially reduced through reinsurance (selling well-defined risks to another insurer, typically a specialist company called a reinsurer), but this itself involves costs. The amount of capital that must be held to cover these risks is regulated by the Financial Services Authority. In addition to all of these costs, the annuity provider has to earn a sufficient return on capital to make it worthwhile to undertake the business (which economists would typically denote as ‘normal profit’ to distinguish it from profits that were inappropriately high).

3 The UK annuity market

Assessing whether annuities are fairly priced is important for public policy, since the UK Government has emphasised its commitment to the requirement (DWP, 2002; HM Treasury, 2006) that at least 75 per cent of the funds in a tax-efficient pension scheme should be used to finance a pension income. This is referred to as 'securing' an income. According to regulations laid down by HMRC, securing an income can be achieved either by purchasing an annuity in the 'pension annuity' market (secured income) or drawing down a tightly prescribed income from the pension fund (alternatively secured income). However, the requirement to secure an income only requires that it be secure by the age of 75, and an individual can choose to have unsecured income in the period between retirement and age 75. Unsecured income is also referred to as income drawdown.

Under HMRC rules, the amounts of the three types of allowable pension income that the pensioner can receive depends on the annuity rate. With secured income (buying an annuity) this is obvious. With an unsecured income before 75, the maximum amount drawn in each year is 120 per cent of the best level single-life annuity payment at the respective age and sex available in the pension annuity market (these rates are collected and published by the FSA). With alternatively secured income (post-age 75), it is compulsory to draw between 65 and 90 per cent of the best annuity rate available to someone aged 75, and payments received outside this range are taxed at 40 per cent.

The justification for the requirement to secure income by 75 is that savings in these pension plans are tax-advantaged, and that the reason for the tax relief in the first place is to encourage individuals to save for a pension.[4] It is also important for individuals to have secure income which protects them against the risk of living longer than expected and using up all their capital. This policy has its critics, especially as annuity rates have fallen throughout the 1990s and makes pensioners susceptible to annuity rate risk. Apart from the effects this has on people retiring

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4 With unsecured income and alternatively secured income there are further restrictions or tax considerations for any capital sum left on the death of an individual: these are to discourage using unsecured income or alternatively secured income to effect inter-generational transfers.

now, it may also influence potential saving behaviour of people who will retire in the future.

Interest in the workings of the annuity market is high because of the increasing trend for pensions in the UK to be provided through defined contribution schemes, documented by the Pensions Commission (2004, 2005, 2006). A consequence of this shift, away from unfunded pay-as-you-go and funded defined benefit schemes, is that there will be an increased demand for life annuities, since at retirement the accumulated funds in the defined contribution pension scheme need to be converted into a pension income. A life annuity converts the retirement fund into an income stream payable to the annuitant until their death and hence, insures the individual against insufficient assets to finance consumption due to longevity risk.

The Pensions Commission (2006) proposed the introduction of a national pensions savings scheme as part of a wider package of pension reform, and these recommendations are being implemented in the proposed 'Personal Accounts' outlined in DWP (2006). This new pension scheme is a defined contribution scheme, and this will also need to be annuitised at retirement.[5] Anticipating the increased demand for annuities in respect of its proposals, the Pensions Commission (2005) examined whether there is sufficient capacity in the annuity market to provide for the projected demand.

The amount of new annuity business currently sold by insurance companies in the pension annuity market in 2005 was £8.6 billion.[6] Watson-Wyatt (2003) and Wadsworth (2005) examine a number of scenarios for the growth of annuity demand over the ten-year period 2002-2012, reproduced in Table 3.1, taken from the Pension Commission (2005).

Table 3.1 Scenarios for the size of the annuity market, (estimated annual flows: £billion)

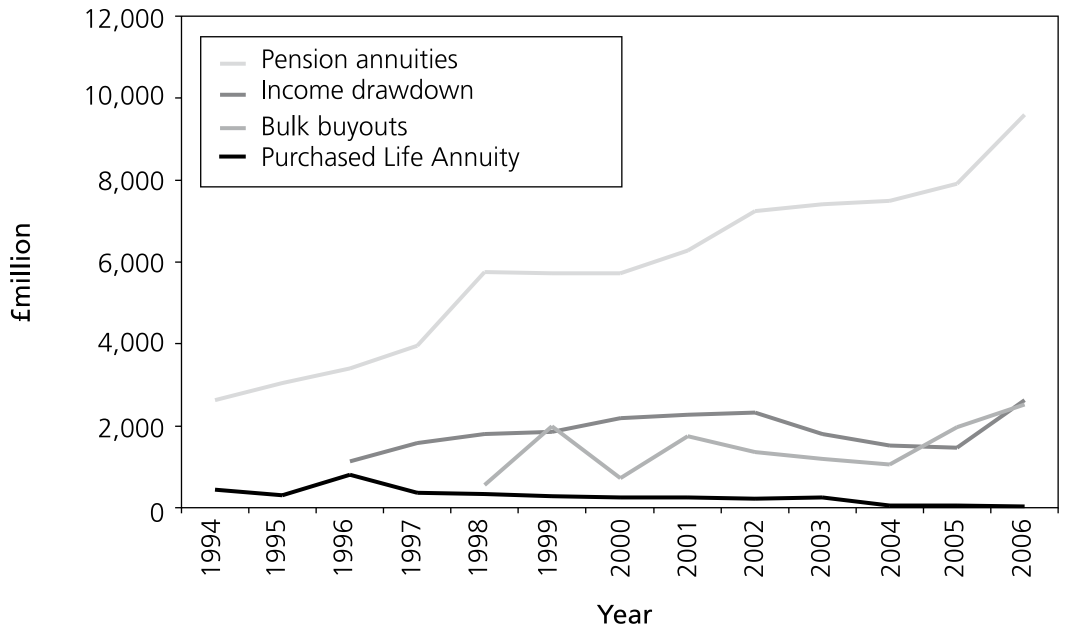
	2002	2012		
		Low	Medium	High
Individual annuities	7.2	16.6	18.1	19.7
Drawdown	2.3	5.3	5.8	6.3
Bulk buyout	1.4	1.5	35.4	128.1

Source: Pensions Commission (2005, Figure 5.16).

5 Legislation for Personal Accounts, as well as automatic enrolment and minimum employer contributions, completed its passage through Parliament in December 2008.

6 Source: Calculations from FSA Insurance Returns, Form 47 from Synthesis Database.

Figure 3.1 Growth in annuity sales 1994-2006



Source: ABI.

Figure 3.1 shows the growth in annuities and income drawdown over the period 1994-2006. In the UK there is both a compulsory (pension annuity or CPA) market and a voluntary (Purchased Life Annuity (PLA)) market. The pension annuity market refers to annuities purchased because of HMRC rules, which state that 75 per cent of an individual's pension wealth (accumulated in a tax-privileged private pension) must be secured. By 2006, the CPA market had grown to £9.58 billion worth of annuity premiums. In contrast, in 2004 the PLA market only amounted to £56.4 million worth of sales and the diagram shows that the PLA market has shrunk as the CPA market has grown. This suggests some substitution between compulsory and voluntary annuities, as people who previously purchased annuities in the voluntary market undertake their desired degree of annuitisation in the pension annuity market first. From Figure 3.1, it can be seen that income drawdown continues to represent a significant alternative to annuitisation.

All of this evidence suggests that the demand for annuities will continue to rise substantially in the coming years and, therefore, examining the functioning of the annuities market is relevant and timely for public policy.

4 Definition of the money's worth

To calculate the fair vale of an annuity we can calculate the expected discounted annuity payments promised by the annuity provider, based on the annuity rates that we have collected, and compare this value with the actual cost. This statistic is called the 'money's worth'. It is the ratio of the expected present value of the flow of payments made by an annuity to the money paid for an annuity. This procedure has been used by Mitchell *et al.* (1999) to analyse the annuities market in the USA and by Murthi, Orszag and Orszag (1999), Finkelstein and Poterba (2002) and Cannon and Tonks (2004a) to analyse the UK annuity market. For a general discussion of the calculation of the money's worth see the introduction to the collection of papers in Brown *et al.* (2001).

To calculate the money's worth approach: define the annuity rate A_t as the annuity payment received by an individual per year, per £1 purchase price in year t.[7] The expected present value of this annuity stream is called the money's worth. For a level annuity with no guarantee period, this can be calculated using:

$$\begin{aligned}\text{Money's Worth } &\equiv A_t \left\{ \frac{\pi_{t,t+1}}{1+R_{t,1}} + \frac{\pi_{t,t+2}}{\left(1+R_{t,2}\right)^2} + \cdots \right\} \\ &= A_t \sum_{i=1}^{i=T} \pi_{t,t+i} \left(1+R_{t,i}\right)^{-i}\end{aligned}$$

where $\pi_{t,t+i}$ is the probability of someone living i more periods, believed in period t. T is chosen so that $\pi_{t,t+i} \approx 0$ and $R_{t,i}$ is the appropriate discount rate in period t for payments received in period $t + i$, expressed at an annual rate.

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7 It is possible for the annuity rate to depend upon the purchase price as discussed in Cannon and Tonks (2005).

Notice that annuitants of different ages or sexes would have different values of $\pi_{t,t+i}$ since the probability of living a given length of time depends upon both age and sex. Clearly the annuity rate A_t will also depend upon age and sex.

We calculate the money's worth using the term structure of interest rates at date t and expectations of survival probabilities $\pi_{t,t+i}$ that we believe were available at time t.

With a zero load factor, under fair pricing the money's worth would be exactly equal to unity and hence, money's worth will reflect whether annuities are fairly priced. However, any positive load factor will result in the money's worth being less than unity. If data were available on the size and components of the load factor, then it would be possible to compare the money's worth with the load factor to assess the degree of fair pricing. Estimating load factors is extremely difficult, since nearly all annuity providers are life insurers and sell a range of financial products. In practice it would be complex to apportion most costs to the separate categories. For example, the same people who are selling annuities are responsible for selling life insurance and savings products as well. Even if life insurers had their own estimates of the costs of the separate lines of business they would be unlikely to reveal this information since it would be commercially sensitive. In the absence of information on load factors, we instead compare the money's worth of annuities with similar financial and insurance products to assess whether annuities are fairly priced.

A number of studies have examined the extent to which annuity prices are actuarially fair. Mitchell, Poterba, Warshawsky and Brown (1999) suggest that the market is approximately efficient and that annuities are not actuarially mis-priced in the USA. In their analyses of the UK annuity market Murthi, Orszag and Orszag (1999), Finkelstein and Poterba (2002) and Cannon and Tonks (2004a) all report similar results that annuities are approximately fairly priced in the UK by computing an annuity's money's worth.[8]

Although we are primarily interested in the pension annuity market, the absence of pension annuity data for some time periods in the UK and for other countries (where there is no pension annuity market) mean that it is necessary to consider results from the voluntary-purchase market as well. To get some idea of the range of money's worth estimates, we consider previous results for the money's worth for 65-year old men in the voluntary market.

Finkelstein and Poterba (2002) calculate the money's worth of voluntary annuities for 65-year old men to be 99 per cent, using data from a cross-sectional sample of annuity providers in the year 1998. In comparison, Murthi, Orszag and Orszag (1999) reported a figure of 93 per cent, and Cannon and Tonks (2004a) calculated a value of 98 per cent, in the same year. Murthi *et al.* (1999) also provide money's

8 James and Song (2001) report that annuities are fairly priced in a number of other countries.

worth estimates of 100 per cent in 1990 and 92 per cent in 1994: Cannon and Tonks' (2004a) analogous figures are 98 per cent and 89 per cent. Cannon and Tonks' (2004a) figure of 98 per cent for 1990 is based upon the money's worth calculated using the a(90) table, but using the IM80 table (which was only published in that year), the figure would be 103 per cent. Thus, over a period of eight years, using different estimates of life expectancy and using different data sets of annuity rates, the range of estimates for the money's worth of just one type of annuity is quite large, varying from 89 per cent to 103 per cent

Finkelstein and Poterba (2002, 2004) specifically assess the degree of adverse selection in annuities markets, and find evidence of adverse selection in the voluntary annuity market. They note that it is difficult to distinguish between adverse selection and passive selection (purchasers of annuities tend to be richer and therefore longer-lived), and in Finkelstein and Poterba (2004) recognise the limitations of their small sample from a single annuity provider.

Cannon and Tonks (2004a) assess the fair-pricing of UK annuities over a much longer time period 1957-2002, and for data from a wide range of annuity providers. They report that over the whole period 1957-2002 the average money's worth of voluntary annuities was 97 per cent, and conclude that annuities are fairly priced over this time period. Since the pension annuity market did not exist (or was very small) for much of this period, it is impossible to compare the two markets over a long time period.

5 Data for money's worth calculations

As can be seen in Chapter 4, three data series are needed for our money's worth calculations: annuity rates, interest rates and survival probabilities. In this chapter we discuss each data series in turn.

5.1 Annuity rate data

The only long-run time series of annuity rates for the UK is that constructed by Cannon and Tonks (2004b) for the voluntary annuities market for the period 1957-2002. For much of that period the pension annuity market was very small and no data are available for most of the period. The data we use in the current analysis are quoted annuity rates for the pension annuity market provided by Moneyfacts from July 1994 to March 2007. The data are for various annuity providers for both men and women of different ages. Annuity prices are usually quoted in the form of an annual annuity payment of £X per £10,000 purchased, which we refer to as an annuity rate of X/100 per cent.

For example, Table 5.1 reproduces annuity rates for men of different ages for a level annuity in March 2002. A 65-year old man could purchase an annuity for £10,000 from different providers: if he had chosen AXA Sun Life he would have received £800 per year for the rest of his life, which we would denote as eight per cent. Some of the annuity rates quoted are much more generous than this: B & CE Insurance offers £874 and BRS Smoker offers £913. However, these last rates would not be generally available: B & CE Insurance annuities are only open to construction workers and BRS Smoker annuities are only open to smokers. In our analysis we exclude such annuity rates and use the average of the annuity rates which are available to anyone.

Table 5.1 Example of annuity quotes (source: Moneyfacts)

	Age			
Company	**60**	**65**	**70**	**75**
AMP NPI	672	789	960	1,211
AXA Sun Life	698	800	951	1,160
B & CE Insurance	752	874	1,054	1,314
BRS Smoker	786	913	1,102	1,375
BRS Plus	799	938	1,146	1,444
BRS Special	822	979	1,215	1,553
Canada Life	709	809	952	1,156
Friends Provident	716	817	951	1,129
GE LIFE	652	727	836	998
GE LIFE (special)	787	926	1,130	1,428
Legal and General	722	817	947	1,121
MGM (Select)	783	899	1,064	1,317
Norwich Union	683	764	902	1,076
Pension Annuity FS	855	1,003	1,171	1,490
Prudential	724	836	999	1,234
Royal Liver	682	783	931	1,147
Scottish Equitable	696	800	939	1,133
Scottish Widows	723	830	984	1,204
Standard Life	690	788	925	1,120

Numbers show promised level annual annuity payments for males of different ages, for a premium of £10,000.

In most of our analysis we use the average annuity rate calculated from these data, although, in practice, annuitants may purchase only the higher priced annuities (in which case our money's worth calculations would be biased down). We will provide some evidence on the improvement in the money's worth figure from using the best annuity rates. Moneyfacts provide annuity quotes for level annuities without an additional guarantee period that pay a constant monthly income stream over the lifetime of the annuitant.[9] Moneyfacts also publish Retail Price Index (RPI)-linked annuities, which pay an annuity income that rises in line with the UK's RPI and hence, provides protection against inflation to the annuitant in the form of an RPI-linked annuity. Although level annuities carry risks from inflation, according to Stark (2002) over 70 per cent of pension annuities purchased are of this form.

9 Moneyfacts also publish annuity quotes in the CPA market for level annuities with a five-year guarantee, meaning that in the event that the annuitant dies, the annuity income continues to be paid into the annuitant's estate for five years after their death. We do not compute the money's worth for these annuities.

Figures 5.1 and 5.2 plot a series of annuity rates for men and women aged 65 and 75 over the period 1994 to 2007 (75-year old annuity rates were only quoted in Moneyfacts from August 1997 and RPI-linked annuities were only quoted from September 1998 – in addition, two months' data are missing). It can be seen that annuity prices move closely together. Figure 5.3 plots a representative annuity rate alongside the bond yield to show that annuity rates move in line with interest rates.

Figure 5.1 Annuity rates for men in the compulsory annuity market

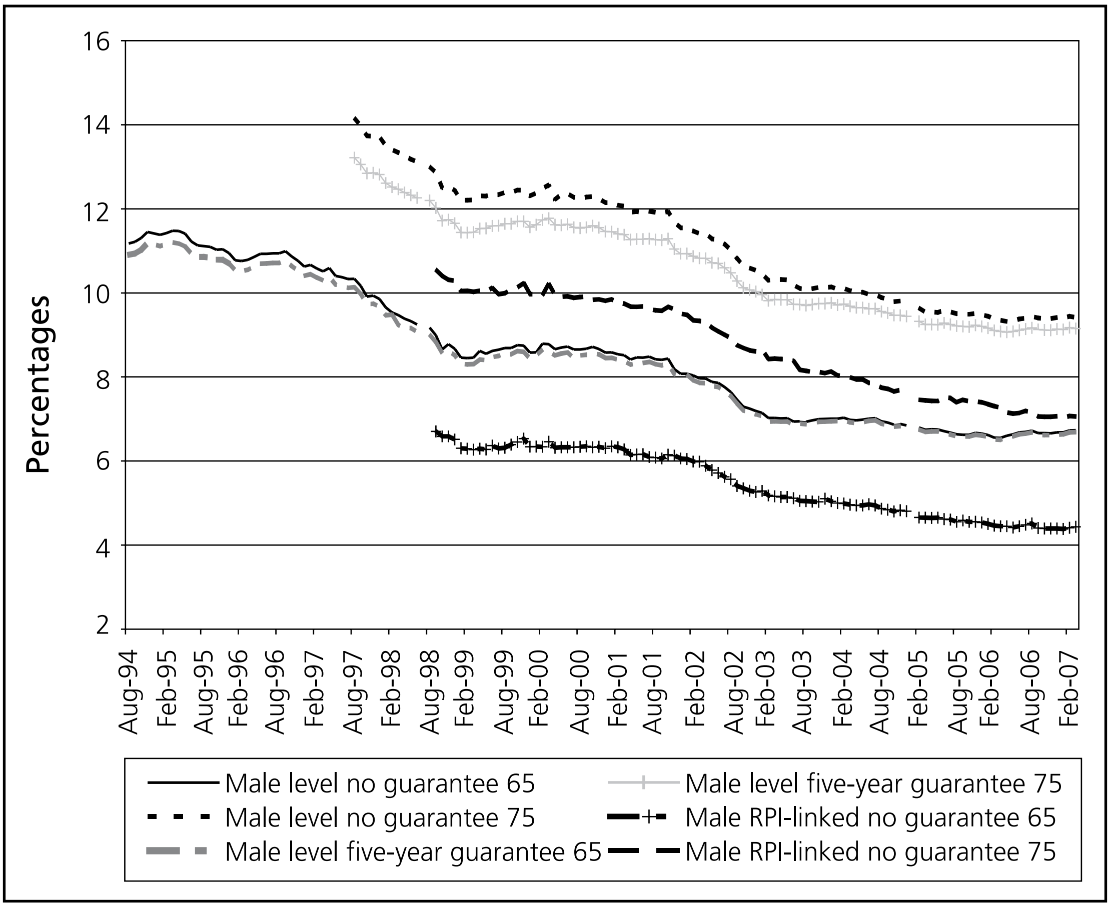


Figure 5.2 Annuity rates for women in the compulsory annuity market

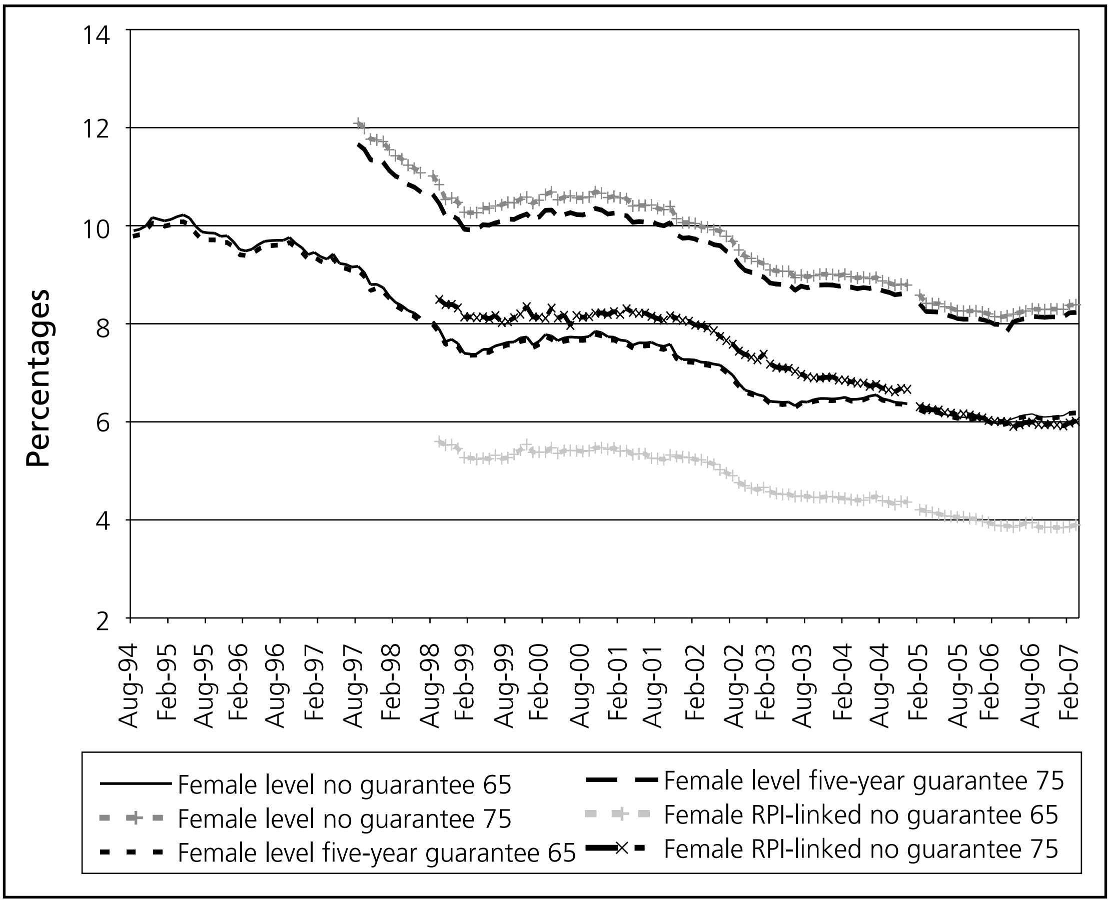
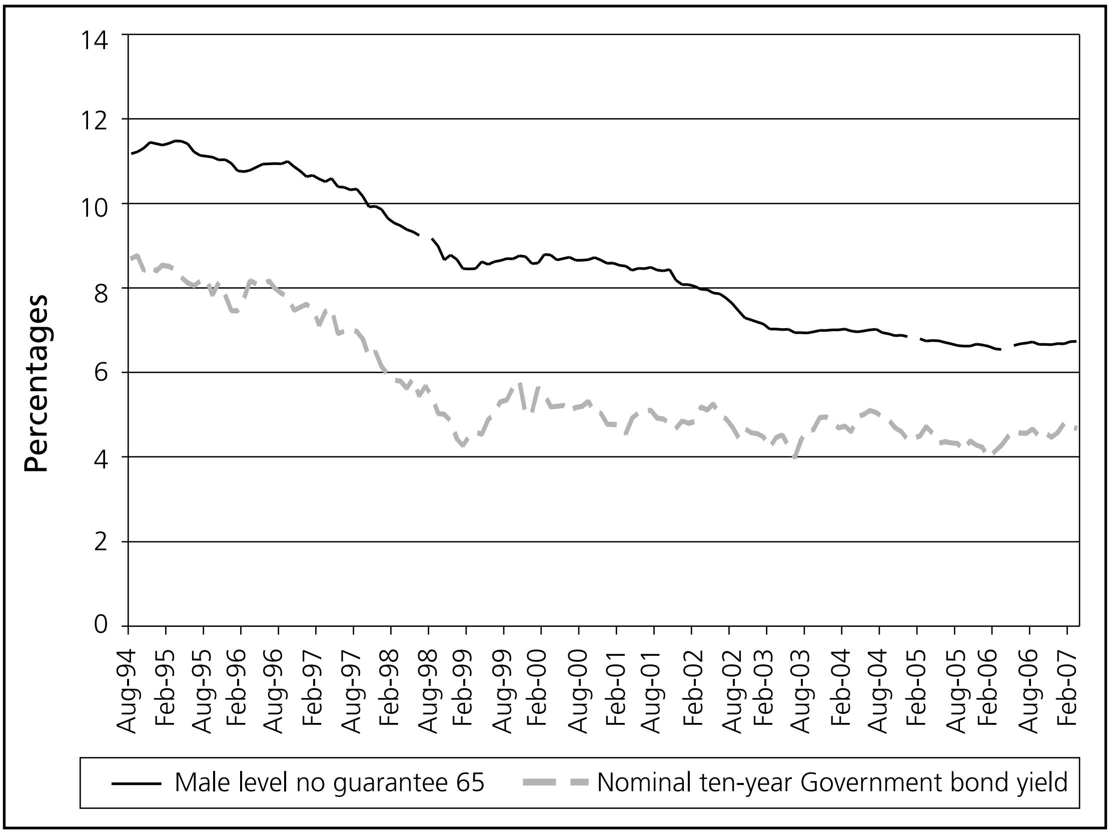


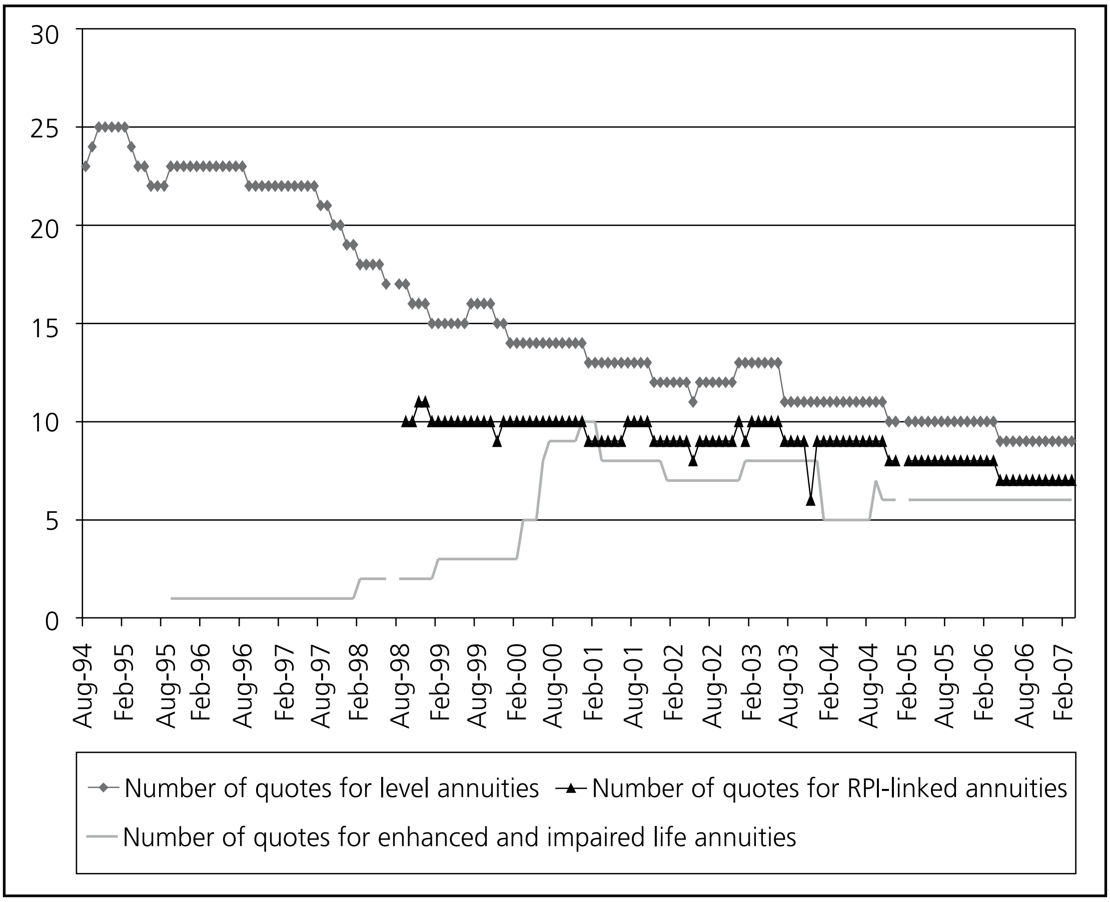
Figure 5.3 Comparison of annuity rates with bond yields



It can be seen that annuity rates for men are consistently higher than for women of the same age; and that annuity rates are higher for both men and women as age increases. Age and sex are two personal characteristics that annuity-providers condition on when quoting annuity prices, since life expectancy of women is higher than men, and of younger adults of both sexes is higher than older adults. The annuity rates on guaranteed annuities always lie below non-guaranteed annuities, and the rates on RPI-linked annuities lie below those on nominal annuities. The striking aspect of Figure 5.1 to 5.3 is the extent to which the series move together.

Figure 5.4 documents that the number of main annuity providers during this period has fallen substantially for both nominal and RPI-linked annuities. In 1994 Moneyfacts reported 23 to 25 insurance companies providing quotes, but this fell to about nine sets of quotes by the end of the period. The FSA website has also reported price quotes from about nine or ten annuity providers over the period 2005 to 2007.

Figure 5.4 Number of annuity quotes in Moneyfacts



In addition, some of the annuity providers only supply enhanced or similarly-restricted annuities, such as B&CE Insurance which supplies annuities to former construction workers and there are also special rates for smokers, called impaired-life annuities. The number of impaired-life annuities quotes in the Moneyfacts database has grown from just one quote to six, partly due to the entrance of specialist providers such as Just Retirement (some impaired-life annuities are provided by companies that also provide non-impaired life annuities).

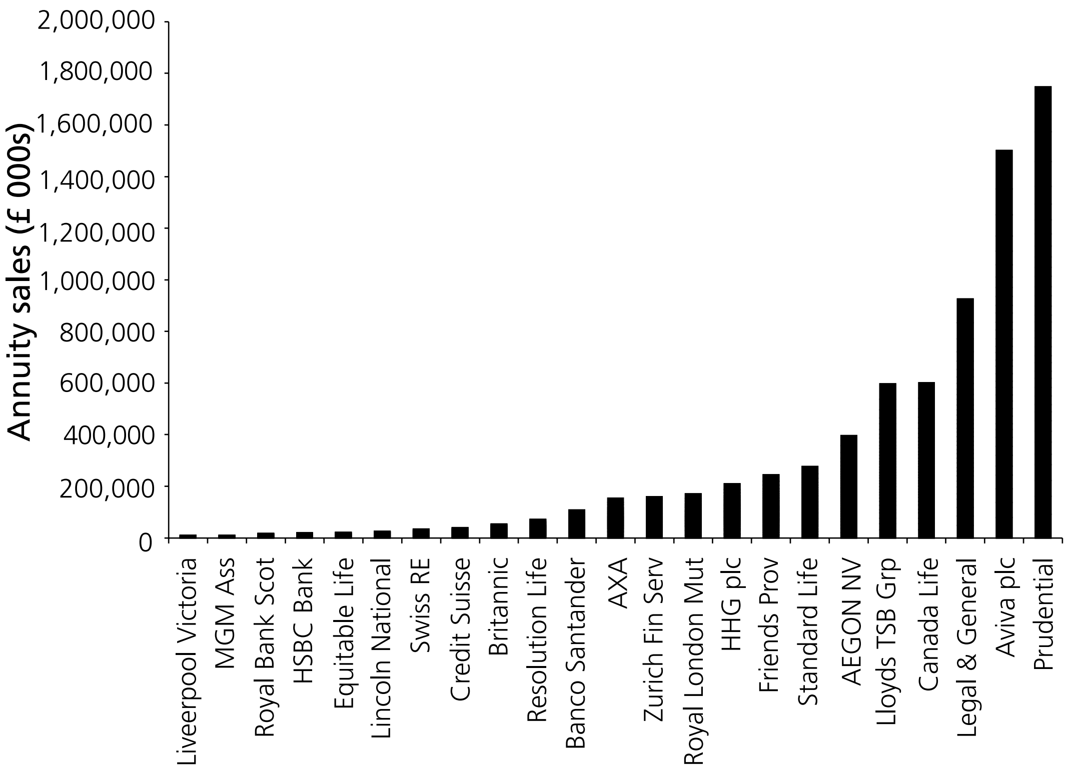
Although the number of annuity providers quoting annuity prices in the Moneyfacts database has fallen, insurance companies may still be willing to provide annuities if contacted directly by individuals or annuity brokers, for example they will sell annuities to those who have built up pension savings with the company. According to the FSA life insurance returns 62 insurance companies sold pension annuities in 2005. In Figure 5.5 we reproduce the distribution of non-profit pension annuity sales in 2005 across the largest 23 of the 39 parent companies that sold annuities (since a parent company may submit more than one insurance return for its subsidiary companies).[10] These 23 companies sold £7,398 million of CPA non-profit annuities in 2005 out of a total of £7,433 million for this category. There were a small number of other categories of pension annuities sold in 2005: with-

[10] Form 47, Synthesis Database.

profit annuities (£229 million), RPI-linked (£510 million), and impaired-life (£387 million), but these are not included in the figure.

Figure 5.5 shows that the CPA market is dominated by a small number of insurance companies. The number of companies in this figure implies that the five-firm concentration ratio is 72 per cent, with the Prudential – the largest supplier of pension annuities – having over 23 per cent of new business in 2005.[11]

Figure 5.5 Distribution of CPA annuity sales in 2005 across parent companies



Source: Synthesis 2005, FSA Life Returns, Form 47, line 400.

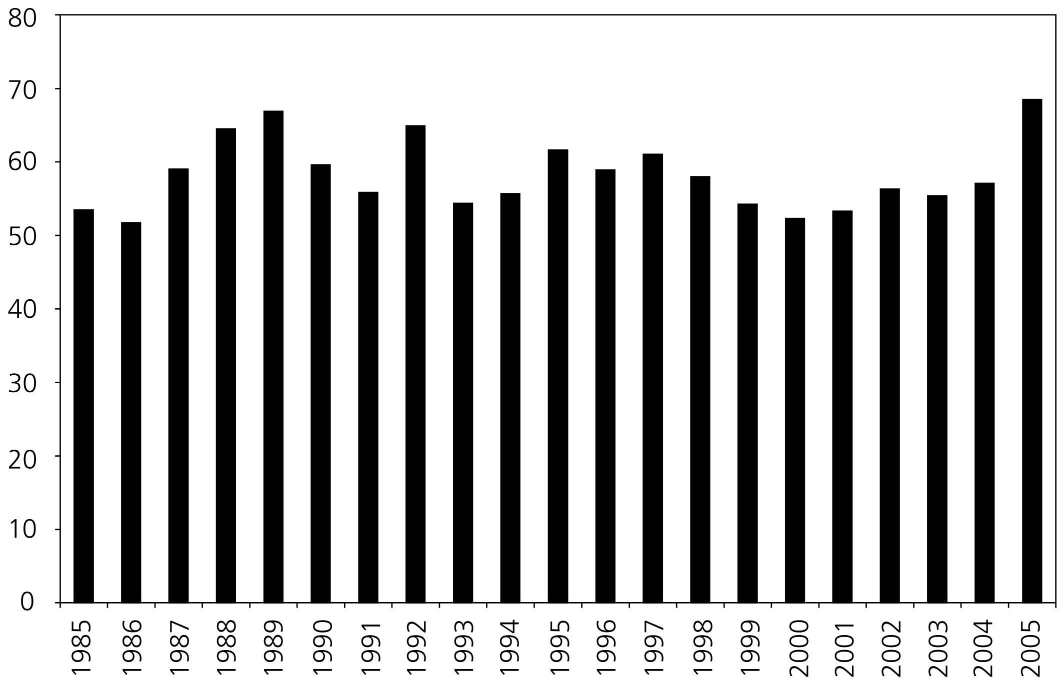
Comparing the providers of sales of annuities in Figure 5.5 with the list of providers of annuity quotes in Figure 5.4, it can be seen that our dataset contains price quotes from all the major sales providers.

We may also examine the pattern in the concentration ratio over time. In Figure 5.6 we plot the six-firm concentration ratio from 1985-2005 of CPA sales. This figure is based on the CPA annuity sales of the individual company FSA returns, rather than aggregate sales across the parent companies. Ideally, an analysis of market concentration would use data at parent company level, but insurance company mergers would make it very difficult to extract the parent information in a particular year and thus we confine our analysis to the individual companies.

11 The five-firm concentration ratio shows the percentage of total industry annuity sales contracted by the largest five annuity providers.

Because we are analysing individual companies Figure 5.6 may understate the true degree of concentration, but this effect is likely to be small. For example, in 2005, Figure 5.6 reveals that the six-firm concentration ratio was 68 per cent (based on individual company returns) compared with the five-firm concentration value of 72 per cent (based on the parent company's returns) derived from Figure 5.5.

Figure 5.6 Six-firm concentration ratio 1985-2005 in CPA market (based on individual company FSA returns)



Source: Synthesis 2005.

5.2 Interest rates and the term structure

The term structure of interest rates is available on a detailed basis on the Bank of England's website. The Monetary Instruments and Markets Division of the Bank of England estimates nominal and real yield curves for the United Kingdom on a daily basis. These estimates are based on yields on UK Government bonds and on yields in the general collateral repo market. They are constructed by fitting a smooth curve through data points for rates of return on Government stock of different maturities, as described in Anderson and Sleath (1999). However, the current published series were only calculated from 1999 and so these estimates would not have been available in this form to insurance companies pricing annuities contemporaneously between 1994 and 1999. Up to 1999, published yield curve data was available in *Financial Statistics* for representative Government bonds at five, ten and 20 years, and it would have been possible to infer rates of return on intermediate maturities by interpolation or on longer maturities by extrapolation. In Cannon and Tonks (2004a) we compared the current Bank of England term structure series for 1979-2002 with the interpolated series, and found that the results were very similar. Therefore, in the current analysis we will rely solely on the Bank of England term structure series for 1994-2007. Sample interest rates are illustrated in Figures 5.7 and 5.8 and compared with annuity rates in Figure 5.9.

Figure 5.7 Nominal UK spot yield curves

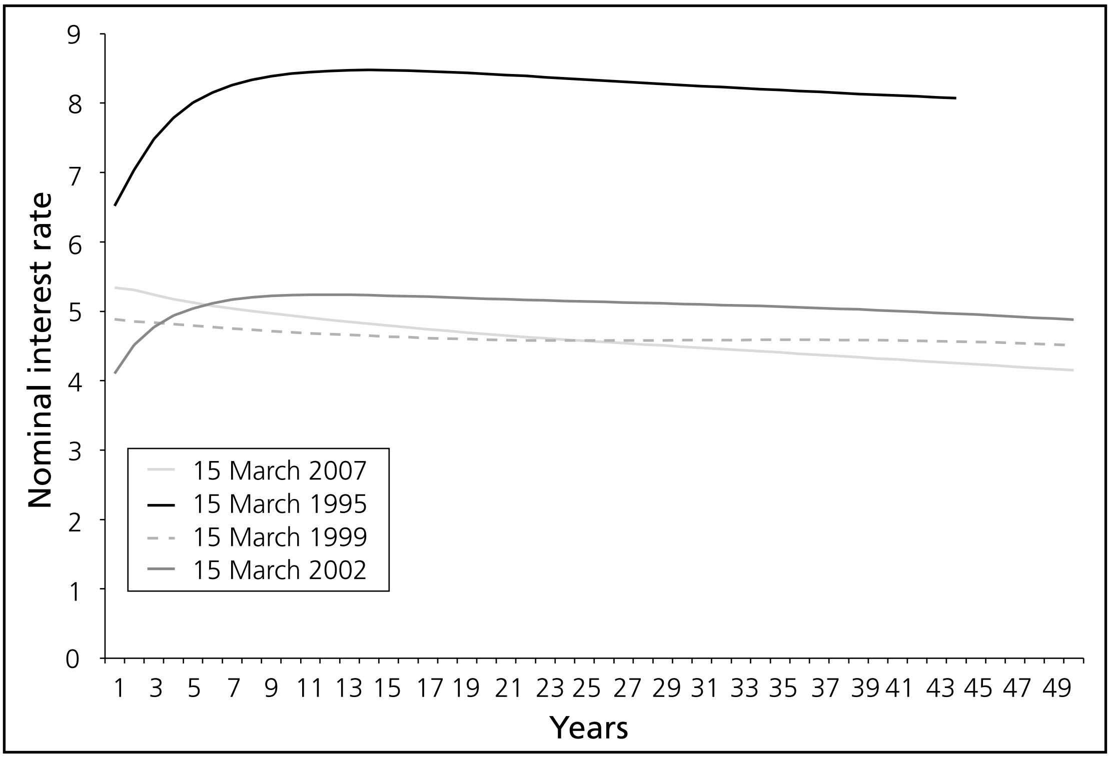
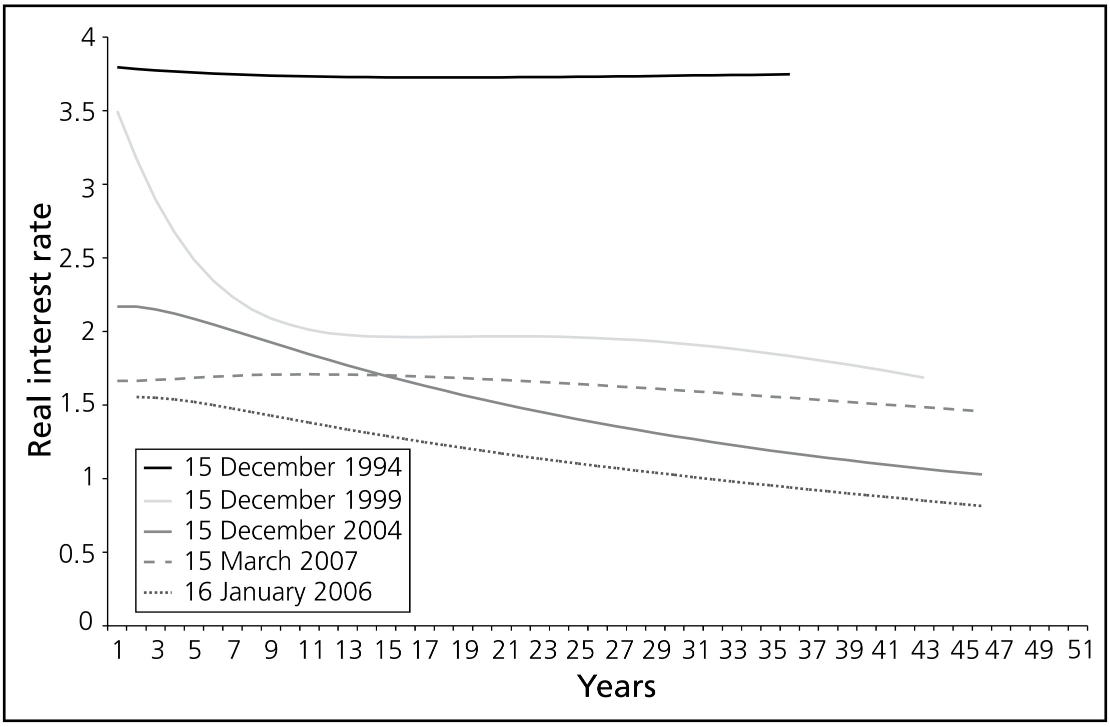


Figure 5.8 Real UK spot yield curves



What are the implications of the shape of the term structure for the pricing of annuities? Consider the optimal investment strategy for the annuity provider: to meet future liabilities a long way into the future the life insurer can either:

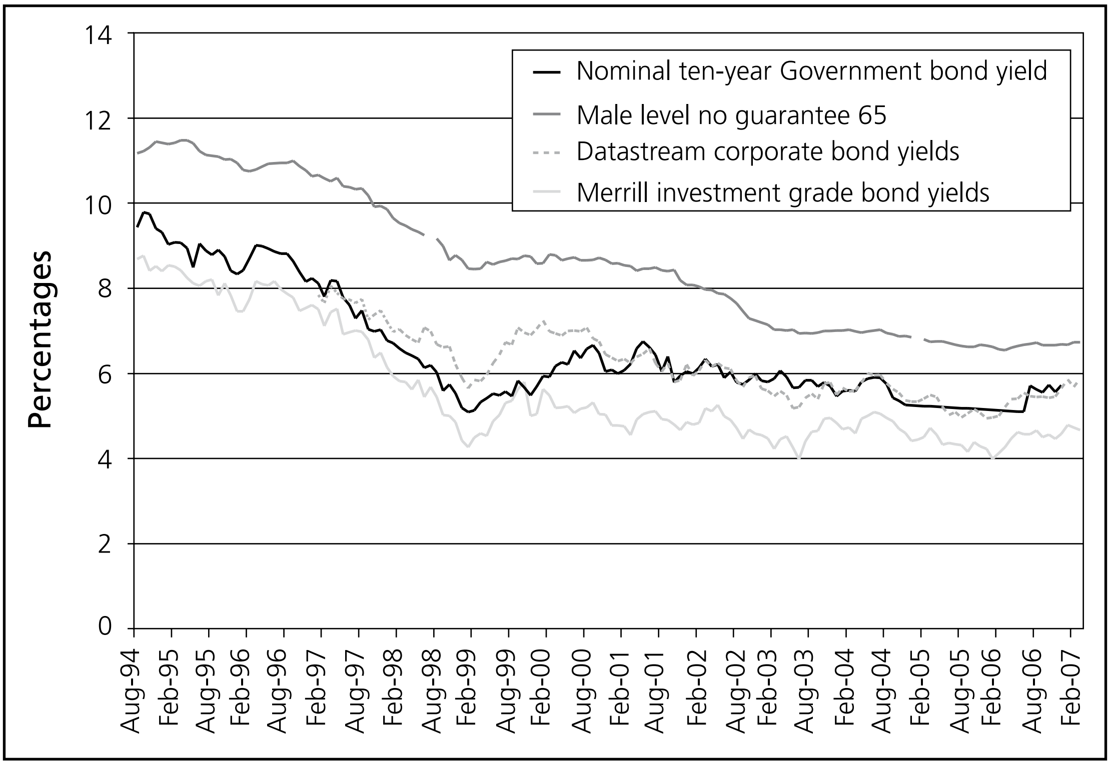
- make a single purchase of an asset making a payment at that point in the (long-distant) future: when the payment is received then the funds are automatically available to meet the life insurer's liability to make the annuity payment; or
- invest money short-term and continuously re-invest it until it is needed for the annuity payment.

Historically, most of the time the yield curve has sloped up: the interest rate per annum for payments a long way in the future is higher than for those in the near future. This means that the obvious strategy for a life insurer selling an annuity is to match annuity payment liabilities that are a long way in the future with financial products making payments a long way in the future. There are three advantages to this approach: first, buying long-dated assets has a higher rate of return. Second, it involves less administrative costs, since only one transaction is needed, rather than continuous transactions as short-term investments are rolled over. Third, there is no risk, since the payment in the future from a Government bond is certain (Government default risk is clearly negligible in the UK), while investing short-term and rolling over the investment is risky as short-term rates of return are variable. Given these advantages the FSA strongly encourages life insurers to match their annuity liabilities with an appropriate mix of assets with differing maturities and the life insurers are obliged to provide details of their asset portfolio in the FSA returns, which show that they do behave in this way.

For this reason it is appropriate to use the rates of return from the term structure to obtain the present value of annuity obligations. One slight problem arises, however, when the yield curve slopes down (i.e. long-term interest rates are less than short-term interest rates) as has been the case in the UK recently. In this situation, investing short-term and rolling over the investment has a higher expected return on average; but this is at the expense of there being higher risk. If this risk were sufficiently low then it might be optimal for life insurers to invest short-term and it would not be appropriate for us to value annuity liabilities using the term structure.

However, we believe it more appropriate to continue to use interest rates drawn from the term structure even in this situation. First, data limitations mean that there is little alternative: clearly there is no independent source of information on future short-term interest rates or the value of risk in investing short-term and rolling over investments rather than investing long-term (indeed, the obvious way to estimate these values would be to use the term structure, which brings us back to where we started). Second, it is not clear that life insurers have used such a strategy (or that the FSA would allow them to do so).

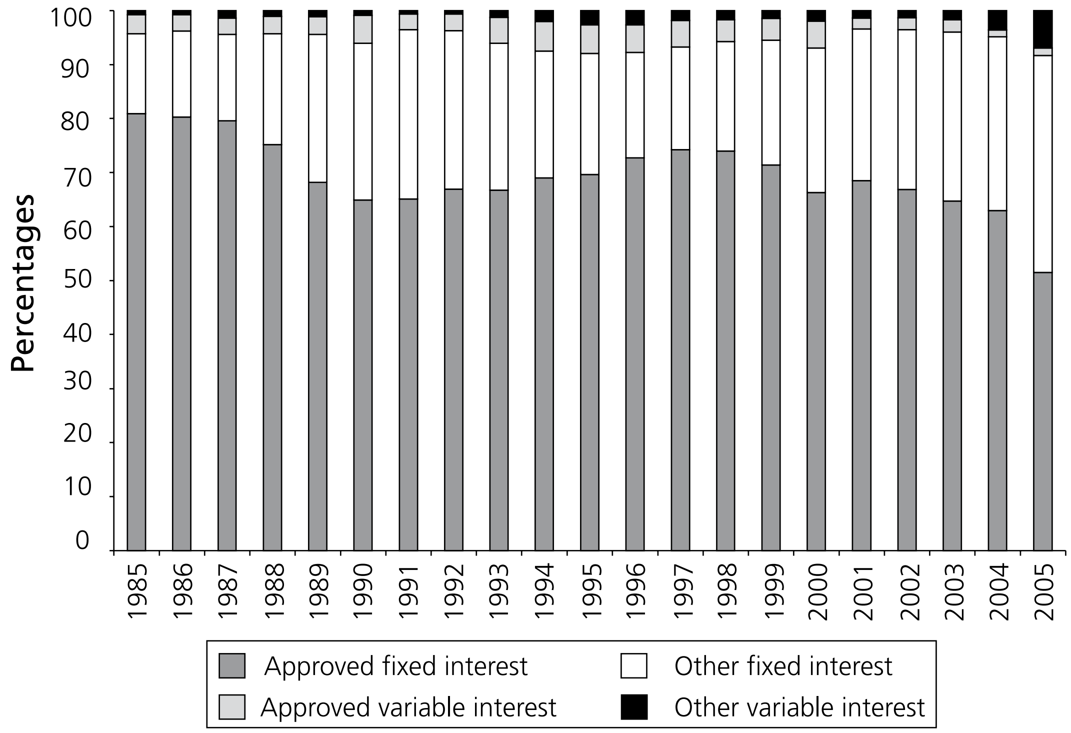
Figure 5.9 Comparison of annuity rates with bond yields



We will use term structure projections in the computation of money's worth in Section III, but first Figure 5.9 provides a comparison of annuity rates with long-term interest rates. It compares the annuity rate for 65-year-old males with the UK Government ten-year bond yield.[12] It can be seen that the two series clearly move very closely together, although the annuity rate is slightly smoother. In fact these two series should be linked because they are both long-term assets: indeed if longevity was constant and the short-term rate was not particularly variable then the two would differ, on average, only by a constant. On the other hand if life expectancy were infinite we would expect these two curves to converge. In addition, Figure 5.9 also plots the yield on corporate bonds from Datastream (an index of bonds of various qualities) and Merrill Lynch (an index of investment grade bonds). Finkelstein and Poterba (2004) use the yields on corporate bonds as a deflator rather than Government bond yields. Form 49 of the FSA insurance returns provides information on the types of bonds in which life insurance companies invest. Figure 5.10 shows that the mixture of Government bonds (approved) and corporate bonds (other) has shifted over time: in 1985 life insurance companies held five times as many Government bonds as corporates, by 2005 this ratio was almost one, though over most of the sample, 1989-2004, the percentage of debt instruments that were Government bonds lay between 60 and 70 per cent.

12 We use the ten-year Government bond as a comparison because: a) the term structure after ten years is relatively flat; and b) it is the longest maturity instrument with consistent yields on the Bank of England website.

Figure 5.10 Type of debt instrument held by life insurance companies



Source: Synthesis 2005.

Descriptive statistics for annuity rates and bond yields are presented in Table 5.2 for the period as a whole, and for two sub-periods. As expected, the series are highly correlated, but this correlation has decreased from 0.98 in the late 1990s to 0.57 over the last six years. The difference between the two series is falling over time because as life expectancy increases, the expected payment stream from an annuity becomes more similar to that of a conventional bond. The lower correlation over the latter part of the sample appears to be driven by the higher short-term volatility in bond yields: bond yields have become more volatile but annuity yields have not responded to this volatility on a month-by-month basis. The annuity rate was 9.9 per cent between 1994 and 2000, but had fallen to 7.2 per cent over the second half of the dataset for 2001-2007. Table 5.2 also reports the yields on corporate bonds, and this has averaged about 90 basis points above the yield on government bonds[13]. Using the corporate bond rate as the appropriate discount rate, or including the risk premium on corporate bonds, will therefore reduce the present value of annuity payments and hence, reduce the money's worth.

[13] We use the Datastream corporate bond index rather than the Merrill Lynch index, since the two series are highly correlated, but the Merrill series only started in 1997.

Table 5.2 Time series properties on annuity and ten-year bond rates

	Annuity rate (%)		10-year Government bond yield (%)	Datastream corporate bond yield (%)	Difference in annuity rate and Government bond yield (%)
Panel A: 1994-2007					
Mean	8.59		5.61	6.52	2.98
Standard deviation	1.62		1.39	1.33	
Correlation		0.93			
Panel B: 1994-2000					
Mean	9.91		6.55	7.29	3.36
Standard deviation	1.10		1.39	1.42	
Correlation		0.98			
Panel C: 2001-2007					
Mean	7.22		4.65	5.70	2.57
Standard deviation	0.65		0.29	0.41	
Correlation		0.57			

Table 5.1 presents descriptive statistics on the time series of average annuity rates, Government rates and corporate bond rates over the period 1994 to 2007 and for the two sub-periods.

5.3 Life expectancy

Having discussed the role of interest rates, we now turn to the behaviour of life expectancy over the period 1994 to 2007. Clearly annuities are (or should be) priced on future life expectancy, so we are dealing with past values of expectations about the then future (much of which is still in the future). Cannon and Tonks (2004a) discussed some of the issues in working out what expectations of mortality might have been in the past, using the actuarial tables that were available at various points from 1950 onwards. The period in which we are interested saw some major revisions to actuarial projections and this means that changes in expectations are the largest cause of changes in annuity rates over this period.

Two initial issues that we need to consider are the fact that pension annuitants may have different life expectancy from other individuals and that life expectancy differs by 'lives' and 'amounts', as explained below. The life expectancy of pensioners is quite different from that of the population as a whole, and there is also considerable variation in life expectancy between the different sorts of pensioners for which data are available. A large quantity of data is collected by the Institute of Actuaries and analysed by the Continuous Mortality Investigation (CMI) Committee which publishes its results at regular intervals, typically publishing the data for four-year periods ('quadrennia'). We follow Finkelstein and Poterba

(2002) and our own analysis in Cannon and Tonks (2004a) in using the CMI data. The CMI collects data for individuals with the following types of pension:

1 Immediate annuities, which would only be appropriate for the analysis of annuities purchased voluntarily in the 'purchase life' market.

2 Retirement annuity contracts (RACs), an early version of personal pension introduced in 1957 primarily designed for self-employed workers to have a mechanism to receive the tax privileges available to workers in company pension schemes.

3 Personal pensions (PPs), introduced in 1987 and for which the data set is small until about 1995, since most such pensions are still in accrual rather than in payment.

4 Life office pensions, which are company pension schemes administered by life insurers and for which the most comprehensive data are available.

5 Self-administered pension (SAP) schemes, ie company pension schemes, typically for large companies, which are run by the company without recourse to life offices (although they would be advised by actuarial consultancy firms).[14] The CMI has started collecting these data only very recently and hardly any data are available.

Summary statistics of some of these data are shown in Table 5.3, which illustrates the small size of the voluntary annuity market, the relatively large size of the RAC market and the phenomenal growth of the PP market. Table 5.3 shows the number of annuitants by annuity type over various quadrennia, and the associated death rates for each group.

14 SAP schemes are those self-administered by the company and should not be confused with Self-Invested Personal Pensions (SIPPs) which are a form of personal pension, where investment decisions are taken by the pensioner.

Table 5.3 CMI estimates of numbers of annuitants and death rates, by categories of annuity types

	Males				Females			
	1987-1990	1991-1994	1995-1998	1999-2002	1987-1990	1991-1994	1995-1998	1999-2002
Panel A: Immediate annuitants								
Exposed to risk (000s)	50	40	31	36	101	74	52	53
Crude death rate	0.081	0.075	0.074	0.072	0.076	0.082	0.086	0.082
Panel B: Retirement annuities in accrual								
Exposed to risk (000s)	6,358	4,511	3,795	3,880	1,097	829	672	679
Crude death rate	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002
Panel C: Retirement annuities in payment								
Exposed to risk (000s)	648	641	638	893	134	151	156	291
Crude death rate	0.035	0.032	0.03	0.033	0.018	0.018	0.016	0.016
Panel D: Personal pensions in accrual								
Exposed to risk (000s)	1,332	3,831	6,043	8,563	593	1,883	2,998	4,327
Crude death rate	0.001	0.002	0.002	0.002	0	0.001	0.001	0.001
Panel E: Personal pensions in payment								
Exposed to risk (000s)	2	50	207	692	0.6	20	84	294
Crude death rate	0.013	0.011	0.012	0.014	0.003	0.006	0.005	0.006

Source: CMI 21 (2004).

Clearly, in an ideal world we would use the PP life expectancy data, since most people who purchase annuities in the pension annuity market are classified as personal pensioners by the CMI, and we would like to ensure consistency in the data. However, as can be seen from Panel E in the table, it is only recently that significant numbers of individuals have been monitored by the CMI and so these PP data alone could not be used reliably for projection into the future. Furthermore, they were first published only in 2004 (although a smaller sample had been available before then) and so were unavailable for most of the period.

An alternative would be to use the RAC life expectancy, but Panel C in Table 5.3 suggests that the death rate of such pensioners is twice as high as the death rate of personal pensioners (looking at pensions in payment rather than in accrual) and hence, the life expectancy is much lower. In fact these summary statistics exaggerate the difference since the average age of RAC pensioners is higher than PP pensioners, but differences remain even when we disaggregate the data by age. This difference in life expectancy may be because the two groups have different socio-economic characteristics. A possible explanation is that originally purchasers of RACs were self-employed and thus, they may have different characteristics from people in employment: certainly they are likely to have worked in different occupations and this may explain some difference in life expectancy (some occupations have significantly different life expectancies from others: eg construction workers tend to have lower life expectancy).

Since the number of RAC pensioners in accrual has fallen by 7.5 to 4.6 million over the period, coinciding with an increase of PP pensioners in accrual from 1.9 to 12.9 million, it is almost certain that some individuals who would have taken up RACs are now taking up PPs (as we would have expected) and this would suggest that their life expectancies would be similar. However, there have also been changes in the composition of the workforce and this effect may be larger.

Given the problems with interpreting RAC and PP life expectancy, it seems prudent to follow Finkelstein and Poterba (2002) and resort to a larger and more consistent set of data, namely the Life Office Pensioners, of whom there were over one million in 1999-2002 and for whom data are available for a longer period of time. Use of the Life Office Pensioner data has the additional advantage that life expectancy is available on both a lives and an amounts basis.[15] The former shows the life expectancy of each life (possibly more accurately, of each policy – if a pensioner has more than one policy then they may be counted twice). The latter basis re-weights the life expectancy by the size of the pension so that richer

15 In Chapter 6 we will refer to Pensioner Male Lives (PML) as Life Office Pensioner data for males based on lives. Similarly, Pensioner Female Amounts (PFA) refers to Life Office Pensioner data for females based on amounts. The most recent life expectancy tables also refer to Pensioner Male Normal Lives (PNML) to distinguish between those people retiring at normal retirement age as distinct from early retirees.

pensioners have a higher weight – unsurprisingly, life expectancy of amounts is longer than life expectancy of lives since richer people tend to live longer. From the point of view of the Life Office, what matters is the amounts measure, since that is what determines the profitability of the life business: from the point of view of a 'typical' pensioner, the lives basis may be more relevant in terms of the 'value for money' of the annuity.[16]

We now turn to the way in which actuaries have projected life expectancy over the relevant period. Since their projection methods have changed, this will involve a summary history of actuarial thinking. It is not possible to identify how actuaries in specific insurance companies made their projections in the past, but we can consult the CMI reports as a 'best practice' guide. At discrete intervals the CMI produces 'standard tables' usually through the medium of a CMI report, accompanied by a software package for calculating certain functions based on the mortality data.[17] Recently, the CMI has started producing working papers to supplement the reports, partly so that information can be disseminated in a more timely manner (since working papers contain provisional results). In addition to this, reports have a semi-official status: for example, they are recognised by the regulatory authorities. Since working papers do not have any official status they are a means of promoting discussion within the actuarial profession while avoiding any obligation on actuaries to utilise results which are only provisional. The relevant tables for the sub-periods in our sample are described in Table 5.4.

Table 5.4 Data used by CMI Committee of the actuarial professional organisations in the UK to calculate life tables

Table	Publication	Publication date	Based on data up to year
80 Table	CMIR 10	1990	1982
92 Table	CMIR 17	1999	1994
92 Table interim adjustments (with short, medium and long cohort assumptions)	CMI WP 1	2002	1999
00 Table	CMIR WP 22	2006	2002

16 However, we cannot assume that an individual with lower life expectancy than average will necessarily get less additional utility from purchasing an annuity (based on average life expectancy) than an individual with higher life expectancy. We discuss this later in the report.

17 We have not consulted the software package directly since it is primarily a tool for actuaries. So far as we are aware it is not able to produce money's worth calculations, since it does not contain interest rate term structure data.

Three different methodologies were used in the actuarial tables identified in Table 5.4, and we now describe these in turn. In all cases the actuarial methodology relies upon the 'mortality', or probability of dying at a given point of time for someone of a given age (males and females are always treated separately). Since the probability of dying at age 62 is very similar to the probability of dying at age 61, it seems reasonable to fit a smooth curve to the data (called a 'graduation'), which summarises the mortality-age relationship and smoothes out idiosyncratic variations in the observed death rates. Differences in methodology depend primarily on the method of curve-fitting and how this is projected into the future. Once we have suitable mortality projections, it is possible to calculate the probability of the annuitant receiving each annuity payment and hence the money's worth of the annuity. To illustrate this, suppose we treat the data in discrete annual terms, and write $m(x,t)$ as the probability of dying (mortality) in year t of a person aged x.[18] Then the probability of being alive in year $t+s$ is:

$$\prod_{i=0}^{i=s-1}\left\{1-m\left(x+i,t+i\right)\right\}$$

and the expected value of an annuity paying £1 per year is:

$$\sum_{s=1}^{s=\infty}\delta\left(s\right)\left[\prod_{i=0}^{i=s-1}\left\{1-m\left(x+i,t+i\right)\right\}\right]$$

where $\delta(s)$ is the net present value of £1 s years hence.

Table 5.5 Illustration of data availability and mortality predictions

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
60	✓	✓	✓	✓	✓					
61	✓	✓	✓	✓	✓					
62	✓	✓	✓	✓	✓					
63	✓	✓	✓	✓	✓					
64	✓	✓	✓	✓	✓					
65	✓	✓	✓	✓	✓					
66	✓	✓	✓	✓	✓					
67	✓	✓	✓	✓	✓					
68	✓	✓	✓	✓	✓					
69	✓	✓	✓	✓	✓					
70	✓	✓	✓	✓	✓					

Consider the mortality data available at some point in time, for example in 1995. If data were available up to 1994, then data would be available up to 1994 for all

18 Typically actuaries would work in continuous rather than discrete time. For expositional purposes, we stick to the discrete time model.

ages. To calculate the value of an annuity for a man aged 65 in 1995 it would be necessary to predict the mortality for a 65-year old in 1995, a 66-year old in 1996, a 67-year old in 1997 and so on. In Table 5.5 we illustrate some of the cells for which mortality estimates would be needed with the series of obliquely adjacent shaded cells. Data are only available in the cells containing a tick (✓). The way that the 80 and 92 Actuarial Tables would have done this is as follows: they would start by fitting a curve to mortality data for a particular year: for example, the yellow cells in 1992 (which indeed is the base year in the 92 Tables, hence their name). By looking at the trends of mortality for up to 1994, it would make predictions for the curve for years 1995 and onwards and hence extract the relevant mortalities that would be needed.

The 80 tables used 1980 as the base year and then projected mortality rates forward using the following formulae:

$$m(x,t + 1980) = RF(x,t)m(x,1980)$$

so that the mortality at a given age in a given year was the 1980 mortality reduced by a 'reduction factor' defined by:

$$RF(x,t) \equiv \alpha(x) + [1 - \alpha(x)] \times [1 - f(x)]^{t/20}$$

$$f(x) = 0.6$$

$$\alpha(x) = \begin{cases} 0.5 & x < 60 \\ \dfrac{x-10}{100} & 60 \le x \le 110 \\ 1 & x > 110 \end{cases}$$

The reduction factor consists of two parts. The $\alpha(x)$ component determines the 'limiting' reduction, ie how much the mortality is assumed to fall by in the indefinite future. For ages of 110 and above this is one, so that the mortality never falls at all: for ages of 60 and less $\alpha = 0.5$ so it is assumed that eventually the mortality of 60-year olds would be only half that of 60-year olds in 1980. The function f determines how quickly the mortality is assumed to move from the 1980 value to the limiting value. It can be seen that the speed of adjustment is independent of age in the 80 tables; in the 92 tables both functions were made age dependent so that:

$$f(x)=\begin{cases} h & x<60 \\ \dfrac{(110-x)h+(x-60)k}{50} & 60\le x\le 110 \\ k & x>110 \end{cases}$$

$$\alpha(x)=\begin{cases} c & x<60 \\ 1+(1-c)\left(\dfrac{x-110}{50}\right) & 60\le x\le 110 \\ 1 & x>110 \end{cases}$$

$$c=0.13$$
$$h=0.55$$
$$k=0.29$$

Both of these tables viewed mortality as being based on age and time. An alternative viewpoint is that mortality would depend upon age and cohort of birth. In Table 5.5, the base year graduation of 1992 used data on both 60-year olds in 1992 and 70-year olds in 1992: people born in 1932 and 1922 respectively. If mortality improvements were a smooth continuous process then the use of age and time instead of age and cohort would make no difference. However, towards the end of the 1990s evidence began to appear suggesting that the mortality experience of people born before 1926 was markedly different from people born after 1926, a phenomenon which was first highlighted by Willets (1999). In other words there was a discontinuity in the improvement of mortality and hence, using age-time would result in different projections from using age-cohort.

Table 5.6 Mortality predictions and cohort effects

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
60	✓	✓	✓	✓	✓					
61	✓	✓	✓	✓	✓					
62	✓	✓	✓	✓	✓					
63	✓	✓	✓	✓	✓					
64	✓	✓	✓	✓	✓					
65	✓	✓	✓	✓	✓	Post				
66	✓	✓	✓	✓	✓		Post			
67	✓	✓	✓	✓	✓			Pre		
68	✓	✓	✓	✓	✓				Pre	
69	✓	✓	✓	✓	✓					Pre
70	✓	✓	✓	✓	✓					

To see why this matters, consider Table 5.6 and suppose, for the sake of argument, that people born after 1926 had substantially lower mortality than people born before.[19] In 1992 people aged 66 and younger belonged to the lower mortality cohorts and people aged 67 and over to the higher mortality cohorts. The 80 and 92 tables would make mortality projections sideways, so all mortality projections below the blue line would be based on people born pre-1926, so mortality projections for a 65-year old man buying an annuity in 1995 would be based on post-1926 individuals' cohorts only for years 1995 and 1996 and thereafter on people born pre-1926. Ideally, the 1926 effect would allow for larger mortality projections for all cells in the table above the orange line.

Of course, one of the biggest problems in making such projections is the fact that when the 92 tables were produced there was hardly any information at all on the mortality of people born after 1926 during the later part of their lives. However, the CMI did have access to the mortality of such people in the earlier part of their lives, not from annuity data, but from life assurance data. Using the male mortality life insurance data (based on lives rather than amounts), revisions were made to the 92 tables which were published in 2002 and called the 'interim adjustments'.[20] The size of the revision depended upon the size and dating of the cohort effect and this cohort effect was difficult to estimate precisely on the data available. Accordingly, three different assumptions were made and three corresponding sets of revisions produced, called respectively the 'short', 'medium' and 'long' cohort assumptions. The difference between these three assumptions is the point at which they assume that the improvement in mortality ceases to be relevant. The short cohort projections assume that the mortality improvements observed in the post-1926 cohort cease to occur after 2010: the medium cohort projections assume 2020 and the long cohort projections assume 2040. The differences between the medium cohort and long cohort are sufficiently far in the future that they make relatively little difference for immediate annuities (obviously they have much larger impacts for pensions still in accrual) and in our money's worth calculations below we concentrate just on the short and long cohort projections.

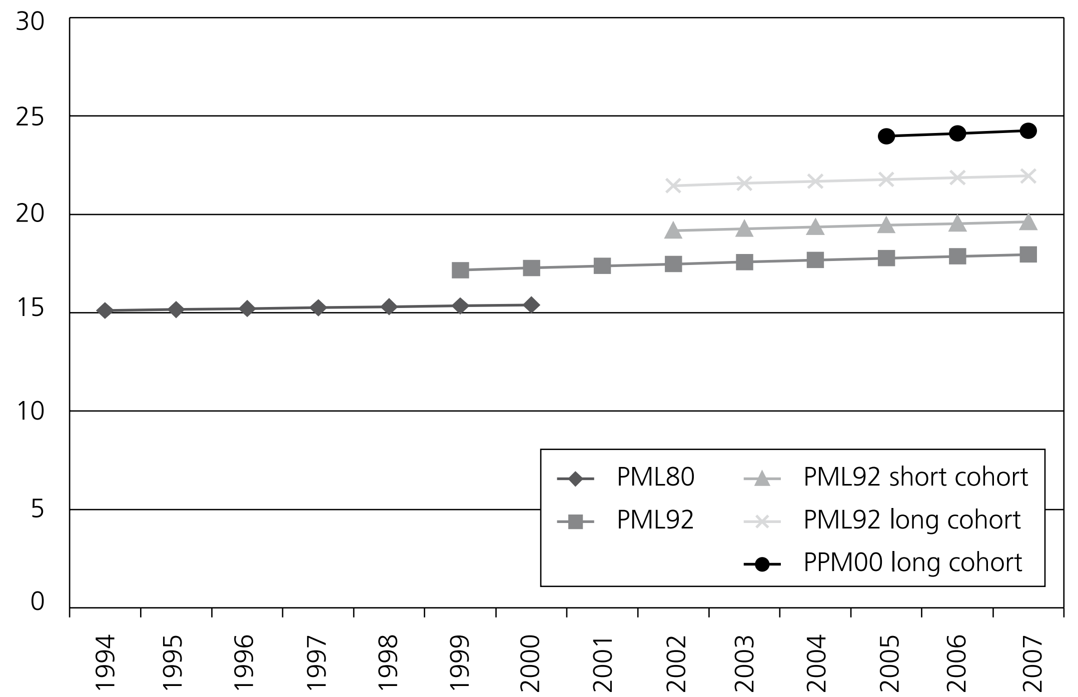
To give some idea of the magnitude of the changes due to revisions to the Actuarial Tables, the life expectancy of a 65-year old man (based on the projected mortalities) are illustrated in the Figure 5.11, based on the PML80 and PML92 Tables, and PML92 with the interim adjustments. Life expectancy of a 65-year old man was little more than 15 years in the mid-1990s and predicted to rise only

19 Clearly every cohort has tended to show an improvement in mortality compared with the previous cohorts: someone born in 1925 tends to have lower mortality compared with someone born in 1924 and someone born in 1928 has lower mortality compared with someone born in 1927. The suggestion being made here is that the difference between the 1925 and 1926 cohorts was much larger.

20 In producing these adjustments, the actuaries also used population data supplied by the Government Actuary's Department (GAD).

slowly: shortly after 2000 this had been revised upwards to about 22 years, a huge change. Also for comparison we show the life expectancy based on the personal pensioner males (PPM00) tables, based on the 2000 base tables and projected forward using the long cohort reduction factors, which suggest that personal pensioners have higher life expectancy than the life office pensioners.

Figure 5.11 Life expectancy of male, 65, using different mortality tables



PML80 refers to PML from the 80 Tables, PML92 PML from the 92 Tables, PML from the 92 Tables with short and long cohort interim adjustments, and personal pensioner males from the 00 Tables using a long cohort adjustment.

Alongside the concerns raised by the possibility of substantial cohort effects, actuaries have become increasingly concerned with the idea of making deterministic projections of mortality into the future, and have developed more sophisticated projection techniques, allowing for uncertainty in projections. One immediate consequence of this was that the 00 Tables, unlike the 80 and 92 Tables, did not contain any suggested projections into the future at all. Instead, two complementary methods began to be employed to provide projections of mortality into the future, called p-spline and Lee-Carter. Since these methods are relatively complicated, we confine ourselves here to a fairly brief exposition.

The Lee-Carter approach was first proposed by Lee and Carter (1992) who suggested that mortality $m(t,x)$ in year t for age x could be modelled by:

$$ln(m(t,x)) = \beta_o(x) + \beta_\kappa(x)\,\kappa(t)$$

where $\beta_o(x)$ and $\beta_\kappa(x)$ are two functions of age and $\kappa(t)$ is a function of time: all three of these functions need to be estimated. Suppose we are prepared to confine ourselves to the mortality of people (either all men or all women, since the two sexes would be considered separately) from age 60 to 100 (41 different ages) over the ten-year period 1991-2000. Then one possibility would be to estimate the following set of coefficients:

$$\beta_o(60), \beta_o(61),..., \beta_o(100)$$
$$\beta_\kappa(60), \beta_\kappa(61),..., \beta_\kappa(100)$$
$$\kappa(1991), \kappa(1992),..., \kappa(2000),$$

The total number of coefficients to be estimated is $41+41+10=92$: if data were available for all the relevant ages in the relevant years then the total number of mortality observations would be $41\times10=410$. The 92 parameters could be estimated by some form of non-linear regression.

Estimating the coefficients in this way might result in very spikey estimates of the functions $\beta_o(x)$, $\beta_\kappa(x)$ and $\kappa(t)$: for example even if $\beta_o(60)$ and $\beta_o(62)$ were not too dissimilar, $\beta_o(61)$ might be different from both. Therefore, the estimation method might try to ensure that the functions were relatively smooth. P-spline methods provide a method of fitting a smooth curve through the estimated functions, which are too complicated to explain in detail here.

The previous tables had used data to fit a curve to a cross-section of mortality experiences, implicitly a two-dimensional relationship. The newer methods fitted a three-dimensional surface to the entire data that existed up to that point in time and then projected this surface into the future with appropriate statistical confidence intervals to provide a guide to the uncertainty of the estimates. CMI Working Paper 20 reports the following results for two variants of the p-spline method of projection, one assuming cohort effects ('Age-Cohort') and one assuming no special cohort effects ('Age-Period'). Table 5.7 shows the appropriate annuity rates based on the central projection of mortality and also the 95 per cent confidence interval.

Table 5.7 Implied annuity rates for 2004 under alternative mortality projection methods (assuming flat term structure with 4.5 per cent interest rates)

	Male, 65		Female, 65	
	Estimate %	Confidence interval %	Estimate %	Confidence interval %
Initial Medium Cohort	7.254		6.750	
Revised Medium Cohort	7.331		6.905	
p-spline:	6.365	6.236	6.712	6.572
Age-Cohort		6.487		6.847
p-spline:	6.369	6.167	6.704	6.483
Age-Time		6.554		6.910

Source: Tables M3 and F3 in CMI WP 20 and authors' calculations.

In Table 5.7, the Initial Medium Cohort row shows the annuity rates implied by the original 'medium cohort' interim adjustments to the 92 Tables, based upon an underlying 4.5 per cent interest rate (ie assuming 4.5 per cent interest rates at all maturities: a flat term structure); the Revised Medium Cohort row updates these projections to take account of the mortality data from 2003 (recall that the interim adjustments were calculated on data up to 2002). Using the p-spline methodology leads to much lower central estimates of the appropriate annuity rate for males (although not females), regardless of whether the cohort or time effect is deemed to be more important. However, the Age-Cohort estimates fit the data slightly better and thus, have narrower confidence intervals, which suggests a 95 per cent confidence interval of about one-quarter of a percentage point. The key point, however, is that the 95 per cent confidence interval for the annuity rate based on the p-spline methodology is lower – for males considerably lower – than that suggested by the Medium Cohort projections.

To get some idea of the importance of this we can compute an implied money's worth reduction from the annuity rates. Suppose an annuity provider priced an annuity for a 65-year old man on the basis of the Age-Cohort p-spline method and a conventional money's worth calculation were done on the resulting annuity rate using the assumptions of the initial medium cohort projections. Assuming a zero loading, then the money's worth figure would be:

$$\frac{6.365}{7.254} = 0.877$$

Thus, moving from one methodology to another could reduce the apparent money's worth by just over 12 percentage points. While it is very unlikely that any annuity provider was doing the precise calculations underlying Table 5.7, it does suggest that similar sorts of analysis to model the riskiness of mortality projections could have reduced the money's worth significantly.

6 Results

The results on the money's worth calculations over various sub-periods of the data sample are presented in Tables 6.1 to 6.6 and Figures 6.1 to 6.7. The general evidence is that money's worth has fallen since the year 2000, but the level of the Money's Worth (MW) and the extent of the fall depend upon assumptions made about the appropriate life expectancy tables. However, annuities are good value.

We first provide a comparison of money's worth based on mortality of male lives, using the contemporary actuarial tables discussed already (Table 6.1 and Figure 6.1). Since it is impossible to date the precise point at which one should move from one life table to another we allow overlap years. The main feature of this graph is one which we shall find in the other graphs too: for any given life table, money's worth appears to be falling over time: for example, using the PML80 table, the money's worth falls from 90 per cent to 88 per cent over the period 1994 to 2000. However, on moving to the PML92 table, the money's worth rises from 88 per cent to 96 per cent in 2000. Almost certainly the gradual decline we appear to observe when using the PML80 table is due to life insurers pricing in higher life expectancy and anticipating the newer mortality tables on the basis of private information. The only new mortality table which makes little difference is the 00 Table, but this is unsurprising since it follows on so quickly from the interim adjustments to the 92 Table.[21]

[21] As we have noted already, the 00 Table does not have projections: to calculate these figures we apply the interim adjustments to the realised mortality in 2000. This is a further reason why our two sets of projections are so close.

Table 6.1 Money's worth 65 year old male level CPA, lives

Year	Summary money's worth of annuities	PML80	PML92	PML92 short cohort	PML92 long cohort	PNML00 short cohort	PNML00 long cohort
1994	0.900	0.900					
1995	0.912	0.912					
1996	0.886	0.886					
1997	0.901	0.901					
1998	0.888	0.888					
1999	0.936	0.865	0.936				
2000	0.955	0.878	0.955				
2001	0.916		0.916				
2002	0.951		0.864	0.923	0.979		
2003	0.912		0.825	0.883	0.940		
2004	0.853			0.827	0.879		
2005	0.863			0.838	0.894	0.835	0.891
2006	0.855			0.829	0.885	0.826	0.883
2007	0.854			0.829	0.885	0.826	0.883

Column labelled PML80 shows money's worth calculated using life expectancy data from the PML 80 Tables; PML92 calculates money's worth from the PML 92 Tables, with short and long cohort interim adjustments. PNML00 calculates money's worth from the PNML00 Tables, with short and long cohort interim adjustments. The first column shows the summary money's worth value for each year, using the appropriate life expectancy figures for the relevant years: where there is more than one estimate for a year, the summary column takes simple averages.

Figure 6.1 Money's worth for male, 65, level annuity, using 'lives' mortality

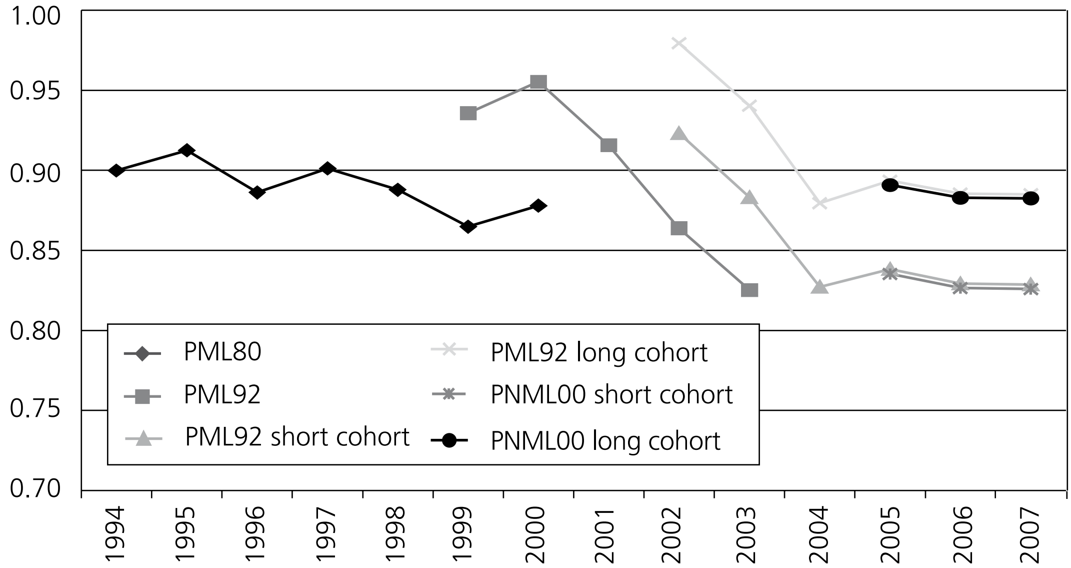
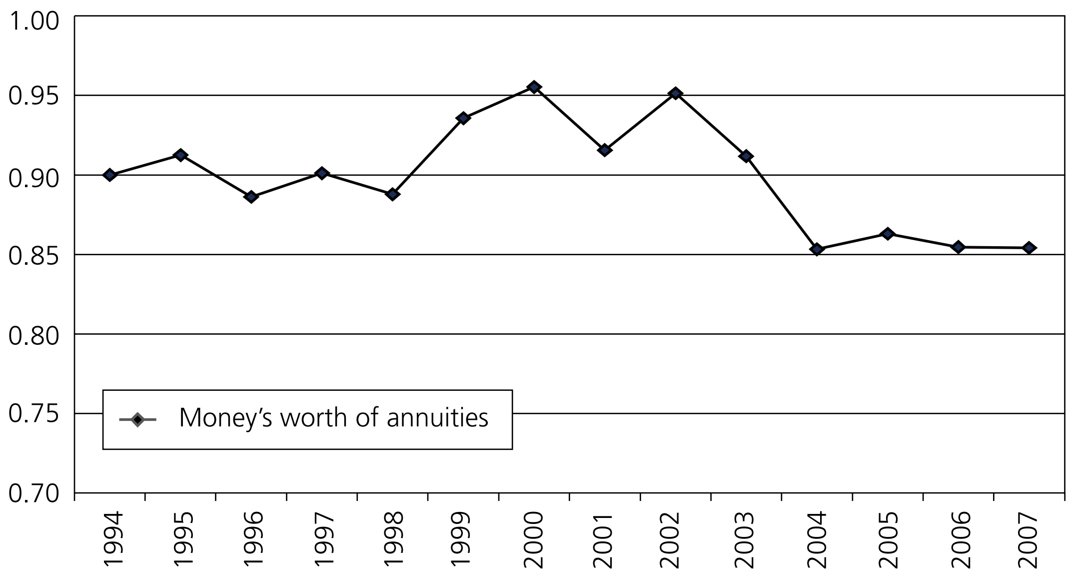


Figure plots the money's worth values from columns 2-7 of Table 6.1. PML80 refers to PML from the 80 Tables, PML92 PML from the 92 Tables, PML from the 92 Tables with short and long cohort interim adjustments, and PNML from the 00 Tables using short and long cohort interim adjustments.

In Figure 6.2 we plot the money's worth of 65-year old males using the combination of life tables in Figure 6.1, to give our estimate of the change in money's worth over the sample. The money's worth profile in Figure 6.2 is a summary of the money's worth values for a 65-year old male from the separate actuarial assumptions in Figure 6.1. The money's worth for a 65-year old male has averaged 89.9 per cent over the period 1994-2007.

Figure 6.2 Money's worth for male, 65, level annuity, using combined 'lives' mortality



Figures plots the summary money's worth values from the first column of Table 6.1, using the appropriate life expectancy figures for the relevant years.

Once we allow for the discrete arrival of revised mortality projections, the decline in money's worth appears to be very small and is itself uncertain because of the uncertainty in which mortality projections to use. If we take the interim short cohort adjustment as the appropriate basis for pricing annuities, the money's worth falls from 90 per cent in 1994 to 83 per cent in 2007, but if we use the interim long cohort adjustment then the money's worth only falls to 88 per cent. To get some idea of the significance of the improvement in mortality for our money's worth calculations, we can consider what money's worth we should estimate if we had used the oldest mortality tables throughout. If the 80 Tables were still being used in 2007, the apparent money's worth would be 70 per cent, suggesting a fall in value of over one-fifth. Of course, it would be entirely inappropriate to use such a table because the cumulative effect of raised life expectancy is between six and nine years.

Table 6.2 and Figure 6.3 show similar results when the money's worth is based on mortality by amounts. As discussed previously, richer people tend to live longer and so when we take an expectation of life weighted by pension size the life expectancy is longer and the money's worth is higher. Using the PMA table, the money's worth is 94 per cent in 1994, falling to between 87 per cent and 92 per cent, depending on whether one uses the short or long cohort assumption. This is uniformly considerably higher than for the figures obtained in the previous graph using the PML table. From the point of view of the life insurers' profits, it is the money's worth weighted by pension that matters and these figures suggest that annuity business has not been excessively profitable. There has been a fall in the money's worth but the change could be consistent with more appropriate pricing of the riskiness of annuities due to greater uncertainty over life expectancy.[22]

Table 6.2 Money's worth 65 year old male level CPA, amounts

Year	Summary money's worth of annuities	PMA80	PMA92	PMA92 short cohort	PMA92 long cohort	PNMA00 short cohort	PNMA00 long cohort
1994	0.940	0.940					
1995	0.953	0.953					
1996	0.924	0.924					
1997	0.943	0.943					
1998	0.933	0.933					
1999	0.993	0.910	0.993				
2000	1.015	0.924	1.015				
2001	0.969		0.969				
2002	0.994		0.914	0.966	1.022		
2003	0.953		0.874	0.925	0.982		
2004	0.891			0.865	0.917		
2005	0.895			0.877	0.932	0.868	0.922
2006	0.886			0.867	0.923	0.858	0.914
2007	0.885			0.866	0.922	0.857	0.913

Column labeled PMA80 shows money's worth calculated using life expectancy data from the PMA 80 Tables; PMA92 calculates money's worth from the PMA 92 Tables, with short and long cohort interim adjustments. PNMA00 calculates money's worth from the PNMA 00 Tables, with short and long cohort interim adjustments. The first column shows the summary money's worth value for each year, using the appropriate life expectancy figures based on amounts of annuities for the relevant years.

22 The Board of Actuarial Standards (2008) have recently issued a paper on the uncertainty in forecasts of mortality rates, emphasising that there is no consensus on the best type of model to use for deriving assumptions about future changes in mortality.

Figure 6.3 Money's worth for male, 65, level annuity, using 'amounts' mortality

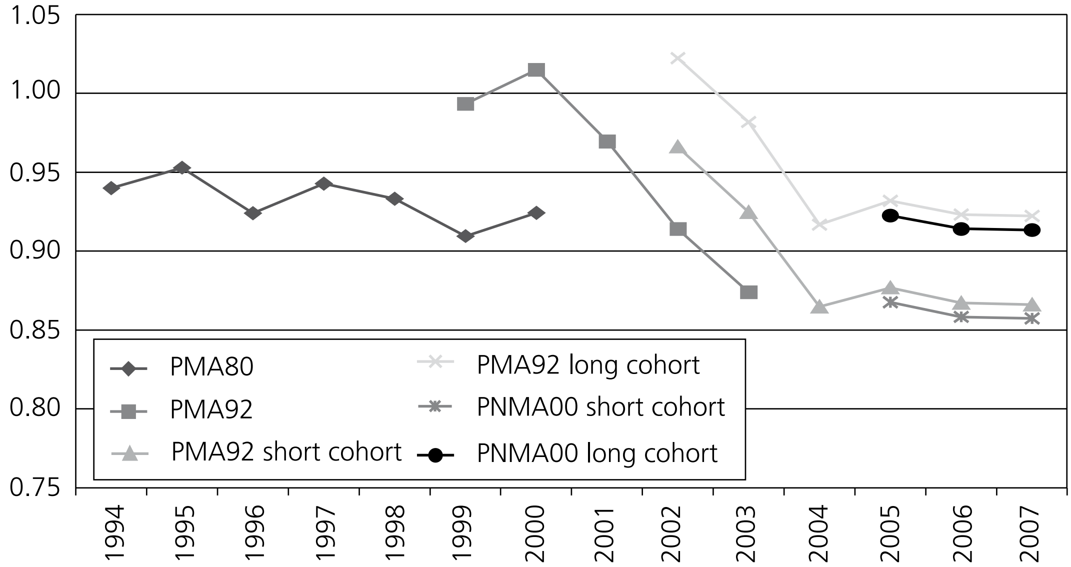


Figure plots the money's worth values from columns 2-7 of Table 6.2. PMA80 refers to PMA from the 80 Tables, PMA92 PMA from the 92 Tables, PMA from the 92 Tables with short and long cohort interim adjustments, and PNMA from the 00 Tables using short and long cohort interim adjustments.

Table 6.3 Money's worth various ages male level CPA, lives

	60-year old PML80	60-year old PML92	60-year old PML92 long cohort	65-year old PML80	65-year old PML92	65-year old PML92 long cohort	70-year old PML80	70-year old PML92	70-year old PML92 long cohort	75-year old PML80	75-year old PML92	75-year old PML92 long cohort
1994	0.916			0.900			0.880					
1995	0.928			0.912			0.892					
1996	0.895			0.886			0.871					
1997	0.920			0.901			0.878					
1998	0.909			0.888			0.863			0.837		
1999	0.886	0.955		0.865	0.936		0.842	0.911		0.817	0.884	
2000	0.905	0.982		0.878	0.955		0.844	0.918		0.813	0.883	
2001		0.938			0.916			0.886			0.857	
2002		0.880	0.960		0.864	0.979		0.846	0.995		0.823	0.977
2003		0.834	0.913		0.825	0.940		0.811	0.963		0.796	0.961
2004			0.865			0.879			0.889			0.887
2005			0.887			0.894			0.905			0.906
2006			0.882			0.885			0.890			0.886
2007			0.878			0.885			0.888			0.890

Columns labelled PML80 shows money's worth calculated using life expectancy data from the PML 80 Tables; PML92 calculates money's worth from the PML 92 Tables, and with long cohort interim adjustments.

Figure 6.4 Money's worth for different ages (male, lives)

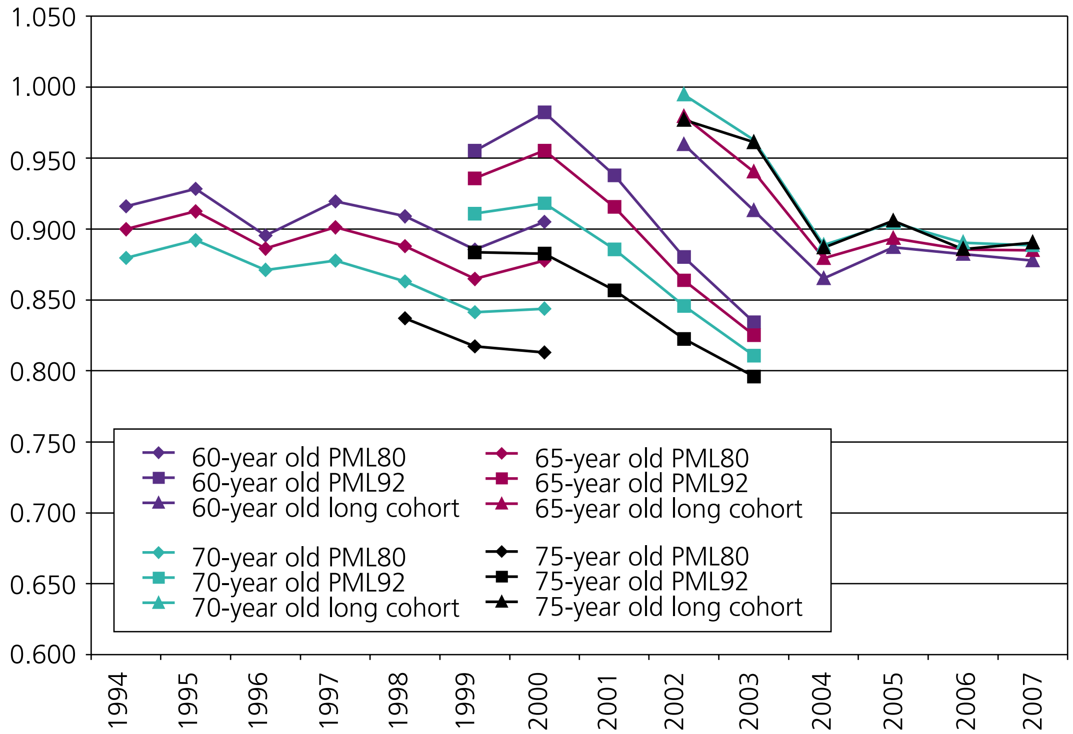


Figure plots the money's worth values from columns of Table 6.3. PML80 refers to PML from the 80 Tables, PML92 PML from the 92 Tables, and PML from the 92 Tables with long cohort interim adjustments.

Table 6.3 and Figure 6.4 show the corresponding money's worth for different ages. As reported in Finkelstein and Poterba (2002) it initially appears that the money's worth is lower at older ages, but this ordering rather dramatically disappears or even reverses when using the long cohort adjustment (the short cohort adjustment, which is omitted from the graph for clarity, does not suggest such a reversal). It is also the case that at the older ages, and using the relatively optimistic long cohort adjustment, there has been no fall in money's worth at all: for example for 70-year olds the money's worth is 88 per cent in 1994 and 89 per cent in 2007.

Table 6.4 and Figure 6.5 illustrate similar results for women, although, interestingly, women always tend to have higher money's worth, suggesting that the actuaries are underestimating women's life expectancy. The money's worth for a 65-year old female has averaged 90.8 per cent over the period 1994-2007.

Table 6.4 Money's worth, 65-year old female level CPA, lives

Year	Summary money's worth of annuities	PFL80	PFL92	PFL92 short cohort	PFL92 long cohort	PNFL00 short cohort	PNFL00 long cohort
1994	0.915	0.915					
1995	0.932	0.932					
1996	0.898	0.898					
1997	0.925	0.925					
1998	0.920	0.920					
1999	0.923	0.896	0.923				
2000	0.958	0.925	0.958				
2001	0.924		0.924				
2002	0.950		0.882	0.925	0.976		
2003	0.914		0.845	0.888	0.940		
2004	0.870			0.846	0.894		
2005	0.871			0.846	0.896		
2006	0.853			0.836	0.887	0.828	0.878
2007	0.857			0.840	0.892	0.832	0.882

Column labelled PFL80 shows money's worth calculated using life expectancy data from the PFL 80 Tables; PFL92 calculates money's worth from the PFL 92 Tables, with short and long cohort interim adjustments. PNFL00 calculates money's worth from the PNFL 00 Tables, with short and long cohort interim adjustments. The first column shows the summary money's worth value for each year, using the appropriate life expectancy figures for the relevant years.

Figure 6.5 Money's worth for female, 65, level annuity, using 'lives' mortality

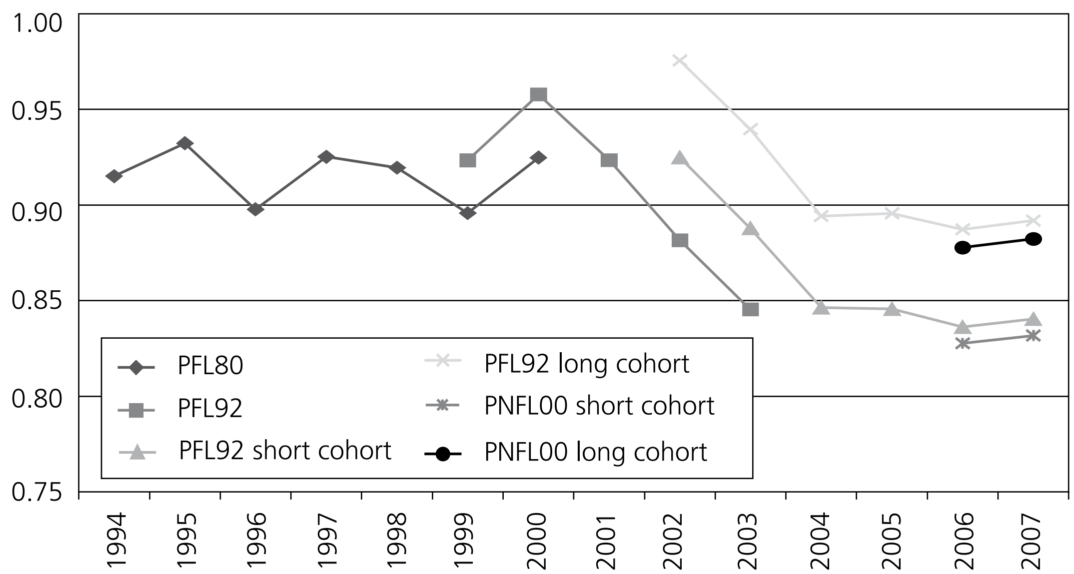


Figure plots the money's worth values from columns 2-7 of Table 6.4. PFL80 refers to PFL from the 80 Tables, PFL92 PFL from the 92 Tables, PFL from the 92 Tables with short and long cohort interim adjustments, and PNFL from the 00 Tables using short and long cohort interim adjustments.

Table 6.5 Money's worth 65-year old male real (RPI-linked) CPA, lives

Year	Summary money's worth of annuities	PML80	PML92	PML92 short cohort	PML92 long cohort	PNML00 short cohort	PNML00 long cohort
1999	0.895	0.812	0.895				
2000	0.860	0.778	0.860				
2001	0.820		0.820				
2002	0.900		0.796	0.862	0.938		
2003	0.884		0.779	0.845	0.922		
2004	0.806			0.770	0.841		
2005	0.774			0.741	0.812	0.739	0.810
2006	0.753			0.719	0.790	0.717	0.789
2007	0.744			0.710	0.782	0.708	0.780

Column labelled PML80 shows money's worth calculated using life expectancy data from the PML 80 Tables; PML92 calculates money's worth from the PML92 Tables, with short and long cohort interim adjustments. PNML00 calculates money's worth from the PNML00 Tables, with short and long cohort interim adjustments. The first column shows the summary money's worth value for each year, using the appropriate life expectancy figures for the relevant years.

Figure 6.6 Money's worth for male, 65, real annuity, using 'lives' mortality

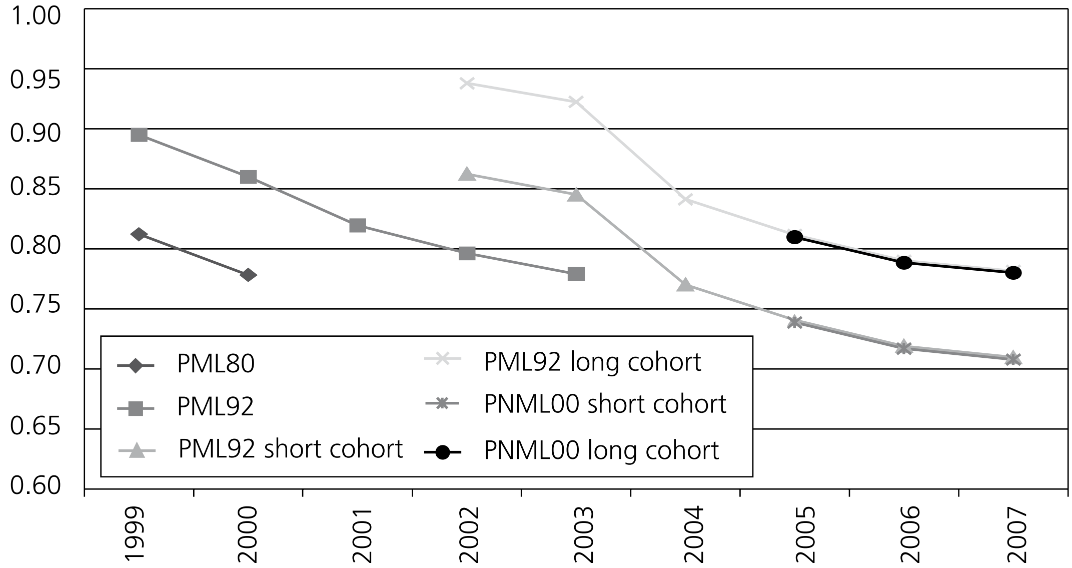


Figure plots the money's worth values from columns 2-7 of Table 6.5. PML80 refers to PML from the 80 Tables, PML92 PML from the 92 Tables, PML from the 92 Tables with short and long cohort interim adjustments, and PNML from the 00 Tables using short and long cohort interim adjustments.

Table 6.5 and Figure 6.6 turn to RPI-linked or real annuities, for which we only have data for 1999 onwards. The money's worth is always lower for such annuities: compare the money's worth of 94 per cent for a nominal and 90 per cent for an RPI-linked annuity for a 65-year old man in 1999. Finkelstein and Poterba (2002) suggest this is due to selection effects, as longer lived people would be more likely to choose real to nominal annuities. However, the discrepancy has more than doubled since 1999: using the 92 Table with the long cohort projection the money's worth are 89 per cent for nominal and 78 per cent for RPI-linked. It is implausible to suggest that this is entirely due to selection effects and this raises the question of whether other issues, such as higher costs of inflation-proofing annuities, are the major cause of the difference in the money's worth.

Table 6.6 and Figure 6.7 provide the most dramatic revision to our estimates of the money's worth. In our discussion of life tables we have already seen that there is considerable variation in the life expectancy of different groups of pensioners. Until this point we have continued to follow Finkelstein and Poterba in using Life Office Pensioner mortality to calculate the money's worth. However, although members of occupational pension schemes may top up their pensions with defined contribution additional voluntary contributions (AVCs), these members of defined benefit schemes are likely to have different characteristics to those people who are buying a pension annuity (Cocco and Lopes, 2004; Brander and Finucane, 2007).

Table 6.6 Money's worth 65-year old male level CPA, various lives assumptions

Year	PML92	PML92 long cohort	RMV92	RMV92 long cohort	PPM00 long cohort
1999	0.936		1.006		
2000	0.955		1.030		
2001	0.916		0.981		
2002	0.864	0.979	0.926	1.035	
2003	0.825	0.940	0.886	0.995	
2004		0.879		0.929	
2005		0.894		0.945	0.946
2006		0.885		0.938	0.940
2007		0.885		0.937	0.941

Column labelled PML92 shows money's worth calculated using life expectancy data from the PML 92 Tables; and from the PML 92 Tables, with short and long cohort interim adjustments. RMV92 calculates money's worth from the RAC Males Lives 00 Tables, and from the RAC males lives 00 Tables with long cohort interim adjustments; PPM00 calculates money's worth from the PPM00 Tables with long cohort interim adjustments.

Figure 6.7 Money's worth for male, 65, level annuity, using different mortality tables

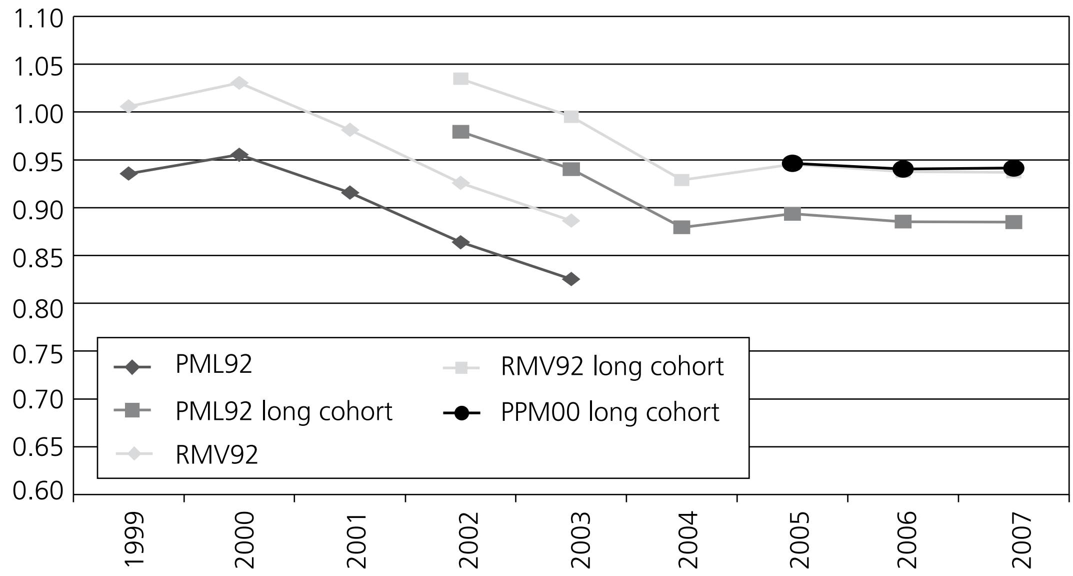


Figure plots the money's worth values from Table 6.6 PML92 refers to PML from the 92 Tables, and from the 92 Tables with long cohort interim adjustments, RMV92 RAC from the 92 Tables, and from the 92 Tables with long cohort interim adjustments, PPM00 PPML from the 00 Tables with long cohort interim adjustments.

So in Table 6.6 and Figure 6.7 we now consider the effect of using the mortality of people with RACs, and for the few years that they are available, the data based on personal pensioners. Using these tables adds just over five pence to the money's worth, suggesting that the money's worth was actually greater than one in 2000 and 2002. These figures suggest that annuities have been very good value for the typical annuitant.

The most recent revisions to mortality projections by the actuarial profession have been published (in provisional form) in CMI Working Paper 20. These projections are not provided as a central projection but as a distribution of projections. In other words they attempt to model the uncertainty about the projections (as is conventional in the finance literature). The amount of uncertainty shown by these projections suggests that the 95 per cent confidence interval for annuity prices (the reciprocal of the money's worth) is about six per cent: ie that the money's worth could be up to three per cent higher or lower than the central projection. This is clearly a large range of uncertainty. We have not incorporated these uncertainties into our projections, because there is some doubt as to whether these are the real ranges of uncertainty – the actuarial profession itself is still looking at new techniques for measuring this.

As a final robustness check, we considered the sensitivity of our results to two separate assumptions with respect to the annuity rate and the appropriate discount rate.

So far we have used the average annuity rate quoted each month across the sample of annuity providers. However, these quotes may be stale or an annuity provider who wishes to manage the risk of their annuity book may quote uncompetitive rates. In addition, the open-market option means that an annuitant could obtain the maximum of the annuity rates quoted and, therefore, the maximum annuity rate quoted by a particular annuity provider each month may be a better indicator of the money's worth. We repeated our money's worth calculations for 65-year old males purchasing level annuities, and we used the PML92 (long) tables for the whole sample, and compared the money's worth from using the average annuity rate with that from the maximum annuity rate. The money's worth increased from an average value of 98.9 per cent to 103.4 per cent. So we may conclude that using the maximum annuity rate increases the money's worth of the base-case 65-year old males by 4.5 per cent.

As a second robustness check, instead of using the yields on Government bonds to calculate money's worth, we may use the corporate bond yield as the appropriate discount rate. From the information in Table 5.2, we may infer that the risk premium on corporate bonds averaged 0.9 per cent over the sample. We repeated our money's worth calculations for 65-year old males purchasing level annuities, and we used the PML92 (long) tables for the whole sample, and compared the money's worth from discounting the average annuity rate at the Government bond yields with a discount rate that imposed a 0.9 per cent risk premium. We found that the money's worth decreased from an average value of 98.9 per cent to 91.6 per cent. The implication is that imposing a corporate bond risk premium in the discount rate reduces the money's worth of the base-case 65-year old males by 7.3 per cent.

We may combine these two assumptions on: i) the best annuity rate; and ii) a risk premium for corporate bonds with our base estimates of money's worth for 65-year old males and females from Tables 6.1 and 6.4 respectively. In which case these robustness checks would suggest that the average money's worth for 65-year old males could lie between 83 and 94 per cent, and for 65 year-old females between 84 and 95 per cent.

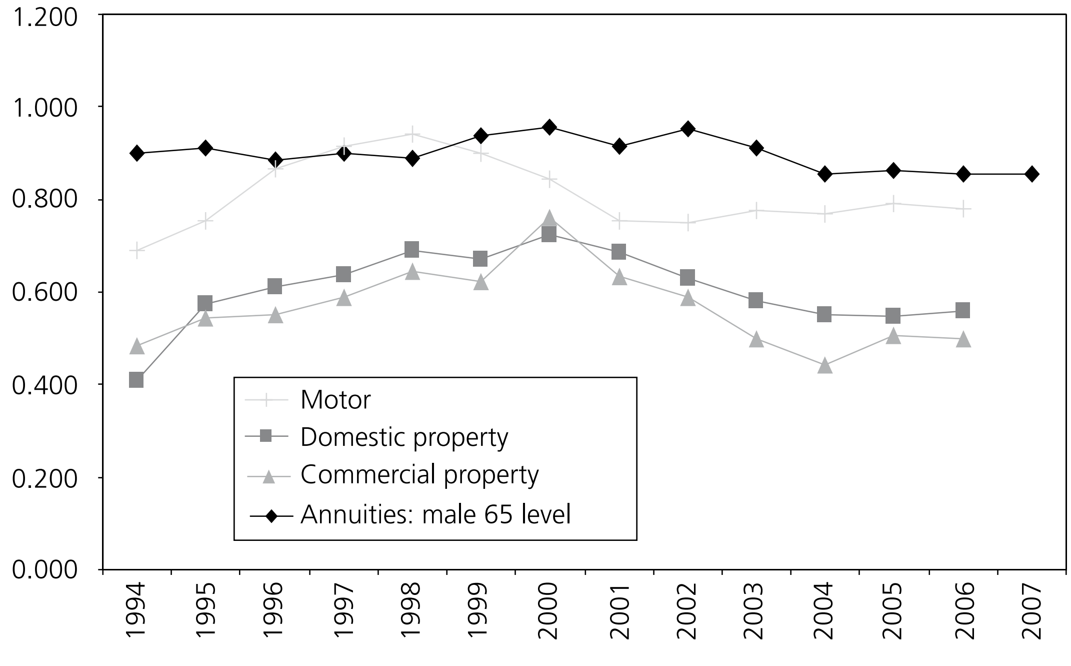
7 Discussion

We conclude our analysis with a brief comparison of our money's worth calculations with the money's worth of other insurance products and then discuss possible explanations for the decline in the money's worth.

7.1 Evaluation of the money's worth

The numbers for the money's worth of pension annuities for males have averaged around 90 per cent over the period 1994-2007. As we have discussed in Chapter 4, it is difficult to evaluate the money's worth figure because we cannot obtain information on the costs of life insurers. One possible means of evaluating money's worth figures is to compare the money's worth on annuities with analogous figures for other forms of insurance. The Association of British Insurers (ABI) has provided us with estimates of the premiums paid, and the claims made for a number of insurance markets: motor, domestic property and commercial property insurance over the period 1994-2005. The ratio of the value of claims to premiums paid is a crude measure of the money's worth of these insurance products. We plot these ratios for each year, for level annuities for 65 year-old males, and for the three general insurance products in Figure 7.1. It can be seen that the money's worth of annuities is consistently higher than the other insurance products. There was only a brief period in the late 1990s when motor insurance was better value than annuities.

Figure 7.1 Money's worth of annuities and claims ratios for motor, domestic and commercial property insurance



Source: ABI.

James (2000) examines the cost of investing in a variety of retail investment products in the UK, and finds that to get the market rate of return on £1, a consumer would have to invest £1.50 in a managed fund, and between £1.10 and £1.25 in an index tracker. These figures imply a money's worth of 66 per cent for a managed fund, and less than 91 per cent for a tracker. This suggests that it is during the accumulation phase that charges from the insurance companies have a significant reduction on the effective rate of return and not in the decumulation phase.

7.2 Possible explanations for the decline in the money's worth

Notwithstanding the high value for money of annuities relative to other insurance and financial products, the evidence in Figure 6.2, is that the money's worth of annuities has fallen slightly over the sample. We now discuss various factors that could explain this recent decline:

- insurance regulation;
- concentration in the insurance industry;
- insurance cycle;
- pricing of mortality uncertainty;
- impaired lives.

7.2.1 Insurance regulation

An important development during the sample period has been the changes to life insurance regulation since 2002. Life insurers in the UK are regulated by the UK's FSA, which incorporates the European Union Life Directives for the insurance industry. As explained in Jordon (2006) the bases of insurance regulation are prudential requirements, meaning that the regulations require insurance companies to have sufficient financial resources to provide for its liabilities. The FSA's General Prudential Sourcebook GENPRU 2.1.8 implements the minimum EU standards for the capital resources required to be held by an insurer undertaking life business. These EU Life Directives set the base capital (currently) at €3.2 million, and the percentage of capital that must be set against technical reserves to cover four risk components: death risks; expense risks; market risks and health risks. In the case of annuities, the amount of capital set aside to cover liabilities is a total of four per cent of the mathematical reserves.

Anticipating a move to a more risk-sensitive EU regulatory approach in the proposed Solvency II, and also because a number of events specific to the UK's insurance industry[23], the FSA has proceeded with its own risk-based solvency requirements, in part anticipating the likely Solvency II rules (FSA 2003, 2005). This new regime may have increased the regulatory cost associated with providing annuities, by imposing higher levels of regulatory capital on annuity providers.

7.2.2 Concentration in the insurance industry

We have seen that in Figure 5.6, although there has been a number of mergers within the life insurance industry over the last ten years, industry concentration has not altered greatly, with the six-firm concentration ratio averaging around 58 per cent since 1985 with no discernable trend. There is no evidence of monopoly pricing within the industry, and the industry has witnessed some new entrants, but the small number of annuity providers remains a potential cause for concern, given the projected increase in annuity demand reported by the Pension Commission in Table 3.1. The FSA comparative tables provide information on annuity rates in the CPA market, which ensures that consumers are kept aware of price dispersion and can use the open-market option to obtain the best annuity rates.

7.2.3 Insurance cycle

There is a wide literature referring to a phenomenon called the 'insurance cycle' (surveyed in Harrington, 2004). This refers to the tendency of insurers to increase their premia after periods when negative shocks have resulted in ex post losses, resulting in significant reductions in capital. Since it appears that life insurers may have been making ex post losses on annuities over some of this period, due to unanticipated reductions in mortality (ie when the money's worth was

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23 Including the closure of Equitable Life, the Baird Report, the Sandler Review of Medium and Long-term savings in the UK, a number of high profile compliance failings, and the fall in equity values after 2000.

above unity), the observed reductions in annuity rates may be an example of the insurance cycle.

Standard economic theory suggests that insurers would be unable to increase prices to recoup losses after a negative shock, due to competitive pressures. However, more sophisticated theories suggest that increasing premia may be rational: first, the negative shock may have resulted in rational updating of probabilities and hence, life insurers reduced their projections of mortality by more than suggested in the CMI reports; secondly, the negative shock would have resulted in a reduction in life insurers' capital on annuities in payment which could not be replaced in the short-term, or which could only be replaced at relatively high cost.

7.2.4 Pricing of mortality uncertainty

We have already discussed changes in actuarial methodology and how the most recent estimates attempt to include both cohort effects and estimates of the uncertainty in mortality projections. Setting aside the issue of cohort effects, pricing cohort-mortality uncertainty into annuity premia would tend to result in lower annuity rates. For example, suppose the annuity rate was set to be actuarially fair based on the best, or central estimate, of future mortality rates. Then, roughly speaking the life insurer would make a profit about half of the time and a loss about half of the time (with a very small chance of exactly breaking even). In an ideal world, the life insurer might hedge this cohort mortality risk, but this would involve payment of a premium and would lower the money's worth since, in fact, secondary markets for such risk are negligible, so the life insurer has to bear this risk.

One strategy to cover this risk would be to set an annuity rate so that the life insurer would be 90 per cent sure that enough funds were available to meet the liabilities. This would involve setting an annuity rate based not on the central estimate of future mortality rates, but on the 90th centile of future estimates. Blake, Cairns and Dowd (2007) show how appropriate centiles can be calculated (which they present using 'fan charts'). The resulting annuity rate would not be actuarially fair but would limit the risk to the life insurer.

During the period that we have been considering it is probable that life insurers have been paying more explicit attention to cohort mortality risk. Since our money's worth estimates in this paper are based on central estimates, any move by life insurers from an actuarially-fair pricing policy to a more conservative pricing policy would appear as a reduction in the money's worth.

In April 2007, the FSA sent a 'Dear CEO' letter to chief executives of annuity providers, reflecting on the debate over future annuitant longevity improvements. The letter recognised that companies would usually make assumptions based on their own mortality experiences:

'However, if this is not possible we would expect firms to consider the different industry views in this area and to err on the side of caution.'

(FSA Dear CEO letter, April 2007)

In other words, annuity providers, according to the regulator, should price annuities conservatively to reflect the risk of mortality improvements. These concerns on the appropriate pricing on risk, have been echoed by the Governor of the Bank of England in a paper submitted to the Treasury Committee explaining the turmoil in financial markets. The paper concludes that the 2007 credit crisis had been caused by financial institutions under-pricing risk:

'The key objectives remain,…ensuring that the financial system continues to function effectively, including the proper pricing of risk. If risk continues to be under-priced, the next period of turmoil will be on an even bigger scale. The current turmoil, which has at its heart the earlier under-pricing of risk, has disturbed the unusual serenity of recent years,…'

(King, 2007 [10])

The implication is that institutions should ensure that risk is appropriately priced, to ensure stability of the financial system.

7.2.5 Impaired lives

According to Quinton (2003), there was an increase in the impaired life market of 23 per cent between 2001 and 2002. In 2005, the **Synthesis** database reports that of £8.5 billion sales of CPA annuities, only £386 million (4.5 per cent) were impaired life. According to Ainslie (2000), the impaired life annuity market needs a market share of 7.5 per cent per annum to be a viable business model, but once it achieves this level, it will have an impact on the profitability of the remaining standard model. Our estimates of money's worth make no allowance for any growth in the impaired life market, since the life tables that we use are unable to distinguish between impaired and non-impaired lives. This growth in the impaired life market would have resulted in the remaining annuitants in the conventional market having average lower mortality. If life insurers priced this information into annuities, they would have been assuming lower mortality than in the standard tables: this could have explained a decline in our measure of the money's worth.

8 Conclusions

This report has examined a time series of pension annuity rates in the UK for 1994-2007. We computed the money's worth of annuities, and found that on average the money's worth over the sample period for 65-year old males has been 89.9 per cent, and for 65-year old females has been 90.8 per cent. Taking into account load factors associated with annuity contracts and in comparison with other financial and insurance products this implies that annuities are fairly priced. However, the value of the money's worth is sensitive to the assumptions made about life expectancy, and we explained the assumptions made about the appropriate life tables to apply to annuitants in the pension annuity market. There is some evidence that money's worth has fallen since 2002. We discussed a number of factors that could have effected the fall in money's worth, including: changes in insurance regulation; changes in industrial concentration; life expectancy shocks and the insurance cycle; pricing of mortality uncertainty and the growth in the impaired lives market.

Appendix
Welfare benefits of annuitisation

Retirement consumption problem

Consider the consumption problem of an individual i who has just retired with pensions wealth W_0 who must allocate this wealth over two remaining periods of his life (c_0, c_1). However, there is uncertainty over whether individual will be alive in the second period. In the absence of an annuities market, individual i maximises expected utility (A1) subject to a budget constraint (A2):

$$\max \frac{c_0^{1-\gamma}}{1-\gamma} + \delta p_1 \frac{c_1^{1-\gamma}}{1-\gamma} \tag{A1}$$

Subject to:

$$c_1 = (W_0 - c_0)(1+r) \tag{A2}$$

where p_1 is the probability of surviving into the second period ($p_0=1$); δ is the rate of time preference, and r is the rate of return on savings. The budget constraint is identical to a certain world case and says that initial wealth must be no less than the present value of consumption over the consumer's lifetime. Solution to the consumption decision problem is:

$$c_0 = \frac{W_0}{1+(\delta p_1)^{1/\gamma}(1+r)^{(1-\gamma)/\gamma}} \quad \text{and} \quad c_1 = \frac{W_0[\delta p_1(1+r)]^{1/\gamma}}{1+(\delta p_1)^{1/\gamma}(1+r)^{(1-\gamma)/\gamma}}$$

In the special case where $r = 0$ and $\delta = 1$, without annuities, the consumption solution simplifies to:

$$c_0 = \frac{W_0}{1 + p_1^{1/\gamma}} \quad \text{and} \quad c_1 = \frac{W_0 p_1^{1/\gamma}}{1 + p_1^{1/\gamma}}$$

Note that if $p_1 = 0$; ie if there is no probability of living until next year, then $c_0 = W_0$ and $c_1 = 0$; and consumer spends all wealth in the first period. On the other hand if $p_1 = 1$; ie if there certainty of living until next year, then $c_0 = c_1 = W_0/2$, and the consumer splits consumption equally between the two periods. For intermediate values of p_1, the individual will tilt consumption between today and tomorrow depending on probability of survival and degree of risk aversion. For example, if $p_1 = 0.5$; and $\gamma = 1$, then $c_0 = 2W_0/3$ and $c_1 = W_0/3$. So the individual with a 50:50 chance of living to the second period will consume more in the first period and less in the second, but this is inefficient for two reasons: firstly, consumption is not the same in each period for those individuals who survive; and secondly, consumption in the second period is left unconsumed for those individuals who die.

Introduce fair priced annuities

Now suppose that an annuities market with fair priced annuities exists. An annuity contract is offered by an insurance company to an individual such that in return for a payment $(W_0 - c_0^A)$ in the first period called the annuity premium (or annuity price) the insurance company will pay out an income y_1 in the second period if the individual survives but will pay out nothing if the individual dies. This contract is fair priced if the insurance company breaks even, so that the price of the annuity contract equals the expected annuity payment $(W_0 - c_0^A) = p_1 y_1/(1+r)$. Then the budget constraint facing the individual becomes:

$$c_0^A + \frac{p_1 c_1^A}{(1+r)} = W_0 = y_0 + \frac{p_1 y_1}{(1+r)}$$

and the individual uses the promised annuity payment to fund second period consumption:

$$p_1 c_1^A = (W_0 - c_0^A)(1+r) \qquad \text{(A3)}$$

So the budget constraint changes to the equality of wealth and the expected value of consumption: the individual exchanges wealth for a promise from the insurance company to pay out an income stream y_t as long as the annuitant lives. The term $p_t/(1+r)^t$ can be thought of as a price, and since:

$$\frac{p_t}{(1+r)} < \frac{1}{(1+r)}$$

then the existence of an annuities market is equivalent to no annuities market but with lower prices of future consumption. So access to an annuities market increases utility by expanding the budget frontier.

With a fair-priced annuity market the solution to the consumers' maximisation problem is:

$$c_0^A = \frac{W_0}{1+p_1\delta^{1/\gamma}(1+r)^{(1-\gamma)/\gamma}} \quad \text{and} \quad c_1^A = \frac{W_0[\delta(1+r)]^{1/\gamma}}{1+p_1\delta^{1/\gamma}(1+r)^{(1-\gamma)/\gamma}}$$

And again for the special case where $r = 0$ and $\delta = 1$, consumption with annuities is:

$$c_0^A = \frac{W_0}{1+p_1} \quad \text{and} \quad c_1^A = \frac{W_0}{1+p_1}$$

Optimal consumption in each period, with and without annuities, is illustrated in Figure 2.1.

We can make a number of observations from Figure 2.1:

a With annuities, $c_0^A = c_1^A = W_0/(1+p_1)$, ie consumption is exactly the same in each period: the situation of consumption smoothing.

b Annuities do not make any difference to consumption when the consumer knows for certain that they will live into the next period.

c We suggested above that if $p_1 = 0.5$; and $\gamma = 1$, then $c_0 = 2W_0/3$ and $c_1 = W_0/3$. Whereas when annuities are available the comparable consumption profile is $c_0^A = c_1^A = 2W_0/3$. This case clearly illustrates that consumers are better off with access to annuities markets.

d Even if an individual has a very low probability of surviving, they are still better off annuitising their wealth: with the implication that all individuals should annuitise.

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