New Evidence on the Money's Worth of Individual Annuities

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[I]f you observe, people always live forever when there is any annuity to be paid them ... An annuity is a very serious business; it comes over and over every year, and there is no getting rid of it. Jane Austen (1962 pp. 10–11)

As baby boomers near retirement, policy analysts have begun to ask how this cohort will handle the process of drawing down its retirement saving. One mechanism for doing this is the life annuity, an insurance product that pays out a periodic sum for life in exchange for a premium charge. The main appeal of the life annuity is that it offers retirees the opportunity to insure against the risk of outliving their assets by pooling mortality experience across the group of annuity purchasers.

The market for individual life annuities in the United States has historically been small. Previous researchers working in the context of the standard life-cycle model, notably Benjamin Friedman and Warshawsky (1988, 1990), have argued that it is puzzling that so few people avail themselves of the private market for annuities. This market has recently begun to attract substantial attention from those considering proposals to replace part of Social Security with private retirement saving accounts, because one way individuals might choose to spread the payouts from these accounts over their retirement years is by purchasing individual annuity contracts.

The standard explanation for the limited size of the individual annuity market is adverse selection. As the foregoing quotation from Austen suggests, those who voluntarily purchase annuities may tend to live longer than average; insurance premiums therefore must be set high enough to compensate insurers for the longer life expectancies of purchasers. The extent to which adverse selection reduces the attractiveness of life annuities for potential annuitants is an empirical question.

In this paper, we present new data on the value of individual life annuities that were available in the private market in 1995. We develop a more sophisticated algorithm for annuity valuation than that in previous work. We value single-life annuities for a wider range of ages than previous studies, and we also value joint-and-survivor annuities. We allow for a term structure of interest rates instead of using a single long-term interest rate to value payouts, thereby obtaining a more accurate measure of the present value of payouts, and we consider the special federal tax treatment of income paid from annuities. We also recognize the impact of uncertain inflation on the subjective valuation of nominal annuities. We apply our algorithm to annuity policies that were available in 1995, as well as to policies that were offered in 1985 and 1990. Previous studies of annuity valuation relied on data from more than a decade ago, and many factors have changed in the intervening years, including a sharp decline in nominal interest rates and a general increase in life expectancies at older ages. Even without our methodological improvements, there is a substantial rationale for revisiting the question of annuity valuation.

We present several empirical findings. First, the prices charged for a single-premium immediate life annuity vary widely. For policies with the same initial cost, the difference in annuity payouts between the ten highest-payout and the ten lowest-payout insurance companies is close to 20 percent. The dispersion varies by age and by sex of the insured.

Second, we find that the expected present discounted value of annuity payouts per dollar of annuity premium averages between 80 and 85 cents for an individual chosen at random from the population, and between 90 and 94 cents for an individual chosen at random from the pool of individuals who purchase annuities. This implies that a typical retiree with average mortality prospects faces a significant "transaction cost" if he purchases an individual annuity from a commercial insurance carrier. The differential between the premium cost and the expected payouts must cover marketing costs, corporate overhead and income taxes, additions to various company contingency reserves, and profits, as well as the cost of adverse selection. The expected present discounted value of payouts per premium dollar generally declines as the age of the annuity purchaser increases and, regardless of age, is typically higher for annuities issued to women and joint-and-survivors than for those issued to men.

Third, we compare current annuity values with those found in the early 1980's. The payout value-per-premium dollar has risen by roughly 13 percentage points during the last decade and a half. This suggests that the effective transaction costs to participating in the individual annuity market have declined during this period.

Fourth, we find that incorporating the specialized income tax liabilities that are associated with annuity income does not significantly affect the expected present discounted value of annuity payouts. This is because the tax rules governing annuity products approximately offset the tax burdens on alternative investments that retirees might make.

Finally, we compute the expected utility that a consumer with a random lifetime and an additively separable utility function would derive from following an optimal intertemporal consumption plan in the absence of annuity markets, and the same individual's utility if he can purchase an actuarially fair nominal annuity. We then calculate the fraction of his initial, nonannuitized wealth that this individual would be prepared to pay to gain access to such an annuity market. This fraction is of the same order of magnitude as the "transaction cost" that we observe in the current annuity market. We perform these calculations assuming certain, as well as random, inflation, and find that our results are not very sensitive to the presence of random price fluctuations.

The paper is divided into six sections. The first provides an overview of the market for individual annuity products. Section II describes the expected present discounted value approach that we use to value the stream of payouts from annuity products. Section III describes our key data inputs. The fourth section presents our results on the present value of individual annuity payouts relative to their premium cost. Section V explores the gain in expected utility from purchasing an individual annuity instead of following the optimal post-retirement consumption strategy in the absence of annuity contracts. It considers nominal annuities in a setting with positive, but certain, inflation, and also allows for uncertain inflation. Section VI concludes by indicating a number of directions for future research and by discussing the relevance of this research to national retirement policy concerns.

I. Overview of the Private Annuity Market

Annuities are contracts between an insurance company and an insured person or persons in which the insured receives a monthly or annual sum as long as he lives, in exchange for a one-time premium payment or flow of premium payments. The date at which level payouts begin can be different from, and in some cases many years later than, the premium payment date(s). The annuity protects the individual against the risk of outliving his saving, given uncertainty about his remaining lifetime.

The annuity contract generally specifies what happens during two distinct phases. These are the *accumulation phase,* when the premium is paid and capital accumulates, and the *decumu-*

lation phase when the benefits are paid out.[1] There are many different paths for building up the annuity capital. One approach is to deposit a single-premium lump sum with the insurer; another is to gradually accumulate capital over a long period. A defined benefit pension plan can in some ways be viewed as an example of a slowly accumulating annuity. The annuity's payout path can also vary a great deal. Popular options include a life annuity with payments over the annuitant's lifetime, a joint-and-survivor annuity with payments to the annuitant and to his survivor, and a "years certain" annuity in which payments to the annuitant or his heirs are guaranteed to continue for at least a certain number of time periods, even if the annuitant dies before this number of periods has elapsed. Historically, most annuities offered periodic payouts and accumulations fixed in nominal terms, but variable annuities in which accumulations and/or payouts are linked to the returns on an underlying asset such as stocks have become increasingly popular in recent years.

The annuity market, including fixed as well as variable annuities and individual as well as group annuity contracts, has grown sharply in the last decade. In the mid-1990's, individual annuity sales were nearly as large as group annuity purchases, the latter mainly from defined benefit pension plans. The American Council on Life Insurance (1996) reports that there were roughly 23 million individual annuity policies in force in 1995. The Life Insurance Marketing Research Association International (LIMRA International, 1996) reports that reserves to cover promised payments for individual annuity benefits stood at $792 billion.

Variable annuities account for the bulk of current annuity sales, and they account for most of the growth of the annuity market in recent years. Although assets held in variable annuity contracts can be withdrawn in annuity form, they can also be withdrawn in other ways, for example with a stream of lump-sum payouts. Because most variable annuity contracts have not yet reached their payout phase, it remains to

be seen whether many variable annuity purchasers will choose the annuitization payout option. This underscores the fact that aggregate data on "annuity purchases" often include many insurance products other than life annuities. We do not include variable annuities in our analysis because they typically do not provide any guarantee of principal or return. Valuing the expected payout from a variable annuity therefore requires forecasting the future returns on various types of securities in a way that valuing a fixed annuity does not.

There are two primary types of premium payment in the individual annuity marketplace: flexible premium and single premium. Flexible-premium payments are in turn divided into first payments for newly purchased annuities, and renewal payments for existing annuity contracts. The single-premium category is divided into single-premium deferred annuities (SPDA) and single-premium immediate annuities (SPIA). LIMRA International (1996) reports that SPIAs accounted for only $6.2 billion of premium payments in 1995, while SPDAs accounted for $46.3 billion. Moreover, not all SPIA contracts provide payouts that are life contingent. Some SPIAs provide for a stream of fixed periodic payments, and therefore do not provide "life length insurance" of the type traditionally associated with annuity products. The small volume of SPIA purchases suggests that the recent growth of the aggregate annuity market has not resolved the long-standing puzzle, discussed for example in Friedman and Warshawsky (1990), of why individuals do not choose to annuitize their wealth.

The remainder of this paper focuses on the market for SPIAs. Surveys of annuity buyers provide some information on the nature of this market. According to LIMRA International (1996), the average SPIA premium in 1995 was $79,600. An unpublished LIMRA International 1993 survey of 26 companies selling SPIAs found that 55 percent of individual annuities were sold to men.[2] Most SPIAs (74 percent) were not part of a tax-qualified retirement plan such as an individual retirement account.[3] The

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[1] Poterba (1997) provides a typology of various annuity contracts, describing their provisions during both the accumulation and decumulation periods.

[2] We thank Walter Zultowski of LIMRA for providing us with these unpublished data.

[3] According to the 1993 survey, although the majority of SPIA annuitants had chosen a life annuity payout option, most selected some form of period certain or installment

modal purchaser is between the ages of 66 and 70 and nearly three SPIA buyers in four are between the ages of 61 and 80.

II. The Money's Worth Framework

The centerpiece of our analysis is a calculation of the expected present discounted value (EPDV) of payouts for immediate annuities in relation to the premium cost of the annuity. The expected present discounted value depends on three inputs: the *amount* of the annuity payout, the *interest rate* that is used to discount future payouts, and the *mortality rates* used to compute the probability that the representative annuity purchaser will still be alive at a given future date.

The most straightforward component of the EPDV calculation is the amount of the annuity payout (A). Data are available on the monthly payout to an individual purchasing an immediate single-life annuity for a set of initial purchase prices, most commonly $100,000. This amount varies across annuity policies, but for the policies we will consider, it remains fixed in nominal terms for the life of the annuity contract.

To discount nominal cash flows received j periods into the future, we make two alternative assumptions about the term structure of future short-term nominal interest rates. First, we use the term structure of yields on Treasury bonds to estimate the time series of expected, future, nominal short-term interest rates.[4] We use i_k to denote the nominal short rate k periods into the future. The present discounted value today of one dollar paid j periods in the future is there-

fore $1/[(1 + i_1)^* \cdots *(1 + i_j)]$. In addition to this term structure for riskless interest rates, we also consider a term structure of interest rates for risky bonds. We compute the difference between the average yield on BAA corporate bonds, and the yield on a Treasury bond with ten years to maturity; let v denote this yield differential. Then, we assume that this risk premium is constant at all maturities, and we construct a term structure of interest rates on risky bonds using nominal future short-term rates of $i_k + v$. We label the two term structures "Treasuries" and "Corporates" in what follows.

Estimating anticipated future mortality rates represents the most complex step in our EPDV calculation. We let $q_{a,t}$ denote the probability that an a-month-old individual who is alive at the beginning of month t will die during that month. To illustrate this notation, consider an individual whose 65th birthday is this month, and normalize this month to be calendar month one. The probability that this individual will die this month is $q_{780,1}$, where $780 = 12*65$. The probability that this individual will be alive at the end of the current month is $1 - q_{780,1}$, and the probability that this individual will still be alive in two months is $(1 - q_{780,1})*(1 - q_{780,2})$. We summarize future mortality experience by defining P_j as the probability that someone who is 65 years old at the time when he purchases an annuity survives for at least j months:

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

We set $P_{600} = 0$, which imposes the restriction that no one lives beyond age 115 years.[5] To compute the EPDV of an annuity that a 65-year-old person might purchase in 1995, we need to forecast this individual's *future* mortality rates. We consider this issue in the next section.

We use $V_b(A)$ to denote the EPDV of a life annuity with monthly payout A purchased by an

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refund option as well: only 8 percent chose zero refund and only 7 percent elected a joint-and-survivor life option. The age distribution of annuitants clearly tends toward older ages. The relatively small group of young annuitants below age 50 may include substantial numbers of individuals receiving annuities in structured payment of legal settlements.

[4] We use the nominal yields on Treasury bonds with fixed maturities of 1, 2, 3, 5, 7, 10, 20, and 30 years to estimate the term structure of expected short-term interest rates. We calculate the expected nominal short rate in each future period as the nominal short rate that would satisfy the expectations theory of the term structure for the two adjacent long-term bonds.

[5] The calculations reported below are relatively insensitive to assumptions about the upper limit on lifespan. Assuming a value of 100 years instead of 115 years results in estimates of the expected present discounted value within 0.02 percent of those reported below.

individual of age b. The expression we evaluate in our "before-tax" calculations, which differs from that in Friedman and Warshawsky (1988, 1990) and Warshawsky (1988) primarily in our allowance for a term structure of interest rates, is:

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

In calculations not reported in this paper, we have recomputed our key findings under the assumption that the term structure is flat, with the discount rate given variously by the 10-year Treasury bond yield, the 30-year Treasury bond yield, and the BAA corporate bond yield. Allowing for slope in the term structure, as we do, does not account for an appreciable share of the difference between our findings and those in earlier studies using older data.

Taxes are not included in the foregoing valuation expression, even though after-tax annuity payments determine the consumption opportunities of individual annuity purchasers. The federal tax treatment of annuities is governed by a specialized set of rules which are described by the U.S. General Accounting Office (1990) and James Trieschmann and Sandra Gustavson (1995), among others. For any annuity contract, the Internal Revenue Service (IRS) specifies the expected number of years over which the annuitant can expect to receive benefits. We label this expected payout period T'; it is determined by the IRS using the 1983 Individual Annuitant (Unisex) Mortality Table and the individual annuitant's age at the time when payouts begin. Using T', the tax law prescribes how to calculate an *inclusion ratio* (λ), which determines the share of annuity payments in each period that must be included in the recipient's taxable income. The inclusion ratio is designed to measure the fraction of each annuity payout that reflects the capital income on the accumulating value of the annuity premium.

For an annuity policy with a $100,000 premium, during the first T' years of payouts, the inclusion ratio is defined by:

$$(3) \qquad \lambda = 1 - \frac{100000}{A*T'}.$$

After T' years, all payouts from the annuity policy are included in taxable income. Assuming that the annuitant faces a combined federal and state marginal income tax rate of τ, the tax-adjusted expression for annuity value (V'_b) is:

$$(4) \quad V'_b(A) = \sum_{j=1}^{12*T'} \frac{(1 - \lambda*\tau)*A*P_j}{\prod_{k=1}^{j} (1 + (1 - \tau)*i_k)}$$

$$+ \sum_{j=12*T'+1}^{600} \frac{(1 - \tau)*A*P_j}{\prod_{k=1}^{j} (1 + (1 - \tau)*i_k)}.$$

In the after-tax calculation, the appropriate interest rate is the after-tax interest rate facing the annuitant. We report both the before-tax and after-tax calculations, V_b and V'_b, in our analysis below. Because virtually all annuity purchasers are taxable individuals, we focus on the after-tax case. We also consider annuity policies that are offered to individuals at age 55, 65, and 75; the money's worth framework described above generalizes easily to different ages.

III. Data on Annuity Premiums and Mortality Projections

This section describes the data that we collect on annuity premiums and the algorithm that we use to project future mortality rates. These are important inputs to our analysis of the expected present discounted value of annuity payouts.

A. *The Purchase Price of Individual Annuities*

We assume that an individual is contemplating the purchase of a *nonparticipating, single-premium, immediate, individual life annuity* from a commercial life-insurance

company. "Nonparticipating" means that the benefit payment is fixed and guaranteed, and does not reflect the insurance company's subsequent unanticipated experience with mortality, investment returns, or expenses.[6] "Single-premium immediate" means that the investor pays a one-time premium and then begins receiving annuity payments within the next month, quarter, or year, depending on the payment frequency chosen. "Individual" means that the annuity is purchased directly from an insurance company, generally via an agent or broker, for the named investor, and is not obtained through a group annuity owned by an employer-sponsored pension plan.[7] A "life" annuity means that payments are promised to continue for the investor's lifetime.[8] "Commercial life-insurance companies" include U.S. mutual and stock companies of all sizes, domiciles, and financial strength classifications, but exclude most of the life-insurance organizations, generally nonprofit, that have memberships in specialized industrial, religious, or professional groupings.

Premiums for life annuities are reported periodically in numerous publications issued by A. M. Best. We gathered data on annuity policies offered by a wide range of life-insurance firms in 1985, 1990, and 1995. We collected data for single-life annuities, as well as joint-and-survivor annuities. For 1985 and 1990, we drew reported annuity premiums from Best's *Flitcraft Compend,* which is the source used by Warshawsky (1988) in his analysis of annuity prices over the period 1919 through 1984. For premiums charged in 1995, we used data from the July 1995 issue of *Best's Review,* where Best's reports the results of its annual survey of insurance companies issuing single-premium immediate annuities.[9] The Best's data correspond to single-premium annuities with a $100,000 premium; we do not have any information on how the ratio of annuity payouts to the premium varies as the size of the premium changes. TIAA is not included in the Best's data because its policies are not available to the general public and because it does not offer single-premium nonparticipating immediate annuities.

The number of companies in the Best's annuity data base varies over the years. Large life insurers with a national presence and immediately recognizable names are almost always included, along with many small companies with apparently regional customer footings or firms that emphasize special insurance product lines. In 1985, for example, there were 47 companies in the A. M. Best's database; in 1990, 133 companies appeared, and in 1995, 100. For 1995, we gathered annuity premiums charged to men, women, and couples purchasing these products at ages 55, 65, and 75, respectively. For the comparative analysis over time, we collected data only on premiums for annuities issued to 65-year-old men using the 1985 and 1990 publications. In all cases, the premiums published are gross of state premium taxes, as well as federal and state income taxes that apply to the annuity payouts.

To provide illustrative information on annuity policies, Table 1 indicates the monthly income payment per $1,000 of premium for annuities issued in 1995 to single men and women, and to couples, of different ages. The first panel in the table records the average monthly annuity payment offered by all companies in the data base. For example, a 65-year-old man purchasing a typical $100,000 single-premium annuity at age 65 would receive a monthly payment of $794, or $9,528

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[6] Participating annuities, in contrast, guarantee principal and minimum investment return payments and supplement those payments with dividends that depend on the insurance company's evolving investment, mortality, and expense experience. Because of a lessened need to maintain large contingency reserves to cover reinvestment and other risks, an insurer issuing participating contracts should be able to offer higher returns than one issuing nonparticipating contracts. With the prominent exception of TIAA, the nonprofit insurer issuing annuity contracts exclusively to workers in higher education and nonprofit research institutions, participating annuities are rare.

[7] We also consider a "joint-and-survivor" life annuity purchased by a couple, where the level benefit payments continue as long as one member of the couple is alive.

[8] We do not consider annuity contracts that guaranty payments for a "fixed-period certain," although it would be straightforward to extend our money's worth framework to analyze these contracts.

[9] The Best's survey is conducted at the beginning of May, and we use the term structure of Treasury yields for the first week of May in calculating the discount factors that we use below.

TABLE 1—IMMEDIATE MONTHLY ANNUITY PAYOUTS PER
$1,000 PREMIUM, BY AGE AND SEX, 1995

	Age 55	Age 65	Age 75
All companies, average:			
Men	6.64	7.94	10.52
Women	6.24	7.17	9.22
Joint and survivor	5.78	6.48	7.94
Ten highest payouts, average:			
Men	7.38	8.72	11.61
Women	6.88	7.76	9.99
Joint and survivor	6.39	7.07	8.60
Ten lowest payouts, average:			
Men	5.98	7.25	9.45
Women	5.59	6.56	8.63
Joint and survivor	5.14	5.84	7.23
Twenty highest-rated firms, average:			
Men	6.50	7.78	10.35
Women	6.09	7.07	9.09
Joint and survivor	5.72	6.40	7.82
Ten largest annuity firms, average:			
Men	6.72	7.98	10.43
Women	6.31	7.21	9.14
Joint and survivor	5.84	6.43	7.79

Source: Annuity payout data provided in *Best's Review,* July 1995. Each entry indicates the monthly income based on the purchase of a $100,000 single-premium immediate life annuity policy. The $100,000 purchase price is inclusive of policy fees, but excludes state annuity premium taxes.

per year, for life. Because women live longer than men on average, a 65-year-old woman paying the same $100,000 premium would receive about 10 percent less, $717 per month, or $8,604 per year. A 65-year-old couple buying a joint-and-survivor annuity would receive $648 monthly, about 18 percent less than a single male.

Monthly annuity payments also increase with the age of the individual or couple to whom the annuity is issued. For example, a 75-year-old man paying $100,000 for an annuity would receive a payout of $1,052 per month, almost one-third more than his counterpart ten years his junior. For women, aging also raises the value of the annuity payout, but by less: a 75-year-old woman receives only 28 percent more than a woman a decade younger. Table 1 also shows that the male/female annuity payout differential changes with age. At age 55 men receive annuity payouts that are 6 percent higher than those for women, but by age 75, the monthly payout to men is 14 percent higher than that for

women. The joint-and-survivor benefit payments also change with age. At age 55, the couple receives a monthly benefit 13 percent below that paid to a single man, but by age 75, the couple's annuity amount is 25 percent lower. These payment patterns reflect differential mortality patterns for the various types of annuity purchasers.

The next two panels in Table 1 suggest the rather wide range of benefits paid by companies in Best's database. The range of payouts between the ten highest-payout annuity contracts and the ten lowest-payout policies, all conditional on a $100,000 premium payment, is 18 percent for 65-year-old men [(8.72 − 7.25)/0.5*(8.72 + 7.25)]. A 65-year-old man might receive from $725 to $872 monthly depending on the identity of the company from which he purchased the annuity. The all-firm average for such a purchaser was $794. The range of payouts for 65-year-old men is slightly lower than the range for 75-year-old men (about 20 percent), and slightly higher than that for 65-year-old women (about 16 percent). These data suggest that the benefits of "shopping around" for an annuity policy vary by age and by sex.[10] Our finding of substantial price variation in the annuity market supports earlier studies such as Bev Dahlby and Douglas West (1986) and G. Frank Matthewson (1983) that find price dispersion in automobile- and life-insurance markets.

A possible explanation for the variation in annuity payouts across firms is differences in the financial stability of the insurance companies selling the annuities. It is conceivable that insurers rated as more stable would pay lower annuity amounts, while companies rated as riskier might be forced by the market to pay higher monthly benefits to attract investors. One way to judge whether this is true is to examine the fourth panel of Table 1, which sets out average annuity payments made by the 20 highest-ranked companies according to Joseph Belth's

[10] We found substantial correlation in the relative payouts that different firms offered to annuitants of different ages. For example, eight of the ten firms that offered the highest payouts to 65-year-old male annuitants were also among the ten firms offering the highest payouts to 55-year-old male annuitants.

(1995) index of financial strength.[11] The results are similar to those in the top row of Table 1, and they suggest that annuity investors do not pay a substantially higher price when purchasing an annuity from a firm with an above-average financial rating.

The final panel of Table 1, which shows payments made by the ten insurance companies with the largest market share in the individual annuity market as reported by A. M. Best's, suggests a similar conclusion with respect to firm size. The average price for the large firms is similar to that for all firms.

B. Current and Projected Mortality Rates

Valuing an annuity stream requires estimates of the relevant mortality probabilities facing an individual annuitant or couple. Since future mortality probabilities are not known, it is necessary to use available data on past mortality rates to forecast future rates.

There are two relevant types of mortality probabilities. The first set reflects the expected mortality experience of the *general population,* based on mortality tables created by the Office of the Actuary at the U.S. Social Security Administration. These tables are used in the annual Social Security Trustees Reports to project the future financial position of the nation's major social insurance systems. The second set reflects expected mortality probabilities of the subset of the population that purchases *individual annuities.* Annuitant mortality data are based on tables made available by the Society of Actuaries, and are consistent with data actually used or proposed for use in the calculation of life-insurance company reserves for individual annuity products.

Mortality probabilities for the general population and for individual annuity purchasers differ significantly. The mortality probabilities for both men and women in the general population at every age are higher than the mortality probabilities for annuity purchasers. This difference may be due to two nonexclusive factors. First, individuals with higher-than-average net worth may live longer

than those without substantial assets, and these individuals may be represented disproportionately in the annuity-buying population. Second, *conditional* on net worth, the individuals who purchase individual annuities may live longer, on average, than those who do not.

With respect to the link between wealth and annuitant mortality, it is likely that the individuals and couples who demand an annuity stream beyond that given by Social Security and many private pension plans have higher-than-average net worth. Recent research including Gregory Pappas et al. (1993) and Orazio Attanasio and Hilary Hoynes (1995) suggests that individuals with higher-than-average net worth actually live somewhat longer than the population at large. With respect to other types of adverse selection, it is possible that individuals with higher-than-average mortality risk, such as those with serious illnesses, conclude that their shortened life expectancy makes annuities too expensive. In this case, the mortality probabilities of the group that decides to purchase annuities are truncated. Insurance companies, of course, price annuities with this truncation in mind. Such pricing is the cornerstone of the analysis of equilibrium in competitive insurance markets developed by Michael Rothschild and Joseph Stiglitz (1976) and Charles Wilson (1980).

In addition to deciding whether to use general population or annuity purchasers' life tables, one must also decide whether to use *period* or *cohort* life tables to project mortality rates for annuitants. A period table represents the mortality experience of a group of people during a relatively short period of time, usually a year.[12] A cohort or generation table represents lifetime mortality experience of a cohort of persons born during a particular year.[13] For cohorts that are no longer alive, cohort tables can be compiled from past period tables. For currently living cohorts, however, constructing a cohort table requires blending information from past as well as projected future period tables.

When calculating annuity values it seems natural to use cohort tables, because they reflect

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[11] Belth's (1995) criterion focuses on firms receiving very high ratings from at least two of the four major private rating firms: Standard and Poor's, Moody's, Duff and Phelps, and Weiss.

[12] This approach is taken in the Society of Actuaries' tables and some Social Security tables, as explained by Felicitie Bell et al. (1992).
[13] This second approach is also sometimes used by the Social Security Administration (SSA).

the probabilities that a rational forward-looking individual would likely apply in making his decision concerning the purchase of an annuity. Note that the projected age-specific mortality rate for individuals in a given cohort may change over time as a result of new information on trends in individual mortality patterns and life expectancy. For example, the 1960 cohort mortality table for individuals born in 1930 would show a different projection for the mortality rate of this group when it reached age 70, in the year 2000, than would the 1990 cohort mortality table for the same cohort. The 1990 table would presumably show a lower projected mortality rate as a result of the substantial unpredicted mortality rate declines in the three decades between 1960 and 1990.

We use two different types of mortality probabilities in the EPDV calculations below. Our first approach uses projected cohort mortality tables for the general population as compiled by the Social Security Administration Office of the Actuary in 1995. These mortality tables are based on unpublished statistics used for the 1996 Social Security Trustees' Report projections for each relevant birth cohort.[14] For valuing annuities offered to 65-year-olds in 1995, we use the 1930 birth cohort probabilities. For 55-year-olds in 1995, we use data for the 1940 birth cohort, and for 75-year-olds, we use probabilities from the 1920 birth cohort. In each case we rely on SSA's 1995 projections of the future mortality experience for these cohorts, because such projections should be based on the same information about aggregate mortality trends that insurance companies use in pricing their annuities.

Our second approach uses period tables for the annuitant population, in conjunction with the SSA cohort tables, to construct estimates of the 1995 cohort mortality table for individual annuitants. Cohort tables are unavailable for the annuity purchasing population, so we must make adjustments to the period tables for annuitants in order to mimic the desirable forward-looking properties of a cohort table. In our 1995 calculations, for example, we use information from the unpublished "basic" An-

nuity 2000 period table to estimate the cohort mortality patterns for individual annuitants.[15] The Annuity 2000 life table is designed to reflect projected annuitant mortality experience in the year 2000; it was recently issued by a committee of the Society of Actuaries.[16] To construct a cohort-like table for 1995 annuitants, we first interpolate between the basic Annuity 2000 table and the 1983 Table A reported in the Committee to Recommend a New Mortality Basis for Individual Annuity Valuation (1981). Then, the ratios of relevant mortality probabilities from the 1995 Social Security cohort table to the 1995 Social Security period table are applied to the 1995 annuity period table. This correction, which assumes that the prospective rate of mortality improvement for annuitants will be the same as that for the general population, yields a 1995 cohort-like annuitant mortality table.

Table 2 shows the resulting 1995 population and annuitant mortality rates by gender and age. It illustrates the lower mortality rates for the annuitant population. The differential

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[14] We thank Felicitie Bell of the Social Security Administration for providing these data.

[15] "Basic" in this context means a mortality table formed from industry experience without an additional margin for conservatism. The difference between a "basic" table and a table without this modifier is an implicit load for annuity pricing. The 1983 IAM Table A and the 1983 Individual Annuity Basic A tables, for example, differ by a 10-percent load factor. Throughout our calculations, we use annuitant basic tables.

[16] The Annuity 2000 table has an interesting history. The 1983 annuity table was based on actual annuitants' mortality experience in a large group of companies over the period 1971–1976, updated to reflect and project 1983 conditions. The Society of Actuaries' Individual Annuity Experience Committee (1991–1992) studied the annuity experience of a small group of companies over the period 1976–1986, and concluded that the 1983 table was adequate for the 1980's. More recent population mortality statistics from the Social Security Administration and the National Center for Health Statistics, along with evolving conditions in the group annuity market, however, convinced R. Johansen (1996), an actuary actively involved in the earlier studies, to call for a new individual annuity table. His call, although not his specific recommendations, was answered affirmatively and a Society of Actuaries committee was convened to consider the subject. Because there are no recent studies of industrywide annuitant mortality experience, however, the committee decided simply to use the basic 1983 annuity table projected forward to the year 2000 using mortality improvement factors consistent with the recent experience of the general population as well as that of one company with substantial annuity business.

TABLE 2—GENERAL POPULATION AND ANNUITANT MORTALITY RATES (PER 1,000 PERSONS), 1995

Gender and age	Life table for 1930 birth cohort general population	1995 individual annuitant life table
Men:		
65	22.2	11.5
70	31.5	18.8
75	46.7	30.9
80	73.7	50.4
85	113.8	79.8
90	169.0	120.6
95	238.4	172.6
100	305.3	236.0
105	380.4	341.9
Women:		
65	13.4	7.3
70	19.8	11.5
75	29.1	19.4
80	44.3	33.4
85	69.6	57.6
90	116.7	101.3
95	189.5	158.4
100	259.2	211.3
105	337.1	299.0

Sources: The first column is based on unpublished tabulations provided by the Social Security Administration, Office of the Actuary. The second column is drawn from mortality tables produced as part of the Society of Actuaries' Annuity 2000 project, adjusted to reflect mortality rates in 1995 rather than 2000.

TABLE 3—ANNUITY VALUES-PER-PREMIUM DOLLAR, 1995, AFTER-TAX CALCULATIONS

	Population mortality table		Annuitant mortality table	
	Treasury yield curve	Corporate yield curve	Treasury yield curve	Corporate yield curve
Men:				
Age 55	0.852	0.773	0.934	0.840
Age 65	0.814	0.756	0.927	0.853
Age 75	0.783	0.743	0.913	0.860
Women:				
Age 55	0.880	0.791	0.937	0.838
Age 65	0.854	0.785	0.927	0.847
Age 75	0.846	0.796	0.919	0.861
Joint and survivor:				
Age 55	0.889	0.792	0.930	0.824
Age 65	0.868	0.792	0.929	0.841
Age 75	0.846	0.791	0.922	0.857

Notes: Each entry shows the expected present discounted value of the annuity payouts per dollar of annuity premium. All calculations use the all-company sample average annuity payout rates to estimate the stream of payments associated with individual annuity contracts.

is most notable, greater than one-third, at ages immediately following the traditional age of retirement.

To compare the expected discounted value of annuity payouts in different years, we also require cohort-like general population mortality probabilities for 1985 and 1990.[17] To carry out our analysis for 1990, we made the 1990 Social Security period table in Bell et al. (1992) into a cohort-like table by applying projected annual survival improvements of 0.75 and 1.00 percent for men and women, respectively. These improvement rates were previously used by Friedman and Warshawsky (1988, 1990) and Warshawsky (1988), and they represent half the actual rates observed during the prior 15-year period. For 1985, we created a period table by interpolat-

ing between the 1980 Social Security period table appearing in J. Faber (1982) and the 1990 period table. The resulting 1985 period table was then made cohort-like by applying the same survival improvement rates.

We used a similar methodology to produce cohort-like annuitant mortality probabilities for earlier years. The 1983 Individual Annuity Mortality Basic Table A was brought forward to 1985 and 1990 by using general population survival improvement rates over the relevant periods to produce period tables. These period tables were then made cohort-like by applying the projected survival improvement rates mentioned above.

IV. Empirical Findings: Money's Worth Results

We present our detailed findings for 1995, and then move on to present a restricted set of results for earlier years. Table 3 reports our estimates of the expected discounted value of annuity payouts using the all-company average payout rates from Table 1. It uses the after-tax

[17] It was not possible to obtain the actual cohort tables used by the Social Security Administration in preparing the 1986 and 1991 Trustees' Reports.

valuation formula presented above.[18] The first two columns show calculations based on the 1995 *population* cohort mortality table, while the third and fourth columns use the 1995 *annuitant* cohort-like mortality table in valuation. All annuity values are computed using both the term structure of short-term nominal interest rates implicit in the Treasury bond yield curve, and the related yield curve for BAA corporate bonds. We assume that the annuitant faces a 28-percent combined federal and state tax rate.[19] In 1995, a married joint-filer household would have needed taxable income between $39,000 and $94,250 to face this tax rate. While the vast majority of older households have incomes below this range, the current set of individual annuity purchasers is substantially more affluent than the elderly population at large. In later sections, when we assess the demand for annuities among *all* elderly households, we use a lower marginal tax rate (15 percent). This difference can be thought of as divergence between the "annuitant" and "population" tax rates.

A. *Basic Results on Expected Present Discounted Values*

Table 3 shows the expected present discounted value of annuity payments per premium dollar in 1995. When we use the general population mortality tables for a 65-year-old man, the value-per-premium dollar for a life annuity on an after-tax basis is 0.814 when we use the Treasury yield curve in valuation, and 0.756 when we use the corporate bond yield curve. For a woman of the same age the average values are higher, 0.854 and 0.785, respectively. In general, the fact that all value-per-premium dollar entries in Table 3 are well below 1.00 implies that a typical retiree with average mortality prospects would perceive a noticeable "transaction cost" when purchasing an annuity from a commercial insurance carrier. This transaction cost is equivalent to purchasing an actuarially fair annuity as determined from the general population mortality table, but having to give up roughly one-fifth of one's wealth before investing the remainder in this annuity product.

The results in Table 3 show that the higher the discount rate used in the valuation exercise, the lower the value-per-premium dollar. The expected discounted value of annuity payouts are systematically lower when we use BAA corporate interest rates to discount payouts than when we use the Treasury term structure. Table 3 also shows that for most combinations of mortality tables and interest rates that we consider, value-per-premium dollar declines with age. Values also vary by gender: controlling for age, value-per-premium dollar is lower for men than for women and couples.[20]

Table 3 focuses on annuity valuation using the after-tax valuation equation, equation (4). We show below that the differences between the before-tax and after-tax calculations are not large. There is weak evidence suggesting that annuities are more attractive on an after-tax than on a before-tax basis. This appears to derive from the fact the IRS has mandated the use of an old period mortality table, the 1983 Individual Annuitant Mortality table, in calculating the exclusion ratio.

The results in the last two columns of Table 3 show annuity value to premium ratios using annuitant mortality probabilities rather than general population mortality rates. Because annuitants have longer life expectancies than

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[18] Even when we ignore income taxes, we recognize premium taxes that some states impose on annuity purchases. According to Marci Castillo (1997), only 12 states impose taxes on annuity premiums; their average rate is 1.5 percent. To get the national average state premium tax rate of 0.52 percent, we weighted the individual state tax rates by the percentages of the U.S.-over-65-year-old population residing in each state.

[19] Because many annuity income recipients may also be Social Security recipients, the marginal tax rate on annuity or interest income could exceed the combined federal and state tax rate if this income leads to inclusion of Social Security benefits in taxable income. We explored the sensitivity of our results to higher marginal tax rates, but did not find any substantial changes relative to the findings reported here.

[20] We assume that couples evaluate joint-and-survivor annuities assuming that their individual mortality probabilities are independent. However, recent research by Edward W. Frees et al. (1996) suggests that the mortality of husbands and wives exhibits positive dependence. Canadian insurance data suggest that annuity values for couples should be reduced by about 5 percent when using dependent mortality models, relative to the values computed using standard models that assume independence.

nonannuitants, the entries in this panel are uniformly higher than those in the previous panel. For example, a 65-year-old man using the annuitants' mortality table would assess the value-per-premium dollar as 0.927 on an after-tax basis using the Treasury yield curve. This compares to a ratio of 0.814 using general population survival rates. For a 65-year-old woman, the average value is also higher. The value using the annuitant table is 0.927, compared with 0.854 using the general population table.

The value-per-premium dollar figures vary substantially more as the discount rate changes from the Treasury yield curve to the corporate yield curve in the case that uses annuitant mortality probabilities than in that using general population mortality rates. This is because the effective duration of payouts is greater when the annuity policy is evaluated using the annuitant table. With a longer duration, the present-value calculations become more sensitive to differences in the discount rate.

Regardless of discount rate, and controlling for age, value-per-premium dollar in Table 3 is roughly comparable for men, women, and couples when we use the annuitant mortality tables. In the general population calculations, however, value-per-premium dollar is lowest for men. This result may be due to the fact that the ratio of life expectancies in the annuitant to the general population is higher for men than for women.

The results in Table 3 using the corporate term structure imply that annuity purchasers in the age ranges examined here would expect to receive payouts of between 82 and 86 cents per premium dollar. This set of calculations presumably represents the pure mortality and investment-related costs to the insurance companies of issuing life annuities, assuming that their typical portfolio investment is a BAA corporate bond. This implies that commercial insurance companies in 1995 allowed about 14–18 percent of annuity premiums to cover commissions and other marketing costs, corporate overhead, income taxes, additions to various company contingency reserves, and profits.[21] These figures are smaller than the

figure of 25 percent computed for the 1970's and early 1980's by Friedman and Warshawsky (1988) and significantly smaller than the figure of 31 percent for the early 1980's alone.[22]

We can calculate the cost of adverse selection in 1995 by comparing, for like age, gender and discount rate, the value-per-premium dollar ratios using the population and annuitant mortality tables. For example, for an annuity sold to a man aged 65 and using the Treasury yield curve, the cost of adverse selection is 11.3 percentage points (0.927–0.814). For the 1970's and early 1980's, the cost of adverse selection was 9 percent, similar to the current cost. For an average individual, adverse selection appears to explain roughly half of the disparity between the expected discounted present value of annuity payouts and the cost of an individual annuity.

B. Internal Rate of Return Calculations

Annuities can be compared to other securities—in our case, bonds—either by computing the expected present discounted value of annuity payouts, using the return on the other asset as a discount rate, or by comparing the internal rate of return on annuities with the yield on these alternative investments. Samuel Broverman (1986) describes this second approach in detail. The internal rate of return is the discount rate at which the present discounted value of annuity payouts will equal the cost of purchasing the policy. For the standardized $100,000 SPIAs that we consider, the internal rate of return is the value ρ^* for the no-tax case, or ρ^*_{at} for the after-tax case, that satisfies:

$$(5) \qquad 100000 = \sum_{j=1}^{600} \frac{A^* P_j}{(1 + \rho^*)^j}$$

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[21] For insurance companies licensed to write business in New York State, direct marketing costs, which include commissions to agents and brokers and related direct expenses, are not allowed to exceed 7 percent of the annuity premium.

[22] They are also lower than the estimates of annuity payouts per dollar of premium payment in Canada, as reported in Moshe A. Milevsky (1998). Milevsky suggests payouts with EPDV values of between 0.91 and 0.96 per dollar of premium.

TABLE 4—INTERNAL RATES OF RETURN (PERCENTAGE POINTS) ON ANNUITY CONTRACTS OFFERED TO MEN AGED 65 IN 1995

	Before-tax calculation		After-tax calculation	
	Population mortality	Annuitant mortality	Population mortality	Annuitant mortality
Men:				
Age 55	5.46	6.35	5.17	6.46
Age 65	4.62	6.31	3.81	6.16
Age 75	3.17	6.03	1.39	5.31
Women:				
Age 55	5.68	6.26	5.73	6.55
Age 65	5.13	6.09	4.91	6.24
Age 75	4.47	5.82	3.77	5.61
Joint and survivor:				
Age 55	5.83	6.20	5.95	6.51
Age 65	5.44	6.15	5.33	6.36
Age 75	4.63	5.94	4.08	5.89

Notes: Each entry shows the internal rate of return that equates the expected present discounted value of payouts for an individual annuity, using the all-company sample average annuity payout rates, to the purchase price of the annuity.

or

$$(6) \quad 100000 = \sum_{j=1}^{12*T'} \frac{(1 - \lambda*\tau)*A*P_j}{(1 + (1 - \tau)*\rho_{at}^*)^j}$$

$$+ \sum_{j=12*T'+1}^{600} \frac{(1 - \tau)*A*P_j}{(1 + (1 - \tau)*\rho_{at}^*)^j}.$$

Table 4 presents these internal rates of return for SPIAs that were available in 1995. The table shows that for a 65-year-old man, when we base the calculation on the no-tax formula, the internal rate of return was 4.62 percent when we use the population mortality table, and 6.31 percent when we use the annuitant table. For women, the analogous internal rates of return are 5.13 percent and 6.09 percent. When we do the calculation recognizing the taxation of interest and of annuities, the internal rate of return is 3.81 percent with the population mortality table, and 6.16 percent with annuitant mortality. To place these returns in perspective, the yield on a Treasury bond with ten years to maturity was 7.09 percent at the beginning of May 1995, and the yield on a 30-year Treasury bond was 7.35 percent. BAA corporate bonds yielded an average of 8.57 percent at this time. Thus the internal rates of return on the an-

TABLE 5—VALUES-PER-PREMIUM DOLLAR OF ANNUITY POLICIES OFFERED FOR MEN AGED 65—1985–1995

	Before-tax calculation		After-tax calculation	
	Treasury yield curve	Corporate yield curve	Treasury yield curve	Corporate yield curve
Using population life tables:				
1985	0.749	0.677	0.764	0.704
1990	0.814	0.746	0.812	0.757
1995	0.816	0.742	0.814	0.756
Using annuitant life tables:				
1985	0.827	0.740	0.865	0.790
1990	0.912	0.828	0.926	0.856
1995	0.916	0.825	0.927	0.853

Notes: All entries show the present discounted value of annuity payouts per dollar of annuity premium, assuming a $100,000 single-premium immediate annuity purchase. See text for further details regarding calculations.

nuities we consider are between 100 and 200 basis points below the market returns available to fixed-income investors.

The internal rate of return on SPIA contracts appears to decline as the age at which the contract is purchased rises. For men, there is more than a 200-basis-point differential between the internal rate of return on an annuity contract purchased at age 55 and a contract purchased at age 75.

C. *Comparisons of EPDV over Time*

We now consider how the expected value of annuity products has changed over time, and for this purpose we return to our focus on the expected discounted value of annuity payouts. Table 5 shows the value-per-premium dollar calculations for annuities offered to 65-year-old men, using the Best's all-company average payout for 1985, 1990, and 1995. The table presents calculations using our no-tax as well as our tax-inclusive formula. We present results from calculations without any correction for income taxes to facilitate comparison with earlier studies, since earlier work did not consider annuity taxation.

It is clear that regardless of the discount rate, mortality table, or tax basis, value-per-premium dollar grew roughly 8 percentage points between 1985 and 1995.[23] The present estimates

[23] The dispersion of annuity prices has also declined over time. In 1985, for a 65-year-old man, the monthly income for the ten highest-payout policies averaged 1.152 times that

for 1985 are close to Warshawsky's (1988) calculations for 1984, confirming that our methodology is similar enough to generate comparable results for nearby years. We also note that our 1995 results are reminiscent of the high values-per-premium dollar that Warshawsky (1988) reports for several earlier periods, including the 1940's, early 1950's, and mid-1960's.

The fluctuations in annuity value-per-premium dollar raise questions about the determinants of annuity prices. These prices should be related to the level of real interest rates, but it may also be related to the level and variability of nominal interest rates. When interest rates are low and stable, insurance companies may be able to price nonparticipating annuities more competitively with other fixed-income investments. In contrast, when interest rates are high and variable, insurance companies may be reluctant to assume that current yields will be maintained for the duration of annuities issued in that year, and therefore they act more conservatively and require larger contingency funds in their annuity pricing. A particularly important question concerning the interpretation of the results in Table 5 is whether the increase in the expected present discounted value of annuity payouts per premium dollar is the result of a trend toward higher payouts, or an artifact of cyclical fluctuations in annuity pricing. We cannot resolve this issue with the available data.

V. The Insurance Value of Annuity Contracts

Our discussion of the expected present discounted value of annuity payouts neglects the important insurance value of annuities. To provide some insight on this issue, we invoke an explicit individual utility function and compare the expected *utility* of purchasing an annuity with that from alternative, nonannuitized methods of decumulating assets during retirement.[24]

The alternative we consider is the optimal consumption path that results if the individual solves the dynamic stochastic optimization problem for lifetime consumption.

A. Analytical Framework

We consider an individual who purchases a fixed nominal annuity at age 65. This individual will receive an annuity payment in each year that he remains alive, and his optimal consumption path will be related to this payout. The after-tax annuity payout that the individual receives at age $a(A_a)$ depends on his wealth at the beginning of retirement (W_0), the annual annuity payout per dollar of premium payment (θ), and the tax rules that govern annuity income:

$$(7) \quad A_a(W_0) = [1 - \lambda * \tau * I_{a < 65 + T'} - \tau * I_{a \geq 65 + T'}] * \theta * W_0.$$

The variable $I_{a < 65 + T'}$ is an indicator variable set equal to one for ages less than the date at which all annuity income is included in taxable income, and zero otherwise. The other indicator variable is defined in complementary fashion.

We limit our analysis to annuity contracts that pay fixed nominal benefit streams. We begin our analysis by assuming a fixed inflation rate of 3.2 percent per year, which corresponds to the historical average over the 1926–1995 period as reported in Ibbotson Associates (1996). This means that the nominal annuity is a real annuity with payouts that decline at the rate of 3.2 percent per year.[25] In a later subsection we allow for a distribution of inflation outcomes.

We compute the actuarially fair annuity payout per premium dollar (θ) for a 65-year-old

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for the entire sample of policies in the Best's data base, while the average payout for the ten lowest-payout companies was 0.885 times the sample average. In 1990, the analogous statistics were 1.097 and 0.892, and in 1995, 1.098 and 0.913.

[24] For recent treatments of the question of whether individuals should purchase annuity contracts, see Agar Brugiavini (1993) and Milevsky (1998).

[25] We have done some calculations comparing the utility levels afforded by these nominal annuities and alternative real annuity contracts. Even though the nominal annuities offer consumption streams that decline in real value, this deviation from the constant real consumption path that would be optimal from the annuitant's standpoint does not lead to a large reduction in utility. This is because the tilting of the real consumption profile takes place locally around the optimal path. The graded payment method for annuity payouts, first proposed by John H. Biggs (1969) and implemented by TIAA in 1982, allows for an increasing payout profile roughly in line with the rate of inflation.

male, in 1995, using the Social Security Administration's cohort life table for men born in 1930. We find θ from the following equation:

$$(8) \qquad 1 = \sum_{j=1}^{50} \frac{\theta * P_j}{((1+r)(1+\pi))^j},$$

where P_j denotes the probability of a 65-year-old retiree remaining alive j years after retirement, r denotes the annual real interest rate, and π is the annual inflation rate. In distinction from our earlier analysis, we now focus on years rather than months in our annuity valuation, to simplify our dynamic programming calculations of optimal consumption paths. We continue to assume that no one survives beyond age 115, so $P_{50} = 0$.

We compute the expected discounted utility stream associated with the consumption stream generated by the annuity contract by assuming that individuals have additively separable utility functions of the following form:

(9)

$$U = \sum_{j=1}^{50} P_j * \frac{\left(\left(\frac{C_j}{(1+\pi)^j}\right)^{1-\beta} - 1\right)}{(1-\beta)*(1+\rho)^j}.$$

The parameter β determines the individual's risk aversion and also the degree of intertemporal substitution in consumption. The nominal consumption flow is deflated by the price index, $(1+\pi)^j$.

We perform this calculation in two cases. The first assumes that all of the individual's resources at age 65 have been used to purchase the annuity contract. The other assumes that only half of the individual's resources can be used for such a purchase, and that the other half is already invested in a real annuity. We view this as a stylized characterization of the current Social Security system. We thus investigate whether the marginal gains from annuitization of private assets decline substantially when some wealth is already held in annuitized form. Comparing these two cases may provide some evidence on the time-series variation in annuity demand, since Alan J. Auerbach et al. (1992) observe that over time, the elderly have held a rising fraction of their assets in annuitized form.

We illustrate our procedure for computing the insurance value of purchasing an annuity contract by considering an individual who does not have any annuitized wealth. The generalization to the case with some annuitized wealth follows naturally. First, we find the optimal consumption path for someone with assets of W_0 at age 65, who does not have access to an annuity market, and who maximizes the utility function above over remaining lifetime by choosing a consumption path $\{C_a\}$. This maximization is carried out subject to the initial wealth constraint W_0 and the budget constraint

$$(10) \quad W_{a+1} = (W_a - C_a)*[1 + (r + \pi)(1 - \tau)].$$

In this equation τ denotes the marginal income tax rate that applies to nominal interest income.[26] We solve for the optimal consumption path $\{C_a\}$ using stochastic dynamic programming, where the stochastic component of the problem arises from uncertainty regarding date of death. We then compute the value of the expected utility function (U^*) for this consumption stream.

In the second stage of our calculation, we ask what amount of wealth at age 65 (W_{EQUIV}) the individual would require to reach utility level U^* if he used this wealth to purchase an actuarially fair nominal annuity and thereby obtained a nominal income stream equal to $A_a(W_{\mathrm{EQUIV}})$.[27] We use a standard dynamic programming algorithm to find the optimal consumption profile for an individual with an annuitized income stream, and then to find his expected utility level from implementing this consumption plan. This expected utility level is found by maximizing

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[26] In the analysis reported below, we consider cases with and without taxation ($\tau = 0$).

[27] The individual could choose to consume the nominal annuity payout in each remaining year of life, but in general the optimal consumption path will in general not coincide with the annuity payout stream (see Tadashi Yagi and Yasuyuki Nishigaki, 1993). We assume that annuity recipients cannot borrow against future annuity income, but they can save and invest their annuity income at a return r.

the utility function in (9) subject to the constraints $W_0 = 0$ and

$$(11) \qquad W_{a+1} = (W_a + A_a(W_{\text{EQUIV}}) - C_a)$$
$$\times [1 + (r + \pi)(1 - \tau)].$$

$A_a(W_{\text{EQUIV}})$ denotes the annuity payout stream that can be purchased with an initial wealth of W_{EQUIV}. For a given value of W_{EQUIV}, denote the resulting value of the expected utility function by $U^{**}(W_{\text{EQUIV}})$. We normalize annuitizable first-period wealth at unity ($W_0 = 1$) and then apply a numerical search algorithm to find the value of W_{EQUIV} that yields $U^{**}(W_{\text{EQUIV}}) = U^*$. Since the longevity insurance provided by the annuity market makes the individual better off, W_{EQUIV} is less than W_0.

B. Results with Certain Inflation

Table 6 presents the resulting values of W_{EQUIV}/W_0 for two different assumptions about individual risk aversion ($\beta = 1$ and $\beta = 2$). The table includes results for several different assumptions about the level of real interest rates and individual time preference rates. The upper panel of the table describes the results that assume a fixed annual inflation rate. Because these calculations are designed to indicate the demand for annuities in the population at large, our after-tax calculations assume a marginal tax rate of 15 percent, which is likely to apply to the majority of retired households.

The calculations in Table 6 suggest that, in the canonical life-cycle model with uncertain mortality, consumers would be prepared to give up substantial fractions of their wealth in order to purchase actuarially fair annuities. In the before-tax calculations, for example, we find that individuals would accept a reduction of between 30 and 38 percent in their wealth at age 65 if they were able to purchase actuarially fair nominal annuities rather than pursue an optimal consumption strategy without annuity contracts. The amount of wealth that individuals would forgo is increasing in their risk aversion, and decreasing in the rate of return that they can earn on their own investments.

TABLE 6—WEALTH EQUIVALENCE BETWEEN ANNUITIZED AND NONANNUITIZED ASSETS

Parameter values	Before-tax calculation		After-tax calculation	
	$\beta = 1$	$\beta = 2$	$\beta = 1$	$\beta = 2$
Certain inflation, $\pi = 0.032$:				
No Preexisting Real Annuity				
$r = 0.03$, $\rho = 0.01$	0.659	0.619	0.657	0.604
$r = 0.03$, $\rho = 0.03$	0.678	0.626	0.680	0.614
$r = 0.05$, $\rho = 0.01$	0.692	0.670	0.683	0.653
$r = 0.05$, $\rho = 0.03$	0.703	0.675	0.697	0.659
Preexisting Real Annuity Worth 50 Percent of Wealth at Retirement				
$r = 0.03$, $\rho = 0.01$	0.730	0.695	0.759	0.717
$r = 0.03$, $\rho = 0.03$	0.771	0.723	0.809	0.748
$r = 0.05$, $\rho = 0.01$	0.732	0.714	0.736	0.709
$r = 0.05$, $\rho = 0.03$	0.757	0.729	0.770	0.732
Uncertain inflation (mean $\pi = 0.032$):				
No Preexisting Real Annuity				
$r = 0.03$, $\rho = 0.01$	0.668	0.631	0.664	0.613
$r = 0.03$, $\rho = 0.03$	0.687	0.639	0.687	0.623
$r = 0.05$, $\rho = 0.01$	0.700	0.682	0.689	0.662
$r = 0.05$, $\rho = 0.03$	0.712	0.688	0.703	0.667
Preexisting Real Annuity Worth 50 Percent of Wealth at Retirement				
$r = 0.03$, $\rho = 0.01$	0.737	0.703	0.763	0.721
$r = 0.03$, $\rho = 0.03$	0.778	0.732	0.813	0.753
$r = 0.05$, $\rho = 0.01$	0.739	0.722	0.749	0.723
$r = 0.05$, $\rho = 0.03$	0.764	0.737	0.784	0.746

Notes: In the upper panel, the annual inflation rate is 3.2 percent. In the lower panel, the inflation rate is stochastic, drawn from a four-point distribution described in the text. In both panels, r denotes the real interest rate, and ρ is the individual's time preference rate. The SSA cohort life table for men born in 1930 is used for all calculations. The after-tax calculations assume a marginal income tax rate of 15 percent.

These results are similar to those presented by Laurence J. Kotlikoff and Avia Spivak (1981) for the case of private annuities and by R. Glenn Hubbard (1987) for the case of publicly provided annuities. In contrast, if half of an individual's wealth at retirement were held in an annuitized form (similar to Social Security), the share of nonannuitized wealth that he would be prepared to relinquish in order to obtain access to an annuity market declines. Depending on the real interest rate and discount rate assumptions, individuals would still forgo between 23 and 31 percent of their discretionary wealth to obtain a nominal annuity.

C. Results with Uncertain Inflation

Some might argue that the results in the upper panel of Table 6 overstate the insurance value of nominal annuities, because they do not allow for the possibility that fluctuations in postretirement inflation will alter the utility value of the nominal annuity stream. To address this possibility, we modified our wealth equivalent calculations to allow for uncertain inflation. In lieu of a constant inflation rate of 3.2 percent each year, we allowed the inflation rate in each "year" to take one of four values: −1.4 percent, 1.8 percent, 3.8 percent, or 9.0 percent. The respective probabilities of these inflation outcomes were 0.2, 0.3, 0.3, and 0.2. These inflation values correspond approximately to the 10th, 35th, 65th, and 90th percentiles of the annual inflation distribution for the years 1926–1995, and they imply an average annual inflation rate of 3.2 percent.[28] The stochastic dynamic programming problem is substantially more complex in the presence of stochastic inflation and mortality than in the case of stochastic mortality alone, but the same basic approach can be used to find the wealth equivalent in this case.

The lower panel of Table 6 presents our wealth equivalents for the uncertain inflation case. Compared to our findings in the certain inflation case, a risk-averse individual would forgo less of his wealth to purchase a nominal annuity. The quantitative difference between the results in the upper and lower panels of Table 6 is small, however. In most cases, there is less than a 1-percentage-point difference in the fraction of wealth that an individual would be prepared to give up to purchase nominal annuities in the fixed and random inflation cases. Hence our findings suggest that uncertain inflation is not a key factor explaining the limited individual demand for nominal annuities.[29] These findings may also explain, in part, the relatively limited demand for U.S. Treasury Inflation Protection Securities (indexed bonds) since their debut over a year ago.

D. Implications

The findings in Table 6 imply that even if the EPDV calculations presented above yielded only 0.75 per dollar of premium payment, individuals with preferences such as those modeled here would still prefer to purchase the annuity rather than pursue an optimal consumption strategy without such insurance products. Thus in a simplified stochastic life-cycle model without bequest motives, the fact that the expected present discounted value of annuity payouts is less than the cost of these policies cannot explain the low demand for nominal annuities.

These calculations should be viewed as exploratory for at least three reasons. First, they ignore the possibility of bequest motives, even though a substantial literature suggests that some individuals behave in ways that are consistent with the presence of such motives.[30] Second, they do not recognize the possibility of

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[28] We also examined other inflation processes that allowed for greater year-to-year inflation persistence, but did not find results substantially different from those reported in Table 6.

[29] We have explored the sensitivity of the wealth equivalent calculations with random inflation to changes in the coefficient of risk aversion. More risk-averse individuals value a nominal annuity less when there is uncertain inflation. When we set $\beta = 6$, for example, we found differences of approximately 3 percent in the wealth equivalent values under certain and uncertain inflation. These differences are larger than those reported in Table 6. Brown et al. (2000) discuss the availability of and demand for inflation-indexed annuities in more detail.

[30] John Laitner and F. Thomas Juster (1996) and Mark Wilhelm (1996) represent recent contributions to the literature on bequest motives and provide references to earlier studies. Andrew B. Abel and Warshawsky (1988) discuss alternative specifications of the bequest motive that could be used to modify the calculations presented above. Alain Jousten (1998) explores the link between bequest motives, annuity markets, and optimal consumption profiles. Brown and Poterba (1999) explore annuity valuation for married couples purchasing joint-and-survivor annuities.

large one-time consumption needs, for example for medical and long-term disability care, that might induce some individuals to prefer not to annuitize their assets. Finally, they do not consider the complex issues raised by annuitization decisions of married couples, where the expected time path of consumption needs may differ from the level nominal annuity offered by most insurance contracts.

VI. Conclusions and Future Work

This paper presents new evidence on the expected present discounted value of payments for annuity policies and compares these to the cost of purchasing an individual annuity contract. We find that the average annuity policy available to a 65-year-old man in 1995 delivered payouts valued at between 80 and 85 cents per dollar of annuity premium. There was substantial heterogeneity across annuity providers in the payouts per dollar of premium payment. We also find evidence that the expected present discounted value of annuity payouts relative to premium payments has increased by approximately 8 percentage points during the last decade. Thus, from the standpoint of potential purchasers, an individual annuity contract appears to be a more attractive product today than ten years ago.

These findings bear on a set of issues that arise in designing national retirement policy. Although the individual annuity market is currently quite small, it has attracted substantial interest from researchers and policy makers concerned with the evolving system of retirement income provision. In light of current discussions of Social Security reform and the shift from defined benefit to defined contribution private pension plans, we suspect that there may be increased interest in individual annuity products in the future. Current trends place greater emphasis on individual choice and self-reliance in planning for retirement. These developments may increase the demand for individual annuity products as retirees confront the problems of optimal decumulation of assets amassed in various retirement plans.

Valuation exercises such as those presented here are also important for assessing the extent of adverse selection in the market for individual annuities. This, in turn, is a key consideration in the policy debate regarding whether the government should intervene directly and mandate a national annuity pool, should the current Social Security system be partly replaced by a mandatory private saving system [see the discussion in Technical Panel on Trends in Income and Retirement Savings (TIRS), 1995].[31] These results provide an important input for this analysis, although they should be viewed with caution because a policy change of this magnitude could alter the set of individuals purchasing annuities and therefore affect the pricing of these products.

Our findings raise a number of questions for future research. The most important outstanding issue may be how to explain the differential between the expected present discounted value of annuity payouts and the premiums for these policies. This difference may be partly due to the corporate income taxes on the insurance companies offering annuity products. Our analysis has recognized the effect of annuitant-level taxes on the relative value of annuities and other financial products, but it has not tried to explain how taxes at the corporate level might affect the pricing of annuities. Another portion of the differential between the premium and the discounted benefit flow is attributable to the insurance company load, or charge levied to cover marketing and administration costs and normal profitability. There also may be company-to-company differences in underwriting, making the cross-firm premium variation reflective of specific risk pools that our overall correction does not fully capture. Nonetheless, the fact that the differential has diminished over time suggests that potential imperfections in the annuity business of two decades ago may be attenuated in today's insurance market.

Future research could usefully extend this analysis to consider the pricing and value of group annuity products. Because of the risk pooling inherent in the purchase of group annuities, for example through a pension fund, there is likely to be less adverse selection in the group market than in the individual annuity market.

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[31] The potential for market failure in the individual annuity market has historically been advanced as one of the reasons for government provision of retirement income; see Peter A. Diamond (1977). Abel (1986) provides a formal analysis of the interactions between public retirement programs and private annuity markets. Warshawsky (1997) suggests a clearinghouse mechanism that could be put into place if individual accounts were to be set up under a partially privatized Social Security system.

Hence we would expect to see smaller differences between the expected present discounted values and premium costs for the population, and for group annuitants, than we found in the individual annuity market.

It would also be interesting to expand our analysis to include other components of household portfolios. We have effectively assumed that the payouts from an annuity contract are certain, conditional on individual life length, and that riskless assets such as Treasury securities or investment-quality corporate bonds are the only alternatives to an annuity contract. If an individual's portfolio also included risky securities such as corporate equities, then the comparison between purchasing an annuity and holding other financial assets might change from the one we present. Yet another complexity arises from the recent introduction of government bonds with yields linked to changes in the Consumer Price Index. If such "indexed bonds" prompted the introduction of annuity contracts with fixed real payouts rather than fixed nominal payouts, this could also change the relative appeal of annuity products.

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