CMPO Working Paper Series No. 02/051

Annuity Prices, Money's Worth and Replacement Ratios: UK experience 1972 - 2002

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September 2002

Abstract

In this paper we construct a time series of annuity prices from 1972-2002, and examine whether annuity rates are unfairly priced, and assess the extent to which annuitisation risks hedged by stock market returns. We find no evidence that the average annuity rate is unfairly low. Depending on the assumptions about future longevity, the present value of an annuity (it's money's worth) is of the order of between 90 per cent and 100 per cent of the purchase price. Compared with the typical costs of buying financial services this figure looks suspiciously good.

In addition, we find no reason to suggest that individuals are worse off by annuity rates being low, since this has been off-set by increases in the value of pension funds over the last thirty years. Even apart from the fact that people retiring today expect to live longer, their pension income (compared to their final salary) looks as good as ever.

JEL Classification: G23, J32

Keywords: Annuities, money's worth, replacement ratios

Acknowledgements

We would like to thank Becca Fell and Sally Lane for entering the data and *Pensions World* for assistance in back copies. We should like to thank David Blake, David De Meza, Tim Leuing, Mike Orszag, Laura Piatti and David Webb for helpful comments. We thank the ESRC "Understanding the Evolving Macroeconomy" Programme (under Grant L138 25 1031) and the Leverhulme Trust for funding this research. The usual disclaimer applies.

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CMPO is funded by the Leverhulme Trust.

Non-technical Summary

In this paper we examine patterns in annuity prices over the last thirty years and calculate whether annuities are fairly priced. We find that annuity rates for 65 year old males have declined from a high of 18 per cent in the late ‘seventies to current rates of around 8 per cent, which might appear to suggest that the current generation are being unfairly treated. However we then ask two questions: are these annuity rates unfairly low, and are annuity rates on their own, an important measure of pensioner’s welfare?

To asses whether annuity prices are fair, we calculate the “money’s worth” of an annuity, which is the ratio of the expected present value of the flow of promised payments made by an annuity to the money paid for an annuity. In order to calculate this present value, we use estimates of life expectancy from annuitant life tables over the same period, and estimates of the term structure of interest rates. The results are that although the money’s worth fluctuates over time over the period 1972-2002 its average value is insignificantly different from unity, and sometimes lies above unity. This is a surprising result, because it suggests that not are annuities fairly priced on average, but also at some times they are more than fairly priced: annuitants are getting better than a fair deal.

In answer to the second question, we examine patterns in the replacement ratio over the last thirty years, where the replacement ratio is defined as the ratio of pension income from the annuity to labour income (net of pension contributions). The pension income from an annuity is made up of the annuity rate multiplied by the value of the pension fund at retirement. Using simulated savings rates with reasonable parameter values for an average worker who started saving forty years before retirement in 1932, We find that replacement ratios have actually increased over the last thirty years, mainly because of the tremendous growth in equity markets over the latter half of the 20th century. In conclusion there is no reason to suggest that individuals are worse off by current annuity rates being low, since this has been off-set by increases in the value of pension funds over the last thirty years. Even apart from the fact that people retiring today expect to live longer, their pension income from an annuity (compared to their final salary) looks as good as ever.

Introduction

Although pensions are not usually considered the most interesting of topics, there has been considerable discussion in the British press (e.g., The Sun, 5 March 2002, The Observer, February 17, 2002) about supposedly low rates of return on annuities and the legislative compulsion to devote 75 per cent of one's pension fund to the purchase of such an annuity by the age of 75. The government has become so concerned about the functioning of the annuities market in the UK that it issued a consultation paper[1] in February 2002. In this paper we consider a variety of potential criticisms of both the legal requirements and the way that annuities operate.

We start first by noting that at least part of this discussion seems to be based upon a mis-apprehension, *viz.*, that the money paid towards an annuity by annuitants who then die relatively young is received by the life insurer: this is because any implicit capital available at the point of death is not paid to the deceased annuitant's estate. In fact, however, this money is used to subsidise those people who live for a relatively long time and who receive considerably more money from their annuity than they actually paid in. This is a key component of the idea of an annuity: it insures people against uncertain lifetimes by redistributing from those who die relatively young to those who die relatively old.[2] The risk insured is the possibility that one might live too long, or, if that seems an odd thing to avoid, the possibility that one might live longer than one has assets to finance. Criticism of annuity markets on this basis is clearly faulty and it is a matter of educating the public (or perhaps the press) as to the true state of the matter. It is noteworthy that analyses of the UK annuity market by Murthi, Orszag and Orszag (1999) and Finkelstein & Poterba (2002) suggest that the market is approximately efficient and that annuities are not actuarially mis-priced (Mitchell, Poterba, Warshawsky & Brown, 1999, and James & Song, 2001, suggest that this result is true in the USA and many other countries).

An alternative interpretation of the critique that annuities fail to pay back any capital is that some individuals do not wish to use the pension fund to finance their retirement

[1] Department for Work and Pensions and Inland revenue "Modernising Annuities: A Consultative Document", February 2002.

income at all, but wish to preserve the wealth (which has been accumulated tax-free) to pass on to the heirs. However, the current regulations concerning purchases of annuities mean that this constraint does not bind very tightly. A common form of annuity is one which is guaranteed for a certain length of time: the data we consider below is primarily for annuities guaranteed five years. In this case, if the annuitant dies in the guarantee period the remainder of the payments for the guarantee period are paid to the annuitant's estate. If the guarantee period is relatively long (guarantees of ten years are possible) then the proportion of the annuity which is actually dependent upon the annuitant's death is very low and a high proportion of the value of an annuity can be passed on to heirs. In other words, it is possible to buy an asset called an annuity only a relatively small proportion of which is annuitised.[3]

In addition to annuities with a guarantee period, London & Colonial have recently issued a form of annuity which explicitly involves a component of wealth being paid to the estate of an annuitant at the point of death. Quinton (2001) criticises this innovation, but in the light of annuities with guarantee periods (allowed since 1957) it is difficult to see how tax regulations could be framed to prevent completely pensioners avoiding the need to annuitise all of their savings, especially since they can always reverse any annuitisation by purchasing life assurance.

It is noteworthy that most individuals in the UK have a pension fund of less than £50,000, corresponding to a pension income of at most £4,250 per year at current annuity rates compared with an annual income of £2,300 which could be earned from consols. Given the current level of the UK state pension, such pensioners will need to annuitise their whole pension fund to obtain a satisfactory income. Thus it is unlikely that any except the relatively very rich would wish to use assets in a (tax-exempt) pension fund as bequests. The government would obviously wish to prevent such tax avoidance, but it is not clear that it should do so through any regulation of the annuity market: a more obvious solution would be to limit the amount of savings that can be put into tax-exempt savings vehicles in the first place.

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[2] It might be worth noting explicitly that in the U.K. annuities are insurance against living (too long) and life insurance is actually insurance against dying, since the payment is made when (or if) the insured person dies.

[3] Mike Orszag has informed the authors that the proportion annuitised can be as low as 15 per cent.

A more promising criticism of the current annuity rules is that annuity rates are unusually low. It is certainly true that annuity rates have fallen from about 15 per cent to about 8 per cent over the last ten years. Part of the explanation for this is that longevity has increased. 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 had to fall. This reduction in annuity rates is unavoidable. However, the fall in annuity rates over the last ten years is clearly far too large to be due to changes in longevity alone.

Another important contributory factor is that all interest rates have fallen as can be seen in Figure 1, which illustrates the time series behaviour of the annuity rate alongside that of the consol rate. The question that this paper addresses is whether the fall in annuity rates is larger than justified by the fundamental changes in interest rates and longevity. However, even if low annuity rates are in some sense "justified" it is still reasonable to ask whether pensioners should be forced to purchase annuities at such low rates. To do so appears to make pensioners particularly susceptible to annuity rate risk. Apart from the effects this has on people retiring now, it may also influence potential saving behaviour of people who will retire in the future. Blundell and Stoker (1999) have shown that the timing of risk may be significant in determining agents' savings decisions and that even quite small future risks may influence current savings behaviour.

To answer this question we need to consider the effects of two additional effects on people's pensions. The first is the interaction of government legislation with the national debt and the second is the behaviour of the stock market.

Because annuities are relatively long-lived financial liabilities from the point of view of an insurance company, it has been common practice to match these with long-lived assets such as long-dated government debt: in fact this is virtually a requirement under current government regulation responding to the Maxwell pension scandal. Unfortunately, this increased demand for long-dated government debt coincides with a reduction in the size of the national debt through a series of budget surpluses or very small deficits, as well as the large transfer to the government of the money raised in the 3G telecommunications auction. This has led to very high prices of long-dated government debt and relatively low yields, to the point where the yield curve is now perversely shaped, i.e., downward sloping, at the long end. Thus, although low annuity rates merely reflect low long-term interest rates, this may be because long term interest rates themselves have been artificially distorted. This phenomenon has led to calls for pension funds to be able to hold a wider variety of assets and this alone might allow annuity rates to rise. According to this line of argument (which relies upon a "preferred-habitat" view of the term structure), there is a major distortion of all long-term interest rates which has a corresponding effect on annuity prices.

On the other hand, there is good reason to believe that low annuity *rates* in themselves are less important than is claimed. If the annuity rate is A and the value of a pension fund at the point of retirement is V, then the value of a pension that can be purchased is AV. For a pension fund invested predominantly in the stock market, V effectively represents the stock market index, which tends to be negatively correlated with interest rates. Thus it is quite possible for the annuity rate, A, to be relatively low while AV is close to its long-run value. For this reason, no discussion of annuity rates can be divorced from a wider discussion of financial markets.

The rest of this paper is organised as follows: in the next section we present an annuity rate for the last thirty years for the UK and discuss its relationship with the long term interest rates. We then calculate the net present value of such an annuity over this period, a figure sometimes referred to as the "money's worth". To relate the decumulation phase of a pension to the accumulation phase we then conduct a simple analysis of the relationship of annuity rates and the stock market before concluding.

Annuity Rates and Long Term Interest Rates

There are a paucity of time series data on annuity rates in the United Kingdom, contrasting with the historical analysis of the USA by Warshawsky (1988). Our data are taken from bi-monthly or monthly figures published in *Pensions World* from September 1972 to November 1977 and monthly data from April 1980 to May 1998. During these periods *Pensions World* published a consistent series of data of non-escalating purchase annuities guaranteed for five years, for both men and women of different ages from a variety of different annuity providers. The gaps in the series are filled with data from *Money Management* and *Money Facts.* More details can be found in the Appendix or Cannon and Tonks (2002). One concern with using non-escalating annuities is that these are the forms of annuity most at risk from inflation, apart from the fact that they fail to keep pace with secular increases in average earnings. However, from the point of view of analysing the UK annuity markets they are appropriate, since most annuities which are purchased are of this form. An additional consideration is that data for index-linked or escalating annuities are not available for much of the period.

Our data are illustrated in Figure 1: lest there be any confusion, the annuity prices are usually quoted in the form of an annuity of £600 per £10,000 purchased, which we would represent as 6 per cent on our graph. For comparison with other interest rates we also plot the consol rate. Theoretically these two series should be linked because they are both long-term assets: if longevity were constant and the short term rate were not particularly variable then the two would differ on average only by a constant.

It is clear that from Figure 1 that comparison of the two series will depend largely upon the third observation (1974) which is very different from the others, with the annuity rate equalling the consol rate. In fact this observation is particularly suspect. From our analysis of the data we know that this annuity rates in this particular year are particularly likely to be understated due to the presence of stale prices (see Cannon and Tonks 2002 for details). Omitting this observation, or making adjustments to ensure that prices were not stale, would strengthen our conclusions below.

Descriptive statistics are presented in the table below. As can be seen from the graph, the series are highly correlated (the correlation between the two series is 0.906). Given a 5 per cent critical value of 3.59, it is impossible to reject the null hypotheses that they each have unit roots,[4] but it is possible to reject the null of a unit root in the difference between the two variables, suggesting that the series are cointegrated.[5]

[4] Data is 1973-2000. The unit root tests are based on a regression involving a constant and a trend, since both series are trending downwards over the period, and includes two lags. Alternative specifications yielded very similar results.

[5] One might object to this that (approximately) the annuity rate is the consol rate plus an allowance for mortality and that the latter is also likely to be a unit root: hence the difference between the annuity rate and the consol rate should not be stationary. However, the mortality

	Annuity Rate	Consol Rate	Annuity Rate - Consol Rate
Mean	13.06 per cent	9.85 per cent	3.21 per cent
St. Dev.	2.64 per cent	2.76 per cent	1.18 per cent
ADF test for Unit Root 5 per cent critical value = 3.59	3.31	2.87	3.89*

Multivariate analysis of the two series is hazardous with so few observations and so further analysis of the cointegration properties of the two variables is suggestive rather than conclusive. In a bivariate model of the two series whose residuals seem well-behaved[6] it is possible to reject the null of two unit roots with a trace statistic of 26.2 (p-value 0.43), but it is possible to reject the null hypothesis that the cointegrating vector is simply the difference of the annuity and consol rates but for a linear trend (the test for the homogeneity restriction is $c_1^2 = 12.8$).

Thus we conclude that there is sufficient statistical evidence to confirm what is visible by eye, namely that the annuity and consol rates have behaved similarly over the last thirty years, but insufficient statistical evidence to specify the relationship closely. For this reason we turn to a more theoretically based analysis of the annuity rate.

Net Present Value Calculations

There are two ways to compare the value of annuities with other assets. The simplest way to calculate the value of an annuity is to use the measure called the "money's worth", which is simply 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

variable is very slow moving and, over such a short period of time, has a variance which is tiny compared with that of interest rates (especially since the 1970s are included in the sample). Thus, even if the difference between the annuity rate and the consol rate is integrated, no conventional test would have sufficient power to detect this on our data set.

[6] Our cointegration analysis was based upon one lag of the variables concerned with a linear trend restricted to be within the cointegration space. Apart from the fact that it was statistically significant, the trend was included as a crude proxy for any possible convergence between the two rates over the period due to increased longevity (as life expectancy rises, the length of time for which an annuity pays out increases and hence it becomes "more similar" to a consol). However, since the annuity and consol rates are themselves trending down, the inclusion of a trend is itself problematic. Its exclusion makes it impossible to reject the null hypothesis of no cointegration between the two series.

been used by Mitchell *et al* (1999) to analyse the annuities market in the USA and by Murthi, Orszag and Orszag (1999) and Finkelstein and Poterba (2002) to analyse the UK annuity market. These papers are very similar, the first of does have some information on annuity rates at different points in time and the last two consider the variation between different annuity providers and products. A detailed description of the method can be found in the references cited: for a general discussion see the Introduction to the collection of papers in Brown et al (2001).

The alternative way to compare the value of annuities with other assets is to consider the internal rate of return implied by an annuity rate. The advantage of the latter approach is that it is necessary only to project life expectancies, whereas the money's worth approach requires assumptions about expectations of future interest rates as well. Our results, however, are sufficiently similar that we do not report them here.

Returning to the money's worth approach: define the annuity rate A_t as the payment made per year of an annuity which cost £1 to buy in year t. The money's worth for a level 5-year guaranteed annuity can be written as

(1) $$A_t\left\{\sum_{k=66}^{70}\prod_{j=1}^{k-65}\left(1+r_{t+j}\right)^{-1}+\sum_{k=71}^{\infty}p_{t,k,65}\prod_{j=1}^{k-65}\left(1+r_{t+j}\right)^{-1}\right\}$$

where r_{t+j} is the interest rate in period $t + j$ and $p_{t,65,k}$ is the probability of someone born in year t - 65 surviving to age k having reached age 65.[7] Analogous formulae can be used to calculate the money's worth for annuitants at different ages.

There are two ways to implement the calculation of equation (1), which we shall refer to as *Ex Ante* and *Ex Post*.

Our *ex ante* implementation attempts to use expectations of interest rates and survival probabilities that were available at time t. We estimate expectations of future interest

[7] This appears to assume that no (fraudulent) payments are made to the annuitant or his or her estate after the point of death (disregarding payments made in the guaranteed five years period). Evidence from the Audit Commission (2002) suggests that such fraud may not be insignificant: £24 million of fraudulent payments were discovered for 2000, despite relatively few pensions providers taking part. Since our mortality statistics are presumably based on

rates from the term structure of interest rates. This means that the 1988 interest rates used to value an annuity sold in 1980 are the implicit rates in 1980 yield curve. Apart from consistency across time, the approach has the advantage that it can be compared directly with Mitchell *et al* (1999), Murthi, Orszag and Orszag (1991) and Finkelstein and Poterba (2002).

It is, of course, well known that the term structure is rather a mediocre predictor of future interest rates. According to theories where there is a liquidity or term premium or according to preferred habitat theories, it may be a biased predictor. Most discussion assumes that longer rates are higher because of a term premium, in which case the interest rates we infer from the yield curve (at the long end) will be biased upwards and the money's worth biased downwards. Since we shall be arguing that the money's worth is quite high, this bias will be against our argument and in fact strengthen our conclusions.

As mentioned in the Introduction, however, there may be some reason to believe that long term interest rates are currently biased downwards, in which case we would be over-estimating the money's worth. We shall partially address this problem in the following section where we discuss the value of pensions.

Obtaining expectations of mortality is more complicated. In particular we need to know mortality of voluntary immediate annuitants, since there is clear evidence that the mortality experience of such individuals differs both from other pensioners and the population as a whole (see Finkelstein and Poterba, 2002, for a discussion of this issue). To calculate *ex ante* survival probabilities we used the last published actuarial projected life tables for each year. These are currently published by the Continuous Mortality Investigation Committee of the two actuarial professional organisations in the UK (the (English) Institute of Actuaries and the (Scottish) Faculty of Actuaries). A census of life offices is taken every four years and the aggregate data published with a lag of between three and five years, the delay presumably being due to the time taken to collect the data in a satisfactory format. On a less regular basis, CMIC publishes a statistical analysis of the data and proposes new standard tables which

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death as perceived by the life office (i.e., when it stops making the payments, regardless of when death actually occurred), our money's worth calculations will be unaffected.

include projections of future improvements in mortality. For the period in which we are interested the relevant standard tables (including future projections) are as follows:

Name of Table	Date Table published	Possible dates Table used	Data used to construct the Table
a(55)	1953	1953-1978	1946-1948
(a90)	1978	1978-1990	up to quadrennium of 1971-1974
IM/IF80	1990	1990-1999	up to quadrennium of 1979-1982
IML/IMA/ IFL/IFA92	1999	1999-	up to quadrennium of1991-1994

It might seem surprising that the tables are up-dated so infrequently and this infrequency might prompt doubts as to whether life offices use these tables without making further adjustments which would not be available to us. This problem is particularly acute for the use of the a(55) table in the 1970s. However, there is satisfactory evidence that this table was in use in 1970s: as interest rates rose in the 1970s supplements to the a(55) table containing monetary functions were published in 1971 and 1973 and CMIR 5 (1981) suggests that a(55) was still used extensively in 1981, despite having been superceded by the a(90) table. CMIR 1 (1973), which contained summary details of mortality experience up to the quadrennium 1967-1970, showed that the a(55) projections of mortality fitted the actual data quite well and no detailed statistical evidence was published until CMIR 2 (1976). It may be that no life office would have had the ability to perform the detailed econometric analysis of the CMIC anyway: given the small sample problems that occur at several points in the analysis of the aggregate data, it is highly doubtful whether an individual office would have had sufficient internal data for a meaningful analysis.[8]

These tables all contain estimates of the probability of dying at a given age, often referred to as the "mortality", which we write[9] as $q_{t,65+k}$ for someone aged 65 + k who

[8] The Continuous Mortality Investigation Reports are concerned with a variety of actuarial analysis of which immediate annuities are only a small and diminishing part, eg in 1979-1982, the numbers of Male and Female policies ("Exposed to Risk") for annuities were 67 thousand and 151 thousand respectively compared to the total numbers of all pension policies of 5,244 thousand and 987 thousand.

[9] Our sub-script conventions are different from those in the actuarial tables.

was born in year t - 65. In all of the tables a distinction is made between the probability of dying at a given age in the year after purchasing an annuity (duration 0, sometimes referred to as “select”), q^0, and the probability of dying at a given age after a longer period of time has elapsed (duration 1+, sometimes referred to as “ultimate”), q^{1+}. The mortality at duration 0 is lower than at duration 1+, presumably because agents have some information over their chances of dying and can avoid buying an annuity if the chances of dying in the near future are high: this is a typical selection effect, although since the information is also known to the life offices there need be no issue of adverse selection through asymmetric information. In some of the CMI Reports further distinctions are made between durations 1-4 and 5+ but the overall picture is rather confused and we do not make much use of this information either here or later. We calculate the survival probabilities by the formulae:

$$p_{t,66,65} = 1 - q^{0}_{t,65},$$
$$p_{t,65+k,65} = \left(1 - q^{1+}_{t,65+k}\right) p_{t,65+k-1,65} \qquad k > 1$$

Finkelstein and Poterba (2002) calculate the money’s worth using two sets of mortality statistics: one based on “Lives” (IML), calculated as a simple average of mortality experience and one based on “Amounts” (IMA), calculated as a weighted average of mortality experience where the weights are the size of the policy. Because of selection and socio-economic effects, we should expect the money’s worth calculated on Lives mortality to be lower, which is borne out in the analysis of both Finkelstein and Poterba (2002) and ourselves. Unfortunately the mortality statistics for immediate annuitants were not published on both bases until the 92 tables and so we are unable to make this comparison before 1999: all previous analysis is on the basis of Lives alone.

In addition to the *ex ante* estimates of the money’s worth we also calculate *ex post* money’s worth using the actual interest rate and actual mortality experiences of annuitants. Of course we do not know these data for years after 2002 (in fact we do not know the mortality data after 1998: these data for the quadrennium 1999-2002 will presumably not be published until 2004 at the earliest), so we use projections where data is unknown and only provide *ex post* calculations for annuities bought in years up to 1992.[10] For 1992 the proportion of the money's worth for a Male aged 65 based on actual data is approximately 75 per cent (this proportion is larger for earlier years), so errors in projections will not be too serious. We provide the *ex post* estimates as a check on our ex ante calculations and as being interesting in their own right: we do not attach a perfect foresight interpretation to these data.

The *ex ante* money's worth under these two assumptions is illustrated in Figure 2. The observations for 2001 and 2002 are not perfectly comparable with previous years, since not all of the relevant mortality data is available, and not all of the yield curve data is yet published: the 2002 observation is based on the first quarter only. Over time there have been considerable variations in the money's worth, mainly due to interest rate movements, but it has remained within a band of 90 pence and 110 pence per £1. Both of the more recent revisions to the mortality projections illustrated have shown increases in the money's worth, i.e., actuaries believe that they have underestimated increases in life expectancy. It is noteworthy, however, that actuaries have not always under-estimated increases in longevity and the improvements projected in the a(55) tables were not realised.[11]

This graph also suggests that the *ex ante* money's worth is not particularly poor at the moment. Certainly there have been times when it was worse, notably some of the 1970s. This is in addition to the problem of inflation: a fixed nominal payment was worth less in the 1970s because it was more quickly eroded by the high inflation of that period, something which will be inadequately accounted for by discounting with the yield curve because it is well known that interest rates failed to fully incorporate changes in inflation at that time.

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[10] The data on actual mortality experiences at duration 1+ is available annually for 1983 to 1998 in CMIR 19 (2000) and for 1975 to 1982 in CMIR 8 (1986). In both cases the data is expressed in the form of a ratio of actual mortality to expected mortality where the latter is taken from the respectively from the 92 standard tables (which can be found in CMIR 12, 1999) and the a(90) standard tables. For duration 0, we were unable to use annual data because it had not been published and even the quadrennial data was based upon a very small number of observations, so we used the relevant base tables (without projection) which give the numbers arising from the graduations of the data.

[11] These improvements (for both male and female mortality rates) were based upon the actual improvements in female annuitant mortality over the period 1880-1945: the data for male mortality over this period was too variable to be used for a projection. Note that the number of female annuities in force over that period was considerably larger than the number of male annuities.

Our attempts to estimate *ex post* money's worth in Figure 3 also suggest that the historical norm is for a value about £1. The most recent observations (1992 onwards) are not truly *ex post*, since they rely heavily upon projections of both interest rates and mortality. If it were true that long term interest rates overstate interest rate expectations because of a term premium, then the most recent observations would be biased downwards, but if the term structure is skewed at the long end because of the shortage of long term debt then the most recent observations would be over-estimates. It is certainly true that on this measure the more recent observations suggest a poorer money's worth, but it is still not far short of £1 and only looks disappointing in comparison with the exceptionally high money's worth figures for the early 1990s (see James and Song, 2000 for a discussion of whether and how such money's worths are consistent with life offices making profits).

These results are very similar to the cross-sectional analysis of Finkelstein and Poterba (2002) and Murthi Orszag and Orszag (1999). The former found the money's worth to be 90 pence and the latter 93.2 pence in 1998, comparing with our figure of 99 pence. Murthi, Orszag and Orszag (1999) also provide estimates of 99.6 pence in 1990 and 92.1 pence in 1994: our analogous figures are 98 pence[12] and 89 pence.

Despite the money's worth being quite attractive, there is considerable year on year variation. Since we know all of the determinants of the money's worth, we can ask what is causing this variation.[13]

To do this, we recalculated the means and standard deviations holding some of the determinants of the money's worth constant for the whole period, replacing the time series with the mean of observations over 1972-2002. Since the money's worth is

[12] The figure of 98 pence for 1990 is based upon the money's worth calculated using the a(90) table. Using the IM80 table, which was just available in that year, the figure would be 103 pence.

[13] Note that since the mean money's worth is always close to unity, the standard deviation is approximately the same as the coefficient of variation and can be interpreted as the percentage deviation from the mean.

stationary, this will provide a reasonable description of the underlying causes of the variability.[14] Our results are shown in the Table below:

Money's worth (£)

Mortality	Actual	Actual	Actual	Actual	*Average*
Annuity Rate	Actual	*Average*	Actual	*Average*	Actual
Yield Curve	Actual	Actual	*Average*	*Average*	Actual
Mean	0.973	1.017	0.971	0.976	0.973
Standard Deviation	0.058	0.225	0.191	0.028	0.058

The three determinants of the money's worth are the annuity rate, the yield curve and mortality.[15] Holding either the yield curve or the annuity rate constant on their own leads to a much larger standard deviation in the money's worth, in the region of 20 pence, but this is misleading since we have already seen that interest rates (at least at high maturities) and annuity rates are highly correlated. Holding both the annuity rate and the yield curve constant, the standard deviation falls from the actual figure of 5.8 pence to 2.8 pence.

On the other hand we can consider the money's worth using actual annuity rates and yield curves and using a constant average mortality, but this makes virtually no difference.[16,17]

[14] This is with the *caveat* that the data underlying our money's worth calculations are not stationary, or even stationary around a linear trend, as was shown above.

[15] The data for the yield curve and the mortality are vectors for each time series observation, so we took the average of the vector, i.e.,

$$\bar{x} = (\bar{x}_1, \bar{x}_2, \ldots, \bar{x}_N) = \left(T^{-1} \sum_{t=1}^{t=T} x_{1t}, T^{-1} \sum_{t=1}^{t=T} x_{2t}, \ldots T^{-1} \sum_{t=1}^{t=T} x_{Nt} \right).$$

[16] In fact we used constant survival probabilities rather than constant mortality q.

[17] It might seem strange that holding mortality constant makes virtually no difference to the standard deviation, while holding interest and annuity rates constant only halves the standard deviation: the inferrence might be that there is some variation which is totally unexplained. The reason for this apparent anomaly is that if we calculate the money's worth holding constant interest rates and annuity rates, then the resulting time series of money's worths trends up over time (the variation about this trend is negligible). This is because (apparently) annuity rates do take account of improvements in mortality. To decompose the variation of the money's worth more precisely we should need to take account of the trending nature of

We conclude that although interest rates and annuity rates are highly correlated, it is largely through variations in these variables that the money's worth has changed over time and that changes in mortality have had only a minimal effect. An important implication of this is that the timing of annuitisation taken in isolation does affect the size of the pension income that an annuitant can obtain. However, there are two problems with using this fact: first, choosing the timing of annuity purchase to increase income would only be possible if changes in the money's worth were predictable and given the evidence in Figure 2, this is unlikely.[18] Second, it is not appropriate to consider the money's worth in isolation, since changes in the money's worth might be offset by changes in the value of the assets (i.e., the pension fund) which would be used to buy the annuity, an issue which we consider in the next section.

This section has illustrated that using the money's worth criterion, annuity rates appear competitive compared with the last thirty years. This result depends to a considerable extent on the yield curve being a valid source of information for the calculation of the money's worth. As we have noted, however, this may not be valid if, as would be the case in preferred habitat theories, the long-term interest rate is itself artificially low: the fact that there is efficient arbitrage between annuity markets and bond markets is of little comfort if all financial markets are distorted. We address this question indirectly in the next section by asking how much pension an annuity can buy at the present time.

Value of Pension Funds

The previous discussion centres on the actuarial fairness of annuity contracts. Perhaps more important to the actual annuitant is the pension that he receives, regardless of how long he lives. This means that we need to consider both the accumulation phase (building up the fund) and decumulation phase (buying the annuity) together. The

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mortality: given the relatively small number of time series observations and the magnitude of improvements in life expectancy over this period, this did not seem worthwhile.

[18] A first order autoregression of the money's worth over the period yields an R^2 of 0.022 and an equation standard error of 0.059: the coefficient on the lagged dependent variable is 0.150 (statistically insignificant at the 10 per cent level). This confirms the *prima facie* evidence of Figure 2 that any attempt to predict the money's worth would require additional information.

value of the pension received by a pensioner is *AV*, where *A* is the annuity rate and *V* is the value of the pension fund at the point of retirement (assuming that all of the pension fund is annuitised). It is a well-known empirical regularity that the value of assets is negatively correlated with interest rates. This is theoretically unsurprising, since the formula for the value (strictly speaking net present value) of an asset is negatively related to the discount rate. Thus there is very good reason to believe *a priori* that the variables *A* and *V* will be negatively correlated. If this is so then any discussion of pensions needs to address the relationship between these two variables, since *A* may form a partial hedge against changes in *V*.

To do this we need to determine how the value of individuals' pension funds have changed over time. The earliest discussion of this issue of which we know is the discussion in Diamond (1977). Since we have no data on the value of pension funds, we construct the pension funds of a series of hypothetical individuals who save according to a well-specified rules and use these to calculate the resulting pension.

Diamond introduces the concept of a "replacement ratio", defined as the ratio of the pension income to labour income (net of pension contributions) in the final year of employment. If the savings rate is 10 per cent and pension income is 60 per cent of labour income, then the replacement ratio is 60/90 = 2/3 and Diamond suggests that this replacement ratio might be appropriate. Empirically such replacement ratios are common in UK company pension schemes where employees have completed their full set of contributions.

The optimal value of the replacement ratio is unclear. In a simple utility maximisation framework where agents only wish to smooth consumption flows, the optimal ratio would be one. However, this result does not follow if agents also obtain utility from leisure and utility is not additively separable in consumption and leisure: because leisure discontinuously increases at the point of retirement we should also expect consumption to discontinuously fall. We might note that there are at least two reasons for consumers' expenditure to change upon retirement: the elimination of work-related expenditure (commuting etc) and variation in expenditure on leisure activities. Some of these expenditures may be discrete rather than continuous choice variables (especially commuting) and hence provide a further reason for discontinuity at the point of retirement.[19]

Consider the pension fund of someone retiring at time t, who has contributed a proportion s of their income y_{t-i} in year $t-i$ to a fund for the last R years. Each year $t-j$ the entire value of the fund (including previous years' returns which are re-invested) earns a rate of return r_{t-j}. Then the value of the fund at retirement at time t is

$$s\sum_{i=0}^{R-1} y_{t-i}\prod_{j=0}^{i}\left(1+r_{t-j}\right)/\left(1+r_t\right).$$

(We assume that no return is earned on the last year's contribution.)

To get some feel for the size of the figures, we consider first a very simple example known as the "60:40:20:10:5:2 rule": this will provide a rough and ready benchmark. With a constant rate of return r and with constant income growth so that $y_s = y_0\left(1+g\right)^s$, the formula for the value of the fund at retirement simplifies to

$$s\sum_{i=0}^{R-1} y_0\left(1+g\right)^{t-i+R-1}\left(1+r\right)^i.$$

This fund can then be converted into an annuity over the expected retirement life of the individual. Now make the following assumptions:

- the agent works and saves towards the pension for 40 years;
- the agent will be retired for exactly 20 years;
- while working and contributing to the pension fund the contribution rate is 10 per cent;

[19] Banks, Blundell and Tanner (1998) show that there is a fall in actual consumption upon retirement and argue that it cannot be fully explained within a utility maximising framework unless there is unexpected adverse information at the point of retirement. Demery and Duck (2001) suggest that some, although not all, of the apparent problems in reconciling income and consumption data with the life cycle hypothesis of consumption may be due to selection effects and problems in appropriately mis-measuring pension income.

- the rate of return on both savings during the accumulation and decumulation phases (i.e., while building up the pension fund and on purchasing the annuity) is 5 per cent;
- real wages grow at 2 per cent per year while the agent is working;
- the agent buys a level annuity.

While it is not suggested that any of these assumptions are true for any particular cohort of savers, they are clearly a reasonable approximation to reality.[20] Perhaps surprisingly, the pension that results is almost exactly 60 per cent[21] of final gross income and hence the replacement ratio is 2/3.

Rather than assume a constant rate of return and labour income growth, we use actual data to calculate possible pension fund values. We consider a series of hypothetical individuals whose labour income is proportional to the UK average earnings index in each year of their life.[22] From the age of 26 to 65, they save 10 per cent of their labour income and invest it in some combination of bonds and equity: all returns are re-invested. To account for charges, we assume that there is a 5 per cent charge for purchasing shares, so that the effective savings rate is 9.5 per cent instead of 10 per cent, that there is a 2 per cent charge every year on the equity investments and 1 per cent per year on bonds, and that the spread is zero. These charges are consistent with the estimates of charges found by Chapman (1999). At 65 the agents purchase an annuity at the prevailing annuity rate.

[20] An additional consideration is the rôle of taxation. By ignoring taxation we are clearly doing an "as if" simulation, where tax rules are basically the same as existing tax regulations, although this was not, in fact, the case for all years after 1918. It is also true that someone who did make use of these rules might have purchased a pension scheme different from an immediate annuity. However, given the complexity of the tax structure for much of the period (with highly progressive rates of taxation), any simulation would need to be based upon additional assumptions about the proportions of earnings and income which were taxed at different rates, which is beyond the scope of the present paper.

[21] For pedants, 58.53 per cent.

[22] Earnings actually vary systematically with age, but unfortunately we do not know of any panel data on earnings by age cohort (we should need data back to about 1920) certainly there is none in the *British Labour Statistics Historical Abstract* or Chapman's analysis of wages and salaries over the period 1920-1938. In the absence of such data we have conducted an analysis assuming that the profile of age-specific earnings relative to the average was constant over the whole period using estimates for the 1990s alone using estimates from Miles (1997), but the results were very similar to the ones with no allowance for age specific earnings.

We consider four different investment rules:

1. Invest entirely in equity;
2. Invest half in equity and half in bonds;
3. Invest half in equity and half in bonds until the last three years of work: thereafter everything is invested in bonds. This is the typical rule used in the USA for 401(k) accounts;
4. Invest everything in equity for the first 28 years of saving. Over the next nine years, gradually reduce the proportion in equity and increase the proportion in bonds until everything is in bonds for the last three years.

The fourth suggested rule approximates to the suggested rule of many fund managers, who argue that it is too risky to hold equity towards the end of the accumulation phase.

Figure 4 shows the replacement ratio under these assumptions. The four graphs show the replacement ratios for a series of individuals who have invested their savings in different portfolios of bonds and equity. So the observations in 1972 are for agents who started saving in 1921 and retired in 1972; the observations for 1973 are for different agents who started saving in 1922 and retired in 1973 (and thus faced different wages and rates of return for some of their life.

These replacement ratios for much of the period have been less than 2/3, mainly because bond returns were poor. The best strategy was clearly to invest in equity, which earned higher returns, even for most of the 1970s. Only in the last few years have portfolios using bonds been better: although switching out of equity into bonds meant that such portfolios did not benefit from the stock market bubble (which has since proved short-lived, they did benefit from the large increases in the value of bonds as interest rates fell.

It is clear from the graph that the last two years have been less favourable times to retire than the late 1990s: the last year would also look worse if we had data for more than the first quarter of 2002. But the overwhelming message is that the fall in replacement ratios is largely due to a return to more historical values. The period of the last five years (during which the discussion of low annuity rates has been at its loudest in the popular press) were actually characterised by high replacement ratios. The worst year to retire was certainly 1974, when annuity rates were relatively high, but the stock market had crashed.

Another feature of the replacement ratio is that the annual variation about the underlying trend is considerably less than the variation in the money's worth. This underlines the difficulty in using the timing of annuity purchase to obtain a larger pension: changes in money's worth are presumably offset to a certain extent by changes in pension fund, which is why the replacement ratio graph is smoother than the money's worth graph. So given the choice of instant annuitisation on retirement or deferring for a year, one should presumably annuitise immediately, given the other benefits of annuitisation.

It should also be noted that the steady replacement ratio since 1980 is despite increases in longevity over the last 20 years, which is ignored in this section. Thus individuals retiring in 2002 on the same replacement ratio as people 20 years earlier are better off, since they live longer and have a similar or better annual income.

Conclusion

In this paper we have constructed a time series of annuity prices since 1972. This is considerably longer than the only other time series for UK annuities that we know to have been published in Murthi, Orszag & Orszag (1999) which included a graph of the best annuity rate for the period 1988-98.

Using this series we answer two questions: are annuity rates unfairly low and does it matter that they are low?

In answer to the first question we find no evidence that the average annuity rate is unfairly low. Depending on the assumptions we make about future longevity, the present value of an annuity is of the order of between 90 per cent and 100 per cent of the purchase price. Compared with the typical costs of buying financial services this figure looks suspiciously good: annuity providers must earn a profit and cover the real resource costs of annuity provision. It is possible to turn the question of low annuity rates on its head: are in fact annuity rates too high? James and Song (2001) argue that in fact life insurers may be able to earn a higher rate of return than the riskless rate that we have assumed from the term structure and hence such money's worths are consistent with annuity providers making profits and covering resource costs.

A possible response to this conclusion is that current annuity rates may appear to provide a good money's worth because the latter is calculated using interest rates which are themselves distorted.

In answer to our second question, we find no reason to suggest that individuals are worse off by annuity rates being low, since this has been off-set by increases in the value of pension funds over the last thirty years. Even apart from the fact that people retiring today expect to live longer, their pension income (compared to their final salary) looks as good as ever. This is prima facie evidence to suggest that government policy need not be mis-placed and that any distortions of the pensions or bond markets are unimportant.

Appendix: Discussion of the Data

A more detailed discussion of the data can be found in Cannon and Tonks (2002).

The majority of our data are taken from bi-monthly or monthly figures published in *Pensions World* from September 1972 to November 1977 and monthly data from April 1980 to May 1998. During these periods *Pensions World* published a consistent series of data of non-escalating purchase annuities guaranteed for five years, for both men and women of different ages from a variety of different annuity providers.

Because the *Pensions World* series is incomplete, we have also used data from *Money Management* and *Money Facts* to fill in the missing periods from 1978-1980 and 1998-2001 respectively. A consequence is that there are a total of three problems in aggregating these data: changing composition of annuity providers, stale prices and inconsistent series. We discuss how we overcome these problems in turn.

The first problem that we have is that the composition of annuity providers changes over time even within *Pensions World*. To overcome this we have analysed several different measures: the mean of all prices quoted, the median of all prices quoted, the best price quoted, the mean of prices from a relatively constant sub-set of companies and the median from the same subset.

The second problem is that some companies appear to keep their prices exactly constant for long periods of time, during which time they are often quite uncompetitive. This may be because the price in the data source is stale, being just rolled over from the previous month, or it may be because the company was not actively seeking to gain custom, in which case the annuity price may be unrepresentative of annuities which were actually purchased at that time. To overcome this situation we have also considered using only those prices of firms which have changed since the previous month. With the possible exception of 1974 this makes little difference: in that year there is some evidence that annuity rates of firms whose prices had changed were systematically 1 per cent better than all annuity rates, consistent with some stale prices during a period of rising prices. From the purposes of our annual analysis, the difference is so small (and only affects one observation), that this makes virtually no difference.

This brings us to our third problem of maintaining consistency between the data in *Pensions World* and the data in the other two sources. The data in *Money Management* are for annuities paid half yearly in arrears and not guaranteed, whereas the data in Pensions World are for annuities paid monthly in advance, guaranteed for five years.

Because of the inconsistency in type of annuity, we provide two sets of numbers for this period. In our own analysis we prefer to use the raw data and amend our analysis to allow for the change in definition. In our analysis above we perform money's worth calculations on annual data using the original data for years 1978 and 1979 and the appropriately different definition of money's worth for a non-guaranteed annuity. However, where the objective is to have a consistent time series (perhaps to be graphed for illustrative purposes), we infer a monthly guaranteed rate from the *Money Management* data.

Our inference to correct for this definitional difference is based on some simple actuarial calculations: recall that we make this correction only on our annual data series. To make the series compatible we performed a calculation in two steps. Annuities paid half yearly in arrears result in payments being paid on average a quarter of a year later, so we subtracted one-quarter of the then prevailing consol rate (actually 11.5 per cent) to effect the increased discount given to payments made further in the future.

The probabilities of dying for a man between the age of 65 and the ages of 66-70 can be rewritten $1-p_{t,66,65}$, $1-p_{t,67,65}$, etc., where $p_{t,k,65}$, is the probability of someone aged 65 in year t living to age k (and hence receiving the annuity payment) for the two years 1978 and 1979. Write the headline annuity rate (i.e., the payment per year) as A per £1 paid to the annuity provider on retirement.

Assuming a constant interest rate *r*, which we assume to be equal to the contemporaneous consol rate, the present value or "Money's Worth", M_t, of an annuity guaranteed five years is

$$M_t \equiv A_t \left\{ \sum_{k=66}^{70} \prod_{j=1}^{k-65} (1+r)^{-1} + \sum_{k=71}^{\infty} p_{t,k,65} \prod_{j=1}^{k-65} (1+r)^{-1} \right\}$$

whereas that not guaranteed five years is

$$M_t^N \equiv A_t^N \left\{ \sum_{k=66}^{\infty} p_{t,k,65} \prod_{j=1}^{k-65} (1+r)^{-1} \right\}.$$

Finkelstein and Poterba (2002) have argued that the money's worth for the two types of annuities will differ because of adverse selection effects: individuals with private information that they are likely to be shorter-lived self-select into annuities guaranteed five years and thus the true money's worth for the guaranteed annuity should be based on lower survival probabilities. Since we are unable to identify the true survival probabilities the money's worth appears to be higher. Then, assuming a constant interest rate,

$$\frac{M_t}{A_t} - \frac{M_t^N}{A_t^N} = \sum_{k=66}^{70} (1-p_{t,k,65})(1+r)^{65-k} \approx 0.37$$

where the number 0.37 arises from the data for a Male aged 65 and the interest rates prevailing at that time. Rearranging this expression we obtain

$$A_t = \frac{M_t}{M_t^N / A_t^N + 0.37}.$$

In the absence of any data on the money's worth values for the relevant years, we use those calculated by Finkelstein and Poterba (2002, Table 5, p.46) for annuities sold in 1998, which are reproduced in the table below:

	No guarantee	Guaranteed 5 years
Male 65	0.862	0.865
Male 70	0.833	0.844
Female 65	0.854	0.857

It is this estimate of the annuity rate that we use (for illustrative purposes only) in Figure 1: analogous adjustments are possible for Males aged 70 and Females aged 65.

The data in *Money Facts* are defined similarly to those in *Pensions World*, but are drawn from a different list of companies. More worrying, the annuity rates for the subset of companies in both sources are different. We have contacted the relevant annuity providers to seek an explanation for this and have been told that it arises due to different commission charges being included in the two quotes (e.g, one included a commission of 1 per cent and the other a commission of 1.3 per cent). To overcome this difference we have spliced the series together using a shift factor derived from the overlap period of four months (1998 January-April), which turns out to be 0.38 per cent, comfortably close to figure we might expect given the commission charges quoted.

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Figure 1: Interest Rates and Annuity Rates

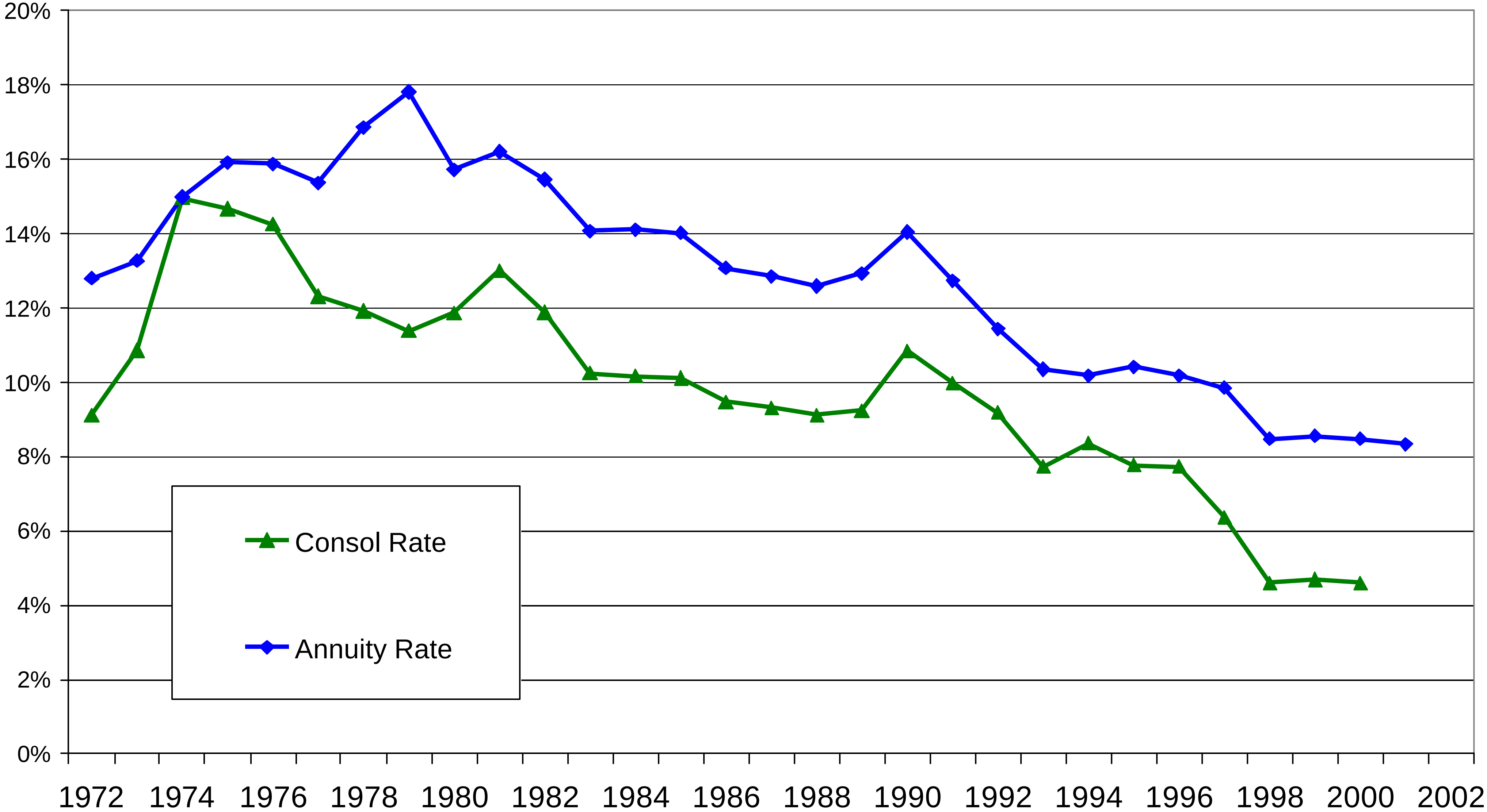
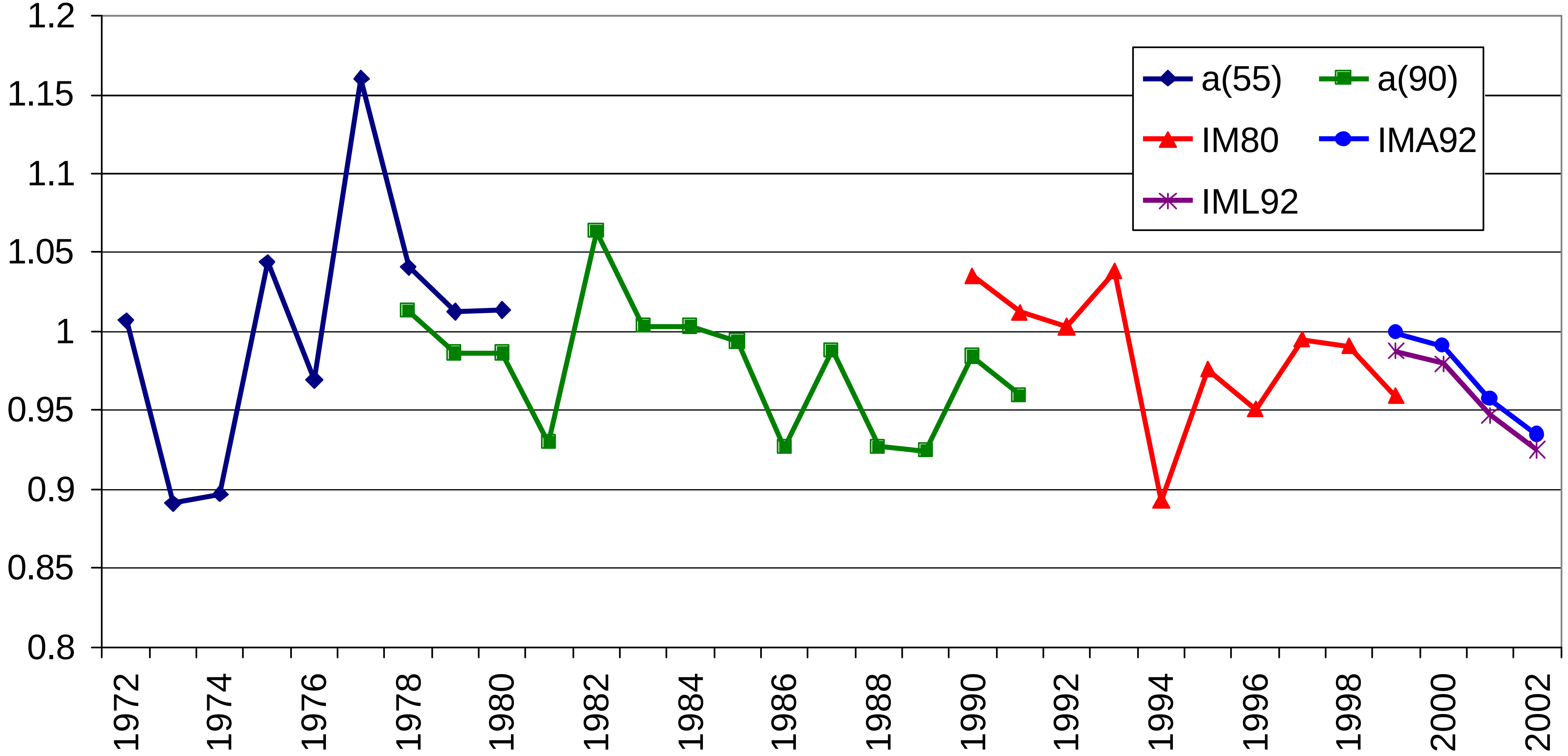
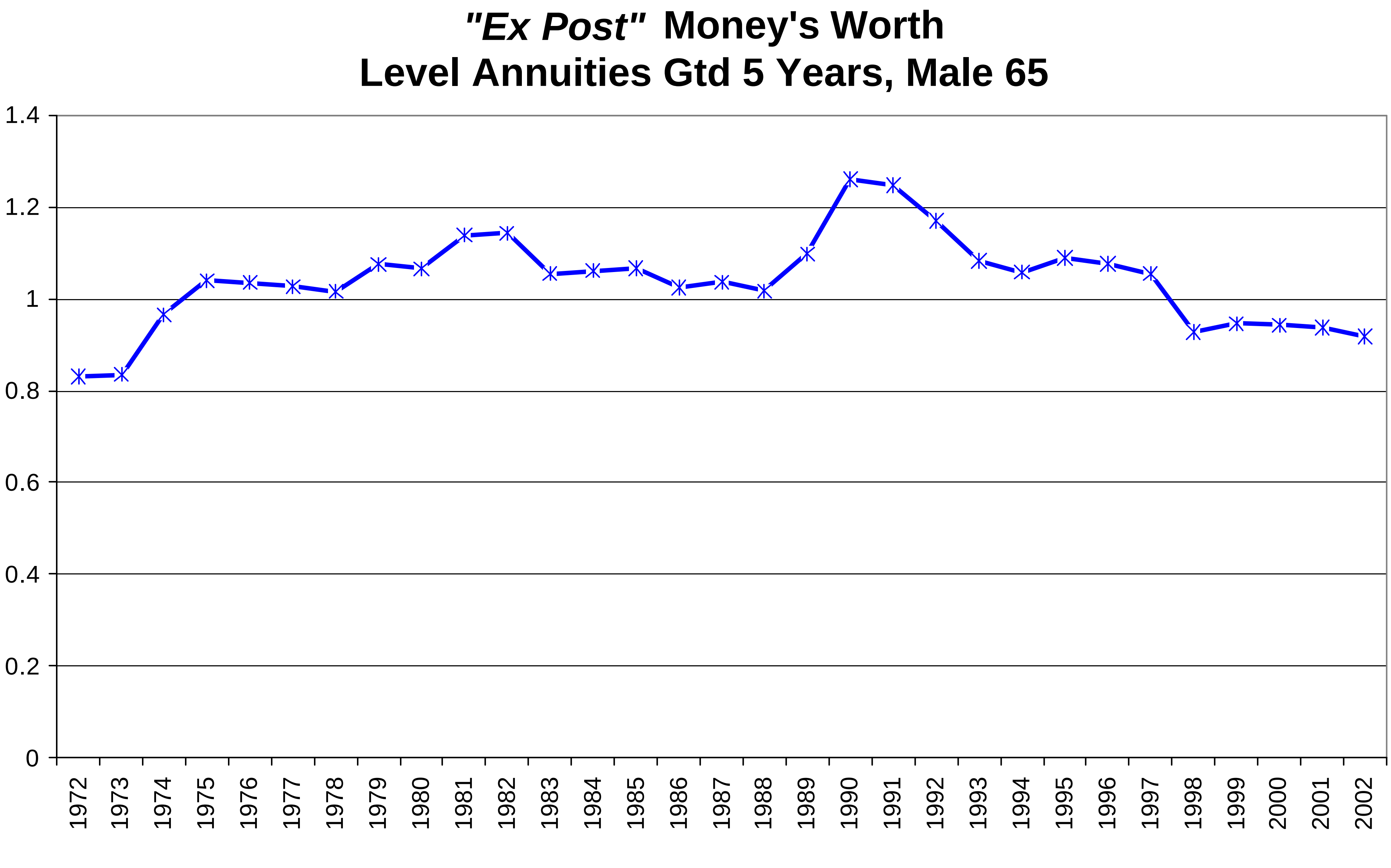


Figure 2: Money's Worth (Male 65)
Contemporary *ex ante* estimates




"Ex Post" Money's Worth
Level Annuities Gtd 5 Years, Male 65
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
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1987
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2002

Figure 4: Replacement Ratios
Different portfolios of bonds and equity