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Olivia S. Mitchell/David McCarthy

Annuities for an Ageing World

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Annuities for an Ageing World

June 9, 2002

Abstract

Substantial research attention has been devoted to the *pension accumulation* process, whereby employees and those advising them work to accumulate funds for retirement. Until recently, less analysis has been devoted to the *pension decumulation* process – the process by which retirees finance their consumption during retirement. This gap has recently begun to be filled by an active group of researchers examining key aspects of the pension payout market. One of the areas of most interesting investigation has been in the area of annuities, which are financial products intended to cover the risk of retirees outliving their assets. This paper reviews and extends recent research examining the role of annuities in helping finance retirement consumption. We also examine key market and regulatory factors.

Annuities for an Ageing World

The recent passing of the British Queen Mother at age 101 has brought home to many observers the very real possibility that living to be quite old is a risk to which many of us are increasingly exposed. Longevity patterns throughout the developed world indicate that many more of us will live beyond what was once considered the "normal" retirement age, surviving to celebrate our 100th birthdays and beyond. One long-term consequence of global demographic aging is that it will become increasingly challenging to maintain a decent standard of living during such a long retirement period. Planning ahead for retirement requires confronting and managing a host of risks that threaten to undermine our prospect of retirement wellbeing.

Over the next half-century, global aging trends will imply that more of the world's population will attain the age of 60 and over than ever before, amounting to a higher fraction than children under 15. By 2050, there will be several million centenarians alive on earth, more than at any prior time in human civilization (Desai, 2002). This dramatic global aging process represents an historical "first" by world standards, and it prompts a fundamental question for retirement systems experts: namely, how can societies finance longevity risk, in the light of ever-longer-lived populations?

In this light, the appeal of life annuities is that they offer retirees an opportunity to protect against the risk of outliving their assets, by exchanging these assets for a lifelong stream of guaranteed income (BMPW, 2001). That is, life annuities are financial products, which, in exchange for an initial premium, pay beneficiaries a periodic benefit as long as the annuitant lives. Contracts protecting people from outliving their life expectancies have been around since at least the 1300s (Jennings and Trout, 1982). Recently, however, insurance companies have taken on the task of pooling annuity purchasers with similar life expectancies but different longevity realizations, to help protect them against longevity risk. In many countries, however, life annuity products have tended to be sold as retirement *accumulation* vehicles, rather than as *decumulation* products. This may explain why annuity markets in the OECD countries have been relatively underdeveloped to date.[1]

[1] See for instance BMPW (2001); Doyle, Mitchell and Piggott (2001); Finkelstein and Poterba (2000); Murthi et al., (1999); Sheshinki (2002); and Tonks (1999).

Nevertheless, global interest in annuity markets is beginning to grow. In Latin America, for instance, more than a dozen countries have recently converted their unfunded national defined benefit (DB) pension plans into funded defined contribution (DC) pensions.[2] With the new models well in place, these nations have now begun to consider how the payout phase of these benefit programs will be handled. Many European countries have also begun moving toward funded pension systems and these reforms are focusing attention on European annuity markets.[3] This paper identifies factors shaping annuity markets in the past, with a primary focus on longevity protection in developed nations. We then identify developments that promise potential growth for annuity markets, over the near term as the baby boom generation retires.

I. Is Longevity Insurance a Good Deal?[4]

In a world with no uncertainty, it would be straightforward for a retiree to allocate his wealth at retirement by spreading payments over his remaining life years. If no formal retirement system were in place, the life-cycle model predicts that rational decisionmakers would save optimally; at retirement, they would merely divide their assets over years remaining, so as to ensure optimal retirement consumption (and cover bequest motives, if any).[5]

In reality, of course, many sorts of uncertainty make it far more difficult to decide how much to consume in old age. One risk is that associated with unknown longevity: retirees could outlive their expected lifespans, and run the risk of exhausting assets before passing away. Retirees can reduce this risk by consuming less per year, but such a tactic then boosts the chance that they might die with *too much* wealth left unconsumed. In other words, dying with too little wealth is undesirable, but having too much wealth is also undesirable since it represents forgone consumption opportunities.

Retirement security can potentially be enhanced with the purchase of a life annuity which provides a steady income stream until the insured party's death. The annuity thus involves a

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[2] See Mitchell and Barretto (1997) and Palacios and Rofman (2001) for a discussion of the Latin reforms.
[3] See Cardinale (2002 and Cardinale et al. (2002); Blake (1999); Disney (2000); Disney and Johnson (2000); European Commission (1997), and Maurer and Schlag (2002) among others, for discussions of the European reforms.
[4] This discussion draws on BMPW (2001).
[5] The classic references are Ando and Modigliani (1963), and Modigliani (1986).

premium paid to an insurer, who then pools retirees with similar *ex ante* longevity expectations but different *ex post* survival outcomes (MPWB, 1999; Warshawsky 1998a).

To illustrate these issues, data from 2000 indicate that 65-year old US males could have anticipated a life expectancy of age 81, but some 18% would anticipate living to age 90 or older. Analogously a 65-year old female expected 19.6 more years of life, but she had a 31% chance of living to age 90 or older (Table 1). The high probability of living to very old age underscores the important degree of uncertainty facing people as they allocate their retirement assets. An alternative approach is depicted in Figure 1, where we illustrate alternative consumption profiles generated by alternative wealth drawdown rules. The profile labeled "1/LE" assumes that the retiree draws down his retirement wealth completely by the time he has reached his life expectancy at age 65. The individual consumes a level amount each year, which takes into account any investment earnings on his retirement wealth (here assumed to earn 4% p.a. fixed). Clearly this strategy has the retiree running out of money if he outlives his life expectancy (probability = 43%). A smoother but declining consumption path is represented by the profile labeled "1/Rem LE," which assumes that each year the retiree recomputes the level fraction of retirement wealth he can consume based on his updated life expectancy. For comparison, the profile labeled "Life Ann" assumes the retiree's entire wealth is used to purchase an actuarially fair life annuity which smoothes consumption from 65.

Table 1 here

Figure 1 here

Alternative Payout Profiles

Recent research has sought to explore the pros and cons of alternative wealth drawdown patterns in retirement, to determine whether higher returns on non-annuitized investments might offset the value of the longevity insurance (which also must take into account insurance loads and fees).

Some might think that an older person might do better by holding onto his assets and investing them directly early in retirement, and waiting to buy an annuity later. This perception arises because annuity payouts are higher for those who purchase them later in life, reflecting higher expected mortality of older purchasers. But as Figure 2 shows, this is not necessarily a good strategy. Buying an annuity implies that survivors share the assets of those who died prematurely – essentially pooling the mortality risk of longer and shorter-lived people. As individuals age, mortality increases, implying that this effect becomes relatively more important. Consequently, the rate of return that a surviving retiree who had not annuitized his wealth would have to "beat" in order to be at least as well off as if he had annuitized his wealth rises with age. In other words, older people's money must work harder "if they are not to lose by delaying buying an annuity" (Inland Revenue, 2002:15).

Figure 2 here

As an alternative approach, Albrecht and Maurer (2002) using German data demonstrate that the probability of exhausting one's assets prior to death without an annuity can be quite substantial, though how likely this is will depend on the asset allocation of the retiree's non-annuity wealth. Not only does the volatility of the self-insurer's investment portfolio matter, but also so does the interest rate assumed on the annuity asset. In this case an actuarially fair annuity is used as a benchmark (see Figure 3). In the German case, holding some equities provides higher expected returns as compared to annuities, depending on the assumed interest rate (AIR) used in pricing the annuity product.

Figure 3 here

Assessing Payoffs from Life Annuities

One way to assess the value of longevity protection is to measure the "money's worth" (MW) of life income products. This is facilitated by computing the expected present discounted value (EPDV) of the lifelong benefit stream paid out to the annuitant, and comparing this discounted cashflow to the annuity premium. In the economics literature, the MW is most easily understood in the instance of an immediate single-life annuity which pays out $A per period for life, in exchange for an initial purchase price (e.g. $100,000).

For a nominal annuity, MPWB (1999) specifies that $q_{a,t}$ is the probability that an a-month-old individual alive at the beginning of month t will die during that month. P_j is the probability that a 65-year old retiree survives for at least j months after he purchases a lifelong annuity: [6]

(1) $$P_j = (1 - q_{780,1}) * (1 - q_{781,2}) * \ldots * (1 - q_{780+j1,j}).$$

[6] To compute the EPDV of an annuity purchased by a 65-year-old, one must forecast *future* mortality probabilities, discussed below. Computations also assume that no one lives beyond age 115 years; our calculations are insensitive to this upper limit on lifespan.

In this context, the EPDV of a life annuity with monthly payout A purchased by an individual of age b is $V_b(A)$, which can depend on a term structure of interest rates, i_k, expressing the nominal short rate k periods into the future:

(2) $$V_b(A) = \sum_{j=1}^{600} \frac{A * P_j}{\prod_{k=1}^{j}(1+i_k)}$$

In much annuity research, the term structure of yields on Treasury bonds is used to estimate the time series of expected future nominal short-term interest rates.[7] For inflation indexed, or real annuities, equation (2) incorporates the fact that payout is fixed in real terms (but varies in nominal terms). As BMP (2002) illustrate, this is easily expressed by letting A_r represent the real annual payment (and nominal interest rates in the denominator of equation (2) are replaced with real interest rates r_k). Then the EPDV of the real annuity becomes:

(3) $$V_b(A_r) = \sum_{j=1}^{115-b} \frac{A_r * P_j}{\prod_{k=1}^{j}(1+r_k)}.$$

Irrespective of the payout format, an annuity product's "money's worth" is then defined as the ratio of the EPDV of the annuity's payout stream to its purchase price. For instance, a nominal annuity selling for \$100,000 has a money's worth defined as $V_b(A_n)$/100,000. Such a money's worth ratio represents a currency-independent metric for comparing annuities across different groups, over time, and across countries.

Annuity Prices and Benefit Flows

In practice, constructing MW measures requires that the analyst obtain data on several key parameters, some of which are difficult to obtain and complicated to understand. Most importantly, data are needed regarding the payout stream and the premium charged by the annuity issuer. These are not always simple to model, since many products are on the market taking many different payout forms and structured with a wide range of premium payment paths. For example, a buyer may pay for the annuity with one lump sum or in many payments over a long period of time. Further, the benefit payments may be fixed in nominal terms for the life of the annuity contract, or they may rise at a predetermined rate over time. In yet other cases a

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[7] In addition we evaluate the responsiveness of conclusions to taxes; in the US, federal tax treatment of annuities is quite complex (BMWP, 1999). A useful comparison of tax treatment for annuities across Europe is provided in Wadsworth et al. (2001).

retiree may receive dividends that vary with the value of the underlying assets in which the premium is invested, and/or an annuity policy may include a feature guaranteeing a death benefit to one's heirs.

The complexity of the annuity product market and the fact that products are not widely advertised makes it relatively difficult to compare them around the world. In some countries, such as the US and Singapore, prices and structures of annuity products are available on the internet; in other countries, however, it is more difficult to compare annuity benefit and cost structures. The simplest product is a *single premium immediate annuity*, for which data appear in Table 2 for men and women at alternative ages in the US. Several sensible conclusions emerge from a scan of these data. First, monthly payouts are higher for older people, given the same immediate premium, due to the higher expected mortality of the older buyers. Second, men receive higher payouts than women, due to their higher anticipated mortality. Third, the dispersion across insurance companies indicates that it would pay to shop around, and fourth, payout levels are not closely correlated with the strength of the insurer.

Table 2 here

Mortality Tables

To convert annuity payout data of this sort into money's worth measures, it is critical to obtain high-quality information on mortality tables depicting a particular group's distribution of expected remaining lifetime. Many developed nations have their own mortality tables,[8] having invested in the substantial effort and cost of collecting data on the incidence of deaths by age and sex. Then experts convert these raw data into projection tables by estimating the probability that a group member aged x will die in the next year of life by fitting hazard models to observed distributions of deaths, or by applying a smoothing algorithm to the raw maximum likelihood estimates (McCarthy and Mitchell, 2002). Of course mortality rates tend to be low except at the oldest ages, so obtaining reliable estimates of small probabilities depends on observing a large number of lives. It is also important to recognize that these tables are not fixed, but rather change due to improvements in life expectancies. Particularly among older people, mortality

[8] The Society of Actuaries maintains an excellent database of international mortality tables on its website www.soa.org. Recent European population, insured lives, and annuitant mortality tables may be obtained from MacDonald (1997). The Berkeley Mortality Database (http://demog.berkeley.edu/wilmoth/mortality) is an invaluable resource for those investigating population mortality in developed countries.

experiences have declined rapidly in developed countries, and this trend is expected to carry over to the future (Executive Committee, 1999). Consequently, those seeking to value future annuity payouts must take this into account by developing forward-looking cohort mortality tables, generally based on past trends.

Not only do mortality patterns change over time; there are important cross-country differences as well.[9] Inasmuch as US and UK data collection efforts are relatively consistent, these tables have been adopted by numerous other developed and developing countries: we have observed that US mortality tables tend to be used in the Western hemisphere, while UK tables are often adopted in former British colonies or where British influence was strong. Frequently local actuarial adjustments are applied to the tables so as to make them more reflective of local conditions, though without good mortality data it is probably impossible to know whether the adjustments are adequate. Unfortunately uncertainty regarding mortality tables can also cause insurance companies to raise prices, with adverse consequences for annuity markets in general. Conversely, countries seeking to develop annuity markets may find there is a strong public good aspect to the development and dissemination of mortality data.

There is no single metric to assess such mortality differences, the A/E ("A over E") method expresses the number of deaths anticipated in a given group with a specified age structure using one mortality table, and compares these to the expected number of deaths in a population of the same size using a second mortality table. This is equivalent to a ratio of the weighted average probabilities of death for the two mortality tables, using a specific population structure for the weights (McCarthy and Mitchell, forthcoming):

(4) $$\text{A/E} = \frac{\sum_x w_x q_x^*}{\sum_x w_x q_x} \times 100$$

where q_x^* is the probability that an individual of age x dies according to the table in question, and q_x is the probability that an individual of age x dies according to the base table. The weights, w_x, are set so that w_{65} = 100,000, and $w_x = w_{x-1}(1-q_{x-1})$.

Two examples of A/E measures are provided in Figures 4 and 5. Figure 4 represents mortality trends for US men age 65+ over time, using the 1991 male population table as the

[9] This discussion draws on McCarthy and Mitchell (forthcoming).

benchmark. The trend shows clearly that men's mortality has fallen by just under one-third since 1965, a rather remarkable achievement; results are similar for women. A/E population metrics that can be computed across the OECD appear in Figure 5. All statistics assume a benchmark of US age 65+ male population tables using the US 1991 tables as a benchmark. These data show that Canada and Australia have very similar mortality patterns as the US, whereas Japan has much lower male population mortality rates. Results for Italy as well as Germany indicate substantially higher mortality patterns (among others).

Figures 4 and 5 here

An additional, and key aspect, of cross-national mortality table comparisons for annuity purposes pertains to the role of *adverse selection*. This arises in the present context if buyers of annuities prove to be longer lived than average, prompting actuaries to devise separate mortality tables for annuitants versus the general population. Whether adverse selection is quantitatively important may depend on whether annuitization is optional or mandatory: for example, in the US, purchase of annuities has become increasingly a matter personal choice, since defined benefit pension plans are in decline (Brown and Warshawsky, 2000). As a result there are substantial differences in the US, as well as many countries, between population and annuitant mortality tables as illustrated in Figure 6.

Figure 6 here

Measuring the extent of adverse selection among annuity purchasers as compared to the population is critical for proper annuity pricing, but some countries lack the data necessary to do this with care. Table 3 present A/E results for men and women age 65 in the US, UK, and Japan, for voluntary as well as compulsorily purchased annuities (where available). In the UK, for example, a portion of retirement benefits is often subject to mandatory annuitization, with other benefits voluntarily annuitized. As a result, the insurers have generated separate UK mortality tables for both voluntary and compulsory-purchase annuitants, each of which differs from that of the general population (Finkelstein and Poterba, 1999; Murthi et al, 1999). In this case, the reference or "base" table is the population table for that country. Patterns for men, in the top panel, as well as women in the bottom panel, indicate that voluntary annuitants experience much lower mortality than do compulsory annuitants. Results for Japan are markedly different, with male insurance purchasers having apparently *heavier* mortality than voluntary annuitant holders, but rates equalizing for women.

Table 3 here

Next we use available population and annuitant mortality data from a range of developed countries, to measure the empirical degree of adverse selection in annuitant mortality tables internationally.[10] The derived average measure of adverse selection then becomes a benchmark that can be held up against results for specific countries, to evaluate whether and how far a particular country may deviate from the standard.[11] The dependent variable in this analysis is the A/E value for each table relative to the US Male Population period table (=100). The model relates this to the degree of selection associated with annuitants, controlling on regressors including country-specific indicators (the US is the omitted category), indicators of whether the table was for male or female (male is the omitted category), for period or cohort (period is the omitted category), and whether the table was a population or compulsory or voluntary annuitant table (population is the omitted group). Other cross-country effects are assumed to be uncorrelated and captured in a disturbance term in the following regression model:

(5) $$Y_{ijkl} = a + \text{ß}'\mathbf{C_i} + ?'\mathbf{S_j} + dG_k + zT_l + q(S*G) + l(T*G) + e_{ijkl}$$

where Y_{ijkl} refers to the A/E metric for the mortality table in question; C_i is a vector of indicator variables representing country; S_j is a vector representing the degree of selection; G_k is a scalar representing gender; and T_l is a scalar representing table type (cohort or period). Remaining noise is summarized in the error term e_{ijkl}, modeled as independent, identically distributed random variables.[12] If mortality tables display no additional statistically significant adverse selection, after controlling on the country-specific effects as well as table and gender

[10] This section draws on Mitchell and McCarthy (2002).
[11] Our work acknowledges that the distinctions between population versus compulsory and voluntary annuitant tables may not be precisely identical across countries. Selection is defined here as 'compulsory' if the mortality table relates to annuitants of pension plans, and 'voluntary' if it refers to voluntary individual annuitants. Countries may have different voluntary or compulsory selection effects, even within these categories, due to different labor force demographics (including participation rates), compensation packages, tax codes, and legislation.
[12] Our earlier work also explored results in which "table type" was treated as a random effect with non-zero mean and variance s_T^2, to allow for the possibility that cohort mortality tables may be based on period mortality tables. We reject the null hypothesis that $s_T^2 = 0$ using a likelihood ratio test and coefficient estimates are virtually unchanged. We also estimated standard errors robust to heteroskedasticity and found these to be lower than OLS standard errors; here we report the more conservative OLS results.

differentials, γ will equal 0. Our alternative hypothesis is that $\mathbf{?} \neq \mathbf{0}$; the coefficient magnitude is then an indication of the extent of predictable adverse selection in annuitant mortality tables.

Regression results appear in Table 4, based on data on over 60 population and annuitant mortality tables for ten countries including Australia, Austria, Canada, Chile, Germany, Israel, Italy, the United Kingdom, and the US, representing more over half a billion lives.[13] Estimated results show the model fits very well overall with an adjusted R-squared of 98.8%. Turning to specific coefficients, we find that the "female effect" turns out to be negative and statistically significant for the A/E measure, and implies that mortality rates for women are 35 percent lower than the benchmark US male population rates. This is comparable to the 33 percent and 26 percent lower relatively mortality experienced for voluntary and compulsory annuitants, versus the population. Only one of the interaction terms is statistically significant, indicating that selection between female voluntary annuitants and the population is one-third lower than among men.

Table 4 here

The results also show no significant difference between estimated coefficients for the voluntary versus compulsory selection variables. This implies that the extent of compulsory and voluntary selection overlaps in different countries to some extent. The data series are consistent with an average degree of adverse selection for annuitants versus the general population, of at least 25 percent. The cohort effect is much smaller, on the order of 12 percent relative lower mortality. Another factor to emphasize is fact that many of the country-specific effects are statistically significant, with the exception of Italy, and Germany. Some countries, such as Austria and Israel, have substantially higher (12-13%) mortality than the US benchmark, while Japan, Switzerland, and Canada have 10-14% lower mortality than the US.

Predicted male A/E cohort values derived from this regression analysis are provided for male population and annuitant mortality in Figure 7. The results indicate that according to our model, Italy and Germany both have higher annuitant mortality than US tables, but Switzerland, Australia, Canada and Japan appear well below the US benchmark.

Figure 7 here

[13] For sources see McCarthy and Mitchell (2002 and forthcoming).

While some countries have the necessary mortality data needed to produce annuitant tables for voluntary versus compulsory annuities, others do not. For instance, Italy does not – the 1995 RG48 annuitant mortality table used in our analysis was constructed by applying an estimate of adverse selection obtained from UK annuitant tables.[14] Therefore in Figure 8 we use the results of the regression analysis to generate predicted values of the A/E metric, and also we represent male and female voluntary annuitant tables for Germany and Italy, as well as Japanese compulsory and voluntary annuitant tables. The vertical axis represents the A/E measure, while the vertical bars represent confidence intervals for predicted levels of the A/E metric. The points show where we calculated that these tables actually life. Examination of the results indicates that predicted values for the German annuitant tables are well within estimated confidence intervals. However results for Italian male annuitants fall outside the confidence intervals, as do the results for Japanese male and female tables (circled in the Figure). In other words, these findings indicate excess mortality as compared to what international norms would suggest for tables of this type.

Figure 8 here

The fact that annuitant tables differ so much in Japan and Italy from the international norms could indicate either that these countries have annuity markets that are unusual in an international context, or that there is some problem with the way the annuitant mortality tables are computed. In fact, in both cases, these mortality tables are derived without reference to the mortality of actual annuitants, suggesting a possible reason why they fall outside our predicted confidence intervals. Of course, these results need not imply that annuity prices or liability estimates are incorrect for the annuity business in those countries, because actuaries use many different assumptions to value annuities, and it is not uncommon to alter one or more other assumptions to compensate for a mortality assumption known to be inaccurate. But there is a chance that using offsetting assumptions can lead to inaccurately estimated reserves, distort sensitivity estimates, and complicate analyses of insurer surplus/strain. In general, such practice is best avoided.

Discount Rate Assumptions

[14] In fact, when we performed this analysis we did not have the actual RG48 table. We used life expectancies of individuals on the RG48 tables, obtained from MacDonald (1997) and the fact that life expectancy is very closely related to the A/E measure to derive confidence intervals for the actual A/E metric for the RG48 tables.

As with all economic assumptions, there is no single and clear-cut rule about what discount rates to use when deriving annuity valuation formulas. One approach uses term structures for yields on government bonds, on the argument that the annuity payoff depends on an individual's mortality, which is essentially uncorrelated with market risk. Yields on government bonds are particularly appropriate when insurers are backed by government solvency funds, as is often the case. Another tactic uses riskier corporate bond yields to proxy for expected future interest rates, on the view that insurers often hold such instruments to back their annuity promises. Others argue that discount rates for annuity computations should recognize that governments frequently regulate insurance company investment practices. For instance, the fraction of annuity assets that insurers can hold in equities is capped at 30% in Peru and 40% in Chile; no real estate investment is permitted in Argentina (Palacios and Rofman, 2001). In other countries there may be few or no long-term government bonds, and even when they exist, markets may be thin (James and Song, 2001).

In our research on US annuities, we use nominal yields on US Treasury bonds to estimate the term structure of expected short-term interest rates; the expected nominal short rate in each future period is computed as the nominal short rate that would satisfy the expectations theory of the term structure for the two adjacent long-term bonds (BMP, 2000 and 2002). We also explore the sensitivity of results to flat term structures, with the discount rate given variously by the ten-year Treasury bond yield, the thirty-year Treasury bond yield, and the BAA corporate bond yield.

Utility Value of Annuity Products

Before turning to the results, we note that risk-averse consumers would be expected to value annuities more highly than the simple financial money's worth ratio, since the insurance component provides additional utility against the shortfall risk. It is not surprising that the economics literature shows that annuities should appeal most to risk-averse consumers,[15] while less risk-averse retirees, and people seeking to provide their heirs with bequests, will be likely to want to self-insure with some portion of their assets.

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[15] See, for instance, Albrecht and Maurer (2002); Milevsky (1998, 1999); Blake and colleagues (1999, 2001, 2002); and Warshawsky (1998a and b).

A commonly-used metric for the utility value of annuities is the *equivalent wealth measure*. Specifically, this concept identifies the additional wealth a consumer would require, if he did not have longevity protection, to achieve the same lifetime utility as with that annuity (MPWB, 1999) . This approach assumes that the consumer elects an optimal consumption path $\{C_t\}$ from time 0 to time T (the maximum possible lifespan), given his rate of time preference ρ and a vector of cumulative survival probabilities $\{P_t\}$ to maximize an expected utility function V: $\underset{\{C_t\}}{Max}\sum_{t=0}^{T}\frac{P_t U(C_t)}{(1+r)^t}$. The consumer's budget constraint depends on whether he has access to a fair annuity market. If he does not, the present value of future consumption, discounted using the riskless interest rate r, must equal to his initial wealth, W_0: $W_0 = \sum_{t=0}^{T}\frac{C_t}{(1+r)^t}$. If he can purchase actuarially fair annuities, the budget constraint then becomes: $W_0 = \sum_{t=0}^{T}\frac{P_t C_t}{(1+r)^t}$. The difference between the two budget constraints is due to survival probabilities. That is, lacking access to annuity markets, a retiree's future consumption cannot exceed his initial wealth; by contrast with an annuity, his expected future consumption cannot exceed his initial wealth. In other words, access to annuity markets reduces the relative price of future consumption and lowers the amount of precautionary saving that he must undertake.

To actually measure how much a consumer might value an annuity requires that the researcher specify the functional form for the utility function, along with the relevant risk-aversion parameters. In much economic research, a one-period utility function, $U(C_t)$, is assumed to exhibit constant relative risk aversion: $U(C_t) = \frac{C_t^{1-b}}{1-b}$, where β is the Arrow-Pratt coefficient of relative risk aversion, and 1/β is the elasticity of intertemporal substitution in consumption. The indirect utility function V(.) which corresponds to the budget constraint permits evaluation of the maximum utility that an individual might attain by following his optimal consumption path. Finally, it is possible to evaluate the utility gain in financial terms by computing how much additional wealth the retiree would require if he lacked access to annuities, if he were to be made as well off as with annuities. This computation requires solving for α such that: $V_0\left(aW_0\right)^{no\ annuities} = V_0\left(W_0\right)^{annuities}$. In this formulation, α is the "Annuity Equivalent Wealth ."[16]

Illustrative Money's Worth and Annuity Equivalent Wealth Computations[17]

Panel A of Table 5 presents money's worth calculations for annuities offered across a range of developed countries, specifically, for the Australia, Canada, Switzerland, the UK, and the US.[18] These results were developed using both *annuitant* as well as *population* mortality tables, in order to indicate the extent to which adverse selection may play a role.

Table 5 here

These estimates indicate that annuities computed in each of these countries using population tables prove to have very high money's worth ratios. Estimates are at 0.90 or better in all countries but the US. This implies that a typical member of the population could anticipate receiving at least 90 percent of his premium from the single life annuity. The results also imply that adverse selection as well as loadings and administrative charges must be below ten percent of the purchase price.[19]

Results are even more consumer-favorable using the figures computed with annuitant mortality tables. In the US, for instance, the MW ratio with annuitant survival rates stands at around 93% for both men and women, versus figures of 81-85% using population tables. The difference between these numbers, 8-11%, is indicative of the extent of adverse selection. That is, the difference is a measure of how much longer annuity buyers live than people in the general population. The remaining load of 7% indicates relatively low charges and fees levied by US insurers; this number is half what it was in the previous decade (Brown et al. 2000). Panel A also implies that annuity products are exceptionally good investments in a few countries – perhaps too good to be believable. In Canada, for instance, the estimated values using annuitant tables are above 1.0, meaning that an annuitant could anticipate receiving more than his money back on this financial asset. This may be the result of using overly conservative discount rates to

[16] The derivation requires dynamic programming algorithms described in MPWB (1999) for the case of a single individual; Brown and Poterba (1999) discuss the case of couples: and BMP (2002) discuss the case with uncertain returns and/or inflation.
[17] This discussion draws on Mitchell (2002).
[18] For other countries see Cardinale et al. (2002), Doyle et al. (2001), Finkelstein and Poterba (2001), James and Song (2001), James and Vittas (1999), and Murthi et al. (1999).
[19] The Swiss money's worth figures may be overly high, the result of quite conservative discount rates; see James and Song (2001).

compute the expected present values. In any event, a financial assessment of these life annuity products indicates that (a) adverse selection explains a substantial portion of the load perceived by potential purchasers in the general population, and (b) these products would be expected to be quite valuable to annuitant purchasers.

Panel B moves from a strict financial computation to the broader utility-based measure of annuity values. Specifically we report computations on annuity equivalent wealth for the US case, which it will be recalled represents the amount of wealth that a consumer would need *if he did not have access to an annuity market*, in order to achieve the same lifetime expected utility level that he could achieve by using that wealth to purchase a nominal annuity.[20] To illustrate the results we employ a logarithmic utility function to represent the consumer's utility, and a relatively low level of risk aversion (CRRA = 1). For such a person, a real (inflation-protected) single annuity would be valued at 1.5, assuming the retiree had no other annuitized wealth. This signifies that such a consumer lacking access to an annuity, would be willing to give up half of his investment to obtain a real lifetime annuity with the same investment. At higher levels of risk aversion, the annuity equivalent wealth value rises to 2, meaning that access to a real annuity is worth double the wealth than the same value invested in a nominal annuity. Evidently, an annuity would be valued much more highly in utility terms, than in money's worth terms.

Results in Panel B also show that an inflation protected annuity is more valuable to the risk-averse consumer than is a nominal annuity. The CRRA=1 consumer, for instance, finds the real annuity worth 5-8 cents more per dollar invested versus a nominal annuity, and the value rises with higher risk aversion (at CRRA=10, the gap is 40-60 cents). Our results do show that the valuation depends on how inflation is expected to move, however, since a real annuity is valued at 1.451 with i.i.d. inflation and 1.424 in the case of persistent inflation.[21] It is also critical to take into account the fact that the AEW measure depends on whether a retiree has some portion of his wealth already annuitized. The leftmost subsection of Panel A (labeled I)

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[20] This section draws on MPWB (1999) and Mitchell (2002).

[21] BMP (2001) note that risk aversion and annuity equivalent wealth are not linearly related for nominal annuities in the presence of uncertain inflation, because risk aversion works in opposing directions in the face of inflation uncertainty. On the one hand, higher risk aversion makes the consumer value an annuitized payout more highly since he avoids the risk of outliving his resources, and this is all that matters in the case of the real annuity. On the other hand, a risk-averse consumer dislikes the uncertainty introduced into the nominal annuity stream by stochastic inflation. Increased variability in the real value of the nominal annuity payouts reduces utility, and this effect is larger for those with the highest degree of risk aversion. At low levels of risk aversion, the first effect dominates, and the annuity equivalent wealth for a nominal annuity rises with risk aversion.

assumes no other annuities, while the rightmost (II) section assumes that half of retiree wealth is already annuitized, perhaps through Social Security or occupational pensions.[22] In this case, the AEW associated with annuities is still substantial, but its value is reduced. For instance, the half-annuitized consumer with CRRA=1 would need only one-third more wealth to be made as well off as if he had a real annuity, compared to 50% in the case where he lacked an annuity altogether. Clearly having a pre-existing real annuity provides retirees with insurance against very low consumption values, and it drives down the value of additional privately-purchased annuities.

II. Future Determinants of Annuity Markets

The economic literature over the last decade underscores the conclusion that annuities deserve an important role in retiree portfolios of the future. Though annuity markets in the past might have been underdeveloped, there are several reasons for optimism about their future potential.[23] We discuss these next in terms of demand-side factors, pertaining to reasons that retirees might find them more attractive in the future, and supply-side factors, relevant to the enhanced role that providers might play. Our final section offers a discussion of public policy changes that may also play a prominent role.

Demand-side Factors

Some have claimed that retirees have shied away from annuities in the past because they were perceived to be "too expensive." But the evidence presented above indicates that this is not necessarily true currently, and other information implies that it is even less valid now than in the past (BMPW, 2001). Our finding of relatively moderate adverse selection and relatively low administrative loadings suggests that such charges can be and are being moderated over time. In addition, the research shows that retirees should reap substantial utility benefits from insurance protection against longevity risk. Thus well-managed annuity markets with charges of the magnitudes seen should be appealing to purchasers. Of course, as insurers in Europe and Asia build the markets there, it will still be essential to understand that consumers will expect reasonable money's worth from the products.

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[22] For instance, the median US older household holds about three-fifths of its retirement resources in the form of expected future Social Security and pensions benefits, payable only as life annuities (Moore and Mitchell 2000).
[23] For further discussion of these points see Mitchell (2002) and BMWP (2001)

Retirees' decisions are also driven by people's perceptions about the appeal of alternative retirement investments. For instance, some financial planners have advised retirees to avoid annuitizing, on the grounds that they can manage their money better than institutional pension managers. Others propose that annuitization decisions be delayed to older ages, on the grounds that young retirees can then benefit from the upside potential of investment portfolios (Milevsky, 1999). Still others argue that retirees should invest in financial assets since these may keep up with inflation better than annuities. This is an area of substantial ongoing research, though the prediction has been inaccurate for the US at various times (BMP, 2000), but may be better supported in Europe (Albrecht and Maurer, 2002).

A different reason that older people might avoid buying annuities is than some might wish to remain somewhat financially liquid in old age, whereas the traditional immediate annuity does not provide this option. For instance, the risk of perhaps having to pay large medical bills or cover nursing home costs could induce many elderly to hold on to the assets they have, instead of annuitizing them. This concern may be mitigated in the future for several reasons. One is that some insurers have brought to market new financial products that merge life annuities with nursing home insurance (Warshawsky et al.,2002). Related to this point is the finding that improved health among older people may actually reduce the need for nursing home care, as a consequence curtailing the demand for long-term care (Lakdawalla and Philipson, 2002). Yet another factor that can enhance the demand for annuities is that financial products are being devised to help meet liquidity requirements, affording older people the chance to consume the net equity in their homes (Caplin, 2002). This of course may conflict with older peoples' desires to leave bequests, but economic research has no clear answer regarding just how a bequest motive can best be incorporated into models of annuity demand (Gale and Slemrod, 2001). Brown (2001) argues that most specifications imply that full annuitization is no longer optimal, and Blake et al. (2000) explore a range of possible and interesting alternative formulations.

Yet a further concern regarding the future demand for annuities is the possibility that retirees might seriously underestimate their survival prospects, which, if true, would lead them to downvalue longevity insurance. An interesting survey on this point finds, however, that older people in the US at least are in fact very well-informed about their survival probabilities. That is, their expected survival patterns track actuarial tables quite closely (Figure 9). Whether this is more of a problem in Europe would be worth investigating empirically. It is our impression that recent discussion of plummeting fertility and population aging in Europe would likely imply that many older people are reasonably well-informed about future survival patterns.

Figure 9 here

Looking ahead, there are a number of other reasons that one might anticipate growth in demand for annuities in the European market. One is that mortality patterns are continuing to decline, and in many countries, actual longevity may be even higher than reported in official government statistics (Schieber and Hewitt, 2000). This is tied up with major changes forecasted in the role and function of traditional old-age retirement systems in the European region. Paralleling a movement that began in the US two decades ago, many countries have recently witnessed a trend toward company-sponsored defined benefit plan termination (Mitchell, forthcoming). Furthermore, in much of Europe, state-financed public pensions will be forced to moderate benefit promises going forward. Both these factors imply a drop in the fraction of retirees' retirement wealth that is a mandatory annuity, and in turn they suggest that insurance-based and privately purchased annuity products will be in increasing demand as substitutes.

Supply-side Considerations:

In many ways, the successful development and growth of annuity markets must depend on supportive public policy.

Large government social security systems may have crowded out annuity demand in many European countries. This may explain why there is a small market for private annuities in European countries with the largest social security systems. Figure 11 and Table 6 report after-tax replacement rates for selected OECD countries in 1995, divided by source of income. Germany, Sweden, and Italy have the highest proportion of retirement income coming from government transfers, over 55%, and it is probably no coincidence that in these countries, the private annuity market is fairly small. Nevertheless, as these countries' populations age, their PAYGO systems will have to be reformed. Consequently the proportion of retirement income coming from government transfers will likely decrease, implying potential for growth in annuities markets.

Figure 11 here

Table 6 here

The Need for Better Mortality Information and Clear Supervision

Regulatory policy regarding mortality tables can drive both the demand and supply of annuities. Well-functioning annuities markets depend on accurate mortality data. Insurance companies that do not have access to high quality data will tend to price annuities conservatively, exacerbating adverse selection problems and lowering access to annuities markets. Not only the mortality of current annuitants is needed, but also good projections about how mortality is likely to change in the future. In most countries, this data is simply not available. Cardinale et al. (2002) hypothesize that mortality data may in fact be a public good whose production costs are outweighed by positive externalities.

Regulations regarding how mortality data are used are also key to shaping the annuity market. For example the UK requires that unisex mortality tables are used to compute pension payouts (for benefits offered under "protected rights" legislation). As a result, mortality differences between men and women cannot be used to price payouts, which generates cross-subsidization between male and female retirees on average. The common mortality table combined with mandatory annuitization thereby restrict the potential for adverse selection that otherwise might occur in voluntary annuitizations. By contrast, unisex tables are required for employer pension calculations in the US but are not imposed on individual purchases; moreover many workers are permitted to take lump-sum cashouts from their company pension. This structure implies that informed and rational workers anticipating shorter-than-average life expectancies have incentives to cash out rather than take life annuity streams. The policy issue, then, is how to integrate pension and insurance regulations so as not to detract too strongly from the appeal of annuities (Mitchell, 2000b). Prior to the introduction of the Third Life Directorate of the European Union in 1994, many European countries regulated the tariffs that insurance companies were able to charge, often specifying out-of-date mortality tables or unisex tables (Davis 2002). MacDonald (1997) reports that since this time, many countries in Europe have started to collect and use annuitant mortality data in pricing, although this practice continues in countries such as Japan and Mexico.

New Roles for Government Provision of Financial Products.

One supply-side explanation for thin annuity markets in some countries may be that insurers lack assets with which to back the long-term promises represented by annuities. Standard theory suggest that, in order to immunize themselves from small changes in interest rates, insurance companies would do well to back their annuity portfolios with assets whose duration equals the duration of the annuity liabilities. This is difficult to do in practice if long-term bonds are not available in national markets.

Figure 12 shows the term of the financial instruments needed to back actuarially fair annuities priced using US male voluntary annuitant cohort mortality tables. As is evident from the figure, the term varies with the bond interest rate. This is due to so-called “convexity risk”, which results from the fact that the incidence of payments on an annuity portfolio and that of a coupon-bearing bond portfolio are necessarily different.[24] The figure indicates that in the US market, at least, insurers would require twelve-year par bonds to exactly immunize themselves from interest rate changes, at zero interest rates. If the company wished to sell annuities to females, it would require 13-year bonds trading at par (results not shown). Should interest rates rise, the implied bond terms required fall somewhat, but only slowly.

Figure 12 here

While the US does have a relatively well-developed long-term bond market, many other countries lack long-term assets. This implies that annuity markets would likely benefit from the issuance of longer term government bonds than are currently available. In addition, if real annuities are to be provided, real long bonds will have to be provided as well. At present, only a select handful of countries currently offers inflation-linked bonds, including the US, UK, Israel, and most recently France. Down the road, European insurers may therefore benefit from the recent entry by France into the Euro-denominated inflation-protected bond market.

Insurers, and customers purchasing the insurance products, should also consider the quality of the assets concerned. Recent events in Argentina and Russia have shown that it is possible for governments to default on their debt. The risk increases with the term of the bond, implying that insurers in emerging economies may be unwilling to sell annuities even if assets of sufficient term are available. It is worth noting in this context that the debt rating of the Japanese

[24] Of course, an insurer could exactly match the outgo of an annuity portfolio and the income of a bond portfolio by investing in zero-coupon bonds of varying terms. However, zero coupon bonds of the term and quality required (>35 years, AAA+) currently exist in no bond market.

government was recently cut by Moody's to the same risk class as Cyprus, Greece, Latvia and South Africa, indicating that this problem may not be confined to emerging markets.[25]

There also remains a very real concern over cohort mortality risk. This is due to the chance that entire cohorts live longer than anticipated, which is of grave concern to those selling the products since substantial changes in mortality patterns could seriously challenge their profitability. Some contend that governments will have to issue cohort "survivor bonds" (Blake, et al. 2002). On the other hand, this problem may be resolved in the private market, by annuity providers which hedge longevity risk with offsetting life insurance contracts. Initial research on this topic using international data suggests, however, that this may be difficult to do in practice (McCarthy and Mitchell, forthcoming), though more research is needed on this point.

A related argument was made by financial experts and economists seeking to encourage the US government to issue inflation-linked bonds (Brynjolfosson and Fabozzi, 1999). Retiree demand for these products in the US has been modest, though inflation rates have been quite low of late. In other pension markets, including the UK and Israel, inflation-linked bonds have become a mandatory component of the retiree portfolio and demand for these assets has been more substantial.

Regulatory Policy Toward Annuities

The long-term solvency of insurance companies should also be important factor to consider, for individuals purchasing annuities. In an environment where the liquidity position of insurance companies is sometimes in question due to the lack of an effective regulatory environment – as is the case in many emerging and developed countries – individuals may be deterred from participating in the annuities market (Mitchell, 2000a). Of course, in some cases there are guarantees provided to individual policyholders in the event of insurance company insolvency. In turn, this highlights the importance of effective solvency regulation because it introduces the possibility of moral hazard on the part of the annuity seller. In some cases, the regulation of reserves can be a barrier to sellers because it imposes a large or highly variable need for capital or onerous reporting or valuation requirements (Lemaire 1997).

[25] Standard and Poor's (2002) also warns that the sovereign credit ratings of the majority of highly rated European Union members (EU-15) could fall to non-investment grade unless governments bring debt and deficit burdens under control.

A key policy level influencing the future shape and form of annuity offerings is how governments encourage or discourage the growth of annuity products via tax incentives. Across Europe and around the world, the range of tax programs is so extensive and complex as to be bewildering, most likely the result of tax law accretion over many years, and often producing conflicts with sensible social policy. In Italy and France, for example, tax policy discourages companies from building up collateral assets that back pension promises, and also it encourages workers to take lump-sum withdrawals of deferred earnings instead of periodic payments or annuities (Cardinale 2002; Wadsworth et al., 2001). In the US, tax policy favors funding and provision of employer-sponsored annuity promises (to a limit), but it also establishes a rather undesirable profile of taxation on private annuity payouts that taxes people more heavily after retirees attains one's life expectancy (BMPW 1999). In Australia, tax and transfer policy favors purchase of fixed nominal annuities, but inflation-linked payouts and variable annuity programs are not similarly tax-favored.

Other regulations also apply to annuity products, and it is fair to say that in general, these are often complex and differ widely across countries. Yermo's (2001) review of annuity regulation across OECD countries illustrates for example that Italy requires mandatory annuitization of half workers' accumulated pension balances while Portugal requires annuitizing two-thirds of the balance; and Spain offers free choice between lump sum, term and life annuities. Germany's new Reister-reform law permits workers to take 20% of their accumulated assets at retirement in a lump sum, another 20% as a graduated withdrawal payment, and the remainder can be paid out in periodic payments with the stipulation that at age 85, the retiree must annuitized his balance and the benefit cannot be less than the periodic payment received before that age (Maurer and Shlag, 2002). Similarly, retirees at age 75 in the UK are required to annuitize their pension assets.

The Need for Consumer Education

Some countries have taken the perspective that it is the government's responsibility to promote public education and understanding regarding annuity products. Thus, for instance, the Financial Services Authority (FSA) in the United Kingdom was recently charged with statutory responsibility for enhancing consumer understanding and protection regarding annuity products (Inland Revenue, 2002). This is to take the form of internet and paper explanations of terms and pricing, as well as annuity types. Not only will this agency help new purchasers, but it will also take on the task of helping people contemplating switching providers, with a focus on fees and switching costs. As a different approach, the Italian government requires that annuity payouts be explicitly described to purchasers using real returns of 1% and 3%, so that buyers can compare payouts across products (Cardinale, 2002). In Mexico and several other Latin American countries, annuity providers must submit competitive bids to workers as they draw near their retirement dates, so as to enhance comparability and competition across insurers.

III. Conclusions

As the world ages, it will become increasingly critical to develop and offer new financial products that help protect economic security during the retirement period. This paper demonstrates that several factors will drive modernization of global annuity markets in the future, particularly in European nations which are among the most challenged by rapid population aging.

Our review suggests several conclusions. First, the demand for annuities is likely to rise in the future, even for risk averse elders who want to keep some portion of their assets liquid. This will be driven by increased longevity, diminished public and corporate pensions, and the availability of new annuity linked products. Second, the supply of annuities is likely to grow, but here thoughtful public policy can play a beneficial role. Specifically, there are important ways in which governments can play a potent role in strengthening annuity markets. These include developing and disseminating high-quality data on mortality tables, enhancing consumer education and awareness of longevity insurance and how to compare prices, and streamlining tax policy to make it more attractive to invest in sensible products. It may also be useful for governments to mitigate the potential problems caused by adverse selection, including encouraging group annuities and possibly requiring some minimum level of annuity provision. Finally, there may be new a role for governments in the future, if annuity markets are to thrive. Specifically, they can serve as sponsors of new financial products that can help insurers provide annuities more efficiently. These could include longer term government bonds that can be used to match annuity liability patterns, inflation-indexed bonds, and possibly, survivor bonds.

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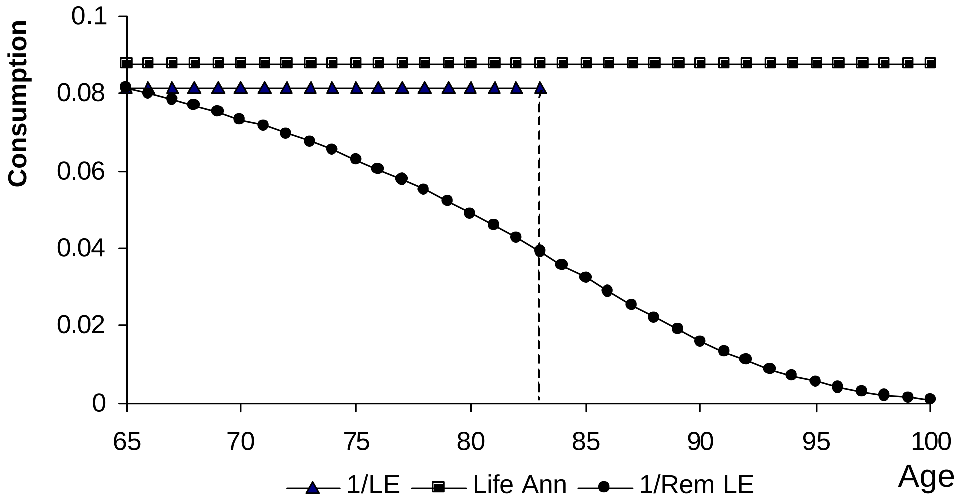
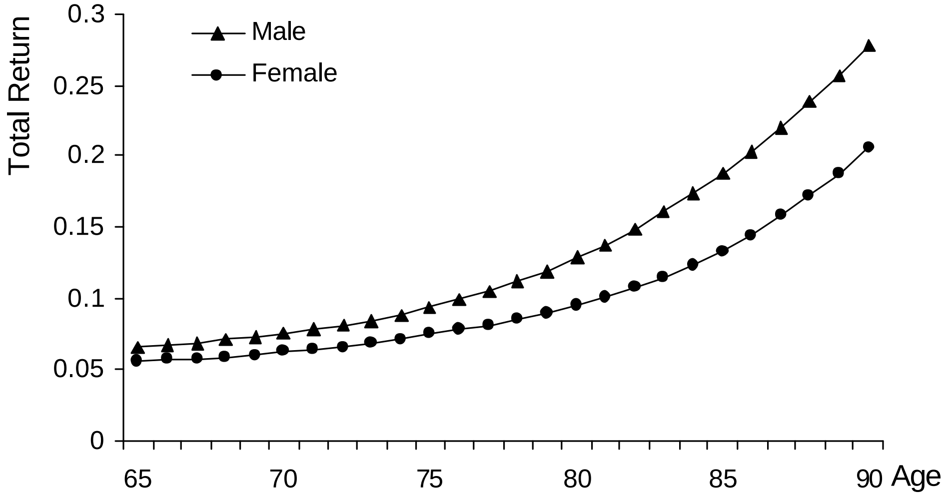
Figure 1: Alternative Consumption Profiles as a Function of Age



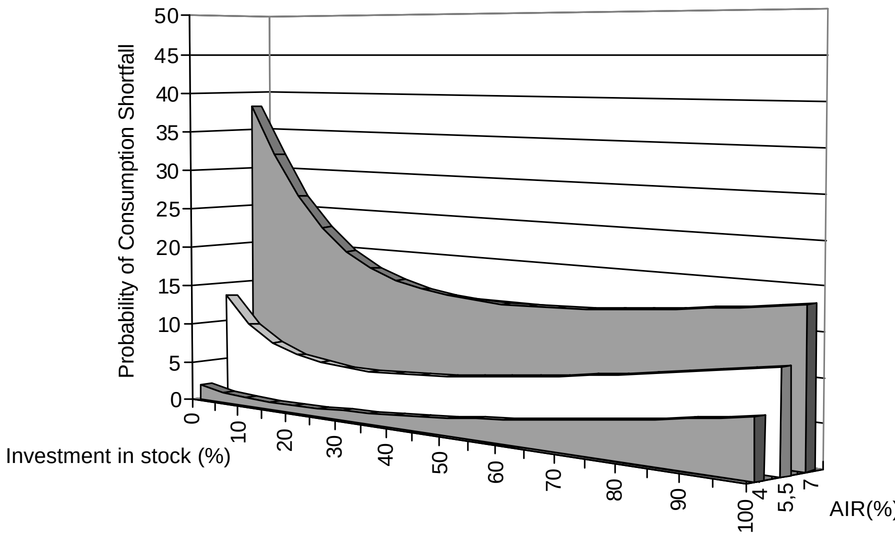
Note: Figure assumes worker attains retirement age with assets normalized at 1.0, and he draws down fractional amounts of remaining assets over his remaining lifetime. The "1/LE" profile assumes that the retiree consumes a level proportion of his retirement wealth each year, at a rate sufficient to completely draw down all his wealth (and investment earnings) by the time he reaches his life expectancy (as of age 65). The "Life Ann" profile assumes that the retiree's entire wealth is converted into an actuarially fair life annuity payable from 65. The profile labeled "1/Rem LE" assumes that the retiree recomputes the level consumption that will draw down his wealth over his remaining life expectancy each year, based on annually updated life expectancy. All profiles assume retirement at 65 and a real investment return of 4%.
Source: Authors' computations using US Male population cohort table from McCarthy and Mitchell (2002).

Figure 2. Return Benchmark On Residual Capital That Would Have to Be Earned to Compensate For "Mortality Drag"



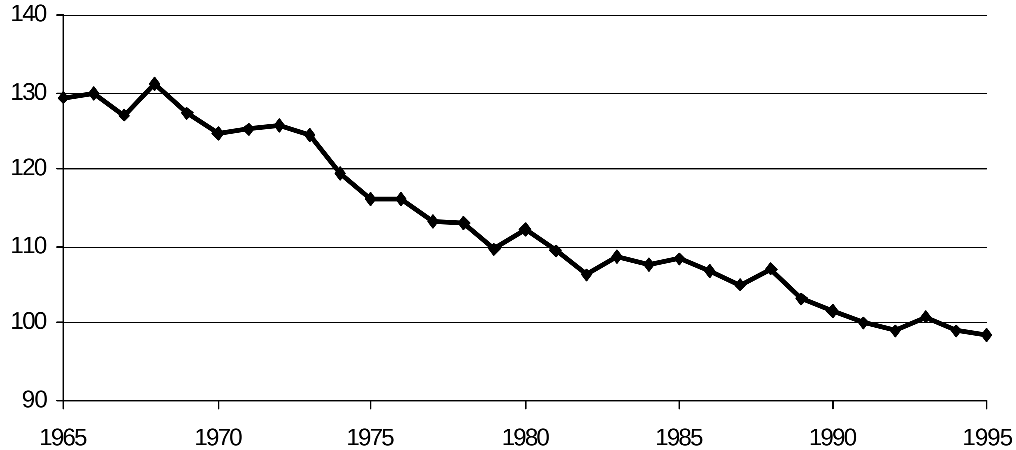
Note: Figure shows the return required to be earned on privately invested capital to compensate for the risk pooling aspect of annuities (which increases with age). Figure assumes a real annual interest rate underlying annuity prices and US Male population cohort mortality from McCarthy and Mitchell (2002).
Source: Authors' calculations.

Figure 3: Shortfall Risk From Self-Insuring



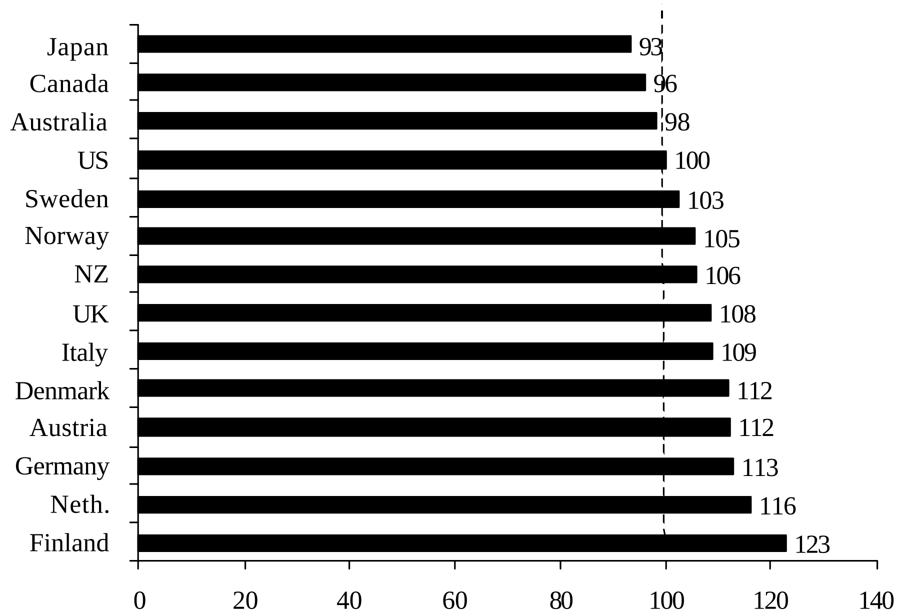
Note: Probability of consumption shortfall in retirement for a male retiring at age 60 who does not annuitize, but instead invests his portfolio in the specified mix of German stocks and bonds. The shortfall is computed compared to consumption that could be purchased with an annuity priced using the specified Assumed Interest Rate (AIR).
Source: Albrecht and Maurer (2002).

Figure 4: Time Series Decline in US Male Mortality: 1965-1995



Note: Data represent Actual/Expected death rates for US males, standardized so the 1991 table is equal to 100.
Source: Social Security Administration, Male Population Mortality, reported on Berkeley Mortality Database, http://demog.berkeley.edu/wilmoth/mortality.

Figure 5: A/E Metrics for Selected OECD Countries

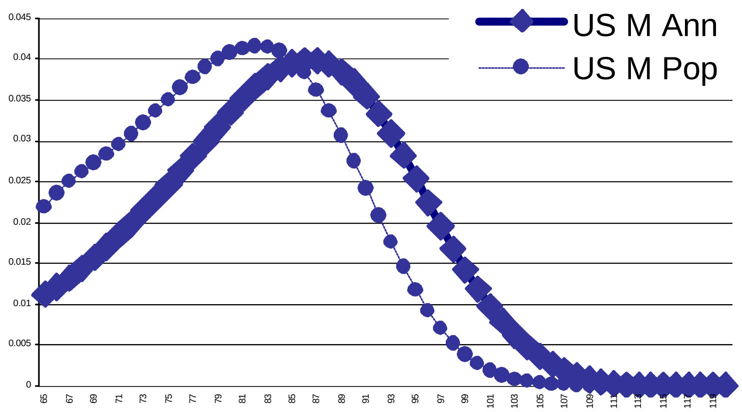


Notes: The following male mortality tables from ~1991 were used for these computations (in some cases these were extended to 111):

Finland	Central Bureau of Statistics 1986-1990
Netherlands	Central Bureau of Statistics 1985-1990
Germany	Federal Statistics Office 1990-1992
Austria	Statistische Zentralamt 1990-1992
Denmark	Danmarks Statistik, Statistical Yearbook 1990-1992
UK	Government Actuaries Department 1999
NZ	Statistics New Zealand, 1990-1992
Norway	Statistics Norway, 1993
Sweden	National Central Bureau of Statistics, 1993
Australia	Statistics Australia 1990-1992
Canada	Statistics Canada Life Tables, 1990-1992
US	Social Security Administration, 1991
Japan	Japanese Ministry of Health, Labor and Welfare, Statistics Division, 1990
Italy	National Institute of Statistics, 1991

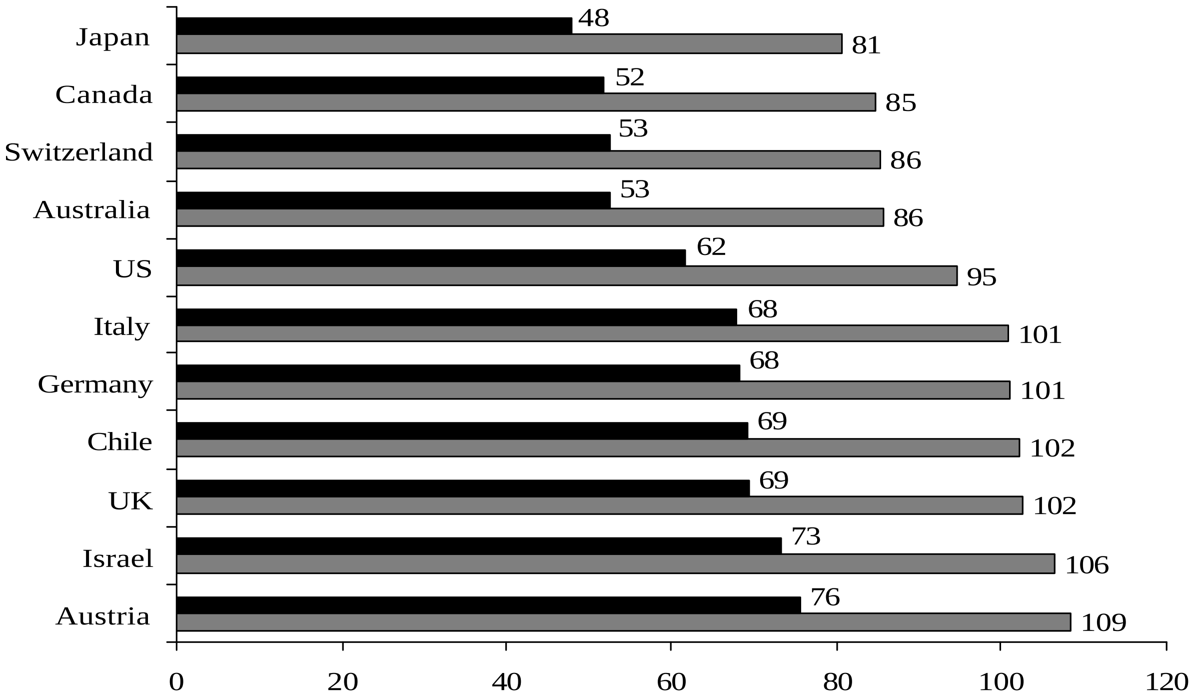
Source: Authors' computations; see McCarthy and Mitchell (2002).

Figure 6: Distribution of US Male Population versus Annuitant Age at Death, Conditional on Survival to Age 65 (US Male)



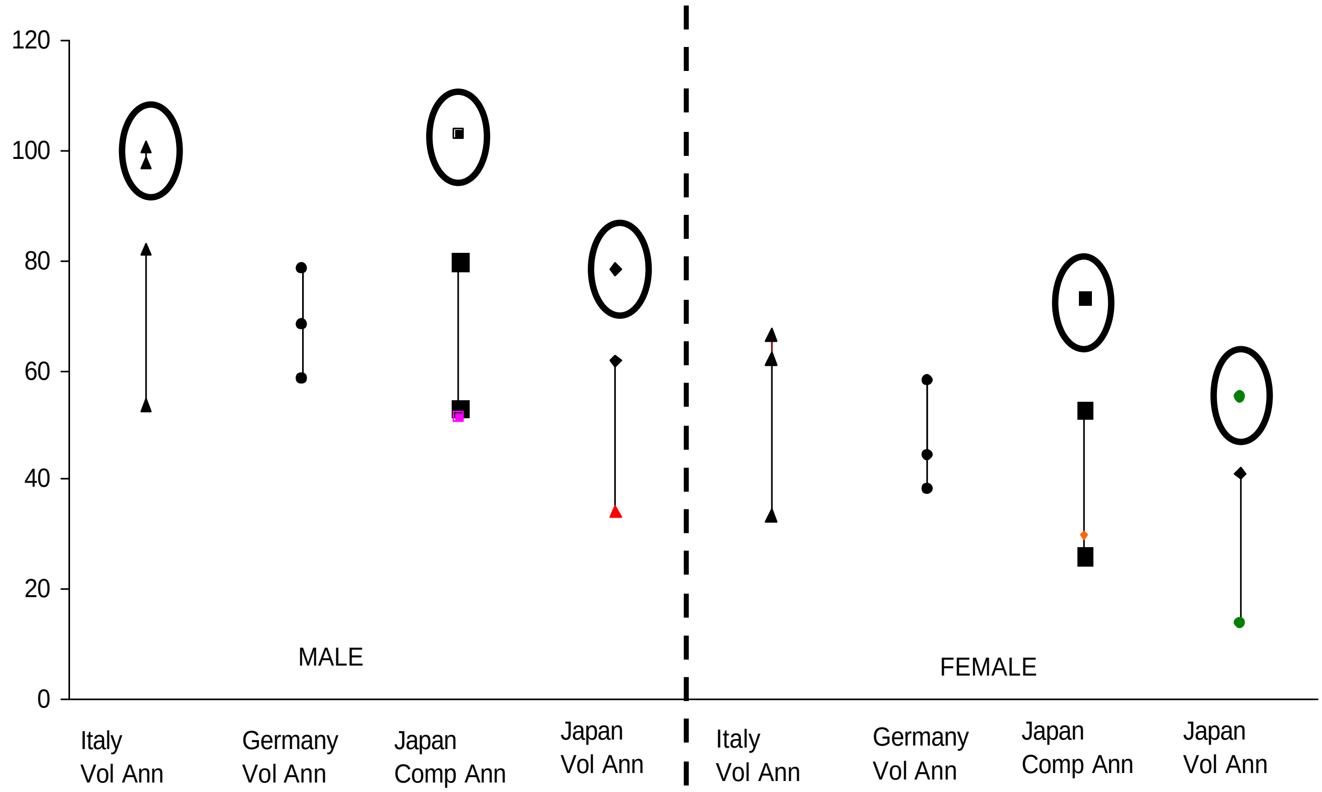
Source: Mitchell (2002)

Figure 7: Predicted Male Cohort A/E Values for Variety of Countries; Male Population Mortality and Annuitant Mortality



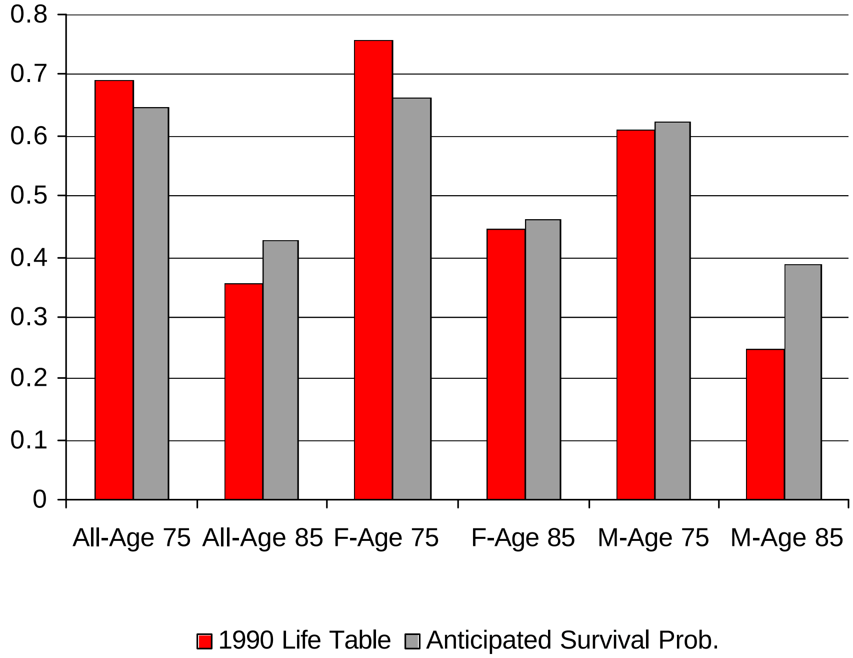
Notes: Figure derived from A/E values predicted using regression estimates in Table 4.
Source: Authors' computations.

Figure 8: Cross-national Predicted Values: Actual and Predicted Values of A/E Metrics



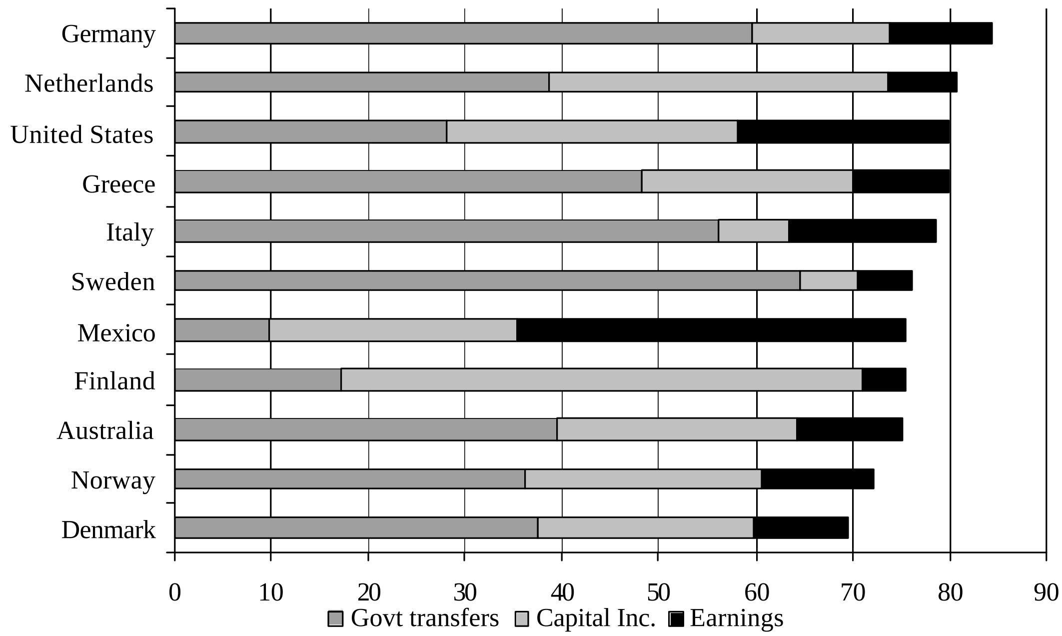
Note: A/E values for male and female annuitant mortality computed from RG48 tables for Italy (estimated from MacDonald, 1997), DAV1994R tables for Germany (MacDonald, 1997), EPF and TQPP mortality tables for Japan compulsory annuitants (data kindly provided by the Ministry of Health, Labor and Welfare) and the Japan Institute of Actuaries for Japan annuitants. Figure shows actual A/E values and 95% confidence intervals for predicted A/E values from model described in Table 4. Circled values fall outside the 95% confidence intervals; see text.
Source: Authors' computations following methodology described in McCarthy and Mitchell (2002).

Figure 9: Objective and Anticipated Survival Probabilities to Ages 75 and 85



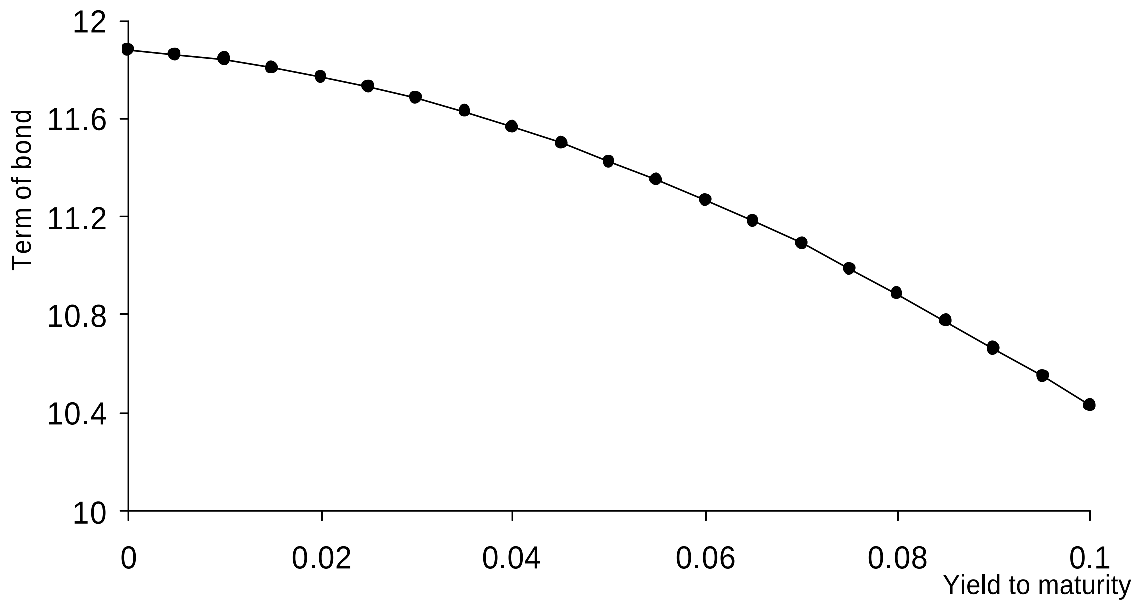
Note: Subjective probabilities of survival to age 75 and 85 reported by Wave 2 respondents in the Health and Retirement Study, born 1931-1941 and interviewed in 1994. Responses weighted by sample weights.
Source: Hurd and McGarry (1997)

Figure 11: Old Age Replacement Rates for Selected OECD Countries



Note: Figure shows show disposable income for persons aged 65-74 as a percentage of those age 55-64.
Source: Table 6

Figure 12: Term of Bond Required to Match Mean Duration of Life Annuity, As a Function of the Interest Rate



Notes: Bonds assumed to trade at par with coupons paid continuously.
Source: Authors' computations using US Male Voluntary Annuitant Cohort Mortality (see McCarthy and Mitchell, 2002).

Table 1: Life Expectancy Remaining and Probabilities of Survival to Selected Ages: Men and Women at Age 65 (in 2000)

	Men	Women
Remaining Life Expectancy (years):	16.4	19.6
Probability of Surviving to Age:		
70	88%	92%
75	74	82
80	56	69
85	36	51
90	18	31
95	6	14
100	1	4

Source: Brown (2000)

Table 2: Immediate Monthly Annuity Payouts Per $1000 Premium, By Age and Sex

	Age 55	Age 65	Age 75
All Companies, Average:			
Men	6.64	7.94	10.52
Women	6.24	7.17	9.22
Ten Highest Payouts, Average:			
Men	7.38	8.72	11.61
Women	6.88	7.76	9.99
Ten Lowest Payouts, Average:			
Men	5.98	7.25	9.45
Women	5.59	6.56	8.63
Twenty Highest Rated Firms, Average:			
Men	6.50	7.78	10.35
Women	6.09	7.07	9.09
Ten Largest Annuity Firms, Average:			
Men	6.72	7.98	10.43
Women	6.31	7.21	9.14

Note: Each entry indicates the monthly income payable as a life annuity, based on the purchase of a $100,000 single premium immediate policy at the ages specified. The $100,000 purchase price is inclusive of policy fees but exclusive of annuity premium taxes. Data are for 1995.
Source: MPWB (1999).

Table 3: Comparative Data on Actual/Expected (A/E) Mortality Measures for Purchasers of Voluntary and Compulsory Life Annuities versus Population: Age 65 by Sex.

	Voluntary Annuities	Compulsory Annuities	Population
Males			
UK	67.5	82.6	100
US	65.3	84.0	100
Japan	81.8	na	100
Females			
UK	73.5	84.9	100
US	73.6	90.8	100
Japan	100.7	na	100

Notes: na means not available. Base table (=100) is population table for each country and gender.
Source: McCarthy and Mitchell (forthcoming).

Table 4: Regression of A/E Metrics on Type of Mortality Table, Country Effects, and Interactions

	Coeff.	Std Err
Female	-34.68**	2.79
Comp Ann	-26.17**	3.47
Vol Ann	-32.95**	3.01
Cohort	-12.33**	2.85
FxCompAnn	6.88	4.65
FxVolAnn	11.48**	4.14
FxCohort	3.33	3.79
UK	7.79**	2.91
Canada	-9.93**	3.35
Chile	7.57*	4.31
Australia	-8.95**	3.67
Israel	11.68**	4.31
Italy	6.14	5.66
Austria	13.94**	4.17
Germany	6.49	4.19
Switzerland	-9.10**	3.72
Japan	-13.91**	5.66
Intercept	106.97**	2.94
Adj R-square	98.8%	
N of Obs	64	

Notes: * = significant at 10%; ** = significant at 5%.
Source: Authors' computations following McCarthy and Mitchell (forthcoming).

Table 5: Comparisons of Annuity Values: Money's Worth and Annuity Equivalent Wealth

A: Money's Worth of Nominal Annuity Payouts: Single Premium Nominal Life Annuities Offered to 65-Year Olds Across Countries

	UK		Australia		Canada		Switzerland		US		Italy	
	Pop	*Ann*	*Pop*	*Ann*	*Pop*	*Ann*	*Pop*	*Ann*	*Pop*	*Ann*	*Pop*	*Ann*
Men	0.897	0.966	0.914	0.986	0.925	1.014	0.965	NA	0.814	0.927	NA	0.958
Women	0.910	0.957	0.910	0.970	0.937	1.015	1.115	NA	0.852	0.927	NA	0.965

Note: Computations use country Treasury yield curve. Pop refers to population mortality table while Ann refers to annuitant mortality table.
Source: James and Vittas (1999) for UK, Australia, Canada, and Switzerland; MPWB (1999) for US; Cardinale (2002) for Italy.

B: Annuity Equivalent Wealth Values: US Male Age 65

	(I)			(II)		
	Annuity Equivalent Wealth for Real and Nominal Annuities					
Coefficient of Relative Risk Aversion (CRRA)	Consumer with No Pre-Existing Annuity Wealth			Consumer With Half of Initial Wealth in Pre-Existing Real Annuity		
	Real Annuity	Nominal Annuity: i.i.d. inflation	Nominal Annuity: Persistent Inflation	Real Annuity	Nominal Annuity: i.i.d. inflation	Nominal Annuity: Persistent Inflation
1	1.502	1.451	1.424	1.330	1.304	1.286
2	1.650	1.553	1.501	1.441	1.403	1.366
5	1.855	1.616	1.487	1.623	1.515	1.450
10	2.004	1.592	1.346	1.815	1.577	1.451

Note: The annuity equivalent wealth calculation for the nominal annuity assumes inflation takes one of six possible values, roughly capturing the distribution of inflation outcomes over the 1926-1997 period. Inflation shocks are assumed independent across periods in the i.i.d. case and follow a stylized AR(1) process in the persistent inflation case.
Source: Mitchell (2002)

Table 6: Old Age Replacement Rates for Selected OECD Countries

Country	**Govt Tsfr**	**Capital/SEInc.**	**Earnings**	**Total**
Denmark	37.6	22.3	9.6	69.4
Norway	36.1	24.5	11.7	72.3
Australia	39.5	24.7	10.9	75
Finland	17.1	54	4.4	75.5
Mexico	9.7	25.6	40.3	75.6
Sweden	64.6	6	5.5	76.1
Italy	56.2	7.2	15.3	78.7
Greece	48.3	21.6	10	79.9
United States	28	30.2	21.7	79.9
Netherlands	38.6	35	7.2	80.8
Germany	59.6	14.4	10.4	84.4
Average	*39.57*	*24.14*	*13.36*	*77.05*

Note: Table reports show total disposable income for persons aged 65-74 as a percentage of those age 55-64.
Source: OECD data from Feldstein and Seibert (2002).

Table 7: Implicit Tax Rates on Continued Work at Older Ages, due to Benefit Programs for the Elderly: OECD countries, 1995

	Old-age pensions	Old age pensions plus:		
		Unemployment related benefits [1]	Disability benefits [1]	Special early-retirement [2]
United States	12	..	..	..
Japan	28	..	..	..
Germany	14	37	46	..
France	14	49	..	57
Italy	79	.. [3]	.. [3]	.. [3]
United Kingdom	5	15	..	..
Canada	6	..	..	..
Australia	0	20	21	..
Austria	34	34	64	..
Belgium	23	37	44	56
Denmark	0	51	37	22
Finland	22	42	71	..
Ireland	14	32	32	..
Luxembourg	29	65	63	51
Netherlands	8	57	41	.. [4]
New Zealand	9	27	..	..
Norway	15	..	65	17
Portugal	4	33	66	..
Spain	18	33	53	..
Sweden	18	..	76	..
Switzerland	0	..	..	..

Notes:
1. ".." denotes that early retirement into non-employment benefit system is not an option because of entitlement conditions.
2. ".." denotes no public schemes or such schemes are not much used.
3. Schemes not relevant for a worker with a long contribution history as he can retire prior to standard retirement age with full old-age pension.
4. Special early retirement schemes in the Netherlands are not mandatory.

Source: Feldstein and Seibert (2002)