Retirement Income, Bequests, and Insurance:
Implications of Mortality Risk in a Stochastic Life Cycle Model

by

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Abstract

This thesis is composed of four studies on the role of annuities and life insurance in the portfolios of elderly households. It has long been known in the economics literature that annuities should be of substantial value in the portfolios of retired individuals. However, outside of private pension plans, the purchase of private annuity contracts is relatively rare. This paper explores the issues associated with this "Annuity Puzzle" using the framework of a life cycle model of consumption, extended to account for mortality uncertainty.

Chapter 1 empirically examines household decisions about whether or not to annuitize balances in defined contribution pension plans upon retirement. This study calculates a utility-based measure of annuity valuation for households nearing retirement, and allows for variation across households to result from variation in mortality rates, risk aversion, marital status, and the presence of pre-existing annuities such as Social Security. It finds that a one percentage point increase in the calculated gain from annuitization is associated with a one percentage point increase in the ex ante probability of annuitizing one's retirement resources. It also finds that the presence of bequest motives has no effect on the disposition of defined contribution plan assets.

The finding that bequest motives do not affect marginal annuity decisions is in contrast to some of the previous literature. In particular, previous research has argued that a significant fraction of the elderly are over-annuitized by Social Security, as evidenced by their decision to hold life insurance. Chapter 2 re-examines this finding using new and better data on the age 70+ population, and finds little support for the existence of strong bequest motives.

One important source of variation in the decision of whether or not to annuitize is marital status. Chapter 3 explores the demand for joint-life annuity products among married couples, and finds that couples should value annuitization less than single individuals. This is because couples have opportunities to share risk between them, and as such, marriage is a partial substitute for perfect annuity markets. This may help to explain the relative scarcity of private annuity contracts in the U.S.

Chapter 4 extends the analysis of annuities to account for inflation risk. It explores the relative value of real versus nominal annuities, and also explores the gains to purchasing annuities that are linked to an underlying portfolio of risky assets.

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# Table of Contents

Acknowledgements .................................................. 7

Introduction .......................................................... 11

Chapter 1: Private Pensions, Mortality Risk, and the Decision to Annuitize .................................................. 17

Chapter 2: Are the Elderly Really Over-Annuitized? New Evidence on Life Insurance and Bequests .................................................. 69

Chapter 3: Joint Life Annuities and Annuity Demand by Married Couples (Joint with J.M. Poterba) .................................................. 113

Chapter 4: The Role of Real Annuities and Indexed Bonds in an Individual Accounts Retirement Program (Joint with O.S. Mitchell and J.M. Poterba) .................................................. 149
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Introduction

The four papers comprising this dissertation each deal with a different aspect of what has come to be known as “The Annuity Puzzle.” The essence of this puzzle is that an individual, life-cycle consumer who faces an uncertain lifetime should find annuities to be of substantial value in his or her retirement portfolio. Yet it is well documented that outside of pension plans, the private market for annuities is virtually non-existent. Why this might be so is the primary question motivating the four studies in this thesis.

When an individual purchases an annuity, he or she exchanges a sum of wealth for a life-contingent income flow. The annuity income provides the individual with “longevity insurance” by protecting the individual from outliving his or her fixed retirement resources. An actuarially fair annuity pays a rate of return that is higher than the risk-free rate due to the fact that there is a chance the annuitant will not be alive to receive the payments. This extra return is known as the “mortality premium.” For these reasons, actuarially fair annuities can be shown to dominate riskless bonds in the portfolio of a life-cycle consumer with an uncertain lifetime and no bequest motive.

Understanding the annuitization decisions of households has become increasingly important in recent years for two reasons. First, the dramatic shift away from traditional defined benefit pension plans, which usually paid out as a life annuity, and towards defined contribution plans, which are usually not annuitized, has led to an increased interest in how individuals will handle lifetime uncertainty when making consumption decisions in retirement. The extent to which individuals can adequately provide for their own consumption at older ages has a direct impact on their individual welfare, and also potentially affects the incidence of poverty among
elderly widows, and the degree of reliance on needs-based social insurance programs such as SSI.

The second reason that annuitization issues have become more prominent in recent years is the current debate about the future of the Social Security system in the United States and elsewhere. Concerns over the future solvency of the existing pay-as-you-go system has led to a number of proposals that would supplement or partially replace the existing system with a system of individual accounts. Whether or not these individual accounts would be annuitized publicly, in private markets, or not at all has potentially important welfare implications. Thus, a better understanding of how individuals value annuitization is an important input in evaluating alternative reform proposals.

Chapter 1 of this thesis, entitled “Private Pensions, Mortality Risk, and the Decision to Annuitize,” constructs a utility-based measure of a household’s valuation of marginal annuitization. It then tests the extent to which this measure helps predict household decisions about whether or not to annuitize balances in defined contribution plans upon retirement. Variation in the calculated annuity value is based on differences across households in mortality risk, risk aversion, marital status, and the fraction of wealth that is already annuitized through Social Security. It finds that differences in the “annuity equivalent wealth” are significantly correlated with household’s expected decisions about whether to annuitize their pension account balances. This finding supports the notion that the predictions of the stochastic life-cycle model are correlated with real behavior.

The empirical results suggest several additional conclusions as well. First, health status is an important indicator of annuitization propensity. Specifically, individuals in poor health are significantly less likely to annuitize their retirement resources. To the extent that poor health is
an indicator of high mortality, this is exactly how households should be responding. Second, there appears to be a subset of the population (approximately 15%) for whom the model does not predict annuitization behavior. This subset consists of individuals with self-reported financial planning horizons of one year or less. The calculated annuity value for these “myopic” individuals is not correlated with their annuity decision. Finally, this paper also finds that bequest motives do not appear to be an important determinant of this decision.

The finding that annuitization decisions are not affected by bequest motives is at odds with some of the previous literature. In particular, a previous study in this area indicated that bequest motives among the elderly are strong enough that a quarter of the population is over-annuitized by Social Security and purchase term life insurance as a way of offsetting this government provided annuity. Chapter 2 of this dissertation, “Are the Elderly Really Over-Annuitized? New Evidence on Life Insurance and Bequests” re-examines this argument using new data on the elderly, and finds little support for the over-annuitization story. It finds that once one accounts for the important economic distinction between whole and term life insurance, there is no evidence that people are offsetting Social Security through the purchase of term life insurance contracts. This finding reinforces the result of Chapter 1 that bequest motives are not an important determinant of marginal insurance decisions of the elderly.

The third chapter, which is co-authored with James Poterba (MIT), examines annuity products that are written on two lives, rather than one. We examine a variety of joint life products that differ in terms of the extent to which the annuity income stream changes upon the death of one spouse. These “survivor” options are important in determining the allocation of income across survival states of the spouses. We study the impact of risk-pooling opportunities within a marriage on the demand for these joint life annuity products. When husbands and wives
share financial resources, they are engaging in a limited form of risk sharing. This means that
the gains from risk sharing in an actuarially fair market for annuities, while positive, is
significantly smaller than for single individuals. Given that the majority of individuals entering
retirement are married, the finding that couples value annuities less than single individuals can
help explain why the demand for these products is limited.

The final chapter, which is a joint paper with Olivia Mitchell (The Wharton School,
University of Pennsylvania) and James Poterba (MIT), examines the impact of inflation
uncertainty on annuity demand. Most annuities in the United States provide a stream of
payments that is fixed in nominal terms. The real value of these payments is subject to
variability and erosion in the face of an uncertain inflation rate. The introduction of Treasury
Inflation Protected Securities (TIPS) in the United States in 1997 opened up the possibility that
inflation indexed annuities could be offered. This paper first examines the experience with real
annuity products in the U.S. and the U.K., and finds that the private market is capable of
providing these products. It then compares the utility value of access to inflation indexed
annuities relative to fixed nominal annuities, and finds that for plausible parameterizations,
individuals are willing to pay a modest amount for the inflation protection afforded by real
annuities. This paper then goes on to examine variable annuity products, the income from which
is linked to an underlying equity portfolio. These products offer a higher mean return, but
subject individuals to substantial uncertainty due to the variability of the underlying portfolio. It
finds that at low levels of risk aversion, these variable annuity products are preferred to real
annuities, but at higher levels of risk aversion, the opposite is true.

Taken together, the findings of these four studies significantly increase our understanding
of how annuities fit in the portfolios of elderly individuals. This dissertation has shown that a
stochastic life cycle model represents a good first approximation to the value that households place on annuities. It also has demonstrated that bequest motives do not appear to be an important influence on these decisions.
CHAPTER 1

Private Pensions, Mortality Risk, and the Decision to Annuitize
1. Introduction

It is a well-established fact that very few individuals purchase life annuities in the United States. Why this is the case has long been a puzzle to economists. Annuities should be of substantial value to risk averse individuals in a life-cycle model with uncertain lifetimes. Despite the large literature that explores possible resolutions of this puzzle, surprisingly little direct empirical evidence exists to guide our understanding of who annuitizes, and what factors influence this decision. Reconciling the theory with such empirical evidence is essential to understanding the annuity puzzle.

The primary contribution of this paper is to use micro data to directly examine household decisions about whether or not to annuitize balances in defined contribution pension plans. A central goal is to test whether or not this annuitization decision is consistent with the stochastic life-cycle model that economists commonly use to study annuitization decisions. Using dynamic programming techniques, I construct a utility-based measure of a life-cycle consumer’s valuation of additional annuitization, or the “annuity equivalent wealth” (AEW). This measure varies across households based on mortality, risk aversion, marital status, and the presence of pre-existing annuity flows from Social Security. I then ask whether this single annuity equivalent wealth measure can explain annuitization intentions, as the life-cycle model suggests it should. The results indicate that this calculated measure of annuity value is significantly correlated with expected annuitization decisions.

Whether or not households choose to annuitize their retirement assets has a number of important economic implications. First and foremost, it has a direct effect on how well prepared individuals are to provide for consumption in old age. Adequacy of resources for old-age consumption in turn directly affects the extent of poverty among elderly widows, and the
financial pressure placed on needs-based social insurance programs for the elderly such as SSI and Medicaid. Second, households who annuitize their assets will not leave these resources to their heirs when they die. Thus, the extent of annuitization can potentially affect the aggregate amount of intergenerational transfers taking place in the economy, the distribution of wealth in the younger generation of inheritors, and even the amount of estate tax revenue collected.

There are at least two reasons that these questions are becoming ever more important. First, the past 25 years has witnessed a dramatic shift in the composition of private pension plans away from traditional defined benefit plans, which typically paid out in the form of a life annuity, towards defined contribution plans, which offer the individual choice over the form of the benefit payment. This trend towards increased importance of DC plans is expected to continue. For example, by the year 2025 the average value of 401(k) plan assets is expected to rival the present discounted value of Social Security benefits (Poterba, Venti, & Wise 1998).

Second, the current debate over the future of Social Security has spawned a number of proposals that would create a system of mandatory individual savings accounts as a supplement to or partial substitute for the current annuitized system. One of the key issues in this debate is whether or not to mandate annuitization of these individual account balances. An examination of current behavior with respect to DC pension plans is a starting point for understanding how individuals might respond to such a system.

The results of this paper indicate that the utility-based measure of annuity equivalent wealth (AEW) that is constructed from a stochastic life-cycle model is significantly positively correlated with the ex ante probability of actually annuitizing DC balances. Specifically, a one-percentage point increase in the calculated annuity equivalent wealth is associated with nearly a one percentage-point increase in the probability that an individual before retirement reports that
they will annuitize. This effect is highly significant, and robust to many specific modeling assumptions and to the inclusion of a wide range of covariates.

This finding, that the predictions of the life-cycle model are in fact correlated with expected behavior, provides empirical support for many previous studies. Some version of the life-cycle model has been used in nearly every simulation study of annuity demand (for example: Kotlikoff & Spivak 1981, Friedman & Warshawsky 1988, Mitchell et al 1999), yet there has been no prior empirical evidence supporting the use of this model for analyzing annuity choices. The ability of the life-cycle model to predict economic behavior has been questioned in a number of contexts, such as savings behavior (Thaler 1991). This study represents the first evidence that the predictions of the life-cycle model regarding annuity behavior are in fact correlated with the outcome of interest.

However, these results also indicate that while the predictions of the life-cycle model are a good “first approximation” to expected behavior, the model leaves much variation unexplained. There are a number of factors which are difficult to incorporate directly into the calculated annuity equivalent wealth measure that are significant determinants of the annuity decision, such as poor health status. Importantly, one factor that is found not to have a significant effect is the presence of bequest motives. This result is consistent with Hurd’s (1986) finding that bequest motives do not influence wealth decumulation patterns of the elderly. I also find that there is a subset of the population, those with self-reported short time horizons for financial decision making, for whom the predictions of the life-cycle model do not predict annuity decisions.

This paper is organized as follows: Background information on DC pension plans is described in Section 2. The predictions of the simple life-cycle model with uncertain lifetimes are discussed in Section 3, along with a discussion of the model's limitations. Section 4 explains
the methodology for implementing the life-cycle measure of annuity valuation. The data set used, sample selection, and the parameterization of the model are discussed in Section 5. Results are presented and discussed in Sections 6 & 7. Section 8 concludes.

2. Recent Growth in Defined Contribution Plans

Over the past 25 years, the pension landscape in the U.S. has altered dramatically. The 1974 enactment of the Employee Retirement Income Security Act (ERISA) signaled a dramatic change in the regulation and oversight of private pensions in the U.S. This was followed by the introduction of 401(k) plans in 1978, as well as 1981 clarifying regulations that sparked a dramatic increase in 401(k) plan availability and participation.

This change in the legal environment, and the increasing administrative costs that these changes induced for defined benefit plans (McGill, et al 1996), have contributed to making defined contribution plans an increasingly important source of retirement resources. Between 1975 and 1993, the number of private defined contribution plans in existence nearly tripled, rising from 208,000 to 619,000. Meanwhile, the number of defined benefit plans peaked at 175,000 in 1983, and then fell 52% to only 84,000 plans in 1993. (EBRI, 1997). As a result, by 1993, defined contribution plans made up 88% of outstanding plans.

Through the 1980s, however, defined benefit plans continued to cover more participants than DC plans. In 1975, 74% of plan participants were covered by DB plans. By 1993, however, over half (52%) of pension plan participants were covered by DC plans. Barring any future legislative changes that would reverse this trend, DC plans promise to continue to grow in relative importance in the coming years.
A large part of this growth came in the form of 401(k) plan participation. Over the ten-year period from 1984 to 1993, the number of participants in private-sector qualified 401(k) plans rose from 7.5 million to 23.1 million. (EBRI, 1997) In 1991, 35% of those age 65-69 held assets in targeted retirement savings accounts. By the year 2025, assets in 401(k) plans are expected to be 90% as large as the present discounted value of Social Security assets. (Poterba, Venti & Wise, 1998).

DC plan distributions at retirement typically may take the form of lump-sum payments, installment payments, or a life annuity. Most plans allow participants some choice over the form of the distribution. This is in sharp contrast to DB plans, the majority of which do not permit lump-sum distributions at retirement. According to Watson-Wyatt, only 29% of DB plans permit an unlimited lump-sum payment in lieu of an annuitized pension at retirement, with another 8% allowing a partial lump-sum. (McGill, 1996). Many DB plan sponsors discourage lump-sum distributions at retirement to limit exposure to adverse selection, and/or to ensure that employees do not squander or outlive their pension resources.

In the sub-sample of the Health and Retirement Survey that I will use in my analysis, 48% of households expect to annuitize at least some portion of their defined contribution account balances. This is consistent with the aggregate numbers of individuals who appear to be annuitizing DC balances according to the Current Population Survey. In September, 1994, the CPS included a health and pension benefits supplement that asked a limited number of questions about pension coverage among the age 40+ population. For a number of reasons, it is not possible to construct a precise estimate of the annuity decisions of all individuals with defined contribution plans. Nonetheless, one can get a rough estimate of DC pension choice from the supplement by constructing a sample of anyone who is currently receiving their largest or only
annuity from a DC plan, or who has ever received a lump-sum distribution from a DC plan. Among the individuals age 65-75 in this sample, most of whom are already retired, 48% are receiving a life annuity from a DC plan.

3. Theory: A Life-Cycle Model with Uncertain Lifetimes

3.1 The Basic Yaari Model

Yaari’s classic 1965 article was the first to incorporate a random date of death into a life cycle framework. He considered the problem of an individual, facing a known probability distribution over the length of life, determining how to optimally consume out of a given stock of wealth. Yaari worked through the problem with and without bequest motives, and with and without access to actuarially fair markets for annuities.

The most well-known result of this work is the finding that:

“When the consumer has no bequest motive but he is constrained to meet the requirement that his transferable assets at time of death should be non-negative with probability one ... the consumer’s assets will always be held in actuarial notes rather than in regular notes.”

In other words, a life-cycle consumer with no bequest motives will always choose to annuitize 100%, provided that the market for annuities is actuarially fair. The intuition for this result is clear. A consumer can choose to hold assets either as ordinary notes which pay the market rate of interest r, or as actuarial notes, which pay the market interest rate r plus a “mortality premium” equal to the mortality hazard rate. The “cost” of this higher return is that the actuarial notes, or annuities, are cancelled upon his death. In the case where the life-cycle consumer places no value on wealth after death, i.e., he has no bequest motives, then the “cost” of annuities is zero, and the individual will always prefer to invest in the higher yielding actuarial notes.
Previous simulation work has shown that the gains to annuitization in the simple Yaari model without bequest motives are significant. For example, a 65 year old male facing with population average mortality would be willing to give up roughly 1/3 of his wealth to gain access to an actuarially fair annuity market according to this simple Yaari life-cycle model. The gains to annuitization for couples tend to be on order of half that of individuals due to opportunities for mortality risk-sharing within families.

3.2 The Annuity Puzzle

The stylized result of the Yaari model, that individuals without bequest motives will fully annuitize their wealth, is clearly not borne out in the data. Aside from Social Security and private pensions, very few Americans annuitize much of their net worth. For example, Moore & Mitchell (1998) found in the Health and Retirement Survey that 40% of total wealth was held in Social Security and another 20% in private pensions. This leaves an additional 40% of total wealth being held in traditional financial assets and/or housing. Further, the non-pension annuity market in the U.S. is quite small, with single premium immediate annuity (SPIA) products accounting for only a few billion dollars (LIMRA, 1998).

This has led a number of researchers to search for solutions to the “annuity puzzle” in the U.S. Among the explanations explored are a role for bequest motives (Bernheim 1991, Abel & Warshawsky 1988), the role of adverse selection and administrative load factors (Friedman & Warshawsky 1988, Mitchell, et al 1999), and the ability of families to pool risk and thus substitute for a private annuity market (Brown & Poterba 1999, Kotlikoff & Spivak 1981).

3.3 Annuity Demand with Load Factors

It is easy to see why the presence of a load factor would diminish the demand for annuities. Recall that for an individual without bequest motives, part of the value of an
actuarially fair annuity arises from the fact that the rate of return on an annuity is higher than that on ordinary bonds. This mortality premium arises from the fact that the assets from deceased annuitants are paid out to surviving annuitants.

There are two types of load factors that can diminish the value of annuitization, however. The first is a pure "administrative" load cost, i.e., some fraction of the premium that the insurance company takes "off the top" to cover administrative expenses and accounting profits. If the load factor is high enough to offset the benefits of annuitization, a rational life-cycle individual will choose not to purchase annuities.

The second type of load factor arises from the heterogeneity in survival probabilities in the population. The expected discounted value of annuity benefits will vary across individuals in accordance with differences in their survival probabilities. Roughly speaking, individuals with longer life expectancies can expect more benefits than individuals with shorter life expectancies.\(^1\) Insurance companies must take this potential adverse selection into account when pricing annuities, which has the effect of decreasing the level of the monthly annuity payout that is offered for a given premium.

Mitchell, et al. (1999) found that the expected net present value of a single premium immediate life annuity for a 65 year old male in 1995 was approximately 80\% of the required premium. By using the difference between the population mortality table, and the mortality table used by insurance companies to represent the mortality experience of the annuitized population, one is able to partially disentangle these two types of load factors. Using this method, we attributed approximately one-half of this premium, or approximately 10\%, to mortality differences between annuitants and non-annuitants, and the other half to administrative costs of

\(^1\) Strictly speaking, it is the entire trajectory of mortality probabilities, not just the life expectancy, which matters.
the insurance industry. Clearly, load factors are one reason that individuals may choose not to annuitize their resources.

4. Methodology: Implementing the Yaari Model

4.1 Methodological Overview

The simple Yaari life-cycle model without load factors, bequests, or other non-mortality sources of uncertainty indicates that everyone will have an annuity equivalent wealth that is non-negative. The magnitude of this annuity equivalent wealth, however, may vary greatly across individuals based on the behavioral and economic parameters that we assume. For example, more risk averse individuals will have a higher valuation of annuities than less risk averse individuals. Annuity value should also be decreasing with the amount of wealth that is already previously annuitized by Social Security and DB pension plans. Other factors, such as marital status (which captures opportunities for within-family risk sharing) and age at retirement should also affect the demand for annuities.

One econometric approach would be to simply model the annuity decision as a direct function of these variables. However, the Yaari life-cycle model imposes a specific structure on these effects, and also allows more readily for the potentially complicated interactions between these parameters. For example, the effect of a difference in marital status will likely differ in magnitude for individuals with different levels of risk aversion. Therefore, this section develops a dynamic programming algorithm which feeds these behavioral and economic variables through a utility maximizing framework, in order to construct an “annuity equivalent wealth” (AEW) measure that is consistent with the underlying utility theory of a life-cycle consumer.
This AEW approach is directly related to methods of annuity valuation that have been used in simulation models in previous work by several authors (Kotlikoff & Spivak 1981, Friedman & Warshawsky 1988, Mitchell, et al 1999). The primary contribution of this paper is to move beyond simple simulations for hypothetical consumers and estimate the AEW measure for a sample of actual households in the Health and Retirement Survey. I will use HRS data whenever possible to choose parameter values for each individual, thus capturing much of the heterogeneity in annuity values within the HRS population.

4.2 Calculating the Annuity Equivalent Wealth

The annuity equivalent wealth calculation proceeds in 2 basic steps. In all cases, an individual is assumed to be solving an expected utility maximization problem, subject to budget constraints that depend on whether or not annuities are available. In the first step, the individual is assumed to have access to actuarially fair, real annuity markets that enable her to fully annuitize her starting wealth $W_0$. The individual chooses a consumption path to maximize utility, subject to non-negativity constraints on wealth in every period. Let this maximum utility level be denoted $U^*$. It is assumed that the individual does not value bequests.

The second step is to then take away access to the annuity market, and find the amount of additional wealth, $\Delta W$, that must be given to her so that by following her optimal consumption path in the absence of annuitization, she can achieve utility level $U^*$. The only investment opportunity the individual has in this case is riskless bonds. The amount $(W_0 + \Delta W)/W_0$ is the measure of annuity value that I will refer to as the “annuity equivalent wealth.”

This utility-based measure of annuity equivalent wealth is similar to the Equivalent Variation measure in applied welfare analysis. The value $\Delta W$ answers the question, “how much additional wealth must we give a person in the absence of annuitization to make them as well off
(i.e., to put them on the same expected utility curve) as if we provided actuarially fair annuity markets for the individual.” One could alternatively construct the annuity equivalent wealth measure in a manner analogous to Compensating Variation by using the non-annuity level of utility as the baseline for comparison.

More formally, solving for optimal consumption paths in this multi-period, stochastic life-cycle model requires the use of dynamic programming methods. Let \( U(C_t) \) represent the one-period felicity function defined over real consumption, \( \rho \) the utility discount rate, and \( T \) the maximum possible life-span of an individual (assumed to be 115). Then the consumer’s problem, assuming additive separability over time, is:

\[
\max_{t, i, C_t} \mathbb{E}_t \left[ \sum_{t=1}^{T-\text{age}+1} \frac{U(C_t)}{(1 + \rho)^t} \right]
\]

where the expectation \( \mathbb{E}_t[.\] is taken over states of survival, subject to the following constraints:

\[
\begin{align*}
(i) & \quad W_0 \text{ given} \\
(ii) & \quad W_t \geq 0, \forall t \\
(iii) & \quad W_{t+1} = (W_t - C_t + S_t + A_t)(1 + r)
\end{align*}
\]

In these constraints, \( W_t \) is non-annuitized wealth in period \( t \), \( C_t \) is consumption, \( S_t \) is the pre-existing annuity payment from Social Security and DB pensions, and \( A_t \) is the actuarially fair annuity payment that can be purchased when supplemental annuity markets are available. Assume that the individual, prior to any optional annuitization, has financial wealth \( W^* \). Then for the case in which no supplemental annuities are available, \( W_0 = W^* \), and \( A_t = 0, \forall t \). In the case in which the individual fully annuitizes all financial assets, then \( W_0 = 0 \), and \( A_t \) is determined by assuming that the expected discounted value of \( A_t \) is equal to the initial premium (\( W^* \)):

\[
W^* = \sum_{t=1}^{T-\text{age}+1} \frac{A_t \prod_{i=1}^{t} (1 - q_i)}{(1 + r)^t (1 + \pi)^t}
\]
In equation (3), \( q_t \) is the one-period mortality hazard, i.e., the probability of dying before period \( t+1 \) conditional on surviving to period \( t \). The real interest rate is represented by \( r \), and the inflation rate by \( \pi \). Note that this formula determines the nominal value of a fixed nominal annuity. The real value of this annuity declines by the factor \( 1/(1+\pi) \) each period.\(^2\)

In order to use dynamic programming techniques, it is useful to introduce a value function \( V_t(W_t) \), which is defined as:

\[
V_t(W_t) = \max_{C_t} \mathbb{E}_t \left[ \sum_{t+1}^{t+n} \frac{U(C_t)}{(1+\rho)^r} \right]
\]

subject to the constraints in equation (2).

The value function at time \( t \) is the present discounted value of expected utility evaluated along the optimal path. This value function satisfies the following recursive Bellman equation:

\[
\max_{C_t} V_t(W_t) = \max_{C_{t+1}} U(C_{t+1}) + \frac{(1-q_{t+1})}{(1+\rho)} V_{t+1}(W_{t+1})
\]

Note that the expectation operator has been dropped, as we are now accounting explicitly for the survival probabilities, and there are no other sources of uncertainty in this problem. The Bellman equation reduces the full maximization problem to a series of 2-period problems, which can be solved numerically by solving back from the final period. This maximization is subject to the constraints in equation (2). I use standard methods of discretizing the wealth space to closely approximate the solution. While in some special cases it is possible to derive a solution analytically, the presence of pre-existing annuities requires numerical methods in the more general case.

In addition to an amount of financial wealth \( W^* \), I assume that there is an exogenously determined path of pre-existing annuities \( \{S_t\} \). I first find the maximum utility \( V^* \) for the case in

\( ^2 \) By setting \( \pi = 0 \) in equation 3, this formula is used to compute the real value of an actuarially fair real annuity.
which the individual has the ability to fully annuitize $W^*$ in an actuarially fair, nominal annuity market, so that $A_t$ is determined by equation (3). Because this individual fully annuitizes, he starts off with zero non-annuitized wealth, $W_0 = 0$.

I then solve the problem again for the case in which annuities are not available. That is, $A_t$ is constrained to be zero for all $t$. I find the amount of additional wealth, $\Delta W$, which must be given to the individual in the absence of annuities such that the utility without annuities is equal to $V^*$.

That is, I find $\Delta W$ such that:

$$V(W^* + \Delta W | A_t = 0, \forall t) = V^*$$

(6)

Annuity equivalent wealth is then defined as:

$$AEW = \frac{W^* + \Delta W}{W^*}$$

(7)

This calculated AEW measure essentially captures the maximum markup over the actuarially fair cost that an individual would be willing to pay. Notice that this calculation assumes that all wealth is annuitized, as would be the case in a simple Yaari life-cycle model with no bequests.

In the case of married couples, the procedure is the same. However, the value function of the single individual is replaced by a more complicated function that represents the joint decision of the couple. I assume that the couple maximizes a joint utility function that is the weighted sum of the utility of the two individuals, while allowing for economies of scale in consumption. The Bellman equation for couples is:
\[ V_i(W_i) = \text{Max}_{\nu, \lambda', \lambda''} \left[ U^m(C_i^{\nu} + \lambda C_i') + \nu U^f(C_i' + \lambda C_i'') \right] + \frac{(1 - q_i^m)q_i'}{(1 + \rho)} M_{i,1}(W_{i,1}) + \frac{(1 - q_i')q_i''}{(1 + \rho)} F_{i,1}(W_{i,1}) \]

(8)

Here, V represents the value function for the couple, while M and F represent the value functions for the male and female for those states in which they are the surviving spouse. M and F are defined as in the individual case in equation 5. Superscripts “m” and “f” on the consumption and survival probability terms represent the male and the female, respectively.

Once again, this maximization is subject to the constraints in equation 2, using the fact that \( C_i = C_i^m + C_i^f \). Note that the parameter \( \lambda \) determines the degree of economies of scale in consumption within a 2-person household. When \( \lambda = 0 \), there are no economies of scale. When \( \lambda = 1 \), the economies of scale in consumption are complete. In this paper, I will assume that \( \psi = 1 \) and \( U^m(.) = U^f(.) \). These two restrictions imply that the husband and the wife will consume equal amounts when alive.

In the case of couples, equation 3 is replaced with a more general annuity pricing equation for joint life annuities with survivor benefits. In order to simplify notation, let us first define \( P^m_i \) to be the cumulative probability of survival through time t, that is:

\[ P^m_i = \prod_{j=1}^{i} (1 - q_i^m) \]

(9)

This is the probability that an individual alive at time 0 survives to time t. We can define \( P^f_i \) analogously. Then, assuming actuarial fairness, the pricing equation for a joint and survivor annuity is:

\[ W^* = \sum_{i=1}^{\infty} A_i P^m_i P^f_i + \theta A_i \left[ P^m_i (1 - P^f_i) + P^f_i (1 - P^m_i) \right] \frac{1}{(1 + r) (1 + \pi)} \]

(10)
In this equation, the parameter $\theta$ represents the ratio of survivor benefit to the annuity flow when both members of the couple are alive. The most common values of $\theta$ in the private annuity markets are one-half, two-thirds, and one. For example, a “joint and half survivor” annuity that pays out $800 per month when both spouses are alive, will pay out $400 after the death of the first spouse. This equation assumes that spouses are treated symmetrically with regard to the survivor benefit. There is also a class of products known as “joint and contingent” annuities that distinguish between primary and secondary annuitants. With these products, the annuity only drops upon the death of the primary annuitant, not the secondary.

5. The Data & Parameterizing the Model

5.1 The HRS Sample

The analysis of how individuals dispose of their DC account balances would ideally be based on a large data set of DC participants near retirement, and would follow them for many years to track the ultimate disposition of these resources. The multi-year time frame is potentially quite important, because many individuals may not make a single, irrevocable decision at the date of retirement. For example, a person may, upon retirement, roll their DC plan over into an IRA and allow it to grow for 5 more years before taking any withdrawals. Then, several years after taking withdrawals, they may choose to take the rest out in one lump sum. Alternatively, they might leave the money in the employer’s account for several years before annuitizing.

This ideal data set does not yet exist. Most long-term panel studies of the elderly, such as the Retirement History Survey, were conducted before defined contribution plans became an important asset class for a large number of households. Other data sets, such as the Survey of
Consumer Finances, which provide detailed information on assets, fail to have a significant number of retired individuals. These severe data limitations are one important reason that the question of DC plan disposition has not received more attention in the literature.

The Health and Retirement Survey (HRS), fielded by the Institute of Social Research at the University of Michigan, promises to be this ideal data set. The first wave of the study, conducted in 1992, asked detailed financial, health, retirement, and other pertinent questions to a broad cross-section of individuals nearing retirement. Specifically, the HRS target respondents were born between 1931 and 1941, making them approximately 51 to 61 years of age the first interview wave. Spouses of age eligible individuals were also included, so that the age of individual respondent’s in the HRS varies over a wider range. Follow-up surveys are being conducted every two years.

While the HRS promises to be the ideal data set for this question in the future, the young age of the sample currently limits researcher’s ability to observe actual DC disposition behavior of a large sample over a long period of time after retirement. At this time, only two waves of data have been released in their final form, with a third wave in preliminary release. Most respondents are still employed, and as such have not yet made their actual DC annuitization decision.

As a result, I will use as my primary sample those individuals in wave 1 who are currently employed, and who are covered by at least one defined contribution plan. The HRS questionnaire asks these individuals what they plan to do with their DC account balances when they retire, and it is this question that serves as the basis for this analysis.

The 1992 wave of the HRS contains data on approximately 7500 households. In addition to the household responses to the detailed questionnaire, the HRS has collected Social Security
Administration data on earnings and benefits histories. This is an important source of data for this project, since Social Security wealth is an important determinant of an individual’s demand for additional annuitization. As discussed in Mitchell, Olsen & Steinmeier (1996), however, the Social Security administrative records are missing for approximately 1/3 of the sample. The primary source of missing records is lack of permission by survey participants to make such a linkage.

Of the remaining households, approximately 950 have defined contribution plans that have a balance of at least $5000 and that provide the individual with the choice of taking the payout as an annuity. After losing some additional observations due to missing data, I am left with a final sample size of 869 households. Of these, 140 are individuals, and 729 are married couples.

5.2 The Dependent Variable

The HRS asks working individuals a long series of questions about pension coverage. For those individuals who report that they are covered by a defined contribution pension plan, and who report that they have choice over the form of benefits, they are then asked “In what form do you expect to receive benefits?” The questionnaire prompts for lump-sum payment, installments, or monthly pension / annuity. I define the indicator variable “Annuity” to be equal to one if the individual states they will take their DC balances as a monthly pension, and zero otherwise. In cases where the individual has more than one DC plan, Annuity is defined to be equal to 1 if they say they will annuitize any one of the plans.

5.3 Calibration of the AEW Measure

In order to implement the dynamic program to solve for the annuity equivalent wealth.

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1 A $5000 premium will purchase an actuarially fair annuity for a 65 year old male that pays approximately $438 per year. Varying the minimum cut-off did not significantly change the results of this analysis.
one must put some structure on the utility function. I invoke the standard assumption that individuals exhibit constant relative risk aversion:

\[
U(C_r) = \frac{C_r^{1-\beta}}{1-\beta}
\]

(11)

where \(\beta\) is the coefficient of relative risk aversion. Importantly, \(1/\beta\) also measures the elasticity of substitution between consumption at two points in time. One analytical convenience afforded by this choice of utility function is that the problem becomes invariant to the scale of wealth. Therefore, the value of additional annuitization is the same for two individuals if they are alike in all respects except for wealth levels. Importantly, while the level of wealth does not matter in this specification of utility, the composition of wealth between annuitized and non-annuitized assets does matter, and will be discussed below.

I assume that the rate of time preference \(\rho\) and the market rate of interest \(r\) are both equal to .03 for every household. I assume that annuitized DC balances will purchase a nominal annuity that is declining in real terms by the rate of inflation. Inflation is fixed at 3.2%, which is the historical mean of inflation from 1926-1997 (Ibbotsen Associates, 1998).\(^4\) I will compute the AEW using each individual’s expected age of retirement, which has a mean of approximately 63 in my sample.

Extensive simulation work in previous studies has indicated that there are four primary factors that determine an annuity equivalent wealth from annuities within a Yaari life-cycle framework:

1. Mortality Risk
2. Risk Aversion
3. Fraction of Total Wealth that is Pre-Annuitized

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\(^4\) Brown, Mitchell & Poterba (1999) explore the sensitivity of AEW results to the case of a stochastic inflation process. This approach is not used here because the well-known “curse of dimensionality” in dynamic programming adds prohibitive computational burden to making this calculation for the sample sizes in this paper.
(4) Marital Status

Each of these four factors can be parameterized using data from the HRS.

5.3.1. Mortality Risk.

The insurance value of additional annuitization should quite clearly be effected by the degree of mortality risk that an individual faces. For example, an individual who knows their date of death with complete certainty would not be willing to pay any positive amount for an actuarially fair annuity, since there is zero risk to insure against. At the other extreme, an individual with an equal unconditional probability of dying in each of the next 50 years would find annuities quite attractive.

To calibrate differences in survival probabilities, I assign each individual the average population mortality for their birth cohort and gender. I use mortality tables for each birth cohort from the Social Security Administration’s Trustees Report (1995). Using a cohort mortality table, which follow a specific birth cohort through time, as opposed to a period mortality table, which looks at the cross-sectional mortality experience at a point in time, is potentially a quite important distinction. Cohort tables incorporate expected future mortality improvements, and thus account for the fact that the probability of a current 50 year old surviving to age 70, conditional on surviving to age 60, is not equal to the probability of a current 60 year old living to age 70.

For most of my calculations, I assume that mortality differences arise only from variation in birth year, gender, and age at retirement. The use of a different mortality table for each birth cohort and gender does capture variation in survival probabilities for two individuals planning to retire at the same age, but in different years. This approach, however, does not allow for potentially important heterogeneity within birth/gender cohorts. Ideally, one would have a
survival curve that is specific to each individual and that takes into account differences in life expectancies, as well as different slopes in the survival curves. However, obtaining estimates of within cohort heterogeneity that lend themselves to plausible parameterizations in the model is difficult.

As a first step in understanding the effect of mortality differences within cohorts, I will include a separate set of indicator variables for self-reported health status in the equations that I estimate. Using a set of dummy variables to add in health information separately from the AEW measure has the advantage of being easy to interpret, while not requiring that one map health status into a specific change to the trajectory of mortality probabilities. The disadvantage of this approach is that potentially important interactions between health and other determinants of AEW may not be adequately captured. Therefore, in Section 7, I will explore extensions to the basic model that incorporate health and mortality differences directly into the AEW model.

5.3.2 Risk Aversion

More risk averse individuals value the longevity insurance aspect of annuities more highly. In order to calibrate this, I make use of a series of questions in the HRS that are designed to elicit one’s willingness to take actuarially favorable gambles. The responses to these questions have been studied extensively in Barsky, et al (1997). They showed that measured risk aversion has predictive power for choices over a number of risky behaviors, including the decision to smoke and drink, to buy insurance, and to hold stock, though the incremental predictive power is never very high.

Values of beta were chosen based on answers to the following survey questions:

“Suppose that you are the only income earner in the family, and you have a good job guaranteed to give you your current (family) income every year for life. You are given the opportunity to take a new and equally good job, with a 50-50 chance it will double your (family) income and a 50-50 chance that it will cut your (family) income by a third. Would you take the new job?”
If YES:
“Suppose the chances were 50-50 that it would double your (family) income and 50-50 that it would cut it in half. Would you still take the new job?”

If NO to first question:
“Suppose the chances were 50-50 that it would double your (family) income and 50-50 that it would cut it buy 20 percent. Would you then take the new job?”

Based on responses to these questions, it is possible to divide the sample into four groups that can be ranked in terms of their risk aversion. Furthermore, if we are willing to assume that risk aversion is constant, we are able to put specific bounds on the value of beta that would correspond to these answers.

<table>
<thead>
<tr>
<th></th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Value Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reject both 1/3 and 1/5</td>
<td>3.76</td>
<td>∞</td>
<td>5.0</td>
</tr>
<tr>
<td>2. Reject 1/3, accept 1/5</td>
<td>2.00</td>
<td>3.76</td>
<td>2.9</td>
</tr>
<tr>
<td>3. Accept 1/3, reject 1/2</td>
<td>1.00</td>
<td>2.00</td>
<td>1.5</td>
</tr>
<tr>
<td>4. Accept both 1/3 and 1/2</td>
<td>0</td>
<td>1.00</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Approximately two-thirds of the sample falls into the most risk averse category. The rest of the sample is evenly split over the remaining three categories.

5.3.3 Pre-Annuitized Wealth

The primary insurance value associated with annuitization is that it ensures that the individual’s consumption will never fall below the value of the annuity. Since utility is concave in consumption, this means that the first units of insurance are the most valuable. If someone has 0% of his wealth in annuities, then the first instance of annuitization will be quite valuable because it provides a minimum floor. As additional resources are annuitized, the floor rises, and additional annuitization is valued less.

Let alpha (α) denote the fraction of total wealth that is “pre-annuitized.” Specifically, I will define alpha to be the sum of Social Security wealth plus defined benefit pension wealth, divided by total wealth. Total wealth includes all pension wealth, Social Security wealth, all
financial assets, and housing. The annuity value of public and private health insurance is excluded from both the numerator and denominator. Alpha is computed as of the survey date. The implication of this assumption is that the relative composition of wealth between annuitized and non-annuitized assets will remain constant until retirement.

Due to data limitations, I assume that all DB plans will be taken in an annuity form, and thus ignore the possibility that a small fraction of individuals may not view their DB plan as “pre-annuitized” if it has a lump-sum option. I also assume that for couples, both Social Security and DB pension provide survivor benefits equal to 2/3 of the benefit to the couple.

5.3.4 Marital Status

Married couples have the ability to pool mortality risk, and therefore should value annuities less than individuals (Kotlikoff & Spivak 1981). In fact, simulations indicate that the calculated annuity equivalent wealth from annuities by couples is on order of half of that by individuals (Brown & Poterba, 1999). I use marital status at the time of the survey date in 1992 to determine whether AEW is calculated using the individual or joint utility model.

There are additional modeling assumptions that must be made in doing the calculation for couples. The economies of scale parameter $\lambda$ is set in the base case to be equal to 0.6245. This value was determined based on the work done on “equivalence scales” in household consumption by the National Academy of Sciences (Citro & Michael 1995). In Section 7, I will also consider the cases of $\lambda = 0$ (no economies of scale) and $\lambda = 1$ (full economies).

It is also necessary to make an assumption about the “survivorship” decision of couples if they choose to purchase an annuity with their DC accounts. Federal legislation currently requires that individuals who annuitize pension assets must provide at least a 50% survivor benefit, unless the spouse relinquishes this right, which requires a notarized signature. Holden
(1997) has shown that since this requirement was enacted, roughly two-thirds of individuals who annuitize accept the default option. Therefore, I assume a Joint and 50% Survivor annuity is purchased by all couples. This means that the benefit level paid after the death of the first spouse is only half that of the benefit level paid when both spouses are alive.

6. Specification and Results

6.1 Specification

The basic model I estimate is:

$$\Pr(\text{Annuity}_{i} = 1) = f(AEW_{i}, Z) + \epsilon_{i}$$

(12)

Annuity is an indicator variable equal to 1 if the individual plans to annuitize, and 0 otherwise. $AEW$ is the utility-based measure of annuity value that has been computed using the methods described above. $Z$ is a vector of other covariates, which will be discussed below. I will make the assumption that $\epsilon_{i}$ is normally distributed with mean zero, and thus estimate a probit equation using maximum likelihood$^5$. Specifically, I will estimate:

$$\Pr(Annuity = 1) = \int_{-\infty}^{\beta'X} \phi(t) dt$$

(13)

where $\beta'X = \beta_0 + \beta_1 AEW + \beta_2 Z$

6.2 Baseline Results

Table 1 provides summary statistics for the variables of interest. Importantly, nearly half the sample reports that they will annuitize their DC plan. These proportions are consistent with the rough measure of DC annuitization that is available through the CPS pension supplement for the actual annuitization decisions of older, retired workers. On average, these households are willing to give up 16.64% of their non-annuitized wealth in order to gain access to an actuarially
fair market for annuities. The standard deviation is 10.5%, indicating a substantial degree of dispersion in annuity equivalent wealth.

729 of the 869 households (84%) consist of a couple, and the rest of individuals. The average household has just over half of their wealth “pre-annuitized” by Social Security and defined benefit pension plans. Another 10% of wealth is in DC plans, which average $60,000 in my sample. These proportions are consistent with the findings of Moore & Mitchell (1998) who find that the typical household in the HRS has 40% of their wealth in Social Security, and another 20% in total pensions (which includes both DB and DC plans). The average age of the sample in 1992 was 55 years old, with an average expected retirement age of 63. In the majority (62%) of the households, a male holds the (largest) DC plan.

Table 1 also compares the key variables for the group that chooses to annuitize (“annuitants”) and the group that does not (“non-annuitants”). This foreshadows many of the result that will follow. First, the calculated annuity equivalent wealth from annuities is a full 2.6% points higher for annuitants. This appears to be driven by differences in the factors underlying the AEW calculation, including marital status and risk aversion. One can also see that annuitants are less wealthy and have slightly smaller DC balances than non-annuitants.

Table 2 presents the results of a simple bivariate probit equation of annuity choice on the annuity equivalent wealth from the base case. Reported coefficients and standard errors are for the marginal effects of the probit, evaluated at the sample means. Column 1 reports the results for the entire sample of households, including both married and single individuals, for a probit of annuity on AEW. The coefficient on \( \partial \text{Annuity}/\partial \text{AEW} \) is 0.61, and is highly significant. This means that a one percentage point increase in the annuity equivalent wealth leads to a 0.61

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\(^4\) Results are not sensitive to the assumption of normality. A linear probability model with White standard errors, and a logit model produce nearly identical marginal effects.
percentage point increase in the probability of stating that one plans to annuitize their DC accounts upon retirement.

In column 2 of table 2, I have added a number of covariates that do not enter directly into the AEW calculation, including indicator variables for race, education, industry, and occupation. Few of these covariates are themselves significant, and they do not significantly alter the coefficient on the AEW measure.

Due to the ability of couples to pool mortality risk, differences in marital status are one important source of variation in the AEW measure. Therefore, if we look separately at individuals and couples, we lose a potentially important source of variation in the AEW measure. Nonetheless, it is instructive to see how well the model performs in these subsets. Columns 3 through 6 in table 2 report these same results separately for single and married individuals. In columns 3 and 4, the results for single individuals indicate that the effect is slightly higher than for the sample as a whole. In column 3, a one-percentage point change in the AEW measure leads to a .75 percentage point increase in the probability of annuitizing. The coefficient is slightly higher (.875) when covariates are added.

The results for married couples only are reported in columns 5 and 6 of Table 2. We see that the effect of AEW is smaller than that for individuals, indicating an increase in the probability of annuitizing of only 0.56 without covariates, and 0.75 with covariates. Furthermore, the coefficient for married couples is not statistically significant. Thus, the AEW model appears to perform better in the single sample than in the married sample. The calculation for married couples must make a number of assumptions that were not required in the individual model, including an assumption about the nature of household decision making, the extent of economies of scale, and the structure of survival benefits. Given the additional assumptions
imposed on the model, it is not completely surprising that the individual model performs better than the joint decision making model. This indicates a potential area for further research.

It is interesting to note that the marginal effect of an increase in the AEW measure for both individuals and couples rises when industry, occupation, and education dummies are included, while these covariates appear to have no effect in the pooled sample of individuals and couples. Recall that in the full sample, an additional source of variation is that the AEW for annuities is higher for individuals than for couples, as is the probability of annuitizing. Thus, the inclusion of covariates, while it increases the coefficient of AEW in each sub-sample, is offset by the fact that these covariates soak up some of the variation that is induced by marital status.

6.3 Allowing for Time Horizon Heterogeneity

The HRS asks individuals a question that elicits their “time horizon” for financial decision-making. I have defined a variable “myopic” that is equal to 1 if the individual states that her time horizon for financial planning is one year or less, and zero otherwise. The term “myopic” often conveys that people are behaving in a manner that is inconsistent with optimizing behavior, but it need not be the case. For example, an individual may have an illness that leads to a very short life expectancy, thus leading to a rationally short time horizon. Alternatively, individuals may be following a life-cycle model, but with a very high discount rate.⁶

Whatever the reason lying behind the time horizon response, it is clear that it matters for annuitization decisions. Table 3 displays the probit derivatives when the myopic variable is included both directly, and interacted with the annuity equivalent wealth term. Columns 1 and 2

⁶ There is an experimental module in the HRS designed to elicit information about discount rates by asking about desired slopes of consumption paths. Unfortunately, the question is asked only 200 individuals in the HRS. Within this small group, there is no correlation between the desire for an upward, flat or declining consumption profile, and
again report the results for the pooled sample of single individuals and couples. We can see that the relationship between annuity equivalent wealth and the annuity decision is even stronger for non-myopic individuals. A one percentage point increase in AEW leads to a .94 percentage point increase in the probability of annuitizing for this group. For the “myopic” types, the relationship between AEW and annuity probabilities is actually negative, though this is offset somewhat by a higher intercept term. Once again, these results are not sensitive to the inclusion of other covariates.

Breaking this effect out by singles and married couples, we see that AEW has a significant effect in both populations of non-myopic individuals. For singles, the effect of AEW is 1.18 to 1.41, and for couples .97 to 1.2. Importantly, the AEW term is now significant at the .05 level even in the “couples only” specification.

This indicates that it is critical to control for this time horizon heterogeneity. For the 83% of the population that is non-myopic, there is approximately a one-for-one relationship between annuity equivalent wealth and the probability of annuitizing. There is, however, a non-trivial 17% of the population whose annuitization behavior is not well explained by a life-cycle model. This supports the methodology used by Diamond (1977), Feldstein (1985), and others who make a distinction between rational life-cyclers and “myopes” when modeling behavior in the presence of Social Security.

6.4 The Effect of Health Heterogeneity

The mortality tables used in computing AEW do not take into account differences in health status. Yet health clearly belongs in the model for a number of reasons. First, to the extent that poor health is negatively correlated with survival, this has a direct negative effect on

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their response to the time horizon question. This casts doubt on the discount rate interpretation of the time horizon question.
the present value of a given annuity stream. Second, if individuals in poor health face potentially large medical bills, they may not want to self-impose the liquidity constraint that is implied by annuitizing wealth.

As a first step in addressing this issue, I define a series of indicator variables for self-reported health status. These capture the DC owner’s response to a question asking them to rate their health status as “Excellent, Very Good, Good, Fair, or Poor.” I treat the “good” response as the omitted category in creating the indicator variables. Table 4 reports the results. In the full sample, the results are insignificant, although they tend to exhibit a plausible pattern. Individuals with excellent, very good, or good health seem more likely to annuitize than those in fair or poor health. The indicator variable for “poor” health is quite large, and statistically significant. It suggests that an individual in poor health is 30% less likely to annuitize. This negative effect is fairly consistent across individuals and married couples, both with and without covariates. I will explore the role of these health issues further in Section 7.

6.5 Wealth Effects

One implication of the CRRA functional form of utility is that the decision of whether or not to annuitize is independent of the level of wealth. However, there are several reasons to suspect that, other things equal, wealthier individuals may be less likely to annuitize. First, the risk of “outliving one’s resources,” which is the primary risk against which annuities provide insurance, is lessened as wealth increases. Second, because one component of total wealth is pre-existing annuities, individuals who have more total wealth tend to have more annuities. As a result, pre-existing annuities from Social Security and DB plans may already provide a consumption floor that is fairly high. Third, individuals with substantial wealth may have become wealthy in the first place due to being savvy financial investors. They may believe,
correctly or incorrectly, that they can earn a return on their investment through careful
investment in equities or small businesses, that exceeds the return on an annuity. Fourth,
wealthier individuals may be more likely to leave a planned bequest, and thus be less interested
in annuitizing.

As the results in Table 4 indicate, there are significantly negative wealth effects.\(^7\)
Specifically, in the full sample a $100,000 increase in wealth is associated with a .72 to .76
percentage point decrease in the probability of annuitizing. Among individuals only, a $100,000
increase in wealth leads to a 1.2 to 1.65 percentage point decrease in annuity probabilities, and
among couples, a decrease of .69 to .77.\(^8\)

6.6 Bequests

The extent to which bequest motives effect marginal economic decisions is an unresolved
issue in the economics literature. Research by Bernheim (1991), Laitner & Juster (1996), and
Wilhelm (1996) all point to the existence of operative bequest motives that affect decisions on
the margin. On the other hand, work by Hurd (1987, 1989) and Brown (1999) finds little support
for such a view. Hayashi, Altonji & Kotlikoff (1996) also reject the implications of an altruistic
model.

To test for the effect of bequest motives on the annuity decision, I make use of
information on children, as well as responses to questions about the importance of leaving an
inheritance. In columns (1) and (2) of Table 5, I include a dummy variable for whether or not
the household has any children. The coefficient is actually of the "wrong" sign for a bequest
hypothesis, though it is statistically no different from zero. It is important to keep in mind,
however, that 94% of the sample has children, so there is little variation in the sample on this

\(^7\) This negative wealth effect is robust to entering wealth lag linearly.
front. Columns 3 and 4 include two separate indicator variables, one for whether any children currently live with in the household, and one for whether any children live outside of the household. Again there is no effect.

The HRS also asks individuals a question designed to elicit opinions and plans about inheritances. The question asks:

"Some people think it is important to leave an inheritance to their surviving heirs, while others don't. Do you (both) feel it is very important, somewhat important, or not at all important, (or do you differ in how important it is)?"

I use this question to create two indicator variables for whether the household believes it is very important, or somewhat important. These results are presented in columns 5 and 6. According to these results, individuals who believe bequests are very important are less likely to annuitize, but the effect is not significantly different from zero. The coefficient on the indicator for thinking bequests are somewhat important is smaller and even less significant. These results confirm the basic finding that bequest motives are not a significant determinant of marginal annuitization behavior.

7. Extensions and Robustness

7.1 Performance of Model versus "Reduced Form"

At this point, one may wonder what the tight link with the underlying theory achieves. In other words, why not simply skip the utility maximization model altogether, and instead enter the underlying sources of variation, such as marital status or risk aversion, directly into the probit model. In order to explore this, Table 6 reports results for a probit model of annuity choice in which the underlying "reduced form" variables that provide the variation in the AEW measure

*The size of the DC plan never has an independent effect on the annuity decision, nor does it change the coefficients
are included, along with the AEW measure itself. Because no claim is being made that the AEW measure has any explanatory value in the myopic sample, I restrict this sample to the non-myopic group\(^9\).

The "reduced form" variables include marital status, risk aversion (beta), the fraction of pre-existing annuities (alpha), retirement age, birth year, and gender. I then conduct two likelihood ratio tests. The first one tests the null hypothesis that the "reduced form" coefficients are all jointly zero, conditional on including the AEW variable. Comparing columns 1 and 2 does this. As can be seen, one cannot reject the hypothesis that the reduced form coefficients are jointly zero. This is evidence that the AEW measure is a sufficient statistic for these other variables.

I then run the test the other way, i.e., to test whether the AEW variable is zero once one has controlled for the reduced form. Comparing column 1 to column 3 does this. In this case, I strongly reject the null hypothesis that the AEW measure is zero. This supports the fact that the structure imposed by the life-cycle model has value in predicting annuity decisions that is not captured by the simply including the reduced form variables directly\(^{10}\).

7.2 Accounting for Heterogeneity in Survival Probabilities

Heterogeneity in survival probabilities is an important source of variation in how households should value the insurance aspect of annuities. Specifically, if an individual has survival prospects that are more favorable than those assumed by the insurance company in pricing the product, her annuity equivalent wealth from the annuity should be greater. In

---

\(^9\) I have run the same likelihood ratio tests on the full sample and the conclusions from the tests do not change.

\(^{10}\) I have also run this test allowing for the continuous reduced form parameters to enter as 2\(^{nd}\) order polynomials, as well as including all possible first-order interactions. This results in a total of 24 reduced form coefficients. Even with this full saturation of the model, one still cannot reject the null hypothesis that the reduced form coefficients are all jointly zero. However, one can also no longer reject the null that the AEW term has zero effect, unless the confidence level is .15 or higher.
addition, for a given life expectancy, if the uncertainty about mortality is greater, this would also lead one to have a higher valuation for annuities. Up to this point, the impact of heterogeneity in survival probabilities has been explored only by entering health status indicator variables linearly into the probit specification. Ideally, one would incorporate differential mortality information directly into the annuity equivalent wealth calculation, and thus account for the potentially important interactions between mortality risk and the other sources of variation, such as risk aversion.

Unfortunately, it is not possible to observe individual-specific survival probabilities. There are at least two approaches that one can use to approximate these effects however. The first is to use the information on health status, which was described in section 6.4, to adjust the survival curves. The second is a direct question that asks individuals to provide a subjective estimate of the probability that they will survive to age 75 and to age 85.

The conceptual difficulty with including the self-reported health indicators linearly is, of course, that it too may interact in important ways with other variables to change the AEW. This is, after all, the same reason that risk aversion and the other reduced form variables were “fed through” the utility model. Incorporating health status into the AEW measure is necessarily much more subject to parameterization difficulties. There is no clear justification for assuming that self-reporting poor health leads to a 5% reduction in mortality as opposed to a 20% reduction in mortality. In this sense, it differs from the other parameter values used in the AEW measure, which lent themselves more readily to such a parameterization.

As a first step, however, table 7 reports the results for a case in which I parameterized the effect of health in the utility maximization model by multiplying each individual’s vector of mortality hazards by a constant. The value of this constant is 1.2 for those in poor health, 1.1 in
fair health, 1.0 in good health, .9 in fair health, and .8 in poor health. Columns 1 and 2 report the results with and without covariates for the full sample. As can be seen, the effect of AEW is slightly smaller than in the case when health differences were not accounted for, but this difference is insignificant. In addition, in column 3, I report the results again when I include the health dummies in the equation, along with the health-adjusted AEW measure. As before, most of the health dummies are insignificant, with the exception of “poor health.” Despite the fact that health status was incorporated into the AEW measure through an adjustment in mortality, there is still a large negative effect of nearly a .3 drop in the probability of annuitizing. While this is only one of an infinite number of potential ways to incorporate health status into the AEW calculation directly, it indicates the difficulties of doing so in a way that meaningfully captures the desired variation.

Another approach that is conceptually appealing, but which is fraught with difficult data problems, is to use the HRS questions about subjective survival probabilities to age 75 and to age 85 to adjust the respondent’s mortality vector. The shortcomings of these data are discussed extensively in Hurd & McGarry (1997). I categorize these data problems into several types, including (a) rounding error, due to the fact that the probabilities are reported in increments of 0.1 only. (b) internal inconsistency error, which occurs when an individual reports an unconditional probability of surviving to age 85 that is greater than the unconditional probability of living to age 75, and (c) “extreme value error,” which is the phenomenon that a large fraction of the respondents choose probabilities of survival of 0 or 1. Nearly one-quarter of the total HRS sample chose an age 75 survival probability of 1, despite the fact that for the average respondent, age 75 is nearly two decades away.
Hurd & McGarry have shown that, despite the limitations of the data, the subjective survival probabilities behave *in aggregate* much like actuarial survival probabilities. This finding is consistent with earlier findings by Hamermesh (1985) which found that subjective life expectancies are approximately “demographically consistent,” in that the average subjective expectation is consistent with actuarial tables. However, in using these data to study a behavioral question such as one’s plans for annuitization, the shortcomings of the data appear to overwhelm the advantages.

Setting aside these difficulties for a moment, however, it is possible in principle to use these subjective probabilities as though they represent the actual survival probabilities for the individual. However, since the utility maximization routine requires knowledge about the entire survival curve, and not just two points, some method is required for converting the two. I make the assumption that the ratio of each subjective one-period conditional survival probability to its actuarial counterpart is constant from the retirement age to age 74. I then adjust the one period survival probabilities from the appropriate Social Security table for these ages by this constant. The constant is determined so that when the one-period survival probabilities for retirement age through age 74 are multiplied together, they equal the cumulative age 75 subjective probability reported by the individual. A similar method is used to adjust the probabilities between ages 75 and 84, so that they are consistent with the age 85 subjective probability. Beyond age 85, I assume that the subjective probabilities are equal to the actuarial probabilities. This ensures that the population “dies off” by age 115, the maximum assumed age in the simulations.

I then use these subjective probabilities in place of the population probabilities in calculating utility. I continue to use the population mortality to price the annuities. The results are reported in Table7. As can be seen, the AEW measure calculated using these subjective
mortality measures has absolutely no explanatory power\textsuperscript{11}. Given the difficulties inherent in the construction of individual specific survival curves based on problematic responses, it is not surprising that we get insignificant results out of the model. There are few economic decisions that should be so clearly effected by individual beliefs about survival as the decision to purchase an annuity. Therefore, I view these results as being indicative primarily of the poor quality of the subjective survival data. Aside from Hurd & McGarry's finding that in aggregate these probabilities mirror population tables, I know of no study that has found these subjective probabilities in the HRS to have explanatory power for economic behavior. Future work in this area could be pursued using an econometric framework similar to that used by Hurd, McFadden, and Gan (1996) in the Ahead survey to adjust the reported subjective measures to account for focal point bias.

7.3 Alternative Couple's Utility Assumptions

In my base case, I assumed a degree of economies of scale in consumption for couples that was based on equivalence scales methodology of the National Academy of Sciences. Specifically, I assumed a value of $\lambda$, the "jointness" parameter, of .6245. In order to test the sensitivity of the results to this assumption, table 9 reports results for $\lambda=0$ (no economies of scale), and $\lambda=1$ (full economies). In neither of these extreme cases does the model perform as well among couples as the intermediate case assumed throughout. For the case of $\lambda=0$, the resulting coefficients on AEW is less than half that of the base case, and the significance is lower. For the $\lambda=1$ case, the coefficients are lower than the base case, but higher than the no economies of scale case. These results may be viewed as justifying an "intermediate" jointness assumption, such as that used in the base case.

\textsuperscript{11} Even if subjective mortality is entered in a simpler form, i.e., including an indicator variable for whether the
8. Conclusions

This paper has shown that marginal annuity decisions are significantly correlated with the predictions of a simple life-cycle model. I have found that a one-percentage point increase in the annuity equivalent wealth corresponds to a one-percentage point increase in the probability of planning to annuitize. These results support the notion that life-cycle simulation models can provide us with a useful first approximation of household annuity behavior.

Marital status appears to be a particularly important source of underlying variation in the AEW measure and the annuity decision. Married couples are less likely to annuitize than are single individuals, presumably due to the ability to pool mortality risk. These empirical results support the simulation findings of Kotlikoff & Spivak (1981) and Brown & Poterba (1999), which demonstrate that couples in a life-cycle model value annuities less than individuals. This is an important result for thinking about the impact of policy changes, such as the introduction of individual accounts as a supplement or partial substitute for the current Social Security system. Analyses that focus on the welfare implications of individuals may miss important variation that arises from differences in the ability to pool mortality risk within larger households, potentially biasing upwards the estimated value of marginal annuitization.

These results also indicate that the ability of the simple life-cycle model to predict annuity behavior is strongest among individuals. Determining the value of annuitization in a couple’s context requires a number of additional assumptions on the structure of the utility function and the structure of survivor benefits. Future work will explore the sensitivity of the results to alternative assumptions in these areas.

While the life-cycle measure of annuity valuation is significantly correlated with expected annuitization, there are several factors that lie “outside” of a simple life cycle model subjective probability is greater or less than the actuarial one, this variable has no explanatory power.
that are important in determining which households annuitize. First, while the life-cycle model appears relevant for the majority of the population, there is a subset of the population with short financial planning horizons that do not behave according to the life cycle model. This is supportive of modeling approaches, such as that used by Diamond (1977) and Feldstein (1985), which account for the existence of both rational life-cyclers and “myopes” in the population.

In addition, these results indicate that individuals in very poor health are significantly less likely to annuitize. This consistent with what a life-cycle model would predict if health status could easily be mapped into a shift in the individual-specific survival curve. However, it has been shown that simple methods for adjusting the survival curve, such as scaling the mortality hazard up or down by a constant based on health status, are insufficient to capture the effect of health on the annuity decision. It is also notable that there is very little difference in the annuitization rates of individuals within the non-poor health sample, i.e., between those reporting fair, good, very good or excellent health.

Finally, this paper casts doubt on the importance of bequest motives in influencing marginal annuity decisions. Neither the presence of children nor the presence of self-reported bequest motives have a significant effect on the annuitization decision. This is in stark contrast to the findings of Bernheim (1991), and Laitner & Juster (1996), that have indicated that bequest motives do influence annuity decisions. These results are supportive of Hurd’s (1986) finding that bequest motives do not have a significant effect on the marginal financial behavior of older households. This indicates that a simple life-cycle model with no bequests generates predictions that are consistent with marginal annuitization behavior, and as such, provides a useful first approximation of household behavior.
REFERENCES


Table 1
Summary Statistics

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<td>Mean</td>
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<td>1.154</td>
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<td>(.379)</td>
<td>.175</td>
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<td>.872</td>
</tr>
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<td>(.199)</td>
<td>.523</td>
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<td>1937</td>
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<td>(.486)</td>
<td>.361</td>
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</table>

Health:
- Excellent: .322  (.467)  .334  (.472)  .309  (.463)
- Very Good: .319  (.466)  .290  (.454)  .350  (.478)
- Fair: .070  (.256)  .077  (.268)  .062  (.242)
- Poor: .009  (.096)  .013  (.115)  .005  (.069)

Wealth (000’s): 607  (658)  664  (769)  544  (507)
DC balance: 60.7  (109)  65.3  (118)  55.7  (97.6)
Educ12: .317  (.465)  .292  (.467)  .343  (.475)
Educ13-15: .222  (.416)  .260  (.440)  .180  (.385)
Educ16+: .337  (.473)  .321  (.467)  .355  (.479)
Nonwhite: .295  (.456)  .268  (.443)  .323  (.468)
Children: .939  (.239)  .942  (.233)  .935  (.246)
Childhome: .451  (.498)  .454  (.498)  .448  (.498)
Childaway: .860  (.348)  .865  (.342)  .854  (.354)
Bequest Very: .197  (.398)  .208  (.406)  .185  (.388)
Bequest Some: .451  (.498)  .458  (.499)  .444  (.497)
Table 2
Effect of Calculated Annuity Equivalent Wealth on Intended Annuitzation
Base Case Probit Results

<table>
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<td>Couples</td>
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<td>(.0544)</td>
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<td>No</td>
<td>Yes</td>
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<td>-84.7</td>
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<td># Obs.</td>
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<td>869</td>
<td>140</td>
<td>140</td>
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</table>

Notes: AEW is the “Annuity Equivalent Wealth” as described in the text. Dependent variable is indicator variable “Annuity,” which equals one if the household expects to annuitize their defined contribution plan, and zero otherwise. Reported coefficients are the marginal effects of the probit evaluated at the sample means. Standard errors of the marginal effects are reported in parentheses.

* NonWhite dropped (column 4) due to collinearity with Industry, Occupation and Education.
### Table 3
Impact of Time Horizon Heterogeneity on Intended Annuitzation

<table>
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<tr>
<th>Sample</th>
<th>(1)</th>
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<td>No</td>
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<td>No</td>
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</table>

Log Likelihood: -587.1   .563.3   -85.63   -76.71   -499.7   -477.2

# Obs.: 869   869   140   140   729   729

Notes: AEW is the "Annuity Equivalent Wealth" as described in the text. Dependent variable is indicator variable "Annuity," which equals one if the household expects to annuitize their defined contribution plan, and zero otherwise. Reported coefficients are the marginal effects of the probit evaluated at the sample means. Standard errors of the marginal effects are reported in parentheses.
<table>
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<th>Sample</th>
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Log Likelihood: -580.1, -557.0, -82.6, -73.8, -494.6, -471.8

# Obs: 869, 869, 140, 140, 729, 729

Notes: AEW is the “Annuity Equivalent Wealth” as described in the text. Dependent variable is indicator variable “Annuity,” which equals one if the household expects to annuitize their defined contribution plan, and zero otherwise. Reported coefficients are the marginal effects of the probit evaluated at the sample means. Standard errors of the marginal effects are reported in parentheses.
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<td>(.0752)</td>
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<td></td>
<td>-.0051</td>
<td>-.0071</td>
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<td>(.0397)</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Education Dummies</td>
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<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Dummies</td>
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<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Occupation Dummies</td>
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<td>No</td>
<td>Yes</td>
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</table>

Log Likelihood:  
-579.8, -556.3, -579.9, -556.4, -579.4, -555.8

# Obs.: 869, 869, 869, 869, 869, 869

Notes: AEW is the “Annuity Equivalent Wealth” as described in the text. Dependent variable is indicator variable “Annuity,” which equals one if the household expects to annuitize their defined contribution plan, and zero otherwise. Reported coefficients are the marginal effects of the probit evaluated at the sample means. Standard errors of the marginal effects are reported in parentheses.
Table 6  
Comparing the Calculated AEW with Reduced Form Specification  
Non-Myopic Individuals and Couples

<table>
<thead>
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<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
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</thead>
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<tr>
<td>AEW</td>
<td>1.191 (.4560)</td>
<td>.9419 (.1911)</td>
</tr>
<tr>
<td>Married</td>
<td>.0802 (.1151)</td>
<td>-.1864 (.0531)</td>
</tr>
<tr>
<td>Alpha</td>
<td>.1979 (.1143)</td>
<td>.0397 (.0969)</td>
</tr>
<tr>
<td>Gamma</td>
<td>.0128 (.0137)</td>
<td>.0303 (.0120)</td>
</tr>
<tr>
<td>RetAge</td>
<td>.0035 (.0073)</td>
<td>.0148 (.0059)</td>
</tr>
<tr>
<td>BirthYear</td>
<td>.0017 (.0050)</td>
<td>.0044 (.0049)</td>
</tr>
<tr>
<td>Female</td>
<td>.0232 (.0415)</td>
<td>.0253 (.0412)</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-481.1</td>
<td>-484.3</td>
</tr>
<tr>
<td># Obs.</td>
<td>718</td>
<td>718</td>
</tr>
</tbody>
</table>

Notes: AEW is the “Annuity Equivalent Wealth” as described in the text. Dependent variable is indicator variable “Annuity,” which equals one if the household expects to annuitize their defined contribution plan, and zero otherwise. Reported coefficients are the marginal effects of the probit evaluated at the sample means. Standard errors of the marginal effects are reported in parentheses.

Likelihood Ratio Tests:

<table>
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<th>Columns Tested</th>
<th>-2 ln(λ₁/λ₂)</th>
<th>d.f.</th>
<th>χ²</th>
<th>P-val.</th>
<th>Reject?</th>
</tr>
</thead>
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<td>H₀: β for Reduced Form Jointly = 0</td>
<td>(1) vs. (2)</td>
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<td>6</td>
<td>.3799</td>
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<td>H₀: β for AEW = 0</td>
<td>(1) vs. (3)</td>
<td>6.88</td>
<td>1</td>
<td>.0087</td>
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Table 7  
Incorporating Health into AEW Calculation  
Full Sample

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</thead>
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<td>.9145</td>
<td>.9194</td>
</tr>
<tr>
<td></td>
<td>(.1854)</td>
<td>(.2139)</td>
<td>(.2178)</td>
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<td>Myopic</td>
<td>.2803</td>
<td>.2835</td>
<td>.2982</td>
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<tr>
<td></td>
<td>(.0778)</td>
<td>(.0823)</td>
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<td>Myopic*AEW</td>
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<td>(.4209)</td>
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<td>(.4532)</td>
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<td>-0.0073</td>
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<tr>
<td></td>
<td>(.0032)</td>
<td>(.0032)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(.0473)</td>
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<td>.0607</td>
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<td>(.0468)</td>
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<td></td>
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<td>(.0771)</td>
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<td>(.1483)</td>
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<td>Yes</td>
</tr>
<tr>
<td>Industry Dummies</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Occupation Dummies</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Log Likelihood       | -588.3 | -561.5 | -558.1 |
# Obs.               | 869     | 869     | 869   |

Notes: AEW is the “Annuity Equivalent Wealth” as described in the text. In this table, the AEW calculation incorporates a mortality adjustment based on respondent’s self-reported health status as described in text. Dependent variable is indicator variable “Annuity,” which equals one if the household expects to annuitize their defined contribution plan, and zero otherwise. Reported coefficients are the marginal effects of the probit evaluated at the sample means. Standard errors of the marginal effects are reported in parentheses.
<table>
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<th></th>
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<td>Education Dummies</td>
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<td>No</td>
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<td>Industry Dummies</td>
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<td>No</td>
<td>Yes</td>
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<td>-570.9</td>
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<td># Obs.</td>
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Notes: Dependent variable is indicator variable “Annuity,” which equals one if the household expects to annuitize their defined contribution plan, and zero otherwise. Reported coefficients are the marginal effects of the probit evaluated at the sample means. Standard errors of the marginal effects are reported in parentheses. AEW calculation incorporates a mortality adjustment based on respondent’s subjective survival probabilities as described in the text.
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<td>(1.169)</td>
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| Log Likelihood | -502.0  | -499.7  | -502.4  | -500.9  | -502.4  | -501.5  |
| # Obs.         | 729     | 729     | 729     | 729     | 729     | 729     |

Notes: Dependent variable is indicator variable “Annuity,” which equals one if the household expects to annuitize their defined contribution plan, and zero otherwise. Reported coefficients are the marginal effects of the probit evaluated at the sample means. Standard errors of the marginal effects are reported in parentheses.
CHAPTER 2

Are the Elderly Really Over-Annuitized?
New Evidence on Life Insurance and Bequests
1. **INTRODUCTION**

It has long been established in the economics literature that annuities ought to be of substantial value to life-cycle consumers who face an uncertain date of death. Yaari (1965) proved that a life-cycle consumer with an uncertain lifetime and no bequest motives would find 100% annuitization the optimal investment. More recent work has quantified the potential utility gains to such a life cycle consumer. For example, a 65 year old male life cycle consumer would be willing to give up nearly one-third of his wealth to gain access to an actuarially fair market for annuities (Mitchell et al, 1999).

Buying a life insurance contract is analogous to selling an annuity. It is generally viewed as an appropriate product for working age individuals who seek to protect their family against the loss of future labor earnings (Lewis, 1989). However, it appears to serve little purpose in the portfolio of a retired life-cycle consumer who is concerned only with self-financing retirement out of his or her accumulated wealth. With no labor earnings to insure, an elderly individual should be purchasing annuities in order to provide a certain consumption stream in retirement, not selling annuities through the purchase of life insurance. Even if the individual wishes to leave a portion of wealth to his or her heirs in the form of gifts or bequests, this can be achieved by investing this portion of wealth in ordinary bonds or other non-annuitized assets. In fact, if life insurance premiums were higher than actuarially fair, holding riskless bonds would strictly dominate life insurance as a form of wealth transfer.

Yet elderly households in the United States overwhelmingly hold life insurance, while only a small fraction hold privately purchased annuity contracts. In the AHEAD survey, which consists of households age 70+, privately purchased annuity contracts (excluding private pensions) are held by fewer than 8% of couples, while 78% of these couples own a life insurance policy on at
least one member. According to the Life Insurance Ownership study (LIMRA, 1992), ownership of individual (non-group) life insurance policies is actually higher among the age 65+ group than any other age cohort. While this difference is offset by much lower coverage by group (usually employer-based) policies, the overall incidence of coverage among the elderly is quite high by any measure.

Two major alternative hypotheses have been explored in the literature to explain the patterns of life insurance coverage among the elderly. Auerbach & Kotlikoff (1987, 1989) explored the idea that married couples were using life insurance to reallocate annuity streams across survival states of the couple. However, they found virtually no support for the notion that older households were using life insurance to protect potential widows against severe drops in living standards upon the death of the other spouse.

The second hypothesis, suggested by Bernheim (1991), is that life insurance is being held by elderly households to offset an excessive level of mandated annuitization in the form of Social Security. He estimates that 25% of elderly households have too much of their wealth annuitized and that they are using term life insurance to sell these annuities in order to leave a bequest. To the extent that this “annuity offset model” is true, it has at least two important implications. First, this would be indicative of very strong bequest motives, which is an issue of perennial controversy in the economics literature (e.g., Kotlikoff & Summers 1981, Modigliani 1988, Hurd 1987, Laitner & Juster 1996). Second, if individuals are over-annuitized due to these strong bequest motives, this would indicate a potential welfare gain from lessening the extent of the extent of mandated annuitization. This is potentially important in the debate about whether individuals would be required to annuitize individual account accumulations as part of a reformed Social Security system. If a significant fraction of households are over-annuitized,
allowing individuals some discretion over the disposition of the assets in their individual account could be welfare enhancing.

This paper re-examines the annuity offset model using more recent and better data than was available for the original empirical tests. The four empirical implications of the model that this paper tests are: (i) no individual would hold both term life insurance and private annuities, (ii) the level of Social Security benefits and term life insurance ownership should be negatively correlated, (iii) term life insurance should behave as an inferior good because it is a negative annuity and annuities are normal goods, and (iv) individuals who hold term life insurance must have a Social Security benefit in excess of desired retirement consumption. These implications will be explained in more detail in the next section. This paper presents results that are inconsistent with all four of these empirical implications, and thus concludes that life insurance coverage is not a good indicator of the extent of over-annuitization.

This paper proceeds as follows: Section 1 summarizes the annuity offset model as posited by Bernheim (1991), and outlines the empirical implications of the model to be tested. Section 2 presents and critiques the empirical results from the previous literature, with particular attention on the distinction between types of life insurance. Section 3 discusses the data used in this paper, from the AHEAD study. Section 4 presents empirical results. Section 5 discusses some alternative explanations for life insurance holdings among the elderly. Section 6 concludes.

1. The Annuity Offset Model of Life Insurance Demand

The basic insight behind of the annuity offset model of life insurance demand is that individuals can purchase term life insurance in order to sell a government-mandated annuity. Bernheim suggests a simple two-period model that demonstrates this point. Assume that an
individual possesses total wealth $W_0$, which he is able to divide between two types of investments. It is assumed that the investment decision is taking place after consumption in period 0 has already occurred. The first type of asset, A, is a life contingent annuity contract which yields a return of $\alpha$ in period 1 if the individual is alive, and $0$ otherwise. The second type of asset, B, is a traditional (bequeathable) financial asset which yields a return of $\beta$ in period 1 regardless of whether the individual is alive or not. If the individual lives, his period 1 resources are $W_1 = \alpha A + \beta B$. If he dies, his heirs receive $\beta B$. Because actuarially fair annuities pay a “mortality premium” equal to the probability of dying, $\alpha > \beta$. Utility of the individual is assumed to be a function of total resources and bequeathable resources in period 1, $U = U(B, W_1)$. Call $A^*$ and $B^*$ the quantities of the two assets that correspond to the optimal division of total wealth, subject to the constraint that $W_0 = A + B$.

Now suppose the government confiscates $A^*_B$ in period 0 and returns $\alpha A^*_B$ in period 1, conditional on the individual’s survival. In other words, the government mandates a minimum level of annuitization. If $A^*_B < A^*$, then the individual simply decreases his private purchase of annuities by an amount equal to $A^*_B$, or alternatively, he buys private annuities in the amount of $A^*-A^*_B$. If $A^*_B > A^*$, then the individual wishes to sell annuities. This can be done through the purchase of a term life insurance contract. When markets for annuities and life insurance are actuarially fair, then the government mandate has no effect on the individual’s division of wealth between A and B. Private insurance contracts offset the government annuity dollar-for-dollar. If insurance is not actuarially fair, then the offset is less than dollar-for-dollar, but the basic story is unchanged. Individuals who wish to hold more annuities than the government mandates will own private annuity contracts. Individuals who wish to hold less in annuities will own private life insurance contracts. No individual will hold both private annuities and life insurance, since
they are offsetting transactions, each with a positive load factor. Some individuals will hold neither, if $A^g$ is sufficiently close to $A^*$. 

There are four major empirical implications that must hold if the annuity offset model is the reason that the elderly hold life insurance. These are:

1. **No individual will hold both private annuities and private term life insurance contracts.**

   Given the existence of significant load factors in annuity markets (MPWB, 1999), no one would rationally purchase annuities above the actuarial cost only to sell them back below the actuarial cost.

2. **An increase in the level of the mandated annuity will increase the demand for term life insurance.** Recall that an individual will hold term life insurance in the amount of $\max\{0, A^g-A^*\}$. Holding $W_0$ fixed, an increase in $A^g$ will increase the total amount of life insurance coverage among those who already hold it. It will also cause some individuals who did not hold life insurance before to purchase it.

3. **Term life insurance will behave as an inferior good.** If $B$ and $W_1$ are normal goods, then an increase in the individual’s total resources will increase the demand for annuities. This is because a person with more resources will wish to buy more annuities in order to increase retirement consumption. Since term life insurance is a negative annuity, an increase in the demand for annuities corresponds to a decrease in the demand for term life insurance. Therefore, term life insurance will decline with total resources, and thus behave as an inferior good.

4. **The Social Security annuity income flow must exceed consumption.** If an individual is over-annuitized due to bequest motives, it must be because his desired consumption is less than the annuity income from Social Security. So long as optimal consumption

75
exceeds the level of the Social Security benefit, there is no need to offset Social Security. Rather, one would want to supplement Social Security through the purchase of private annuities. An equivalent way to state this implication is that an individual who purchase life insurance to offset an annuity will not consume out of their non-Social Security resources. They will save these resources for bequests, and will in fact supplement this bequest with the term life insurance.

It should be noted that there are reasons an individual might be “over-annuitized” that have nothing to do with bequest motives. Hurd (1987) points out that when an individual’s optimal consumption path is constrained by an exogenously given annuity stream, they may be willing to give up annuitization at an actuarially fair rate in order to loosen this “liquidity constraint.” This is especially likely if the individual has little non-annuitized wealth. However, over-annuitization in this case is driven by a desire to re-allocate consumption across one’s lifetime, not to re-allocate between consumption and bequests. Another example is the case in which an individual wishes to hold a buffer stock of assets to cover unforeseen expenditure shocks (e.g., health expenditures). In such a situation, they may wish to hold some of their wealth in a non-annuitized form. Once again, the role of the non-annuitized wealth in this case is still to provide for own consumption, not to leave a bequest to one’s heirs. In this case, the way to “undo” the excessive annuitization, however, is not to purchase life insurance, since these proceeds will be unavailable for future consumption. Rather, the individual would wish to purchase insurance against the risky future event (e.g., health insurance) or alter their savings behavior in order to provide for a buffer stock. The tests that I propose in this paper are meant to test for over-annuitization that derives from bequest motives, not these other factors.
2. Discussion of Previous Empirical Results & Data Contamination

Bernheim tested the first three implications of the annuity offset model using the 1975 cross-section of the Retirement History Survey (RHS), and found support for two of them. The most robust finding was that higher Social Security benefits were correlated both with a higher probability of owning life insurance, and with the amount of coverage conditional on owning a policy. His interpretation of this finding is that individuals are using the life insurance to offset excessive levels of Social Security. He also found some evidence to suggest that life insurance coverage was a decreasing function of lifetime resources, which is consistent with the "inferior good" implication, though this finding was not robust across specifications.

The first implication, that no person would hold both life insurance and annuities, was clearly at odds with the data, as 36% of the RHS sample reported both in-force life insurance holdings and the receipt of pension annuities. He attributes this latter result to data contamination, namely the fact that there is no way in the RHS to distinguish whole from term life insurance. Because much of Bernheim's analysis was focused on trying to overcome this data handicap, it is useful to discuss the relevance of the life insurance typology in more detail.

2.1 Term Versus Whole Life Insurance

The distinction between term and whole life insurance is quite important to the annuity offset model. The difference between the two policy types is quite simple, but has important economic implications. Term life insurance contracts provide insurance protection for a specified limited period. The face amount of the policy is payable to the beneficiaries only if the insured dies within the term specified. Common term periods include 1-year, 5-year, 10-year, and 20-year. Most term policies have options allowing an individual to guarantee renewability at the end of the term specified. This means that an individual is not at risk for losing coverage if she is
diagnosed with a serious health problem, so long as she pays the contract premium. Because the price of a term insurance contract is a function of the probability of the individual dying during that term, premiums are an increasing function of the insured’s age.

Whole life policies, on the other hand, are not limited in duration, but rather protect “the whole of life.” (Graves, 1994) Unlike term insurance contracts, which represent pure insurance, the typical whole life contract is a combination of insurance and tax-deferred savings. The typical “ordinary life” product has fixed (nominal) level premiums and a fixed (nominal) death benefit or face value. As demonstrated in Figure 1, the cash values of these policies rise over time, while the pure insurance component declines. The standard practice among life insurers is for the cash value to equal the face value by age 95 or age 100 (Graves 1994). According to the 1995 Survey of Consumer Finances, the median whole life insurance policy held by individuals age 70+ had a cash value that was 67% of the face value. This means that only 1/3 of the reported face value of whole life policies represents insurance. Most whole life policies have provisions that enable individuals to borrow against the cash value of the policies, and as such provide some degree of liquidity. Importantly for the annuity offset model, the cash value of a policy is not a negative annuity, but rather represents a non-annuitized financial asset, much like a savings account. While it is true that the cash value of a life insurance policy may be left to one’s heirs as a bequest, a large cash value policy would not be indicative of over-annuitization any more than would the holding of a large savings account.

As important as this distinction may be between term and whole life insurance, previous empirical work on the elderly was unable to distinguish between them. The Retirement History Survey provided data only on the total face value of all life insurance policies. Thus, to the extent that ownership of whole life more closely resembles tax-deferred savings than insurance,
previous researchers were unable to disentangle these two potentially different effects. For example, suppose high income individuals are more likely to purchase whole life insurance as a form of tax-deferred savings. Because these individuals are high income, they also receive a higher Social Security benefit at retirement. This could lead to a spurious correlation between total life insurance holdings and the level of the Social Security benefits. As we shall see, this co-mingling of insurance and tax deferred savings has an important impact on the results.

2.2 Group Versus Individual Coverage

Another relevant distinction between types of life insurance that may be important to this model is between “group” and “individual” coverage. Group life insurance policies are commonly provided through employers or unions. An example of a typical group life policy is one that insures an employee for a fixed multiple of their salary. Individual contracts, on the other hand, are purchased directly from the insurance company, most often through an insurance agent or broker.

The primary distinction between these policies is that individual life coverage is clearly a “choice” variable, whereas group coverage is often automatic with employment. While in many instances group coverage simply substitutes for individual coverage that would have been purchased anyway, it will also cover some individuals who may have chosen to hold no life insurance if not covered through their employer. Another reason this distinction is relevant is that since group coverage is usually tied to employment, its purpose is often to protect an employee’s family from the loss of future earnings. This purpose for holding life insurance is distinctly different from using life insurance to offset a retirement annuity.

Group coverage is less common among retired elderly households, since most group coverage is tied to employment. Neither the RHS, nor the AHEAD data used in this study, allow
for this distinction between group and individual coverage. However, by making use of
information about the current employment status of an individual, it is possible to extract some
information about the effects of this difference.

2.3 Previous Empirical Results

Previous empirical support of the annuity offset model rests on two key results. The first is
that there exists a strong positive correlation in a cross section of households between the level of
Social Security benefits, and the holdings of life insurance. Bernheim estimates that
approximately 25% of households own term life insurance, and based on his findings, are
therefore over-annuitized. His central results indicate that they are using term insurance to offset
Social Security by roughly 20 cents on the dollar.

Second, Bernheim finds mixed evidence to suggest that a portion of the total life insurance
holdings are negatively correlated with total lifetime resources, and thus represents an inferior
good. Importantly, in his most direct specifications, he finds that life insurance coverage is
actually increasing with resources for married couples with children. Only when he imposes
more structure on the problem to overcome problems of data contamination does he find a
consistently negative and significant resource effect. However, this approach is unable to
directly identify the effect of resources on term life insurance, and instead relies on modeling
total holdings as the sum of two separate processes (one representing term and one representing
whole, but each unidentified in advance) and testing the sign of various coefficient combinations.

The difficulty with these results is that the potential for bias is quite high due to the inability
to directly identify the term insurance component of total life insurance holdings. Suppose that
individuals purchase insurance during their working lives in order to protect their spouse and
children from the loss of their human capital in the event of an early death. Individuals can
choose between term and whole life insurance to meet this insurance need. The annual premium on a whole life contract is higher than the premium on a term life contract because some of the additional premium essentially goes into a savings account that benefits from tax-deferred inside buildup. Because of this, the whole life contract is more attractive, all else equal, to an individual in a higher marginal tax bracket. Therefore, high earners (who therefore face higher marginal rates) have the most to gain from purchasing whole life contracts. High earners will also be paying more in Social Security payroll taxes, and will thus have a higher benefit upon retirement. Thus, to the extent that whole life contracts held by the elderly represent “residue” from decisions made early in life to protect human capital, this would induce a spurious positive relationship between SSB and whole life insurance coverage.

Two pieces of evidence suggest that this scenario is a strong possibility. First, according to a life insurance ownership study conducted by LIMRA, the median age of the oldest life insurance policy held by individuals age 70+ was 42 years, suggesting that most policies were in fact purchased during one’s working life. Second, there is a clear positive relationship between ownership of whole life insurance and income during one’s working life. For example, if we focus on working age individuals (age 22-65) in the 1995 Survey of Consumer Finances, we find that only 20% of individuals with incomes under $30,000 own a whole life insurance policy. Of those with annual incomes between $30,000 and $60,000, 33% own a whole life policy. Nearly half (48%) of those earning over $60,000 per year own a whole life policy. This relationship is not biased by the age-earnings profile, as a nearly identical trend emerges when one examines ownership patterns conditional on age. Thus, whole life insurance ownership during one’s working life is clearly correlated with income, and thus with OASDI contributions. If individuals continue to hold these policies after retirement, this will lead to a positive correlation
between the level of Social Security benefits and whole life insurance ownership. Newly available data allows for a separation of total life insurance into whole versus term life policies, and as such provides a more direct test of the model.

A second potential source of spurious correlation is that some individuals in the Bernheim study were still in the work force. His 1975 RHS sample was comprised of individuals age 65-69. According to Department of Labor statistics, in that year the labor force participation rate of individuals age 65-69 was 31.7%. High labor force participation can lead to bias in the annuity offset test for two reasons. First, individuals still in the workforce still have positive human capital to protect, and may hold life insurance for this reason. If these individuals also have higher Social Security benefits due to their strong attachment to the labor force, this could induce a positive correlation between benefits and insurance coverage. Second, employed workers are more likely to be automatically covered by group insurance plans. Therefore, even if the person has no demand for insurance, he or she may be insured. If employed workers are more likely to have higher Social Security benefits, a spurious positive correlation would result.

3. Data & Methodology

This paper uses data on elderly households from the first wave of the Asset and Health Dynamics of the Oldest Old (AHEAD) survey. Fielded in 1993/94, this survey collected detailed financial and demographic data on community based individuals born 1923 or earlier, so they are age 70 and above at the date of the survey. The questionnaire collects detailed information on economic and demographic variables, health, work status, and importantly for this study, life insurance coverage.
There are several advantages to the use of this data over the earlier work completed using the Retirement History Survey. First, it allows for the important distinction between term life and whole life insurance coverage. While it still does not permit the decomposition of whole life into its cash versus insurance value, the fact that we can distinguish between pure term policies and whole policies none-the-less represents an important improvement over the total face value of all insurance. Second, because the data consists of individuals age 70+, nearly all of them are retired. This is important both because this means that the individuals no longer carry life insurance to protect against the loss of human capital, and because it is significantly less likely that the individual will be covered by a group life insurance plan through the employer. Therefore, a test of the annuity offset hypothesis will not be contaminated by work-related reasons for insurance coverage. Third, the data is much more recent than the RHS, which is potentially important due to the clear long-term decline in the life insurance coverage of households over the past three decades (LIMRA, 1992). Fourth, because of the advanced age of the cohorts, there are large enough samples to investigate the behavior of widows and couples separately. This may be an important distinction because at least one alternative to the annuity offset hypothesis is relevant to couples but not to widows. This is the notion that elderly couples may use life insurance to re-allocate wealth across states of spousal survival.

The primary disadvantage of the AHEAD data is the fact that it does not currently contain information on the earnings histories of respondents. As a result, it will not be possible to exactly replicate the specification of lifetime resources as used in Bernheim’s work on this subject. However, the information on current income from Social Security and pension plans is quite detailed, and along with information on financial assets it is possible to construct a very good measure of resources available to the household from the date of the survey forward.
This analysis will focus on two subsets of households in the AHEAD data set. The first is married couples in which both spouses were interviewed, and for which we therefore have complete information about important characteristics of both spouses. The second set consists of male widowers and female widows (hereafter often referred to collectively as widows), i.e., formerly married individuals who lost their spouse to death. Excluded from this analysis are "never married" individuals, both because of small sample sizes and because they are less likely to have children or grandchildren to which they may wish to bequeath. Also excluded are single divorcees, due to small sample sizes and the fact that the survey lacks important information about their former spouse. The resulting sample size for married couples ranges from 1750 to 1950 households, and from 2600 to 2800 widows and widowers. The "range" of households arises from missing data for versions of the dependent variable. For example, an individual may state that they do not own a whole life policy, but that they do own a term life policy with an unknown face value. My decision rule was to include the maximum number of households possible, so this person would be included in the whole life regressions, but excluded from the term life and total life regressions due to missing data.¹

In order to test for the effect of Social Security benefits and total resources on the holdings of life insurance, I use the following econometric specification:

\[
L_i = \max \{0, \beta_0 + \beta_1 SSB_i + \beta_2 LR_i + \beta_3 X_i + \epsilon_i\} \tag{1}
\]

LI is the face value of life insurance. In some specifications, this will represent total face value, while in others I will limit it to term life or whole life only, in order to account for the cash value bias discussed earlier. SSB represents the annual flow of benefits from Social Security.

¹ I have conducted exhaustive checks to ensure that my results were not sensitive to the selection process. For example, I have also used the decision rule of including in the analysis only if they answered all questions, resulting in uniform but smaller sample sizes. Basic results were unchanged.
LR is a vector of characteristics that attempts to capture components of lifetime resources. It includes the variable PVR, which equals the expected discounted present value of resources, including net worth, social security wealth, and pension wealth. Because life-time earnings records are not yet available in the data set that I use, the LR vector also includes a number of variables which proxy for the effect of lifetime earnings. These include nine occupation indicators and four educational attainment indicators. For specifications involving couples, these indicator variables are all included separately for each spouse. X is a vector of other relevant demographic characteristics, including age, gender, race, and whether the respondents have any living children. Because the variable L1 is censored at 0, non-linear techniques must be used to obtain consistent parameter estimates. I will assume the normality of ε, and thus report results from Tobit specifications.

This approach closely approximates the main specification used by Bernheim in his test of the annuity offset model in the Retirement History Survey, with three primary differences. The first is that Bernheim was restricted to using total face value of all life insurance as his dependent variable, whereas the current study can examine whole and term separately. The second difference is in the construction of the measure of total resources. The definition used here, PVR, is net worth plus the present value of future income from Social Security and pensions, and thus represents resources available from today forward. Bernheim’s measure was the present value of lifetime earnings plus the present value of Social Security and pensions, and thus represented total lifetime resources. The third difference is that the current study examines behavior of widows and couples in separate regressions. Bernheim ran his model on all households, with appropriate indicators for marital status, but excluded individuals who had been widowed more than 6 years.
4. Results

Table 1 presents summary statistics on life insurance ownership among age 70+ households in the AHEAD data. Several features of the data are worth noting. First, men are more likely to hold all types of life insurance than are women. Nearly 62% of widowed men own a life insurance policy, versus only 49% of widowed women. Among currently married couples, 72% of men are covered by at least one policy, versus only 55% of married women. Looking at term and whole life ownership separately, the same basic pattern emerges, in that men are always more likely to hold insurance than women. In addition, men always hold more insurance conditional on owning, than do women.

A second feature of the data is that most policies tend to be quite small, though the distribution is fairly skewed. The median married household owns a total of $10,756 of life insurance, a figure that includes all types of life insurance on both spouses. Among widowed households, it is even smaller, with a median value of $5000 for men, and $2500 for women. However, the means are roughly two to three times larger than the medians, which is driven by the fact that a small fraction of households own very large policies. For example, the 95th percentile of total household coverage among married couples (conditional on owning) is $113,000. The 95th percentile of coverage for male widowers is $50,000.

The third broad pattern to recognize is that marital status is an important margin along which insurance coverage differs. Married individuals are much more likely to own life insurance than are widows or widowers of the same gender, and hold more of it conditional on owning. There are many reasons why this could be true, including reasons that might bear upon the relative importance of using life insurance to protect a spouse versus providing a bequest. However, a
large part of these differences are undoubtedly attributable to differences in the financial status of married and versus widowed households, which is not captured in these simple tabulations.

4.1 Test of Implication #1: “No simultaneous holdings”

The first implication of the annuity offset model, and the one easiest to test in the data, is the notion no individual would choose to simultaneously hold life insurance and annuities. This is because they are offsetting transactions, each of which may cause the individual to incur transactions costs or “loads” to the fact that private insurance markets are not actuarially fair.

This assumption is clearly violated by the data in Table 2. This is particularly notable if one follows the Bernheim approach of treating annuities from pension plans as voluntarily purchased. Of all married households, 50% own both a private pension and some form of life insurance. Among widows and widowers, 21% own both private pension annuities and life insurance. There are reasons to suspect that private pensions are not strictly “voluntary,” especially among those age 70+ who were likely covered for most of their careers in traditional defined benefit plans. However, even if we restrict ourselves to privately purchased, non-pension annuities, 6.6% of married couples own both. Since only 7.7% of the sample own such an annuity, however, this means that 86% of those married households who have purchased a private, non-pension annuity also own life insurance.

These numbers are not surprising, since in Bernheim’s own sample 36% of households, which included both married and widowed individuals, owned both pensions and life insurance. He attributed this finding to data contamination, namely the fact that he was unable to distinguish between term and whole life insurance. If the 36% of people holding both were really holding whole life policies with cash values approaching their face values (i.e., they contained very little insurance), then this finding would not be inconsistent with the annuity offset model. However,
using the AHEAD data, we can see that this is not the explanation. Roughly one third of married households own both straight term life insurance policies and a private pension, as do 13% of widows. Perhaps the “purest” test of the model is to use term life insurance and non-pension annuities. In this case, 3.8% of couples hold both. Importantly, one half of all married households that own a non-pension annuity also have life insurance coverage. This is clearly inconsistent with the annuity offset model.

4.2 Test of Implication 2: Positive Correlation between Insurance and Social Security

The second, and arguably the most important, implication of the annuity offset hypothesis is that there should exist a positive correlation between term life insurance coverage and the level of Social Security benefits. The heart of this hypothesis, as outlined in Section 1, is that when individuals have higher Social Security benefits, they want to buy fewer private annuities and more life insurance.

Table 3 reports Tobit results for equation (1) in the sample of widows and widowers. Columns (1) – (3) report the results on the combined sample of men and women, columns (4) – (6) report results for male widowers only, and columns (7) – (9) report results for female widowers only. For each sample, the specification is run first on total face value of all life insurance, and then on term and whole life insurance separately.

The coefficient on SSB (annual Social Security Benefit) is the coefficient of interest for testing this implication of the model. If the annuity offset model is correct, the coefficient should be significantly positive. Looking first at column 1, we can see that this relationship does hold for total life insurance coverage, with a coefficient of 0.48 that is highly significant. This says that an additional $1 of annual Social Security Benefits corresponds to an additional 48 cents in life insurance coverage, conditioning on the present value of resources. (Note that since the
hypothesis treats life insurance as a negative annuity, we are interested in the effect on the underlying demand for insurance, so no adjustment to the Tobit coefficient is required. We can translate the life insurance face value into an annuity flow by dividing by the appropriate annuity factor, i.e., the actuarial present value of a $1 annuity flow. Using a real interest rate of 3%, this factor is approximately 10 for the average individual in the AHEAD sample. Therefore, we find that life insurance is offsetting the flow of Social Security benefits by approximately 5 cents on the dollar. This offset is lower than the 10-20 cent offset that Bernheim found because the current sample is of widows and widowers only, while Bernheim’s results were for a mixed sample. Results for couples, discussed below, show a somewhat larger offset that falls in the lower end of the Bernheim offset range.

Columns (2) and (3) of table 3 makes the important distinction between term and whole life insurance. Column (2) in each table reports the results for the case in which only Term life insurance is treated as the dependent variable. Relative to the results for column (1), the difference is striking. The coefficient falls to 0.04, and is statistically no different from zero. The result for whole life insurance in column (3) has the opposite effect – the coefficient on SSB rises to 1.22 and is highly significant. It therefore appears that whole life insurance is completely driving the relationship between the level of Social Security benefits and life insurance coverage found in the initial results.

As discussed by Bernheim and earlier in this paper, the annuity offset model is really a model about term life insurance. Yet the primary implication of this model, that term life insurance ownership will be an increasing function of the level of Social Security benefits, is clearly rejected by the data. The relationship between whole life insurance and Social Security, on the other hand, is strong but subject to numerous sources of bias. As discussed, by age 70, whole
life insurance primarily consists of tax-advantaged savings, and therefore does not serve to “undo” annuitization any more than holding other financial assets. Since the individuals who have the most to gain from the inside build-up associated with whole life policies are people who were in higher tax brackets while younger (and who therefore are also likely to have higher Social Security earnings), the observed relationship may be driven more by tax consequences than by a desire to offset a government annuity.

Columns (4) – (6) of Table 3 repeat the analysis for the male widowers only, and finds a similar pattern. In the specification using total life insurance as the dependent variable, there is a significant positive effect of SSB, and it is much larger in magnitude. Once again, however, when we decompose total life insurance holdings into the two types, we find that the positive relationship is being driven entirely by whole life policies. The final three columns of Table 3 report results for the women in the sample. In this case, the coefficient on SSB in the total life insurance regression falls short of significance, and is smaller in magnitude than for males. Yet once again we find that a strong positive correlation between whole life coverage and the level of Social Security benefits.

Table 4 presents results for married couples. Focusing on column (1), we see that the coefficient on SSB in the “total life insurance” specification is a positive and significant 0.91. This offset is similar to what Bernheim found, though at the lower end of his range. Once again, however, the split of total insurance into its two types yields dramatically different results. The coefficient for Term insurance in column (2) is only 0.27, and is not significant at the 95% level. The coefficient on SSB in the Whole insurance specification (column (3)), on the other hand, is a significant 1.46. Once again, the results appear to be driven primarily by a whole life insurance, not the term insurance that the model is meant to represent.
In columns (4) – (6), the results are repeated on the sub-sample of married couples in which neither spouse is currently in the workforce. This distinction is quite important, as even the coefficient on total life insurance is no longer significant. There are two important reasons to think that working couples may differ from non-working. First, an employed individual still has some (albeit small) human capital to protect, just as a younger working age individual does. Second, a worker is more likely to be covered by a group insurance plan through the employer. In either case, if workers also have higher Social Security benefits because of a stronger attachment to the labor force, this will induce a positive correlation between SSB and life insurance, even in the absence of a desire to undo annuitization.

Table 5 reports results similar to table 4, except that the dependent variable is life insurance coverage on the husband only. The pattern of coefficients on SSB is similar to those found in table 4. Again, any positive correlation appears to be driven entirely by whole life insurance, especially coverage by employed individuals.

In short, there is no evidence to suggest that term life insurance ownership among retired elderly households exhibits the correlation with Social Security benefit levels that the annuity offset model demands.

4.3 Test of Implication #3: Term Insurance as an Inferior Good

The third implication of the annuity offset model is that term life insurance will behave as an inferior good with respect to life-time resources. This is simply because retirement consumption is viewed as a normal good, and therefore the demand for annuities should be an increasing function of resources. Since term insurance is to behave as a negative annuity, this means that the demand for term insurance should be declining with total lifetime resources.
I am unable to exactly replicate Bernheim’s measure of lifetime resources because access to Social Security earnings records is unavailable\(^2\). However, we do observe other components of resources, including the actuarial present value of pensions, Social Security, housing wealth, and financial net worth. I construct the variable PVR (Present Value of Resources) to be the sum of these resource variables. In addition, I am able to use indicator variables for education and occupation to proxy for lifetime earning effects.

Using a measure of lifetime resources that included lifetime earnings and the present value of pensions and Social Security, Bernheim found mixed results in his test of this implication. Specifically, in his basic Tobit results, he found that the lifetime resource effect was negative for the average childless couple, but positive and insignificant for couples with children. He finds better support for the notion that at least some portion of total life insurance demand behaves as an inferior good by conducting “refined estimates” which model total life insurance holdings as the sum of two distinct, but separately unidentifiable, processes. Based on these refined estimates, he concludes that the term part of total life insurance ownership is the component that is behaving like an inferior good.

Looking at the coefficient on PVR among widows and widowers (table 3) and among married couples (tables 4 and 5), we find no significant relationship between PVR and term life insurance. While the sign of the coefficient is negative in some of the term life insurance specifications, it is not even approaching significance at any standard level of confidence. The coefficient on PVR in the whole life insurance specifications, and as a result in some of the total life insurance specifications, is strongly positive. This latter finding is consistent with

\(^2\) The Institute for Social Research at the University of Michigan has recently signed a Memorandum of Understanding with the Social Security Administration that will permit such data to be linked with the AHEAD data at some date in the future.
Bernheim’s conclusion that term and whole life insurance respond rather differently to variation in total resources. In the AHEAD data, however, there is no evidence that term insurance is behaving like an inferior good.

4.4 Test of Implication #4: Term Insurance Owners Consume Less than Social Security Income

The fourth and final empirical implication of the annuity offset model derives from the definition of being “over-annuitized” by Social Security. The basic notion behind this model is that household bequest motives are sufficiently strong that their desired consumption level is less than the annuity provided by Social Security, and that they would therefore prefer to keep some of their wealth un-annuitized in order to leave it to their heirs.

Conceptually, this is a straightforward implication to test, since it requires the simple comparison of consumption to the income provided by Social Security. If a household is consuming more than the Social Security benefit, then they are not over-annuitized. However, this implication is difficult to test directly in the AHEAD data due to the fact that a good measure of consumption is difficult to construct with currently available data. Therefore, I will rely on less direct methods to infer the extent to which households wish to consume less than their Social Security income.

It is useful to first consider a household’s dynamic budget constraint:

\[ W_{t+1} = (W_t - C_t + SSB_t + Y_t)(1+r) \]  \hspace{1cm} (2)

where \( W_t \) represents financial wealth at period \( t \), \( C_t \) is consumption in period \( t \), \( SSB_t \) is the income flow from Social Security, and \( Y_t \) is the income flow from other (non-Social Security) sources. If it is true that individuals are over-annuitized by Social Security, it must be the case that \( SSB_t \geq C_t \). If not, then the constraint of the mandated Social Security annuity is non-binding, and needs not be offset by life insurance. Since we do not directly observe consumption
in the AHEAD survey, this test must necessarily be indirect. To be over-annuitized by Social Security requires \( SSB_t - C_t \geq 0 \). This implies:

\[
W_{t+1} - W_t (1+r) \geq Y_t
\]  

(3)

In other words, we need the amount of net saving done by a household to exceed the level of non-Social Security income that they receive during the period. That is, they must be saving some fraction of their Social Security payment in addition to all non-Social Security income. According to the annuity offset model, households that own term life insurance should be saving all non-Social Security income, and then supplementing this bequeathable savings with life insurance.

One simple way to test for this is to make use of a question asked in the first wave of the AHEAD survey:

"Not counting any money or assets that you may have given children or others, did you [and your (husband/ wife/ partner)] use up any of your investments or savings during (1992/1993) to pay for expenses?"

If households are spending down their existing non-annuitized assets in order to pay for current consumption expenses, then they must be consuming at least as much as their current _total_ income, and therefore at least as much as their Social Security income. Therefore, these individuals would have no reason to hold life insurance.

Table 6 shows that approximately one quarter of all households spend down assets in 1992/93. Importantly, the overwhelming majority of these households own life insurance, and in particular, term life insurance. In fact, the proportion of those owning term life insurance who spend down assets does not appear to be very different from the proportion of those not owning term insurance who spend down assets, for both widows and couples. Specifically, 24% of widows and 25% of couples who own term life insurance engaged in a spend-down of financial
assets. This test clearly understates the proportion of term life insurance owners who are consuming more than their Social Security benefit level, as it does not account for consumption out of non-Social Security income. If a person also has pension or investment income, for example, the individual may consume in excess of Social Security, and yet still be a net saver.

4.5 Summary of Annuity Offset Tests

All four of the major implications of the annuity offset model fail empirical testing in the AHEAD data. As a result, it seems clear that this model does not explain life insurance behavior of elderly households. This leads to the obvious next question of “what is the alternative hypothesis?” This is the subject of the next section.

5. Alternative Explanations

There are a number of plausible alternative hypotheses that could explain why elderly individuals and couples hold life insurance. These alternatives share the common feature that none of them rely on the four empirical implications of the annuity offset model. That is, these hypotheses are still quite plausible even knowing the results of Section 4. It is not the goal of this paper to conduct a definitive test to select from among these alternative hypotheses. I will, however, present some suggestive evidence to provide direction for further research. The four alternative hypotheses I discuss below include:

(i) “Couple Protection”: Elderly couples use life insurance to insure against loss of pension or Social Security benefits upon the death of the first spouse.

(ii) “Inertia”: Life insurance holdings are simply “residue” from attempts earlier in life to insure human capital.
(iii) "Estate Tax Planning": Life insurance is used to assist with estate tax planning in wealthier households, such as to provide liquidity.

(iv) "Funeral Expenses": Many elderly view life insurance as their burial money.

5.1 **Couple Protection**:

The first of these alternatives, the couple protection model, assumes that married couples are purchasing life insurance in order to re-allocate life-contingent income. For example, suppose a husband has a pension plan which is being paid out as a "joint and 50% contingent" annuity. This type of annuity treats the spouses asymmetrically. If the wife dies first, the husband continues to receive the full benefit. If the husband dies first, on the other hand, the pension income paid to the wife drops by 50%. If the couple decides that they would like to re-allocate income from the "husband only" state to the "wife only" state, one way to do this is to purchase a term life insurance policy on the husband.

The evidence on this alternative is mixed. First, it cannot explain the fact that 62% of widowers and 49% of widows hold life insurance policies. Second, Auerbach and Kotlikoff (1987, 1989) tested this model of couples using several data sets, including the RHS, and found little support for the model’s implications. Specifically, they calculated the decline in resources that a married individual would face upon the death of their spouse, and used this variable as a predictor of life insurance ownership on the spouse. They found that most households do not adequately insure spouses against the potential resource loss associated with widowhood.

On the other hand, 95% of husbands in the AHEAD sample who own term life insurance name their spouse as the policy beneficiary. If the insurance was truly being held to leave as a bequest to children, there is no obvious reason to leave the policy to the surviving spouse instead.
Further exploration of this alternative hypothesis using the AHEAD data is a possible subject of future research.

5.2 Inertia

The second alternative hypothesis is that the elderly hold life insurance while old only because they held it when they were young. This could reflect rational or irrational behavior on their part, such as the case when an individual rationally keeps a policy because it represents a good value from here on. This could be because the policy is already paid up, or because someone else is paying for the policy (e.g., a child or a former employer). For example, roughly 40% of the individuals in the AHEAD data who are covered by a term life insurance policy are currently paying no premiums. Alternatively, may have had a multi-year term policy with flat or level premiums, and therefore the policy is better than actuarially fair deal from this time forward because the individual has essentially pre-paid.

There are also non-rational reasons that one might hold onto a policy that was bought earlier in life. Samuelson & Zeckhauser (1988) provide evidence of status quo bias in decision making. They point out that most decisions, such as an elderly individual’s decision about how much life insurance to hold, has a status quo alternative of “doing nothing” or “maintaining one’s current or previous decision.” Using evidence from a series of experiments, as well as data on retirement plan choice, they show that individuals have a strong propensity to stick with the status quo. They attribute this to the presence of “transition costs or uncertainty, cognitive misperceptions, or a psychological commitment stemming from misperceived sunk costs, regret avoidance, or a drive for consistency.”

There are several pieces of evidence that suggest inertia may hold affect a significant fraction of the sample. First, data from the 1992 Life Insurance Ownership Study from the !ife
Insurance Market Research Association indicates that most policies held by the elderly are quite old. When asked the age of the newest life insurance policy held, the median response among those age 70+ was 32 years. The median age of the oldest policy was 42 years. Fully 30% of these elderly individuals bought their newest insurance policy before the age of 30, and have not purchased any additional insurance since that time. Half of those owning insurance have not bought a policy since the age of 43. It thus appears that the majority of policy owners have not purchased any insurance for many decades, at least raising the possibility that their continued ownership is due to a failure to cancel.

On the other hand, 17% of those who own life insurance bought their most recent policy since the age of 65. According to a LIMRA Buyer’s Study (1996), only 8% of all life insurance policies sold by agents to individuals age 65+ were term policies. Most of the rest were whole life policies, which are commonly used for estate planning purposes. The average size of the policies sold to those ages 65+ was $92,800, with an annual premium of $4,698. These are quite large policies compared to the average policy size found in the AHEAD data, indicating that these individuals are likely to be wealthier than average and more concerned with estate planning. While these households may well be concerned about bequests, it is highly unlikely that they would be purchasing large cash value policies in order to offset Social Security.

5.3 Estate Tax Planning

The third alternative hypothesis is that individuals hold life insurance to aid in estate planning. There are several reasons why a wealthy household that would be subject to estate taxation upon death would use life insurance as part of an estate planning strategy. First, owners of family business may wish to provide heirs with sufficient liquidity to pay for the estate taxes associated with the value of the business operation, in order to avoid the need to liquidate
business assets. This point is explored in detail by Holtz-Eakin, Phillips, and Rosen (1998). They find that, other things being the same, business owners purchase more life insurance than other individuals.

While it is undoubtedly true that some high wealth households use life insurance as an effective estate planning tool, this simply cannot explain more than a small fraction of households in the AHEAD data. Fewer than 5% of households in the data have a combined net worth and life insurance face value in excess of $600,000, which was the point at which the estate tax becomes an issue for households at the survey date.

5.4 Funeral Expenses

The fourth alternative hypothesis considered here is most consistent with a mental accounting view of behavior (Thaler, 1985). The notion is simply that many elderly individuals hold life insurance policies as “burial money.” This may explain the preponderance of small face value policies in the sample, since according to the National Funeral Directors Association, the average cost of a funeral in 1997 was $4,782. The author of a popular financial planning book tells the story of a conversation with a widow who asked him to review her finances. She was financially well off, with over $600,000 in net worth, and annual living expenses of only $30,000. When he asked her why she was carrying a term life insurance policy that was costing her several hundred dollars a month in premiums, she replied “that is to bury me” (Gardiner, 1997).

A study conducted by the Life Insurance Market Research Association confirms that life insurance is frequently purchased with the intention of using the proceeds to pay for one’s burial. 83% of widows report using life insurance proceeds of their deceased spouse primarily to pay for death-related expenses. LIMRA also reports that paying for death-related expenses is the most commonly cited reason that consumers give for purchasing life insurance.
5.5 Putting It All Together

Once we account for all the behavior that is directly inconsistent with the annuity offset model and/or potentially explained by alternative hypotheses, what fraction of households exhibit behavior that can be explained only by the desire to offset annuities? A simple running tabulation presented in Table 7 shows that it is likely to be a trivial fraction of the population – far less than the 25% figure resulting from earlier analyses.

Table 7 starts with the full population of widows and widowers in the left column, and married men in the right. As the chart shows, approximately half of all widows and 71% of married men own a life insurance policy. However, the annuity offset model is really a model of term life insurance, which means we are really concerned about the 31.5% of widows and the 41.6% of married men who own a term policy. Next we can subtract off those households which purchase a life-annuity, since these households would clearly not purchase life insurance to offset Social Security, only to turn around and annuitize additional resources. If we follow Bernheim’s lead in treating life-contingent pension annuities as a choice variable, we can further reduce the sample to only 17.7% of widows and 14.5% of married men.

Next, we can eliminate those households who are spending down their financial assets for consumption, since these individuals are also clearly not constrained by the Social Security income floor. At this point, we have 13.9% of widows and 10.7% of married men still in the pool. Now let us account for individuals whose term life insurance coverage costs them nothing. The reasoning here is that if an individual can receive a policy at zero marginal cost, then it is perfectly rational for them to keep it regardless of whether they have bequest motives or not. In any case, since they do not have to use the Social Security benefits to pay for the premium, they are not offsetting the annuity in any direct way. This leaves us with 9.2% of widows and 8.6%
of married men. Using similar logic, we can eliminate those for whom the term premium is an actuarially advantageous deal. Specifically, I exclude those whose term premium is less than half of the actuarially fair term premium of a 70-year old in 1993.

For married couples, I eliminate those who name their spouse as the beneficiary, since this means the policy may be held more for spousal protection than for bequest purposes. Finally, let us take the funeral expense notion seriously, and assume that any policy with a face value of under $5000 is essentially the individual’s “burial money.” This reduces the sample to 2% of widows and 0.5% of married men.

The calculations in Table 7 are meant to be illustrative only, and one can certainly quibble with any one of the above exclusion restrictions. These figures demonstrate, however, that one can “explain away” the finding that individuals use life insurance to offset Social Security. In short, with a few simple assumptions one can show that only a small fraction of households may over-annuitized by Social Security because they have strong bequest motives.

6. Summary & Future Directions

This paper has presented substantial evidence that the reason the elderly hold life insurance is not to offset mandated annuitization in the form of Social Security in order to leave a bequest. Four empirical implications of the annuity offset model were developed and tested, and all four were found to be inconsistent with the behavior of elderly households in the AHEAD data set.

This finding is relevant to the current debate over the future of the Social Security system because it bears upon the question of whether or not mandatory annuitization is desirable. Were it the case that a substantial fraction of elderly households were over-annuitized by the existing Social Security system due to the existence of strong bequest motives, this would be evidence in
favor of allowing choice over the annuitization decision. The results of this paper suggest that households are not over-annuitized by Social Security for bequest reasons. Therefore, the simple fact that many elderly households own term life insurance is not a sufficient reason to argue against mandatory annuitization of retirement resources. This finding is consistent with the idea that annuities are of substantial value in the retirement portfolios of elderly individuals (Mitchell, et al 1999, Brown 1999, Friedman & Warshawsky 1988). As a result, mandatory annuitization may be desirable to overcome adverse selection in the annuity market. However, this conclusion should be tempered by the acknowledgement that individuals can be over-annuitized for reasons other than bequest motives, as suggested in work by Hurd (1987 & 1989).

This paper then suggests several alternative hypotheses for explaining the large fraction of elderly households that own life insurance. While these alternatives were not subjected to formal empirical testing in this paper, informal evidence suggests that some of these alternatives may be relevant. For example, the fact that the vast majority of policies have been held for several decades suggests that many holdings may be due to inertia from insurance decisions earlier in life. This would be consistent with the “status quo bias” in decision making that has been documented by Samuelson and Zeckhauser (1988) among others. It may also be the case that many small policies are held as a method of pre-paying death expenses, such as funerals.

It has also been found that the majority of policies held by married individuals name their spouse as the beneficiary of the life insurance policy rather than their children. This is at least suggestive that the purpose of these policies may be to provide an adequate consumption stream for a widowed spouse. While this hypothesis found little support in earlier empirical work by Auerbach & Kotlikoff, they suggested that this might in part be due to the poor quality of their data. One future use of the AHEAD data could be to examine this alternative in more detail.
REFERENCES


Figure 1

Proportion of Savings and Insurance Elements in an Ordinary Whole Life Insurance Contract

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<tr>
<th></th>
<th>Widows / Widowers</th>
<th>Married Couples</th>
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Source: Author's tabulations from AHEAD survey, using household weights

Notes: Pr(Ownning ____ ) is the fraction reporting ownership of that life insurance contract type.

Amount | Own ____ is the mean or median policy size conditional on ownership.
### Table 2
Cross Ownership Patterns for Life Insurance and Annuities

Proportion of Population Holding Both Products
Married Couples: Total Household Coverage

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Source: Author's tabulations from AHEAD survey, using household weights

Proportion of Population Holding Both Products
Widows and Widowers

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Notes: Standard errors in parentheses
* Denotes significance at .01 level
** Denotes significance at .05 level

Specifications also include Indicator variables for occupation and education.
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Notes: Standard errors in parentheses
* Denotes significance at .01 level
** Denotes significance at .05 level
Specifications also include Indicator variables for occupation and education.
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Table 7
Determining Fraction of Sample Subject to Over-Annuitization Due to Bequests

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<td>FULL SAMPLE:</td>
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<td>100%</td>
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<tr>
<td>Fraction Holding Any Insurance</td>
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<td>70.7%</td>
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<tr>
<td>Fraction Holding Term Insurance</td>
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<tr>
<td>Minus Those Purchasing Private Annuity</td>
<td>29.9%</td>
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</tr>
<tr>
<td>Minus Those With Private Pension Annuity</td>
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</tr>
<tr>
<td>Minus Those Spending Down Financial Assets</td>
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</tr>
<tr>
<td>Minus Those With Zero Term Premium</td>
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<tr>
<td>Minus Those Naming Spouse as Beneficiary</td>
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<tr>
<td>Minus Policies Under $5000</td>
<td>2.0%</td>
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CHAPTER 3

Joint Life Annuities and Annuity Demand by Married Couples
Annuities play an important role in the standard theory of consumer choice when there is uncertainty about length of life. Yaari (1965) showed that an individual with a fixed stock of resources and an uncertain lifetime should purchase an annuity contract to insure against the risk of outliving his resources. More recent work has quantified the gains to annuitization for individual life-cycle consumers, and has found them to be substantial. According to the Yaari model, a typical 65-year old retired male life cycle consumer would be willing to give up roughly 1/3 of his wealth to gain access to an actuarially fair market for annuities. (Mitchell, Poterba, Warshawsky and Brown 1999, hereafter referred to as MPWB).

Two substantial strands of research have built upon Yaari's insight. First, a number of studies have observed that the market for individual annuity contracts in the United States is very small. This has resulted in attempts to explain the limited flow of new annuity purchases with factors such as adverse selection in the annuity market or individual bequest motives. Several empirical studies, including Friedman and Warshawsky (1988, 1990) and MPWB (1999), have explored the extent of adverse selection. Numerous other studies surveyed in Laitner (1997) and (more briefly) in Altonji, Hayashi, and Kotlikoff (1997) have focused on intergenerational altruism as a potential explanation for limited annuity demand. The balance of this work, which considers various explanations for intentional bequests as well as lifetime consumption profiles of those with and without children, suggests that simple altruistic models do not provide a satisfactory explanation for observed patterns of intergenerational transfers.

A second strand of research on annuities has shown that while individuals rarely purchase annuity contracts, a substantial fraction of their retirement resources is annuitized. Auerbach, Kotlikoff, and Weil (1992) show that when Social Security benefits, private defined benefit pension
plan payments, and Medicare benefits are added together, more than half of the resources of the current elderly in the United States take the form of life-contingent payouts (annuities). This provides an alternative explanation for the limited private annuity market: individuals may already be annuitized to a substantial degree.

The functioning of annuities markets has recently attracted new attention as part of the developing policy debate on pay-as-you-go, defined benefit Social Security system as opposed to an individual-accounts arrangement. A central policy design issue in this debate concerns the way a retiree would spread the resources accumulated in an individual accounts over his remaining lifetimes or that of his own life time and his spouse’s. While the treatment of married couples is an important issue in Social Security program design, virtually all of the previous research on annuities has focused on individuals rather than couples as decision-making units. This paper presents new evidence on the value of annuity contracts from the standpoint of couples, and describes the structure of joint-life annuity products that insurers currently offer.

Two previous studies have recognized the potential importance of married couples as opposed to individuals in post-retirement consumption behavior. The first, by Kotlikoff and Spivak (1981), focused on the demand for individual annuities by married individuals. This paper showed that if married individuals, or more generally those in an extended family, were able to contract to share resources over their respective lifetimes, the benefits from purchasing an individual annuity contract were smaller than those for independent individuals. The basis for this result is clear: the risk sharing within families is a partial substitute for risk sharing in an organized annuity market. Kotlikoff and Spivak (1981) did not consider the demand for joint life annuities by married couples. Moreover, subsequent empirical work, particularly Altonji, Hayashi, and Kotlikoff
(1997), casts doubt on the degree of intergenerational risk sharing within extended families.

A second related analysis is Hurd’s (1997) investigation of optimal consumption by married couples when both members of the couple face uncertainty about length of life. Hurd’s study does not consider annuity demand by married couples, but it does show how optimal consumption depends on the structure of the household utility function. Hurd’s work draws attention to the absence of clear empirical evidence on the degree of consumption complementarily among family members, and the lack of an agreed-upon framework for modeling household joint decisions.

Modeling difficulties should not obscure the key role that couples rather than single individuals are likely to play in both public and private annuity markets. In 1995, 77 percent of men over age 65 in the United States were married, as were 43 percent of women in the same age category. Most individuals are members of married couples at the beginning of their retirement years, the age at which annuity purchase is most likely. Not surprisingly, given these demographic facts, LIMRA (1997) reports that married persons buy 77 percent of all annuity contracts, and 85 percent of single-premium contracts. Single-life annuity contracts without any provisions for spouses or survivors are unusual: period certain options and joint-and-survivor annuity contracts, both of which provide some spousal protection, are much more common.

In this paper, we explore two issues related to the demand for private annuities by married couples. First, we describe the range of joint life annuity products that is currently available from insurance companies that sell annuities. We show that the range of annuity products is more complex than textbook level-premium, single-life annuities, and that these products provide married couples with asset allocation options that are simply not achievable with single-life products.
Second, we extend previous work on the gains from annuitization that individuals receive from participating in an annuity market to consider married couples. We specify a household utility function and explore the increase in household utility that takes place when the couple is able to participate in an actuarially fair market for joint annuities. This segment of our research extends the dynamic programming analysis of optimal lifetime consumption in MPWB (forthcoming) from an individual to a household. We recognize the presence of pre-existing annuity benefits such as Social Security in our calculations, and we consider a wider menu of annuity products than previous studies.

The paper is divided into four sections. The first describes the structure of joint annuity products currently available from insurance companies. Section two presents our algorithm for evaluating the utility gains associated with participating in an actuarially fair joint annuity market. Section three reports our basic results on the “annuity equivalent wealth.” We also present evidence on the sensitivity of these findings to assumptions about mortality rates and the degree of pre-existing annuitization. The fourth section concludes and suggests several further research issues.

1. The Marketplace for Joint and Survivor Annuity Contracts

Joint life annuities represent a relatively small share of the single premium immediate annuity (SPIA) market, although they account for a very large fraction of the annuities written in conjunction with defined benefit pension plans.

In the individual annuity market, data from LIMRA (1997) show that most annuity purchases are not for life-contingent payout streams. In 1996, for example, 51 percent of SPIA premiums were spent on period certain annuities – annuities in which there is no life contingency.
This fact has not been recognized in previous discussions of the size of the annuity market, and it leads to overstatement of the size of the private annuity market. In contrast, joint annuities accounted for 11 percent of SPIA premium payments. Of this 11 percent, 7 percent (64 percent of all joint annuity premiums) went to purchase joint life annuities with a “period certain” payout. Joint life annuities were only one third as important as single life annuities in the private market: 33 percent of SPIA premiums were devoted to single life annuities, with the majority (24 percent) going to single-life contracts with period certain provisions. The remaining 5 percent consisted of refund annuities, which are similar to straight life annuities except that the difference (if any) between the original premium and the total annuity payments made as of the death of the beneficiary will be paid as a death benefit to the beneficiary’s estate.

To understand the role of joint life annuity contracts, it is important to recognize that a married couple is concerned with four distinct states of the world. The first state is that in which both members of the couple are alive, and income is used to support the consumption of both spouses. Other states include those in which the wife is a widow, the husband is a widower, and the state in which both spouses are deceased. A couple who is rationally making retirement financial decisions will seek to optimally allocate their wealth across these four states. A joint annuity contract allows a couple to make their income stream contingent on which survival state they are in at a point in time.

To explain further how joint life annuities allow a couple to provide for such state-contingent consumption, we now consider the structure of joint annuity contracts in more detail. There are two primary types of joint annuity contracts. The first is a joint life annuity with a last survivor payout rule. This rule specifies a periodic payment, typically monthly or quarterly, that
the annuitants will receive provided both of them are still alive. In addition, it specifies a fraction of this payment, $\phi$, that will be paid to the survivor after the death of one member of the couple. The fraction $\phi$ is usually set at 1, 2/3, or 1/2, although LIMRA (1997) reports that insurance companies will provide virtually any fractional survivor benefit at the request of the annuity buyer. In the special case of $\phi = 1$, the annuity provides a level payout stream from the time it is purchased until the death of the surviving spouse; this is sometimes referred to simply as a “joint and survivor annuity.”

The definition of an actuarially fair joint and survivor annuity with a last survivor provision is a straightforward generalization of the definition for a single life annuity. Let $A$ denote the fixed nominal benefit that is paid as long as both members of the couple are alive, and let $S_{m,j}$ denote the probability that the husband in the annuity-purchasing couple survives for at least $j$ months after purchasing the annuity. In an analogous fashion, define $S_{f,j}$ as the $j$-period survival probability for the wife in the annuitant couple. The equation for actuarial fairness of the premium ($P$) associated with a joint and survivor annuity contract is:

$$P = \sum_{i=1}^{\infty} \frac{A \cdot S_{m,i} \cdot S_{f,i} + \phi \cdot A \cdot (S_{f,i} \cdot (1 - S_{m,i}) + S_{m,i} \cdot (1 - S_{f,i}))}{(1 + i)^i}. \quad (1)$$

We use $i$ to denote the nominal interest rate at which the insurance company discounts future payouts. One of the difficult practical questions in valuing actual annuity contracts concerns the choice of this discount rate.

The second type of joint life annuity policies is known as a “joint life policy with a contingent survivor benefit.” The key distinction between this type of policy and a last survivor policy is that the contingent benefit policy specifies one member of the couple as a primary annuitant. Provided the primary annuitant is alive, the annuity payout is $A$ per period. If the
primary annuitant predeceases the secondary annuitant, however, the payout declines to a fraction $\theta$ of the primary annuitant’s payment. If $\theta = 1$ then the contingent survivor annuity is equivalent to a last survivor annuity with $\phi = 1$, but when $\theta < 1$, the policy differs from a last survivor policy with $\phi < 1$. The key distinction is that with a contingent survivor annuity, the order in which the two annuitants die matters for the time profile of benefits, and thus the spouses are treated asymmetrically with regard to the survivor benefit.

The condition that defines an actuarially fair joint life annuity with a contingent survivor benefit, assuming for purposes of illustration that the husband is the primary annuitant, is:

$$P = \sum_{j=1}^{\infty} \left\{ A \cdot S_{m.j} + \theta \cdot A \cdot (1 - S_{m.j}) \cdot S_{f.j} \right\} / (1 + i)^j. \quad (2)$$

Contingent payout annuities are likely to be most attractive to individuals in couples with clear ideas about their relative consumption needs. Because we do not have a solid basis for specifying such consumption needs, we focus most of our analysis below on last survivor joint annuities.

Joint life annuities play a potentially important role in completing the market for life-contingent claims. Specifically, while a joint life annuity can be structured to perfectly replicate any combination of single life annuities by adjusting the survivorship ratios, the reverse is not true. That is, standard single life annuities limit the extent to which couples can allocate consumption across the four states of survival discussed above. For example, consider a couple who determines that their optimal allocation of income across states is to have either surviving spouse receive 50% of the income that the couple has while both are alive. This is easily achieved through the use of single life annuities by dividing the wealth in such a way that the annuity income generated for each spouse is equal. Purchasing a joint and 50% survivor annuity
can also achieve this.

Now consider a couple who desires that the surviving spouse not suffer any drop in income upon widowhood. A joint and full (100%) survivor annuity can generate this stream. A portfolio of individual annuities cannot replicate this income flow, however, since income contingent upon one life will, by definition, cease upon that individual’s death. It is true that in the presence of actuarially fair markets for individual annuities and life insurance, a couple could use single life annuity payments to purchase life insurance on each spouse, the proceeds of which could then be converted to an annuity flow. However, in the presence of transaction costs and actuarially unfair insurance markets, this would be an expensive way to replicate a joint life annuity. Joint life annuities with flexible survivor options avoid the need for such complex transactions.

Although joint annuities represent a small fraction of the single premium individual annuity market, they represent a substantial fraction of the annuities written in conjunction with the group annuity policies that are associated with private defined benefit pension plans. This is partly a result of legislation. ERISA, enacted in 1974, includes “Joint-and Survivor Annuity Requirements” which specify that pension plans must offer a default annuitization option that provides at least a joint and one half survivor annuity. The expected present discounted value of this option must be equal to that of a single life, individual worker annuity. Holden (1997) reports that while 48.1% of married men with pensions initiated prior to ERISA chose a survivor benefit, 63.9% of married men initiating pensions after 1974 did so. This is consistent with the view that ERISA increased the use of joint and survivor annuities. The ERISA joint-and-survivor rule was amended in the 1984 Retirement Equity Act to require a spouse’s notarized
signature when the survivor option is not selected. Prior to this amendment, the worker could select a single life annuity without the spouse's consent or notification.

The importance of pension annuities to the retired population can be illustrated with tabulations from the September 1994 Health and Pension Benefit Supplement to the Current Population Survey. In that survey, 17.4 million individuals over the age of 55 reported that they were retired from private sector jobs, and 7.2 million (41.3 percent) reported that they were receiving some annuity income from a private pension plan. The mean annuity payment for this group was $9714, and total amount of annuity income was $69.9 billion. A very substantial component of this income flow is likely to be paid as joint annuities. This importance, and the potential significance of joint annuities in proposals for individual-accounts Social Security reform proposals, is an important motivation for our interest in these insurance products.

2. The “Annuity equivalent wealth” from Access to Actuarially Fair Annuities

This section describes our approach to estimating the amount of wealth that a married couple would be prepared to forego in order to annuitize their remaining wealth holdings. Our thought experiment considers a couple with an initial stock of wealth that they can fully annuitize in an actuarially fair market for joint life annuities. We then take away access to these annuities, and calculate the incremental amount of wealth that the individual would need to achieve the same level of utility as they would have if their wealth was fully annuitized. This approach corresponds to the measure of “equivalent variation” in applied welfare analysis by finding an amount of wealth that would be equivalent in utility terms to providing access to annuitization. This method is related to the “wealth equivalence” calculations presented in MPWB (forthcoming), though that paper used a
compensating variation measure of welfare change. MPWB results suggest that a 65 year old single male with no previously annuitized income, i.e., no Social Security or pension annuities, would be willing to give up approximately one-third of his wealth in return for the opportunity to buy an annuity.¹

At the outset, we should explain two factors that create a presumption for differences in annuity valuation by individuals and married couples. First, the joint and survivor mortality curve facing a married couple differs from that facing an individual. Because the mortality experience of two members of a married couple is not perfectly correlated, the probability that at least one member of the couple will be alive any number of years into the future is always higher than the probability that a single individual will be alive. In other words, the couple’s “life expectancy” is longer than that of either individual in the couple, even if the members of the couple are of the same age. In addition, the degree of mortality risk for a couple will differ from that of an individual, due to the risk pooling that occurs within a couple.

A second factor that may lead to differences between the valuation of an annuity by an individual, and by a couple, is a difference in the time path of their respective consumption needs. In particular, the consumption needs of the couple may change when one member of the couple dies. Under well-known but restrictive conditions described, for example, in Yagi and Nishigaki (1993), an individual may find a level real consumption stream to be optimal, but there is no such guarantee for a married couple. Thus an annuity product that offered a constant payment regardless of the couple’s mortality status might be less attractive to a couple than a similar product would be to an individual.

¹ When there is no pre-existing annuity wealth, the EV measure used here is the reciprocal of the MPWB “wealth equivalence” measure. Therefore, a .67 wealth equivalence in MPWB corresponds to an annuity equivalent wealth of
To develop evidence on the wealth reduction that couples could sustain in conjunction with the opening of an annuity market, while still remaining on a given expected utility curve, we develop a model of optimal consumption by couples. This section describes the specification of the model, while the next section summarizes our principal results.

2.1 The Household Problem without Annuities

We consider a setting in which the utility of a married couple depends on the consumption of the husband \(C^m\) and the wife \(C^f\) according to an additively separable utility function given by:

\[
U(C^m, C^f) = U_m(C^m + \lambda C^f) + \varphi U_f(C^f + \lambda C^m).
\]

The parameter \(\varphi\) determines the relative weights of the husband's and wife's utility in the household utility aggregate. Kotlikoff and Spivak (1981) used a similar specification in their analysis of the gains from annuitization for married individuals. One could imagine using other utility functions to model household behavior, or allowing for within-household bargaining by husbands and wives. We will report results for the case of \(\varphi=1\), which implies that \(C^m=C^f\) at all dates when both members of the couple are alive.

The primary extension to the specification used in Kotlikoff & Spivak is that we consider complementarities in consumption, or "consumption externalities," between the two members of a couple. In particular we allow the utility of the husband to depend on \(C^m + \lambda C^f\), and we make a symmetric assumption for the utility of the wife. When \(\lambda = 0\), there is no jointness in consumption and only the husband's own consumption enters his sub-utility function (similarly

\[\text{\footnotesize 15. This means that a 50% increase in wealth would be equivalent to allowing this individual to annuitize.}\]
for the wife). When $\lambda = 1$, all consumption is joint, and the consumption needs of a surviving spouse are the same as those of the couple. Varying the degree of jointness ($\lambda$) clearly affects the utility level of the couple in all cases. In general, it also affects the value of additional annuitization. As the results will confirm, however, in the special case of log utility with equal division of consumption within the couple, the value of $\lambda$ will not matter because it can be factored out of the objective function as a constant. In the discussion that follows, we present our analytical framework assuming that $\lambda = 0$, though our numerical results will also consider varying degrees of joint consumption as well.

We assume that the household utility function is a weighted sum of the sub-utility functions for the husband and the wife. We assume that each of these sub-utility functions exhibits constant relative risk aversion, so that

$$U_m(C_r^m, C_r^f) = \frac{(C_r^m + \lambda C_r^f)^{1-\beta}}{1-\beta}$$

and

$$U_f(C_r^f, C_r^m) = \frac{(C_r^f + \lambda C_r^m)^{1-\beta}}{1-\beta}.$$  

One important simplification in our analysis is the assumption that the risk aversion parameter $\gamma$ is the same for the husband and the wife in a given household. In this case it is straightforward to show that the wife’s share of total household consumption will be $1/(1+\sigma^{-1})$. The assumption that the husband and wife have the same sub-utility functions could be relaxed in future work, although there is limited empirical work that can be used to calibrate the functions separately.

We assume that married couples attempt to maximize the expected present discounted

\[\text{expected present discounted value.} \]
value of their joint utility over their remaining lifetimes. When couples cannot purchase
annuities, and they have an initial wealth stock $W_0$, they will choose a consumption rule by
balancing the marginal utility associated with current period consumption against the expected
utility of future wealth. Formally, this gives rise to a stochastic dynamic programming problem,
in which the couple has a value function that depends on its current wealth. Because each spouse
faces some risk of dying before the next period, the specification of the value function is more
complex than in the case of a single individual choosing consumption in the face of an uncertain
lifetime.

We use $V(W_t)$ to denote the value function for a couple with wealth stock $W_t$ at time $t$,
and $\delta$ to denote the couple’s time preference rate. With respect to mortality risk, we let $q^m$
denote the one-period mortality rate for the husband, and $q^f$ the one-period mortality risk for the wife.
With probability $(1-q^m)(1-q^f)$ both members of the couple survive until the next period; in this
case, the value function at $t$ depends on the discounted value of the same value function at $t+1$. If
one member of the couple does not survive, however, then the appropriate value function for the
next period is the one-person value function for the husband or the wife. We denote these value
functions by $M()$ and $F()$ respectively, and define them as:

$$M(W_t) = \max U(C_t^m) + \frac{(1-q^m) \cdot M(W_{t+1})}{(1+\rho)}$$  \hspace{1cm} (4)

and

$$F(W_t) = \max \varphi U(C_t^f) + \frac{(1-q^f) \cdot F(W_{t+1})}{(1+\rho)}$$  \hspace{1cm} (5)

Finally, there is a probability $q^m q^f$ that neither member of the household survives until the next
period. Because we are not considering the role of bequest motives in this paper, the utility achieved in this state is zero. Combining all of these considerations yields the value function that the married couple seeks to maximize at period \( t \):

\[
V(W_t) = \max \: U_m(C_t^m + \lambda \: C_t^l) + \varphi \: U_t(C_t^m + \lambda \: C_t^m) + (1 + \rho)^t (1 - q^m)(1 - q^l) V(W_{t+1}) \\
+ (1 + \rho)^t (1 - q^m) q^m M(W_{t+1}) + (1 + \rho)^t q^l (1 - q^l) F(W_{t+1})
\]

In this expression and the similar ones that follow, we suppress the time subscripts on all of the mortality rates. Recognizing that mortality is age dependent makes the value function time- or age-dependent as well, so one would write \( V(W_t, t) \).

In the simplest case, when the household does not have any pre-existing annuity income, the household’s budget constraint consists of a non-negativity constraint on wealth at all dates, \( W_t \geq 0 \) at all \( t \), and a recursive relationship for the evolution of the wealth stock:

\[
W_{t+1} = (W_t - C_t^m - C_t^l) (1 + \tau).
\]

Finding the consumption rule that determines consumption as a function of wealth in each period is a straightforward problem. In some special cases, the optimal consumption path can be solved for analytically. In more general cases, however, it is not possible to obtain closed form solutions. We therefore rely on a numerical stochastic dynamic programming algorithm to find the optimal consumption path in the absence of annuities. We use “years” as the time period for the analysis, and we consider the optimal consumption problem, and the associated annuitization problem, for households in which the husband is age 65. We further assume that no one lives beyond age 115, so there is a fixed last period for our analysis at \( t=115 \). We apply standard discretization methods to find the optimal consumption rule as a function of wealth holdings, conditional on the set of survivors in each period.
2.2 The Household Problem with Pre-Existing Annuities

When the household receives some income from a pre-existing annuity, such as Social Security or a pension plan payout, the budget constraint changes in two important ways. First, there is an income component each period that offsets the wealth reduction associated with consumption outlays. Second, it becomes important to specify three features of the annuity flow: the amount that the household receives when both spouses are alive \( A_b \), the amount that a surviving husband would receive \( A_m \), and the amount that a surviving wife would receive \( A_f \).

The modified wealth accumulation equation is simply

\[
W_{t+1} = (W_t + A_t - C^m_t - C^f_t)(1+r)
\]

where \( A_t \) denotes the survivor-contingent annuity flow that the household receives in period \( t \). The non-negativity constraint on wealth holdings still applies. All of the value functions defined above now have additional arguments, however, because the various annuity flows that the household may receive affect the lifetime utility stream. The maximization is therefore:

\[
V(W_t; A_b, A_m, A_f) = \max U_m(C^m_t + \lambda C^f_t) + \phi U_s(C^f_t + \lambda C^m_t) + \\
(1+r)^{-t} \{(1-q^m)(1-q^f)V(W_{t+1}; A_b, A_m, A_f) + \\
(1-q^m)q^fM(W_{t+1}; A_m) + q^m(1-q^f) F(W_{t+1}; A_f)\}
\]

We assume that all annuity payments are life-contingent, so that they do not enter the bequest valuation function. Our procedure could be generalized to consider period-certain annuities, but we leave that extension for future work. While the problem specified above is substantially more complex than the simpler problem without any pre-existing annuity wealth, it can be solved using the same stochastic dynamic programming techniques.

To parameterize the pre-existing annuities that a household may have access to, we focus on
the ratio of the expected present discounted value (EPDV) of annuity income, relative to household wealth. The EPDV is given by

$$EPDV = \sum_{j=0}^{115} \left\{ A_b \cdot S_{m,j} \cdot S_{t,j} + A_f \cdot S_{t,j} \cdot (1 - S_{m,j}) + A_m \cdot S_{m,j} \cdot (1 - S_{t,j}) \right\} / (1 + r)^{t-65}. \quad (10)$$

In this expression $S_{m,j}$ denotes the probability that the husband is still alive in period $j$; analogous notation yields the survivor probability for the wife. We choose values of EPDV/W of $\frac{1}{2}$ in our calculations below: half of the wealth of the household headed by a 65-year-old takes the form of pre-existing annuities. We also attempt to allow for realistic profiles of the relative payouts to the couple and to either surviving spouse, corresponding roughly to current Social Security and private pension payouts.

2.3 The Household Problem with Access to Annuity Markets

The focus of our analysis is the change in the expected present value of utility (the change in the value function) that arises from access to an actuarially fair annuity market. We first consider the change in the value function when a household uses its wealth to purchase an annuity. In this case the household will potentially receive two annuity streams for as long as either member of the household is alive: one from the pre-existing annuity, and the second from the annuity purchased in the private market. We denote the private market annuity flows with $A'$, and again apply subscripts appropriate for the set of survivors at any moment.

Given our assumptions, when a couple purchases a private annuity, it has no remaining non-annuitized wealth at the beginning of the retirement period. The couple may, nevertheless, choose to save some of the income from annuity payouts early in the retirement period, and accumulate a wealth stock in periods following the initial annuitization decision.

The problem that the couple must now solve is given by:
\[
V(W_t; A_m, A_m', A_n, A_n', A_{m}', A_{m}', A_{t}') = \max \ U_m(C_m' + \lambda C_t') + \varphi U_r(C_r' + \lambda C_m'') + 
(1+\rho)^{-t} \{(1-q'')(1-q')V(W_{t-1}; A_m, A_m', A_n, A_n', A_{m}', A_{m}', A_{t}') + 
(1-q'')q'M(W_{t-1}; A_m, A_{m}') + q'(1-q')F(W_{t-1}; A_n, A_{n}')\}
\]

The couple maximizes this value function subject to:
\[
W_{t-1} = (W_t + A_t + A_{t-1} - C_{t-1} - C_t')(1+r).
\]

Once again, the non-negativity constraints on wealth at all dates apply to this problem.

At the beginning of retirement, when the couple has just purchased an annuity, \(W_{65} = 0\).

We assume that the relationship between the household’s age-65 wealth stock before purchasing the annuity, which we denote as \(W^{*}_{65}\), and the feasible vector of private sector annuity payouts, \(\{A_{b}, A_{m}, A_{n}, A_{t}\}\), is determined by a zero-profit condition for insurers. This implies that
\[
W^{*}_{65} = \sum_{i=65}^{115} \{A_{b, i}^{*} * S_{m, i} * S_{r, i} + A_{f, i}^{*} * S_{m, i} * (1 - S_{m, i}) + A_{m, i}^{*} * S_{m, i} * (1 - S_{r, i})\} / (1+r)^{i-65}.
\]

We consider several possible structures on annuity payouts, including a level nominal payout stream while any member of the couple is still alive, and various options with survivor payouts that are less than the payouts while both members of the couple are alive.

2.4 Utility Comparisons and the “Annuity equivalent wealth”

Our objective is to describe the utility improvement that accrues to couples when they obtain access to an actuarially fair annuity market. To do this we begin with the value of the couple’s expected lifetime utility when the husband is age 65 and has a given wealth stock that is fully annuitized. This is just the value of the value function \(V(0; A_m, A_m', A_n, A_n', A_{m}', A_{m}', A_{t}')\), where we have allowed for the possible presence of pre-existing annuities. Since annuitization, by providing access to insurance that was not otherwise available, will typically raise the couple’s utility level, the value of the value function that allows for the purchase of private
annuities will exceed the value of the value function without such annuities:

\[ V(0; A_h, A_m, A_i, A_{h'}, A_{m'}, A_{i'}) > V(W_{65}; A_h, A_m, A_i) \]  (14)

where \( W_{65}^* = W_{65} \) in the expression that determines the feasible set of \( \{A_{h'}, A_{m'}, A_{i'}\} \). There may be special cases in which the structure of payouts within the private annuity is unattractive relative to the household’s prospective consumption needs, and in such cases this inequality could be reversed if full annuitization were required. For reasonable specifications of the private annuity, however, this inequality is likely to be satisfied.

We measure the utility gain to the household by asking how much more wealth it would need to have, if it did not have access to an annuity market, to obtain the same expected utility that it would have if it did have access to an annuity market. This is just the multiple \( \alpha \) defined implicitly by:

\[ V(0; A_h, A_m, A_i, A_{h'}, A_{m'}, A_{i'}) = V(\alpha W_{65}; A_h, A_m, A_i). \]  (15)

We will present results for \( \alpha \) below, and it represents the amount of wealth that is required to make an individual as well off without annuities as with annuities. We will refer to this equivalent variation measure of the annuity value \( \alpha \) as the household’s “annuity equivalent wealth.” In other words, it is the amount of non-annuitized wealth that would be equivalent in expected utility terms to annuitizing initial wealth \( W_{65} \).

2.4 Calibration

To evaluate the annuity equivalent wealth from access to a joint annuity market, we need to specify parameters that represent inputs to the stochastic dynamic programming algorithm described above. This section discusses the three parameter values, or sets of parameter values, for which we are able to rely on previous empirical literature. Some parameters, such as the degree of
jointness in household consumption, are more difficult to calibrate based on the existing literature. In these cases, we will rely on sensitivity analysis in reporting our results.

2.4.1 Mortality Rates

One of the essential components in valuing the annuity equivalent wealth involves specifying the mortality rates facing potential annuitants. MPWB (forthcoming) explain that there are two mortality tables that could be used to value annuity payouts. The first is the population life table, which is compiled by the Social Security Administration Office of the Actuary and corresponds to the population in general. The second is an “annuitant” mortality table, which more accurately captures the mortality experience of individuals who have historically purchased annuity contracts.

In both cases it is essential to use a cohort mortality table, i.e. a mortality table that describes the mortality experience at different ages of individuals who were born in a given year. (This is distinct from a mortality table that describes the mortality risk facing individuals of different ages in a given year.) Since we are primarily interested in the annuity equivalent wealth for representative couples, we use the population cohort mortality tables in the calculations that we report below.

We noted above that a key difference between the annuitization choice for a couple and for an individual is that the joint-and-survivor mortality table differs from that for an individual. Figure 1 illustrates this point. It shows the probability that a male aged 65 will survive to various ages, the same probability for an age 65 female, as well as the probability that at least one member of a married couple, both of whom are 65, will survive to the same age. The survivor curve for the couple lies above the individual survival curves. This simply indicates that the probability of at least one member of the couple surviving to a given age is larger than that of a single individual. For example, the probability of at least one member of a 65-year-old couple living to age 80 is .86
compared with .54 for a single man. The corresponding life expectancies are 15.7 years for the male, 19.4 years for the female, and 23.1 years for the couple.

In addition to the couple survivor curve in Figure 1 lying above the individual survivor curves, it also has a different shape. Specifically, the curve is steeper in the vicinity of the life expectancy, indicating that there is less probability mass in the tails of the joint length-of-life distribution than in individual distributions. For example, the standard deviation of the life expectancy of a couple is only 7.8 years, which is lower than the standard deviation of 9 years for the male, and 9.5 years for the female. This is potentially quite important because an annuity is most valuable when there is greater uncertainty about the number of years of remaining life. While we recognize that the lower standard deviation is not a sufficient condition for the joint survival curve being less risky than the individual one in a Rothschild-Stiglitz (1970) sense, it does indicate that the degree of dispersion inherent in the two survival curves differ. As the simulations will show, individuals value annuitization more than couples, which is consistent with the notion that the joint survival curve is less risky than the individual one.

2.4.2 Risk Aversion

The second important parameter in our analysis is the coefficient of relative risk aversion, which determines the shape of the sub-utility functions for husbands and wives. A substantial literature in macroeconomics has found levels of risk aversion near unity, which corresponds to log utility (Laibson, Repetto, and Tobacman, 1998). Much higher levels of risk aversion are needed, however, to explain the large historical return premium of U.S. equities over riskless bonds (Mehra and Prescott, 1985). In addition, recent survey work (Barsky, et al, 1997) also suggests that household risk aversion levels are higher than unity. Therefore, we will consider a range of values
of risk aversion, including 1, 2, 5, and 10. As shown by Hurd (1989), if consumers are highly risk
averse they will want to guard against having to consume at a low level if they were to live long
past their life expectancy. Therefore, the household values annuitization more highly when the risk
aversion parameter $\beta$ is larger, because an annuity provides protection against this risk.

3. The Annuity Equivalent Wealth

The foregoing discussion of specification and parameterization sets the stage for our
calculations of the “annuity equivalent wealth” for joint and survivor annuities. Recall that we
are comparing the utility level that a married couple achieves when it uses its wealth to purchase
an actuarially fair joint and survivor annuity with the utility level associated with no purchase of
such an annuity.

Many different parameter values affect our findings, so we begin our analysis with a base
case of a 65-year old male with a 62-year old wife that experience no consumption
complementarities between them ($\lambda=0$). The three-year difference in the age of the husband and
wife is consistent with U.S. experience according to Social Security actuaries. We will then
explore the sensitivity of the value of annuitization to different levels of risk aversion,
assumptions about the presence of pre-existing annuities, the structure of survivor benefits, and
the age of the husband and wife.

Table 1 presents the results for our “base case couple.” There are three main parameter
choices that are explored for this representative couple. The columns of the table represent
alternative assumptions about the ratio of survivor annuity income to the income received by the
couple when both are alive for the privately purchased annuity, or the parameter $\phi$ from equation
1. We consider the three most common survivor benefit ratios of 1/2, 2/3, and 1.

Previous research on single individuals suggests that the utility gain associated with annuitization depends on whether an individual has any pre-existing annuity wealth, or whether the annuity market is providing the first opportunity to obtain any resources that provide longevity insurance. In the context of couples, we must also consider how the income from any pre-existing annuity changes upon the death of one spouse. We therefore consider three different scenarios. The top panel of Table 1 corresponds to the case in which no wealth is in a pre-existing annuity. The middle panel assumes the couple begins with half their wealth in a pre-existing real annuity that pays a survivor benefit equal to one-half of the couple benefit. This is a stylized representation of the case in which both members of a couple are entitled to equal Social Security benefits, and have half their wealth in Social Security. Upon the death of the first spouse, the survivor will continue to receive only his or her own worker benefit. In the bottom panel, we again assume that half of wealth is pre-annuitized, but offers a survivor payout equal to 2/3 of the couple benefit. This corresponds to a stylized case in which the couple’s Social Security benefit consists of a primary worker benefit plus an additional 50% in dependent benefits. Upon the death of one spouse, the Social Security benefit drops to 2/3 of the level the couple received.

Within each panel in Table 1, we consider four different levels of risk aversion, including a relative risk aversion coefficient of 1 (corresponding to log utility), 2, 5, and 10. In the case of single individuals, higher levels of risk aversion have been shown to lead to higher valuation of annuities.

The results in the first panel of Table 1 provide an illustration of our findings. When the
actuarially fair private annuity contract offers a 50 percent survivor's benefit, our base case
couple with a log utility function would find access to annuitization equivalent to a 17.5 percent
increment to their non-annuitized wealth. Increasing risk aversion from 1 to 2 raises the required
wealth increment to 24.4 percent. The final column of Table 1 provides a comparison to the case
of a single male, age 65, who maximizes an individual utility function and who does not have
opportunities to pool risk within a marriage. For all levels of risk aversion, the annuity
equivalent wealth for couples is significantly lower than that for single individuals. This
illustrates that the joint mortality curve differs from the single-life mortality curve in a way that
reduces the value of longevity insurance. Similar comparisons using other parameter values
generate similar findings. The difference between individual annuity valuation, and annuity
valuation by a married couple, is partly explained by the fact that risk sharing takes place within
couples. If one member of the couple lives an unexpectedly long life, there is some probability
of inheriting the remaining resources of an earlier-to-die spouse. This provides some mortality
insurance, even without a formal annuity contract.

The second and third columns of the top panel show the annuity equivalent wealth to
annuitization when we alter the survivor ratio on the private annuity. All of the annuities that we
consider provide a constant nominal payout stream, so different survivor payout structures partly
affect the degree to which real benefits decline over time. In this case of no consumption
complementarities, the survivor ratio of 0.67 provides the highest annuity valuation for most
levels of risk aversion, though 0.5 is preferred for a risk aversion coefficient of 10. As can be
seen, full survivor benefits are not optimal for any level of risk aversion. This is because upon
the death of the first spouse, the income required to provide each individual with a given level of
consumption declines. Providing full survivor benefits places too much income in the state of widowhood, at the expense of lowering consumption in the state in which both spouses are alive.

The results in the lower two panels of Table 1 indicate how these findings are modified when the household has access to a pre-existing annuitized income stream. We think of this as Social Security or the benefits from a defined contribution pension plan. We assume that the pre-existing annuity benefit is indexed to inflation. Comparing the results to the top panel, we see that the couple’s annuity equivalent wealth declines when half of its wealth is already annuitized. The required wealth increment that we report when the household has some pre-existing annuity income is the fraction of non-annuitized wealth that the coupled would require to be made as well off as if they could fully annuitize. For all levels of risk aversion, and for all combinations of survivor benefits, the annuity equivalent wealth is lower when the household has some wealth pre-annuitized. This suggests that pre-existing annuities reduce the demand for additional annuities.

Table 2 explores the sensitivity of the results to alternative assumptions about the degree of “jointness” in consumption. This table continues with our base case couple that consists of a 65-year old male and a 62-year old female, but it now allows the consumption complementarities parameter λ to vary. The first column again reports results for the case of no jointness, or λ=0. The second column assumes that half of all consumption is joint (λ=.5) and the third column assumes complete jointness in consumption (λ=1).

The jointness parameter λ does not affect the annuity equivalent wealth in the case of log utility, so Table 2 reports results for risk aversion values of 2, 5, and 10. We restrict our attention to the case of no pre-existing annuities in order to make clearer the effect of the private
annuity survivor ratio. We vary the survivor ratio on the privately purchased nominal annuity from 0.4 to 1.0 in increments of 0.1.

The jointness parameter clearly effects the desired survivor ratio. In the case of no consumption externalities, a survivor benefit ratio of 0.6 is preferred to the other ratios considered for all levels of risk aversion examined. The preferred survivor ratio rises with the jointness parameter, with full survivor benefits being preferred in the case of full consumption externalities ($\lambda=1$). Full jointness means that a surviving spouse needs just as much income as a widow to maintain the level of consumption as she had when her husband was alive. Said differently, when there is full jointness in consumption, two can consume for the price of one. Therefore, the death of a spouse does not reduce a household’s expenses. Therefore, survivor benefits are more attractive when there are positive consumption externalities within a couple.

Table 3 explores the effect of the age of the husband and wife on the value of annuitization. Results are presented for two levels of risk aversion, 1 and 5. Results also assume that $\lambda=0$, and that the privately purchased annuity has a survivors ratio of 0.67. We present results both for the case of no pre-existing annuity wealth, and for the case in which half of wealth is pre-annuitized with a survivor ratio of 0.5.

The results of this table are clear. The annuity equivalent wealth increases with the age of either spouse. Gaining access to annuities for two 70 year olds with log utility and no pre-existing annuities is equivalent to a 24.2% increase in their wealth, compared to only 11.7% for two 55 year olds. These age effects arise due to differences in mortality risk faced by the individuals. The simplest way to view the effect is that the rate of return on an actuarially fair annuity consists of a mortality premium that is a function of the mortality hazard. Older couples
face higher mortality probabilities, and thus have more to gain from annuitization than do younger couples.

4. Conclusions and Future Directions

This paper presents new results on the market for joint annuities and on the utility gains available to married couples who are able to participate in actuarially fair annuity markets. A couple consisting of a 65 year old man and a 62 year old woman find access to actuarially fair joint and survivor annuities roughly equivalent to an 18% increase in non-annuitized wealth, assuming log utility. Their valuation of annuities is even higher if risk aversion is higher or if the spouses are older at the date of annuitization. We also find that pre-existing annuity wealth reduces the demand for additional annuitization.

These findings should be contrasted with the estimates of the expected present discounted value (EPDV) of joint and survivor annuity payouts in Mitchell, Poterba, Warshawsky, and Brown (1999). Those estimates suggested that for a 65 year old couple, the EPDV of the average annuity in the marketplace is 84 percent of its initial premium. Because couples find annuities less valuable than single individuals, couples may find that these “load factors” in the private marketplace are significant enough to deter them from annuitizing their resources. Given the importance of married couples in the population age groups that are most likely annuity buyers, this may help to explain the rather limited size of the annuity market.

One of the important issues that we have not considered is the possible relationship between mortality risk of married individuals. Frees, Carriere, and Valdez (1996) document a “broken heart effect” in the mortality of married couples: conditional on the death of one spouse, the mortality risk of the surviving spouse rises. Their calculations suggest that this effect reduces
the expected discounted value of joint and survivor annuity payouts by about five percent relative to what they would be without this effect.

A second issue that we have not considered is the impact of bequest motives on the demand for joint and survivor annuities. To the extent that couples value wealth that is left behind to their heirs, this may lessen the value of annuitization. Jousten (1998) discusses in detail how one can model the utility of gifts and bequests for the case of an individual life-cycle consumer. This analysis can be extended to the couples’ context, though is not undertaken here because there is remarkably little empirical guidance regarding the parameterization of the utility of bequest function. One study which has estimated the necessary utility parameters for a bequest motive (Hurd 1987), estimated it for individuals and found the marginal utility of bequests to be statistically no different from zero. Further work exploring the impact of bequests in a couple’s context is left for future research.

A third issue for further study concerns the nature of the utility functions for men and women in married couples. This is important issue about which empirical work offers relatively little guidance. There is some evidence, for example from asset allocation patterns in defined benefit plans, that women are more conservative investors than men. If this reflects higher risk aversion, then it may be appropriate to modify our assumption that men and women have the same preferences, and hence sub-utility functions, in our analysis.

A final issue that is not explored in this paper is the potentially important role of medical expense uncertainty and its impact on annuity valuation. If couples are concerned about the risk of future uninsured medical expenses (e.g., long-term care), precautionary savings motives could make them less likely to annuitize their resources. This will be the subject of future research.
REFERENCES


Economics Department, Cambridge MA.


TABLE 1
Annuity Equivalent Wealth
65 Year Old Husband, 62 Year Old Wife
(No Consumption Complementarities)

<table>
<thead>
<tr>
<th>CRRA</th>
<th>0.5</th>
<th>0.67</th>
<th>1.0</th>
<th>65 Year Old Single Male’s Gain from Single Life Annuity</th>
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**TABLE 3**
Effect of Age Differentials on a Couple’s Annuity Equivalent Wealth  
(No Consumption Complementarities)

| CRRA = 1 | Privately Purchased Annuity  
with Survivor Ratio = 0.67 | Age of Husband |
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<td>70</td>
<td>.168</td>
<td>.193</td>
<td>.217</td>
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</table>
| Half of Wealth Pre-Annuitized  
with Survivor Ratio = 0.5 | | | | |
| Wife’s Age: | | | | |
| 55 | .070 | .082 | .094 | .103 |
| 60 | .082 | .095 | .105 | .118 |
| 65 | .094 | .104 | .118 | .132 |
| 70 | .103 | .117 | .131 | .146 |

| CRRA = 5 | Privately Purchased Annuity  
with Survivor Ratio = 0.67 | Age of Husband |
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<td>.374</td>
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| Half of Wealth Pre-Annuitized  
with Survivor Ratio = 0.5 | | | | |
| Wife’s Age: | | | | |
| 55 | .161 | .178 | .184 | .193 |
| 60 | .181 | .193 | .216 | .252 |
| 65 | .193 | .221 | .265 | .291 |
| 70 | .215 | .265 | .294 | .326 |
Figure 1: Individual and Joint Survival

- Male 65
- Female 65
- Joint 65/65

Prob(Survival) vs. Time

1 5 9 13 17 21 25 29 33 37 41 45 49 53
CHAPTER 4

The Role of Real Annuities and Indexed Bonds in an Individual Accounts Retirement Program
"It is better to have a permanent income than to be fascinating."
- Oscar Wilde, *The Model Millionaire: A Note of Admiration*

The current U.S. Social Security system provides retirees with a real annuity during their retirement years. After a worker’s Primary Insurance Amount has been determined at the date of retirement, the purchasing power of Social Security benefits remains fixed for the balance of the individual’s life. This is accomplished by indexing retirement benefits to annual changes in the Consumer Price Index (CPI). Retirees are therefore insulated from inflation risk, at least as long as their consumption bundle is not too different from the bundle used to compute the CPI.

Several current reform plans propose to supplement, or partially replace, the existing defined-benefit Social Security system with mandatory individual defined contribution accounts. These plans are discussed in Gramlich (1996), Mitchell, Myers and Young (1999), and NASI (1998). In most “individual account” plans, retirees would be required to purchase an annuity with all or part of their accumulated account balances. Yet the existing market for individual annuities in the United States is small, the expected present value of annuity payouts is typically below the purchase price of the annuity, and virtually all annuities currently available offer nominal rather than real payout streams. This has led some to argue that individual account plans would expose retirees to inflation risk that they do not currently face, in that they might purchase nominal annuities with their accumulated funds.

In this paper, we explore four issues concerning real annuities, nominal annuities, and the inflation risks faced by prospective retirees, all of which are relevant to the prospects for individual accounts under Social Security reform. We begin by describing the annuity market in the United Kingdom. Annuitants in the U.K. can select from a wide range of both real and nominal annuity products. The U.K. annuity market demonstrates the feasibility of offering real
annuities in the private marketplace. Moreover, the current U.K. annuity market may indicate the direction in which the U.S. annuity market will evolve, since indexed bonds promising a fixed real return to investors have been available in the U.K. for nearly two decades. The availability of such bonds has made it possible for U.K. insurers to offer real annuity products without bearing inflation risk. Similar bonds have been available in the United States for only two years. Our evaluation of the U.K. annuity market includes an analysis of the relative prices of both real and nominal annuities, and we present estimates of how much a potential annuitant must pay to purchase the inflation insurance provided by a real annuity.

Next we turn to the annuity market in the United States and investigate the availability of real annuities in this country. In early 1997 the U.S. government introduced Treasury Inflation Protection Securities (TIPS) and since then, two products that might be described as “inflation indexed annuities” have come to market. One, offered by Irish Life Company of North America (ILONA), promises a constant purchasing power stream of benefits. Though this product offers buyers a real stream of annuity payouts, to date it has not been a commercial success. The second, offered by TIAA-CREF, is a variable payout annuity with payouts linked to returns on the CREF Index-Linked Bond Account. We describe the operation of the latter account in some detail, and explain why in practice the TIAA-CREF variable annuity proves not be an inflation-indexed annuity. Hence our analysis of these two products leads us to conclude that there are no commercially significant real annuities available in the U.S. annuity market at the present time.

We then consider whether a retiree could use a portfolio of stocks or bonds, in lieu of a portfolio of indexed bonds, to hedge long-term inflation risk. Specifically, we evaluate how much inflation risk annuitants would bear if, instead of purchasing nominal annuities, they purchased variable payout annuities with payouts linked to various asset portfolios. We assess
the potential inflation protection provided by different variable payout annuities using historical correlation patterns between inflation and nominal returns on stocks, bonds, and bills.

The final portion of the analysis explores the expected utility consequences of annuitizing retirement resources in alternative ways. A stylized model is used to calculate the expected lifetime utility of a retiree who could purchase a nominal annuity, a real annuity, and a variable-payout equity-linked annuity. In the first and third cases, the retiree would bear some inflation risk. We calibrate this model using available estimates of risk aversion, mortality risks, and the stochastic structure of real returns on corporate stock. Our results suggest that for plausible values of risk aversion, retirees would not pay very much for the opportunity to purchase a real rather than a nominal annuity. This finding is sensitive, however, to assumptions regarding the stochastic process for inflation. Very high expected inflation rates, or very high levels of inflation variability, can reverse this conclusion.

We also find that a variable payout annuity, with payouts linked to the returns on a portfolio of common stocks, is more attractive than a real annuity for consumers with modest risk aversion. This result rests on assumptions about the expected return on stocks relative to riskless assets and hence must be viewed with some caution, since there is substantial prospective uncertainty about expected stock returns. The finding nevertheless illustrates the potentially important role of variable payout annuities as devices for annuitizing assets from individual accounts.

The paper is divided into five sections. Section one presents our findings on the real and nominal annuity markets in the United Kingdom. The next section describes two “inflation linked annuities” offered in the United States. Section three reports our findings on the correlation between unexpected inflation and real returns on various financial assets and
summarizes previous research on this relationship. This section also presents evidence on the *ex post* real payout streams that would have been paid to retirees had they purchased variable payout annuities at different dates over the last seventy years. The fourth section outlines our algorithm for evaluating the utility benefits of access to various types of annuity products. We link this work with the rapidly growing literature on lifetime portfolio allocation in the presence of risky asset market returns and uncertain inflation. In a brief concluding section we sketch directions for future work.

1. **The Market for Real Annuities in the United Kingdom**

   We begin our analysis by describing the real annuity market in the United Kingdom, since it provides important evidence on both the feasibility of providing real annuities through private insurers as well as the consumer costs of buying inflation insurance. We then calculate the expected present discounted value of payouts on real and nominal annuities currently available in the U.K.

1.1 **The Current Structure of the U.K. Annuity Market**

   Annuities providing a constant real payout stream are widely available in the United Kingdom. This is partly due to the fact that government-issued indexed bonds have been available in the U.K. for nearly two decades. Insurance companies holding these bonds can largely hedge the price level risk that is associated with offering annuity payouts denominated in real rather than in nominal terms. (Payouts on indexed bonds in the U.K. adjust to past inflation with a lag, which results in some residual price level exposure for insurance companies offering
real annuities.) Blake (1999) reports that insurers offering nominal annuities typically back them by holding nominal government bonds, while those offering real annuities hold indexed bonds.

There are two segments of the individual annuity market in the United Kingdom, defined according to where funds used to purchase the annuity have been accumulated. One market segment involves annuities purchased with tax-qualified retirement funds, while the other segment is focused on annuities purchased outside such plans. Qualified retirement plans in Britain include defined benefit occupational pension schemes and “personal pension plans” (PPPs). Most occupational plans are defined benefit plans, and the annuities that are paid out to their beneficiaries are not purchased in the individual annuity market. PPPs, available since 1988, are retirement saving plans that are broadly similar to Individual Retirement Accounts in the United States. (Prior to 1988, a similar type of plan was available only to self-employed individuals.) Contributions to PPPs are tax-deductible, and income on the assets held in such plans is not taxed until the funds are withdrawn. Budd and Campbell (1998) report that in the early 1990s, roughly one quarter of U.K. workers participated in a personal pension plan. These plans are likely to account for most of the purchases of qualified annuities, since defined contribution plans constitute a minority of U.K. occupational pensions.

Those who reach retirement age with assets in a defined contribution occupational pension, or with assets in a personal pension plan, are legally required to annuitize at least part of their pension accumulation. For this reason, the U.K. market for annuities purchased with funds from qualified pension plans is known as the “compulsory annuity market.” In recent years there has been some relaxation of the rules requiring annuitization. Currently, a retiree can withdraw up to one quarter of a personal pension plan accumulation as a lump sum distribution, and assets can be held in the PPP up to age 75 before they must be annuitized.
The U.K. annuity market also includes a second segment, which contains voluntarily purchased annuities. This is known as the "noncompulsory" market. In this second market segment, funds accumulated outside of qualified retirement plans are used to purchase annuity products.

The demographic characteristics and mortality prospects of annuity buyers in the compulsory and non-compulsory markets are likely to differ. The set of people that purchases annuities in the voluntary market is likely to have better mortality prospects (i.e. longer life expectancies) than the U.K. population at large. In addition, workers with PPPs or who covered by defined contribution occupational plans are probably not a random subset of the population. They may also have better longevity prospects than those of the population at large. Finkelstein and Poterba (1999) compare the U.K. compulsory and non-compulsory annuity markets and show that payouts as a fraction of premiums are somewhat lower in the non-compulsory market than in the compulsory market. This finding is consistent with the view that adverse selection among annuitants receiving employer pensions is less substantial than adverse selection among people buying individual annuities outside a retirement plan. Our analysis focuses on annuities offered in the "compulsory annuity" marketplace.

The compulsory annuitization requirement for Personal Pension Plans has created a substantial group of retirement-age individuals in the U.K. who must purchase an annuity. To service their needs, annuity brokers exist to help retirees obtain quotes on annuity products. We contacted several of these brokers and requested data on U.K. annuity prices and the terms of annuity contracts. We obtained data from a number of firms. While we have not established precisely how much of the annuity market our sample firms cover, our sample of insurance companies appears to include most of the major annuity providers.
To focus the discussion we restrict our attention to nominal and inflation-linked single life annuity products. Here the term *nominal* is used to refer to values denominated in current pounds (or dollars), while *real* refers to inflation-corrected pounds or dollars. We analyzed products offered by nine insurance companies offering Retail Price Index (RPI)-linked single life annuity policies, and fourteen companies offering nominal single-life products. (By comparison, there are nearly one hundred insurance companies offering individual annuity products in the United States, according to A.M. Best’s surveys.) We do not consider “graded” nominal annuity policies that offer a rising stream of nominal benefits over the life of the annuitant, with a pre-specified nominal escalation rate. Graded annuities provide annuitants with a way of backloading the real value of payouts from their annuities, but they do not insure against inflation fluctuations as real annuities do. We focus our attention on policies that were available in late August, 1998, and we consider annuities with a £100,000 purchase price (premium).

Table 1 reports mean monthly payouts for both nominal and RPI-linked annuities for the firms in our sample. The first two columns show the sample average payout for each type of annuity. They indicate that the first-month payout on a real annuity is between 25 and 30 percent lower than the first-month payout on a nominal annuity. This reduction in initial benefits is sometimes cited as the reason some consumers shy away from indexed annuities. The data also indicate differences in the ratio of nominal to real annuity payouts across age groups (real annuities are priced more favorably with rising age), and between men and women (real annuities are priced more favorably for men). These presumably reflect mortality-related differences in the expected duration of payouts under different annuity contracts.
We also see substantial variation in the annuity benefits paid by the different insurers, as was previously found for the U.S. annuity market by Mitchell, Poterba, Warshawsky, and Brown (hereafter MPWB) (1999). The third and fourth columns of Table 1 report the coefficient of variation for monthly annuity payouts in both markets; here we see that the pricing of indexed annuities varies more than that of nominal annuities. For five of the six “products” defined by age and gender of buyer, the coefficient of variation is greater for the real than for the nominal annuity. This may be due to the fact that the effective duration of a real annuity is longer than that of a nominal annuity, so that the insurer’s cost of providing a real annuity is more sensitive to future developments in mortality patterns. Explaining the observed price dispersion in annuity markets is an important task for future research.

1.2 Evaluating the “Money’s Worth” of Nominal and Real Annuities

To evaluate the administrative and other costs associated with the individual annuities offered in the U.K. market, we compute the expected present discounted value (EPDV) of payouts for the average nominal and the average index-linked annuity. We compare this EPDV with the premium cost of the annuity to obtain a measure of the “money’s worth” of the individual annuity. Similar measures are available for annuities offered in the United States; Warshawsky (1988) reports calculations for the period from 1920 to the early 1980s, MPWB (1999) examine data through 1995, and Poterba and Warshawsky (1998) offer results for mid-1998.

The formula used to calculate the EPDV of a nominal annuity with a monthly payout $A_n$, purchased by an individual of age $b$, is:
\[ V_b(A_n) = \sum_{j=1}^{12 \times (115-b)} \frac{A_n \times P_j}{\prod_{k=1}^{j} (1 + i_k)}. \]

We assume that no annuity buyer lives beyond age 115 and we truncate the annuity calculation after \(12 \times (115-b)\) months. \(P_j\) denotes the probability that an individual of age \(b\) years at the time of the annuity purchase survives for at least \(j\) months after buying the annuity. The variable \(i_k\) denotes the one-month nominal interest rate \(k\) months after the annuity purchase.

For a real annuity, equation (1) must be modified to recognize that the amount of the payout is time-varying in nominal terms but fixed in real terms. The easiest way to handle this is to allow \(A_r\) to denote the real monthly payout, and to replace the nominal interest rates in the denominator of (1) with corresponding real interest rates. We use \(r_k\) to denote the one-month real interest rate \(k\) months after the annuity purchase. Such real interest rates can be constructed from the U.K. yield curve for index-linked Treasury securities. The expression that we evaluate to compute the EPDV of a real annuity is:

\[ V_b(A_r) = \sum_{j=1}^{12 \times (115-b)} \frac{A_r \times P_j}{\prod_{k=1}^{j} (1 + r_k)}. \]

We evaluate (1) and (2) using projected survival probabilities for the U.K. population as a whole. These mortality probabilities are compiled by H.M. Treasury. We use cohort mortality tables for those who reached age 60, 65, or 70 in 1998. We were not able to obtain mortality tables corresponding to the annuitant population. By using population mortality tables, we are in effect asking what the EPDV of the average annuity would be when viewed from the perspective of an average individual in the population. Of course, the average annuity buyer has a longer life expectancy than the average person in the population. Since a real annuity offers larger payouts near the end of life than a nominal annuity does, using a population rather than an annuitant
mortality table overstates the effective cost of purchasing an inflation-indexed annuity relative to a nominal annuity.

Table 2 reports EPDV calculations for single life annuities for men and women of different ages in the compulsory U.K. annuity market. Results for the average annuity payout are given as a simple average across the firms in our sample. We also provide the EPDV using average payouts for the three highest and three lowest annuity payout firms in our sample. The results show that the cost of buying an inflation-protected annuity in the United Kingdom is about five percent of the annuity premium. In addition, we find that the EPDV of a nominal annuity contract purchased in conjunction with a qualified retirement saving plan is five percent higher than that for a real annuity. While the EPDV for nominal annuities is approximately 90 percent of the premium cost, the analogous EPDV for real annuities is about 85 percent. This difference in EPDVs might explain Diamond’s (1997) claim that most annuitants in the United Kingdom elect nominal rather than real annuities.

Some of the apparent “cost” of inflation protection may arise from adverse selection across various types of annuities. If annuitants who anticipate that they will live much longer than the average annuitant tend to purchase real annuities, because their real payout stream is backloaded, then mortality rates for those who buy real annuities may be lower than those for nominal annuity buyers. We do not know whether such mortality differences actually explain the payout differences between nominal and real annuities.

Our estimates of the expected present discounted value of nominal annuity payouts in the U.K. are somewhat higher than analogous estimates for nominal annuity products in the United States at roughly the same date. For example, in 1998, Poterba and Warshawsky (1998) report that the average EPDV on U.S. nominal annuity contracts available to 65-year-old men (using
the population mortality table) was 84 percent for annuities purchased through qualified retirement saving plans. The lower U.S. payout may reflect differences in the degree of mortality selection, relative to the population as a whole, in the “qualified” (U.S.) and “compulsory” (U.K.) annuity markets.

Table 2 also suggests that there are systematic patterns in the money’s worth values across age groups for both nominal and real annuities in the U.K. market. The EPDV declines as a function of the annuitant’s age at the time the annuity is purchased. One possible explanation for this pattern may be that those who retire later tend to have lower mortality rates than those who retire earlier. Age at retirement and age at annuity purchase may be linked more closely in the compulsory annuity market than in the non-compulsory market. We suspect that many compulsory annuity buyers purchase their annuities when they retire, even though current U.K. rules do not require such purchases.

The results in Table 2 indicate that for a retiree of given age/sex characteristics there is frequently a ten percent difference between the average annuity payout from the firms offering the highest payout annuities and those offering the lowest payouts. Such dispersion is consistent with earlier evidence, such as MPWB (1999), suggesting substantial pricing differences in the U.S. market for nominal annuities. This price dispersion raises the question of how potential annuitants choose among the various annuity products. In the U.S. case, MPWB (1999) report little correlation between factors such as the credit rating of the insurance company offering the annuity and the level of the annuity's payout.

In sum, we draw two lessons from the widespread availability of index-linked annuities the U.K. annuity market. The first is that it is possible for private insurers to develop and offer real annuity products. This is surely easier in a nation with a well-developed market for index-
linked bonds. The second lesson is that, based on the current prices of nominal and real annuities, the costs of obtaining inflation insurance are less than five percent of the purchase price of a nominal annuity contract.

2. Real Annuities in the United States: TIAA-CREF and ILONA

The U.S. individual annuity market differs from that in the U.K. in that virtually all annuity products are nominal annuities. Individuals can purchase a variety of products with a graded payout structure, so that the nominal value of their payouts (and, for low enough inflation rates, the real value of payouts) is expected to rise over time. There are only two annuity products that we are aware of that promise some degree of inflation protection. The first is the "Freedom CPI Indexed Income Annuity," offered by the Irish Life Company of North America (ILONA), and the second is the "Inflation Linked Bond Account" annuity, offered by TIAA-CREF. In this section we describe how these products work, their current prices and payouts, and the degree to which they provide inflation protection for annuity buyers. We also note that since Treasury Inflation Protection Securities (TIPS) were introduced to the U.S. market only recently, additional insurers may offer real annuities as familiarity with these new assets grows. Insurance companies can hedge the inflation risk associated with these price level indexed annuity products by purchasing TIPS bonds.

2.1 The ILONA Real Annuity

Irish Life PLC, an international insurance firm headquartered in Dublin, Ireland, offers index-linked annuities in the United States through the Interstate Assurance Company, which is a division of Irish Life of North America (ILONA). Interstate is a well-regarded company: it had assets of $1.3 billion and it received a AA rating from Duff and Phelps, an A rating from A.M.
Best and Company, and a AA- rating from Standard and Poors in 1996. The indexed annuity product from ILONA is the “Freedom CPI Indexed Income Annuity.” The annuity payout rises annually in step with the increase in the prior year’s CPI. Annuity benefits from the Freedom CPI Indexed Income Annuity cannot decline in nominal terms, even if the CPI were to fall from year to year. The minimum purchase requirement for the ILONA annuity product is $10,000, and the maximum purchase is $1 million. The annuity is available to individuals between the ages of 65 and 85. There are various payout options, including simple life annuities, annuities that provide a fixed numbers of years of payouts for certain, and “refund annuities.” These annuity products are available both as individual and as joint and survivor annuities. Although ILONA offers this real annuity product in the US, the agent whom we contacted indicated that thus far no sales of these annuities have been recorded.

Data were obtained on the monthly payouts offered by ILONA’s indexed and nominal single premium immediate annuities for men and women age 65, 70, and 75, assuming a premium of $1 million in each case. We also obtained data on joint-and-survivor annuities with 100 percent survivor benefits. Policies purchased in mid-1998 offered a monthly payout on a real annuity at the start of the annuity contract about 30 percent smaller than the payout on a nominal annuity issued to the same individual. Table 3 shows that for men at age 65, the ratio of real to nominal payouts is 69 percent. For women at 65, the ratio is 66 percent, potentially reflecting the longer life expectancy and therefore greater back-loading that occurs with a real rather than a nominal annuity for women rather than for men.

To determine the payouts relative to premium cost for these annuities, we calculate the EPDV of annuity payouts for each of the ILONA policies quoted using a procedure similar to that described above. Interest and mortality rates differ somewhat relative to the U.K.
calculations. For discount factors in our EPDV calculations, we use the nominal yield curve for zero-coupon U.S. Treasury bonds. We start from the term structure of yields for zero-coupon Treasury "strips," and work out the pattern of monthly interest rates implied by these yields under the simple expectations theory of the term structure. Data on the zero-coupon yield curve are published in the Wall Street Journal, and we use information from the beginning of June 1998. Because we do not know the precise date at which ILONA offered the annuities we are pricing, and in light of the absence of transactions in this annuity market, we select the term structure for the first week of June 1998 as an approximate guide to discount rates in mid-1998. When evaluating the EPDV of the ILONA real annuity, we use the implied short-term real interest rates that can be derived from the term structure of real interest rates on TIPS in early June 1998.

With regard to survival patterns, we have access to two distinct mortality tables for the U.S. The first, developed by the Social Security Administration’s Office of the Actuary and reported in Bell, Wade, and Goss (1992), applies to the entire population. We update this mortality table to reflect the prospective mortality rates of a 65-year old (or 70- or 75-year old) purchasing an annuity in 1998. For example, in estimating the money’s worth of an annuity for a 65 year old in 1998, we use the projected mortality experience of the 1933 birth cohort. A second set of projected mortality rates corresponds to that relevant to current annuitants. MPWB (1999) develop an algorithm that combines information from the Annuity 2000 mortality table, described in Johansen (1996), the older 1983 Individual Annuitant Mortality table, and the projected rate of mortality improvement implicit in the difference between the Social Security Administration’s cohort and period mortality tables for the population. This algorithm generates projected mortality rates for the set of annuitants purchasing annuity contracts in a given year. It
is worth noting that the population and annuitant mortality rates differ. For instance, MPWB (1999) report that the 1995 annual mortality rate for annuitants age 65-75 was roughly half that for the general population. This mortality differential generates a substantially larger EPDV of annuity payouts with the annuitant rather than the population mortality table.

Table 4 reports EPDV calculations for Irish Life real and nominal annuities. (All EPDV calculations use pretax annuity payouts and before-tax interest rates. MPWB (1999) show that pre-tax and post-tax EPDV calculations for U.S. nominal annuities yield similar results.). For nominal annuities valued using the population mortality table, the expected present discounted value of payouts for men is approximately 85 cents per premium dollar and 89 cents for women. These values are slightly higher than the average EPDV values based on nominal annuities described in A.M. Best’s annuity survey of June 1998, as reported in Poterba and Warshawsky (1998). Using the annuitant mortality table for nominal annuities, the EPDV is larger: approximately 98 cents per premium dollar for men and 97 cents for women.

We next turn to EPDV results for the ILONA real annuity, and we see that the value per dollar of premium is much lower than for the nominal annuity. For instance, a 65-year-old man purchasing a real annuity would expect an EPDV of 70 percent, versus 86 percent for the nominal annuity. At other ages a similar pattern applies: the money’s worth for real annuity products is typically 15-20 percent lower than that for nominal annuities. The fact that inflation protection adds more than 15 percent to the annuity’s cost may explain the limited demand for this product in the U.S.

2.2 Annuities Linked to the CREF Index-Linked Bond Account (ILBA)

In May of 1997 the College Equities Retirement Fund (CREF) launched a new investment account that was intended to appeal to those who are saving for retirement as well as
to retirees receiving annuity payouts. This product, called the CREF Inflation-Linked Bond Account (ILBA), followed from the federal government’s decision to issue TIPS on January 29, 1997. TIAA-CREF (1997a) indicated that its new inflation-linked account was expected to be useful for providing participants with “another investment option that can enhance portfolio diversification and mitigate the long-term impact of inflation on their retirement accumulations and benefits.” The fund’s goal was described, in TIAA-CREF (1997b), as seeking “a long-term rate of return that outpaces inflation, through a portfolio of inflation-indexed bonds and other securities.”

The CREF Inflation-Linked Bond Account has grown slowly since its inception. At the end of September 1998, the account had attracted investments of only $131 million, making it the smallest of all the retirement funds offered by TIAA-CREF. To place this amount in context, on the same date the CREF Stock fund held $96.9 billion, the TIAA Traditional Annuity fund held $94.3 billion, and all other TIAA-CREF retirement funds combined held about $25 billion. Most of the funds held in the ILBA are in the accounts of TIAA-CREF active participants, rather than retirees, and as such they are still accumulating rather than drawing down assets.

To describe the inflation protection that an annuity linked to the CREF ILBA provides, we need to provide some background both on the structure of this account, on the basic structure of variable annuity products, and on the specific operation of the CREF variable annuity.

The CREF Index-Linked Bond Account TIAA-CREF (1998a) explains that the ILBA “invests mainly in inflation-indexed bonds issued or guaranteed by the US government, or its agencies and instrumentalities, and in other inflation-indexed securities” with foreign securities capped at 25% of the assets. At present the ILBA holds 98 percent of its assets in U.S. government inflation-linked securities and 2 percent short-term investments maturing in less than
one year. In principle, the fund’s asset allocation could become broader in the future, with corporate inflation-indexed securities and those issued by foreign governments potentially being included as well as money market instruments. Expenses total 31 basis points annually. This expense ratio is lower than many mutual and pension fund expense levels, but it is as high as other, more actively managed CREF accounts such as the Stock Account (31 basis points) and the Bond Market Account (29 basis points) (see www.tiaa-cref.org/expenses.html).

The ILBA has no sales, surrender, or premium charges. Participants may elect this account as one of several investment vehicles into which new retirement contributions may be made, and/or into which existing assets from other TIAA-CREF accounts may be transferred. As with other CREF accounts, the participant is limited to one transfer per business day in or out of the account during the accumulation phase. The ILBA may be used as a vehicle for accumulating retirement assets, or it can be used to back the payment stream for a variable payout annuity. Most of our interest focuses on the second function.

The ILBA account is marked to market daily, meaning that asset values fluctuate and the account could lose money. For example, if real interest rates rose due to a decline in expected inflation, bond prices could fall. As the Fund Prospectus, TIAA-CREF (1998b), points out, in such an event the inflation-linked bond fund’s total return would then not actually track inflation every year.” This is a key feature of the ILBA, and it means that the account does not effectively offer a real payout stream to annuitants who purchase variable payout annuities tied to the ILBA.

Real interest rate changes are not the only source of variation in ILBA returns. If the principal value of inflation-linked bonds changes in response to inflation shocks, perhaps because investors infer something about the future of real interest rates from inflation news, this would also affect the returns on the ILBA. Similarly, changes in the definition of the CPI might
affect the ILBA return. The ILBA return for 1998 was 3.48 percent. Table 5 illustrates that this made it the lowest earning fund of all the tax-qualified accounts offered by TIAA-CREF in 1998.

Variable Annuities: General Structure  An annuity with payouts that rise and fall with the value of the CREF ILBA is a special case of a variable payout annuity. The key distinction between a fixed annuity (including a graded fixed annuity with a pre-specified set of changing nominal payouts over time) and a variable annuity is that the payouts on a variable annuity cannot be specified for certain at the beginning of the payout period. Rather, a variable annuity is defined by an initial payout amount, which we shall denote $A(0)$, and an “updating rule” that relates the annuity payout in future periods to the previous payout and the intervening returns on the portfolio that backs the variable annuity.

To determine the initial nominal payout on a single-life variable annuity, per dollar of annuity purchase, the insurance company solves an equation like

$$
1 = \sum_{t=1}^{T} \frac{A(0) \cdot P_t}{(1 + R)^t}
$$

where $R$ is the variable annuity’s “Assumed Interest Rate” or the “Annuity Valuation Rate” as in Bodie and Pesando (1983). $T$ is the maximum potential lifespan of the annuitant. This expression would require modification if the annuity guaranteed a fixed number of payments for certain, regardless of the annuitant's longevity, or if there were other specialized features in the annuity contract. This expression ignores expenses and other administrative costs associated with the sales of annuities or the operation of insurance companies.

The annuity updating rule depends on the return on the assets that back the annuity, which we denote by $z_t$, according to:

$$
A(t+1) = A(t) \cdot (1+z_t)/(1+R).
$$
The frequency at which payouts are updated varies across annuity products, and there is no requirement that the payout be updated every time it is paid. One could, for example, have an annuity with monthly payouts but quarterly updating.

In designing a variable annuity, the assumed interest rate (R) is a key parameter. Assuming a high value of R will enable the insurance company to offer a large initial premium, but, for any underlying portfolio, the stream of future payouts will be more likely to decline as the assumed value of R rises. Equation (4) clearly indicates that an individual who purchases a variable annuity will receive payouts that fluctuate with the nominal value of the underlying portfolio.

**Specific Provisions of the CREF ILBA-Backed Annuity.** When a TIAA-CREF participant terminates employment, he or she can begin receiving retirement benefits. The participant then decides how to manage the payouts from accumulated retirement accounts. This includes deciding whether to annuitize the retirement assets, how much to annuitize, and whether to use an inflation-linked annuity. (Some employers may restrict their retirees’ options.) Benefits are payable monthly, though recipients may elect quarterly, semi-annual, and annual payouts as an alternative; TIAA-CREF (1998d) provides more detail on these options. In addition, the participant can chose the form and duration of the payout pattern, subject to minimum distribution rules set by the IRS. If the participant chooses to annuitize part of his or her accumulation, there are a variety of potential annuity structures, including life annuities, 10- and 20-year certain payout annuities, and joint and survivor as well as single life products.

Under TIAA-CREF rules, a CREF participant electing an annuity cannot be more than 90 years of age when he or she initially applies for the annuity. TIAA-CREF (1998a) explains that the applicant must select at least one of the annuity accounts initially for the drawdown phase,
and thereafter, he or she may switch from one annuity account into another as often as once per quarter. There are restrictions on shifting funds from TIAA to CREF: this must take place over a longer horizon. The choice of annuity fund can be altered, but the form of benefit payout cannot be changed once the annuity has been issued.

In order to understand how CREF annuity payments are determined, it is necessary to define the “basic” annuity unit value. This is an amount set each March 31 by dividing an account’s total funds in payment status by the actuarial present value of the future annuity benefits to be paid out, assuming a 4 percent nominal interest rate and mortality patterns characteristics of existing CREF annuitants. A unisex version of the mortality table for individual annuitants is used when the applicant first files for an annuity “set back for each complete year elapsed since 1986” (see TIAA-CREF (1998d)). The same mortality table is applied to all TIAA-CREF annuity accounts, based on participant mortality experience. Mortality experience is adjusted every quarter.

A newly retired participant seeking to annuitize his retirement sum must have his own accumulation amount translated into an initial annuity amount (A(0)), determined by dividing his accumulation by the product of an annuity factor and the basic annuity unit value just described. The annuity factor reflects assumed survival probabilities based on the annuitant’s age and an assumed effective Annual Interest Rate (AIR) of 4 percent nominal, explained in TIAA-CREF (1998c).

The participant’s initial annuity amount is then adjusted over the life of the annuity contract on either a monthly or an annual basis, depending on the participant’s election. The adjustment will reflect the actual fund earnings on a ‘total return’ basis, relative to the assumed 4 percent AIR. Actual investment performance is used to update the annuity values as of May 1.
for those electing to have their income change annually, or monthly for those electing monthly income changes. Because the investment returns on the underlying accounts affect annuity payouts, these TIAA-CREF annuities are variable payout annuities.

The Extent of Inflation Protection. It is evident that a variable payout annuity linked to the CREF-ILBA does not provide a guaranteed stream of real payouts, since it is marked to market daily. Thus if the price drops, or if the unit value fails to rise with inflation, the participant’s unit value would not be constant in real terms. More importantly, the CREF annuity may fail to keep up with inflation because of the way in which it is designed. When the first-year annuity payout is set, it assumes the 4 percent AIR mentioned above, which is the same rate used for other CREF annuities. In subsequent years, if the unit value of the account were to rise less than 4 percent, payouts would be reduced to reflect this lower valuation. Consider the experience of 1998, when the total return (after expenses) on the ILBA account was 3.48 percent. Since the AIR for the CREF annuity is 4 percent, an annuity in its second or later year payout phase would experience a decline in payout of 0.5 percent. Since the price level rose in 1998, it is clear that the annuity payouts are not constant in real terms. A necessary condition for the payouts on this variable annuity not to decline in real terms would be for the real return on the account, i.e. on Treasury Inflation Protection Securities, to exceed 4 percent. At present, it does not.

The precise extent to which payouts on ILBA-backed variable annuities will vary in real terms in the future is an open question. If the prices of inflation-linked bonds are bid up during high-inflation periods, and real interest rates decline at such times, this will partly protect the ILBA account value. One relevant comparison for potential annuitants, however, may be between holding a CREF ILBA-backed variable annuity, and purchasing TIPS bonds directly.
Two considerations are relevant to such a comparison. First, the TIPS bonds offer a more direct form of inflation protection, although they do not provide any risk-sharing with respect to mortality risk. Second, there are tax differences between the two investment strategies. TIPS would be taxable if they were not held in a qualified pension account, while the income from bonds held in the CREF ILBA-backed account is not taxed until the proceeds are withdrawn.

The CREF variable payout annuity linked to the ILBA would be more likely to deliver a future real payout stream if the AIR on this annuity were set equal to the real interest rate on long-term TIPS at the time when the annuity is purchased. In this case, the return on the bond portfolio would typically equal the AIR plus the annual inflation rate, leaving aside some of the risks of holding indexed bonds such as changes in the way the CPI is constructed. This would provide a mechanism for delivering something closer to a real annuity payout stream. One difficulty with this approach is that it would make it more difficult for annuitants to take advantage of some of the investment flexibilities currently provided by CREF. At present, all CREF annuities assume the same AIR, regardless of the assets that back them. This facilitates conversions from one annuity type to another.

To date, there has been very limited demand for CREF's ILBA-backed variable payout annuities. This lack of demand raises the perennial question of why retirees are not more concerned about inflation protection. One reason often given is "inflation illusion"; that is, people simply do not understand how inflation erodes purchasing power. Another reason may be that inflation-proof assets are new so that investors have not yet learned how to think about such assets. Hammond (1998) notes that inflation-linked bonds in other countries took some time to become popular after they were introduced: "After a flurry of initial interest, inflation bonds in those countries went through a period of quiescence -- low liquidity and little interest. Then,
with some sort of trigger—renewed inflation or a strong commitment on the part of central
government—the market picked up and people began to figure out what the bonds were good
for. In the U.K. this process took about ten years.” The United States today may be in the early
stages of this process.

2.3 Conclusions About Real Annuities in the United States

Our analysis of the ILONA and TIAA-CREF experience suggests that there is currently
no market for genuine real annuities in the United States. While ILONA offers a product that
guarantees a real stream of payouts, no one has yet purchased this annuity. This may reflect the
fact that the instrument’s pricing requires relatively high rates of inflation to generate benefits
with expected present discounted values similar to those of nominal annuities offered by ILONA
and other insurers. The inflation-linked bond account offered by CREF has attracted investment
funds since it became available in 1997, but the CREF variable annuity with payouts linked to
returns on inflation indexed bonds does not guarantee its buyers a constant real payout stream.
Although in practice it may come close to delivering a constant real payout, its performance will
depend on the as yet uncertain price movements in the prices of Treasury Inflation Protection
Securities.

3. Asset Returns and Inflation: Another Route to Inflation Insurance

We now shift from our focus on insurance contracts that explicitly provide a constant real
income stream for retirees to consider the possibility of using variable payout annuities linked to
assets other than indexed bonds as an alternative means of avoiding inflation risk. Such variable
payout annuities may reduce the impact of inflation in two ways. First, they may offer higher
average returns than the assets that are used in pricing real and nominal annuities. These returns
may, of course, come at the price of greater payout variability. Second, the prices of the assets that underlie the variable payout annuities may move in tandem with the price level. In this case a variable payout annuity could provide a form of inflation insurance.

To examine these arguments, we begin by summarizing the well-known historical real return performance of U.S. stocks, bonds, and Treasury bill investments. We do this by considering an individual who considers investing one dollar in cash, or in a portfolio of Treasury bills, long-term bonds, or corporate stock. We calculate the real value of an initial $1 investment after 5, 10, 20, and 30 years. We first perform this calculation in 1926, so that the 30-year return interval concludes in 1955. We then repeat the calculation in 1927, 1928, and in all subsequent years for which we have enough data to calculate long-term returns. The last year for which we have return information is 1997, so we finish our five year calculations in 1993, our ten year calculations in 1988, and so on.

To summarize the results on the real value of each investment, we calculate both the average real value of each investment, averaged across all of the years with sufficient data. We also compute the standard deviation of this real return. The results of these calculations appear in Table 6. The underlying calculations have been done using actual returns on stocks, bills and bonds over the 1926-1997 period. For the return after five (30) years, there are 66 (41) overlapping return intervals. The results in Table 6 show that holding cash worth $1 initially would have a real value of only 49 cents after 20 years on average. In contrast, a $1 initial investment in bills or bonds would have increased in real value. For bills, the cumulative real return over 20 years was 1.3 percent, while for bonds, it was 16.1 percent.

The last column of Table 6 shows comparable calculations for corporate stock. Here the real value of the investment after 20 years would have increased by a factor of 4.5. This implies
that an investor who purchased an income stream tied to the total return on the U.S. stock market, such as an equity-linked variable annuity, would have the potential to receive a higher real income stream late in retirement than at the beginning of retirement. This stands in stark contrast to the declining real value of the payouts on a fixed nominal annuity contract.

The substantial real return on U.S. equities suggests that one method of obtaining partial long-term protection against inflationary erosion of annuity payouts might be to purchase a portfolio of equities, and then to link annuity payouts to equity returns. In practice, however, variable annuity policies that offer payouts linked to equity returns do not guarantee real payouts that rise as steeply as Table 6 suggests. This is because the payouts on a variable annuity depend on the performance of the underlying assets relative to the annuity product's Assumed Interest Rate (AIR) (R in equation (3)). Therefore the variable annuity payout for an equity-linked variable annuity can only rise over time if the equity portfolio returns more than the assumed value of R used in designing the annuity. Bodie and Pesando (1983) assume that R equals the historical average return on the assets that back the annuity in their hypothetical evaluation of variable payout annuities. In practice, we have found that nominal R values of 3 or 4 percent per year are common, even for equity-linked variable payout annuities, in the current annuity market. One should note that if a variable payout annuity assumed \( R = 0 \), then the real payouts in Table 6 would in fact describe the experience of an annuitant, since the nominal payout recursion would become \( A(t+1) = A(t)(1+z_i) \).

The high average real return on equities implies that an investor holding U.S. stocks over the last seven decades would have experienced a rising real wealth profile. But to study whether this is because equities provide a good inflation hedge, we must explore the way U.S. equity returns covary with shocks to the inflation rate. If stocks generate positive returns when the
inflation rate rises unexpectedly, then equities operate as an inflation hedge. The fact that U.S. equities have generated substantial positive returns over the period since 1926 does not provide any information on the correlation between inflation and stock returns.

We investigate the historical covariances between real U.S. stock returns, bond returns, bill returns, and unexpected inflation shocks, over two sample periods: 1926-1997 and 1947-1997. If the real return on a particular asset category is not affected by unexpected inflation, then that asset can serve as a valuable inflation hedge. If the real return on the asset declines when inflation rises unexpectedly, however, then that asset does not provide an inflation hedge.

The first step in our analysis involves estimating a time series for "unexpected inflation." We do this by estimating fourth-order autoregressive models relating annual inflation ($\pi_t$) to its own lagged values, or to its own lagged values as well as those of nominal Treasury bill rates ($i_t$). The basic regression specification is either

$$\pi_t = \rho_0 + \rho_1 \pi_{t-1} + \rho_2 \pi_{t-2} + \rho_3 \pi_{t-3} + \rho_4 \pi_{t-4} + \phi_1 i_{t-1} + \phi_2 i_{t-2} + \phi_3 i_{t-3} + \phi_4 i_{t-4} + \epsilon_{it}$$

or

$$\pi_t = \rho_0 + \rho_1 \pi_{t-1} + \rho_2 \pi_{t-2} + \rho_3 \pi_{t-3} + \rho_4 \pi_{t-4} + \epsilon_{it}.$$  

(5a)

(5b)

Table 7 presents the findings from estimating (5a) and (5b) for the two sample periods. Two broad conclusions emerge from the table. First, there is a great deal of persistence in inflation. The sum of the four coefficients on lagged inflation for the 1926-1997 period is .773, while for the 1947-1997 period it is .732. There is somewhat greater inflation persistence in the early years of the sample than in the post-war period. We experimented with extending the length of the lag polynomials in (5a) and (5b). While the fourth-order inflation lag in both equations shows a coefficient that is statistically significantly different from zero, higher lagged values were never statistically significant.
Second, the incremental explanatory power of lagged Treasury bill yields is relatively small after we have controlled for lagged inflation. Bill rates have somewhat greater explanatory power in the postwar period than in the full sample period. Because most of the estimated coefficients on bill rates for both sample periods are statistically insignificant, however, the unexpected inflation series calculated from specifications (5a) and (5b) are likely to yield similar estimates of the correlation between unexpected inflation and asset returns.

We estimate unexpected inflation ($\pi_{u,t}$) by computing the residuals from either (5a) or (5b). These unexpected inflation series incorporate some future information in each case, because the coefficients are estimated over the full sample period. We then use these time series as the explanatory variables in regression models in which real stock, bond, or bill returns are the dependent variables:

\[
  r_{it} = \alpha + \lambda_t \cdot \pi_{u,t} + \xi_{it}.
\]

Table 8 shows the coefficient estimates for $\lambda_t$ from regression models estimated for the two sample periods.

The results provide no evidence to suggest that stocks or bonds have been inflation hedges during the last seventy years. For both of these asset categories, a one percentage point increase in the rate of unexpected inflation is associated with a decline of more than one percent in bond and in stock values. The estimated negative effects are larger, though somewhat less precisely estimated, for the 1947-1997 period than for the longer sample. As noted above, the two unexpected inflation series, one corresponding to a lagged-inflation-only predicting equation, the other corresponding to the augmented specification with lagged Treasury bill returns as well, produce very similar results when they are included on the right hand side of equation (6).
We also find evidence that unexpected inflation reduces real Treasury bill returns. The effect on these returns is more muted than that on bond and stock returns, and for both sample periods we find that a one percentage point increase in unexpected inflation reduces the real return on Treasury bills by less than one percentage point. Nevertheless, for both sample periods we reject the null hypothesis that real Treasury bill returns are unaffected by inflation surprises.

The finding that unexpected inflation is negatively correlated with real asset returns is broadly consistent with previous research. For example, Barr and Campbell (1995) show that the real interest rate on U.K. indexed bonds appears to covary negatively with inflation. Evans (1998) surveys a number of other empirical papers, using data from several nations and various methodologies, all of which reach similar conclusions. Our findings for equities are consistent with Bodie (1976), who suggested that using equities to hedge inflation risk requires a short position in equities.

One question that some might raise about the results in Table 8 concerns the focus on one-year return horizons. It is possible that the high frequency correlation between unexpected inflation and asset returns differs from the lower-frequency correlation. Boudoukh and Richardson (1993) present some evidence for both the U.S. and the U.K. suggesting that the nominal return on corporate equities moves together with inflation at long horizons. To explore this issue, we repeated our analysis using real returns and unexpected inflation over five year intervals. We confined our analysis to the 1926-1997 sample period, and used an AR(2) model to construct an estimate of unexpected inflation. We focused on non-overlapping five year intervals, which provided twelve observations for estimating equation (6). The last row of Table 8 presents the results. They continue to show a negative correlation between real stock and bond
returns and unexpected inflation. The only change relative to the previous findings is that unexpected inflation no longer has a negative effect on real Treasury bill returns.

Our empirical results therefore suggest that the inflation-hedging properties of equities and long-term bonds are limited. Nevertheless, as Siegel (1998) and others have noted, over long horizons equities have typically generated very substantial positive real returns. This appears to be the result of a high average real return on equities, rather than a correlation between equity returns and unexpected inflation. A substantial body of research has tried to explain the high average return on equities in the United States during the last century as a function of the correlation between equity returns and various risk factors. This has proven difficult, and has become known as the “equity premium puzzle.”

The weak high-frequency correlation between equity returns and inflation is a challenge to many traditional models of asset pricing, since equities represent claims on real assets that such hold their value in real terms. Prior studies have suggested a number of potential explanations for the weak empirical correlation between inflation and equity returns. Feldstein (1980) focused on the interaction of inflation and corporate tax rules, while Modigliani and Cohn (1977) emphasized inflation illusion among equity investors. We are not aware of any empirical evidence that provides clear guidance for choosing among these explanations.

4. Evaluating the Utility Gains From Access to Real Annuities

We have not yet considered how valuable inflation protection might be for a retiree seeking to annuitize his retirement resources. We now address this issue by estimating a potential annuitant's "annuity equivalent wealth" from access to real, nominal, and equity-linked variable payout annuities. We focus on equity-linked variable annuities because equities have
historically earned higher expected returns than other assets, and because our findings above showed that while bills offer some inflation protection, their expected return has historically been very small. Bonds offer limited inflation protection and substantially lower average returns, at least historically, than stocks.

The annuity valuation framework employed is closely related to that developed in Kotlikoff and Spivak (1981) and MPWB (1999). These two studies examine the utility gain that a representative individual receives from access to actuarially fair annuity markets. Brown (1999) provides empirical evidence suggesting that this framework has predictive value for explaining whether individuals plan to annuitize the balance they accumulate in a defined contribution plan. In this section, we compare the utility gains associated with access to different types of annuities. Our findings provide some guidance on the value to retirees of real versus nominal annuities.

4.1 Analytical Framework For Evaluating Alternative Annuities

Our basic algorithm estimates the utility gains accruing to someone with no annuity who is offered a fixed, nominal annuity on actuarially fair terms, a real annuity on fair terms, and an equity-linked variable annuity. To illustrate our procedure, we explain how we calculate an individual’s "annuity equivalent wealth" when this individual is offered access to a fixed nominal annuity. We assume that this individual purchases such an annuity at age 65, which we normalize to be "year zero." This individual receives an annuity payment in each year that he remains alive, and his optimal consumption path will be related to this payout. The annuity payout at age a (A_a) depends on wealth at the beginning of retirement (W_{ret}) and the annual annuity payout per dollar of premium payment (0): A_a = 0*W_{ret}. In the case of a fixed nominal annuity, the nominal value of A_a is independent of age. For simplicity, we do not consider the
taxes paid on annuity payouts, or the taxes on the returns to non-annuity assets. MPWB (1999) find that the relative utilities of different annuity products are not sensitive to the inclusion of tax rules.

To find the actuarially fair ratio of nominal annuity payouts to premium cost, $\theta$, for a 65-year old male in 1995, we use the Social Security Administration's cohort life table for men born in 1930. We define actuarial fairness as equality of the premium cost and the expected present discounted value of annuity payouts. This definition ignores the potentially important role of administrative expenses that are incurred by the insurance company offering the annuity, so it is likely to overstate the payouts that would be available in actual annuity markets. We find $\theta$ from the following equation:

\[
I = \sum_{j=0}^{50} \frac{\theta \cdot p_j}{((1 + r)(1 + \pi))^j}.
\]

In this expression, $p_j$ denotes the probability of a 65-year-old retiree remaining alive $j$ years after retirement, $r$ denotes the annual real interest rate and $\pi$ is the annual inflation rate. For computational simplicity, we use years rather than months in our annuity valuation and continue to assume that no one survives beyond age 115, so $p_{50} = 0$.

After finding the actuarially-fair payout value, we compute the expected discounted value of lifetime utility that would be associated with the consumption stream generated by this nominal annuity. To do this we assume that individuals have additively-separable utility functions of the following form:

\[
U = \sum_{i=0}^{50} p_i \cdot \frac{((\frac{C_i}{(1 + \pi)^i})^{1-\beta} - 1)}{(1 + \rho)^i}.
\]
For this functional form, the parameter $\beta$ is the individual’s coefficient of relative risk aversion. This parameter also determines the degree of intertemporal substitution in consumption. The nominal consumption flow ($C_t$) is deflated by the price index, $(1+\pi)^t$.

We consider a first case in which our 65-year-old uses all of his resources to purchase an annuity contract, and a second case in which he purchases an annuity with half of his resources. In the second case, we assume that the other half of the individual’s resources are invested in a real annuity. This case can be thought of as describing the retiree’s choice problem when he has both an individual account balance that can be annuitized, and also a substantial real retirement annuity like that offered by the current Social Security system. As explained by Hurd (1987) and MPWB (1999), the marginal value of an increase in annuitization is greater when fewer resources are already annuitized.

We assume that the retiree has wealth at age 65 of $W_{ret}$, and for illustrative purposes, we focus on the case in which the retiree has no pre-existing annuity wealth. We find the optimal consumption path for someone who receives a nominal annuity of $\theta W_{ret}$ per period. For such an individual, the budget constraint at each age $a$ is given by:

\begin{equation}
W_{a+1} = (W_a + \theta W_{ret} - C_a)[(1+r)(1+\pi)].
\end{equation}

This specification makes the standard assumption that nominal interest rates rise point-for-point with inflation, even though our foregoing results call this assumption into question. The retiree with budget constraint (9) also faces an initial condition on wealth after purchasing the annuity: $W_0 = 0$. It is possible that the retiree will save some of the payouts from the annuity contract, and thereby accumulate wealth, in the early years of retirement.

Equation (9) assumes that the investment opportunity set for the retiree consists of a nominal bond that offers a fixed real return $r$. The utility gains from purchasing an annuity are
likely to depend on the set of portfolio options that investors have outside their annuity contract. Campbell and Vicera (1998) present some evidence on the optimal structure of portfolios at different points in the lifecycle for investors who have access to nominal and real bonds. Extending our framework to allow for more realistic portfolio structure is a natural direction for further work.

We compute the retiree's lifetime expected utility by solving for his optimal consumption path \( \{C_a\} \) using stochastic dynamic programming, where the stochastic component of the problem arises from uncertainty regarding date of death. The result is lifetime expected utility as a function of wealth at retirement, \( U^* = U^*(W_{\text{ret}}) \), for the case in which the retiree has access to a nominal annuity contract.

We define the retiree's "annuity wealth equivalent" as the amount of wealth that he would need, if he did not have access to an annuity market, to achieve the same lifetime expected utility level that he achieves if he uses all of his wealth to purchase a nominal annuity. We note in passing that in some cases, full annuitization does not yield the highest possible level of lifetime expected utility. Hurd (1987, 1989) shows that some individuals can be over-annuitized when their optimal consumption path is constrained by the annuity income flow. This could happen to individuals with high discount rates relative to the interest rate. Nevertheless, our "annuity wealth equivalent" is calculated by comparing full annuitization with no annuitization.

When the retiree does not have access to an annuity market, his problem is to maximize the utility function (8) subject to the budget constraint and initial condition

\[
(10a) \quad W_{a+1} = (W_a - C_a) \cdot [(1 + r)(1 + \pi)]
\]

and

\[
(10b) \quad W_0 = W_{\text{ret}}.
\]
The optimal consumption path in this case yields a value of lifetime expected utility, again as a function of wealth at retirement, \( U^{**} = U^{**}(W_{\text{ret}}) \), for a retiree with no access to an annuity market.

The "annuity equivalent wealth" (AEW) is the amount of wealth that a retiree needs, if he does not have access to an annuity market, to achieve the lifetime utility level that he can attain with access to an annuity market. Formally, annuity equivalent wealth \( W_{\text{aew}} \) satisfies the equation

\[
U^{**}(W_{\text{aew}}) = U^{*}(W_{\text{ret}}).
\]

We use a numerical search algorithm to find the value of \( W_{\text{aew}} \) that satisfies this equation. Since the longevity insurance associated with an annuity makes the individual better off, \( W_{\text{aew}} > W_{\text{ret}} \). The retiree requires more wealth to achieve a given retirement utility level when he does not have access to a nominal annuity market than when he does.

When we report the annuity equivalent wealth in our results below, we normalize \( W_{\text{aew}} \) by \( W_{\text{ret}} \) and we report \( W_{\text{aew}}/W_{\text{ret}} \). This makes our calculations directly comparable to those in Kotlikoff and Spivak (1981), who label this ratio the "wealth equivalent factor." It is, in their words, "the increment in a single person's initial wealth required, in the absence of an annuity market, to leave him as well off as he would be with no additional wealth but with access to annuities market."

Our annuity equivalent wealth calculations differ, however, from MPWB's (1999) estimates of the amount of wealth that individuals would be prepared to give up in order to invest their remaining wealth in actuarially fair annuities. In MPWB (1999), the central focus is on the divergence between the expected present discounted value of annuity payouts, and the purchase price of annuity contracts. Because the EPDV is less than the purchase price, the natural
question to ask is what fraction of their wealth individuals would rationally forego in order to obtain an annuity. Comparing that fraction with the annuity load provides some insight on the effective magnitude of the annuity load.

In the present paper, we follow Kotlikoff and Spivak (1981) in asking how much additional wealth an individual would need to be as well off without access to an annuity market as with it. Our choice of this approach, rather than that of MPWB (1999), was largely motivated by computational concerns. In the present setting we search for $W_{aew}$ in a relatively simple problem, where the only source of uncertainty is mortality risk. Real interest rates are certain in our benchmark case with the budget constraint in (10a). Once we move into a setting where there is additional uncertainty about inflation or asset returns, as in later sections, the numerical solution algorithm used to search for $W_{aew}$ is substantially more computationally demanding.

In simple environments without any pre-existing annuities, the annuity equivalent wealth (AEW) that we report is simply just a transformation of the wealth equivalent (WE) measure in MPWB (1999): $WE = 1/AEW$. Thus, if we find that a retiree requires 1.5 times as much wealth to achieve a given utility level without access to nominal annuities as with them, we could also interpret this as implying that the retiree would be prepared to give up 33 percent of his wealth ($0.5/1.5$) if he did not have a nominal annuity in order to obtain access to one. When the retiree has some pre-existing annuity wealth, however, the relationship becomes more complex and this relationship holds approximately, but not exactly.

Our analysis of the annuity equivalent wealth for a nominal annuity generalizes immediately to the case of a real annuity or a variable-payout annuity. For an actuarially fair real annuity, we determine the annual payout per dollar of premium, $\theta^*$, from the expression

$$l = \sum_{t=0}^{50} \frac{\theta^* P_t^*}{(1+r)^t}. \tag{12}$$
This expression is analogous to (7), but the discount factor involves only real interest rates, and the numerator involves only real payouts. As in the discussion above, we find the optimal consumption profile for a consumer who purchases such an annuity, and we then find the annuity equivalent wealth associated with access to a real annuity.

We also consider the utility consequences of being able to purchase variable payout annuity products, in particular the case in which annuity payouts are indexed to an underlying portfolio of common stocks. To compute the actuarially fair payout on such variable annuities, we assume that a risk-neutral insurance company offers a variable annuity with an initial payout $0^*$ determined by

$$ I = \sum_{i=1}^{S_w} \frac{0^* P_i}{(1 + R)^i}. $$

In this expression, $R$ is the AIR for the variable annuity product. The payout in the first period of the annuity purchase is therefore

$$ A_s(0) = 0^* W_{rel}. $$

The nominal payout on the variable annuity is determined in subsequent periods by the recursion

$$ A_s(t+1) = A_s(t)(1+z)/(1+R) $$

where $z$ denotes the nominal return on the equity portfolio.

In considering the equity-linked variable annuity, it is essential to recognize that the initial payout on the annuity policy is increasing in the assumed AIR. The appeal of the equity-linked variable annuity arises from this higher initial payout stream, and from the higher average returns earned on the assets invested in the variable annuity.

4.2 Calibration of Annuity Equivalent Wealth

To carry out the annuity equivalent wealth calculations described in the previous subsection, we must calibrate the lifetime utility function, the survival probability distribution, and
the distributions for inflation and real returns on the assets that might be held in portfolios backing variable payout annuities. All results will assume that the utility discount rate $\rho$ is equal to the riskless interest rate $r$.

**Risk Aversion.** The parameter $\beta$ in equation (8) represents the household’s degree of risk aversion and its willingness to engage in intertemporal substitution in consumption. This risk aversion parameter is an important determinant of the gains from annuitization when the real value of annuity payouts in future periods is uncertain because of stochastic asset returns or stochastic inflation.

Most empirical studies that attempt to estimate a value of relative risk aversion from household consumption patterns find values close to unity, which corresponds to log utility. Laibson, Repetto, and Tobacman (1998) summarize this literature. Mehra and Prescott (1985), however, note that much higher levels of risk aversion are required, however, to rationalize the presence of the large premium of corporate equity returns over riskless bond returns in historical U.S. data. It is difficult to reconcile the empirical evidence of low risk aversion and the existence of the large historical equity premium. Recent work based on survey questions about household tolerance of risk, reported in Barsky, et al. (1997), also suggests values higher than unity. In light of this dispersion of findings, we present calculations using risk aversion coefficients of 1, 2, 5 and 10. In their related study of the utility gains from annuitization, Baxter and King (1999) consider an even wider range of risk aversion values, ranging from 2 to 25. We are inclined to place the most emphasis on our findings with risk aversion coefficients between 1 and 5, but we present findings using $\beta = 10$ to provide some insight on the robustness of our findings.
Survival Probabilities. The mortality process that we use in our analysis corresponds to the population mortality table supplied by the Social Security Administration. We use a cohort life table with projected future mortality rates, since we are interested in an annuity purchased by someone who is currently of retirement age. We use a 1930 birth cohort table to study a 65-year-old male, so our calculations effectively describe someone who was considering purchasing an annuity in 1995.

The Inflation Process. We use historical data from the period 1926-1997 to calibrate the stochastic process for inflation. The average value of inflation over this period is 3.2 percent per year. We assume that the inflation rate in each "year" takes one of six values: -10.2 percent, -1.44 percent, 1.75 percent, 3.82 percent, 9.06 percent, or 18.2 percent. The respective probabilities of these inflation outcomes are assumed to be .01, .19, .3, .3, .19 and .01. These inflation values correspond approximately to the 1st, 10th, 35th, 65th, 90th, and 99th percentiles of the annual inflation distribution for the years 1926-1997, and they imply an average annual inflation rate of 3.2 percent. We have devoted special attention the extreme tails of the inflation distribution to make sure that our analysis captures the possibility of a very high inflation period, since we might otherwise overstate the value of an annuity that is fixed in nominal terms.

We consider two cases for the inflation process, corresponding to different assumptions about the degree of inflation persistence over time. The first case treats each annual inflation rate as an independent draw from our six-point distribution. This approach to modeling inflation tends to understate the long-run variance of the real value of fixed nominal payments, and thus serves as a lower bound on the impact of inflation. Our empirical findings in the last section demonstrate clearly that inflation is a highly persistent process.
In the second case, we incorporate persistence by allowing inflation to follow a stylized AR(1) process. In the first period, inflation is drawn from the same six-point distribution as in the i.i.d. scenario. In later periods, however, there is a probability $\gamma$ that $\pi_{t+1}$ will be equal to $\pi_t$, and probability $1-\gamma$ of taking a new draw from the six-point distribution. An attractive feature of this approach is that $\gamma$ is equal to the AR(1) coefficient in a regression of inflation on its one-period lagged value, and thus $\gamma$ can be parameterized using historical inflation data. Using U.S. historical data from 1926-97, the AR(1) coefficient for inflation is equal to 0.64, and this is the value of $\gamma$ that we use in modeling a persistent inflation process.

The value of avoiding the inflation risk is shown by comparisons between our annuity equivalent wealth values when retirees have access to actuarially fair nominal annuity markets, and actuarially fair real annuity markets. Our measure is related to, but not equivalent to, Bodie’s (1990) analysis of the value of inflation insurance as the cost of purchasing a call option on the Consumer Price Index. His approach generates the cost of producing an inflation indexed income stream, while our approach focuses on the consumer valuation of such an income stream.

Risky Asset Returns. Our analysis assumes that investors have access to riskless real returns of three percent per year ($r = .03$). While this return is higher than the average return on “riskless” Treasury bills over the 1926-1997 period, it is lower than current return on long-term TIPS. We think of TIPS as the riskless asset with respect to retirement saving, and therefore use a higher return than the historical real return on T-bills. We further assume that inflation raises the nominal return on this riskless asset so that the real return is unaffected by inflation. This is tantamount to assuming that the investor is holding an indexed real bond.

When we consider variable annuity products backed by portfolios of risky securities, we must specify both the mean return associated with these securities and the variability of returns.
around this mean. Higher mean returns on the portfolios that back variable payout annuities will make these products more attractive to potential annuitants, while greater risk will reduce their attractiveness.

We consider a variable payout annuity backed by a broad portfolio of common stocks. Table 9 presents historical information on real returns and the standard deviation of real returns for U.S. stocks, bills, and bonds over the 1926-1997 period. This table is another way of presenting the information in Table 6 on real returns over different horizons. We assume throughout that the standard deviation of real returns on equities equals its historical average value of 20.9 percent per year.

In computing the annuity equivalent wealth for an equity-backed variable annuity, we consider two different assumptions with regard to the mean real return on equities. First, we assume a 6 percent real return (i.e., a 3 percent premium over the indexed bond return). This assumption about the equity premium is substantially smaller than the historical average differential between stock and bond returns, but it is designed to be conservative. Second, we consider a case with a 9 percent real return on equities, which translates to a 6 percent premium above the real bond. This is still a smaller equity premium than historical returns suggest, but it yields a real return on equities close to the historical average. The extent to which historical real returns on corporate stock provide guidance on prospective returns is an open issue; see Campbell and Shiller (1997) and Siegel (1998) for divergent views. In both cases, we assume an AIR on the Variable Annuity equal to the expected return on the underlying portfolio, following the approach of Bodie and Pesando (1983).

In order to account for the variability in returns, we again use a discrete six-point approximation to capture the distribution of real equity returns. Specifically, we constructed a
distribution of the equity excess return over the period 1926-97. By subtracting off the mean excess return, and then adding in our assumed 6% or 9% mean return, we constructed our distribution of equity returns. This approach allows us to alter our assumption about the mean equity premium over the riskless rate while holding the variance of equity returns at historical levels. We pick points from the 1st, 10th, 35th, 65th, 90th, and 99th percentiles of the distribution and use the probabilities 0.01, 0.19, 0.3, 0.3, 0.19, 0.01 for these draws. For the case of a 6% mean real return, the corresponding points in the return distribution are -0.475, -0.182, -0.036, 0.156, 0.306, and 0.506. For the case of a 9% mean real return, the entire distribution of returns is shifted up by 0.03. Real equity returns are modeled as independent across time. This does not allow for any possible variance compression at long horizons.

4.3 Results on the Valuation of Real vs. Nominal Annuities

Table 10 reports our estimates of the annuity equivalent wealth for real and nominal annuities. The first three columns report results for the case with no pre-annuitized wealth, when the potential annuitant places all of his wealth in an annuity. Columns four through six explore the case in which the potential annuitant already holds half of his net worth in a real annuity such as Social Security. To interpret the results, first consider the case in which the potential annuitant has a logarithmic utility function (CRRA = 1). In this case the annuity equivalent wealth is 1.502 for a fixed real annuity. This implies that an individual would be indifferent between having $1 in a real annuity or $1.50 in non-annuitized wealth. Note that the annuity equivalent wealth for this individual is 1.451 in the case of i.i.d. inflation, and 1.424 in the case of persistent inflation. These results suggest that a real annuity is more valuable than a nominal annuity, and more so when the inflation process is more persistent.
For a real annuity, the annuity equivalent wealth is monotonically increasing with the level of risk aversion. When the CRRA coefficient is 10, for example, the annuity equivalent wealth rises to 2.004, meaning that an individual is indifferent between $2.00 of non-annuitized wealth and $1.00 in wealth that can be invested in a real annuity. For fixed nominal annuities in the presence of uncertain inflation, this monotonic relationship between the annuity equivalent wealth and the level of risk aversion does not hold. This is because there are two effects of risk aversion that work on opposite directions in the case of inflation uncertainty. The first is that higher risk aversion leads one to value an annuitized payout more highly because the annuity eliminates the risk of outliving one’s resources. This is the only effect present when examining real annuity products. The second factor, which works in the opposite direction, is that more risk averse individuals have greater dislike for the uncertainty introduced into the real annuity stream by stochastic inflation. Increased variability in the real value of the annuity flows reduced 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 fixed nominal annuities is rising with risk aversion. For example, moving from CRRA=1 to CRRA=2, the annuity equivalent wealth increases from 1.451 to 1.553 in the i.i.d. inflation case, and from 1.424 to 1.501 in the persistent inflation case. However, as risk aversion increases further, the second effect becomes stronger, and the annuity equivalent wealth begins to decrease with risk aversion.

The annuity equivalent wealth values described above provide information on the amount of incremental wealth that individuals would require to be made as well off as if they had access to annuities, assuming that they have no pre-existing annuity coverage. The difference between the annuity equivalent wealth values for real and nominal annuities provides information on how
valuable a real annuity is relative to a nominal annuity. For example, to achieve a given utility target in a world with i.i.d. inflation, the value of a nominal annuity is worth 5.1% of wealth less than a real annuity (1.502-1.451). At higher risk aversion levels the differential between real and nominal annuities rises even further. When CRRA=5 and inflation is i.i.d., the nominal annuity is worth 23.9% of wealth less than the real annuity. In the case that is most unfavorable to nominal annuities, that of persistent inflation and a risk aversion coefficient of 10, the annuity equivalent wealth associated with real annuities is 65.8% of wealth larger than for a nominal annuity.

The results are attenuated when we consider the annuitization decision of an individual who already holds a substantial amount of his wealth in a pre-existing real annuity. Such a potential annuitant would require a smaller increment to wealth to achieve the same utility level, without access to a private annuity market, that he could obtain with such access. For example, a consumer with a risk aversion coefficient of unity would require only a 33% increment to his wealth to be made as well off as if he had a real annuity, compared to 50% in the case when no wealth was previously annuitized. The presence of a pre-existing real annuity offers the potential annuitant some insurance against very low consumption values. This accounts for the diminished value of an additional privately purchased annuity.

When the annuity option is a nominal annuity, rather than a real annuity, the effect of having a pre-existing real annuity is more complex. When inflation draws are independent across years, the results are similar to those for real annuities: the annuity equivalent wealth declines when there is a pre-existing real annuity. When we allow for a persistent inflation process, however, along with very high values of risk aversion, the results change. For example, when CRRA= 10, the annuity equivalent wealth is higher when the potential annuitant has pre-annuitized wealth than when he does not. This is because we have assumed that the pre-existing
annuity is a fixed real annuity, which provides insurance against the annuitant ever experiencing very low values of real income and therefore consumption. Thus the utility cost of having high and persistent inflation erode the value of a nominal annuity is reduced, and the potential annuitant's willingness to purchase a nominal annuity rises.

4.4 Results on the Valuation of Variable Annuities

Table 11 reports our findings for the case of equity-linked variable-payout annuities. We assume that the AIR for such annuities corresponds to the average real equity return that is built into our calculations. Once again we report two panels, corresponding to different degrees of pre-existing annuitization. The first column reports results when the average return on equities exceeds that on bonds by 3 percent, so the real return to equities averages 6 percent. For an individual with logarithmic utility and in this return environment, an equity-linked variable payout annuity generates a higher utility level than a real annuity. In the case of no pre-existing annuities, the annuity equivalent wealth for the variable annuity, 1.623, is higher than that for the real annuity in Table 10 (1.502). For higher levels of risk aversion, however, a variable annuity with a mean return of 6 percent is worth less than a real annuity. In fact, an individual placing 100% of his wealth in a variable annuity can actually be made worse off than not annuitizing at all, when their degree of risk aversion is high enough and the equity distribution is highly uncertain. This can be seen by annuity equivalent wealth values below unity.

The lower panel of Table 11 reports the ratio of the annuity equivalent wealth with an equity-linked variable annuity to that with a real annuity. When these entries are greater than one, a potential annuitant would prefer a variable annuity to a fixed real annuity. When the entry is less than one, the individual would be better off in a real annuity. In the case of log utility, the individual always prefers an equity linked variable annuity product. At higher risk aversion
levels, however, the fixed real annuity usually dominates. The same pattern is evident when we allow a higher real return on equities. For three of the eight combinations of risk aversion and the real equity return that we considered, a potential annuitant who was preparing to annuitize all of his wealth would prefer the variable to the real annuity. For five of the eight combinations, this outcome also emerges in the case with a pre-existing real annuity. Variable annuities are relatively more attractive with pre-existing real annuities than without. This is again because the pre-existing real annuity provides a minimum consumption floor below which the annuitant will not fall. Therefore, the risk of a very low consumption state resulting from a series of negative equity returns is reduced.

These findings suggest that for rates of risk aversion commonly cited in the consumption literature, and for plausible rate of return assumptions, potential annuitants would often prefer to purchase variable annuities with payouts linked to equity returns rather than real annuities offering constant purchasing power throughout the annuity period. Even when the expected real return on stocks is only three percent, the extra return afforded by the variable annuity more than compensates potential annuitants for the inflation risk that they bear. This is particularly evident when the annuitant is already endowed with a real annuity that represents a substantial share of net wealth, because in that case the risk of very low consumption as a result of adverse variable annuity returns is mitigated. Our results on variable annuities are probably sensitive to our restriction of the menu of assets that investors can hold outside the variable annuity: we do not allow investments in corporate stock except through the variable annuity channel. Exploring the robustness of our findings to relaxation of this constraint is an important topic for future work.
5. Conclusions and Further Directions

We have provided new evidence on the functioning of existing real annuity markets, and on the potential role of nominal, real, and variable payout annuities in providing income security to retirees. Three conclusions emerge from the analysis.

First, private insurers can and do offer real annuities to potential annuitants. Although at present there virtually no U.S. market for real annuity products, in the United Kingdom indexed government bonds have been available for nearly two decades and there, indexed annuities are widely available. From the standpoint of an annuity purchaser, the cost of purchasing a real rather than a nominal annuity in the United Kingdom is at most five percent of the annuity principal.

Second, real returns on a broad-based portfolio of U.S. stocks have historically outpaced inflation by a substantial margin. While extrapolating from historical returns must be done with caution, the past returns suggest that there may be benefits for retirees from investing part of their annuity wealth in a variable annuity product with returns linked to the returns on corporate stocks. Nevertheless, our analysis of the correlation between unexpected inflation and equity returns suggests that the appeal of an equity-linked variable annuity is primarily the result of the equity premium, rather than a strong positive correlation between inflation shocks and equity returns. At least at high frequencies, U.S. equities do not appear to offer an inflation hedge.

Third, consumers place a modest value on access to real rather than nominal annuities. We consider our results for retirees with a coefficient of relative risk aversion of two as a "benchmark" case. We find that a potential annuitant would need roughly 1.5 times as much wealth in the absence of annuities to achieve the same lifetime utility level that he could obtain by annuitizing his initial wealth using nominal annuities. He would need 1.65 times as much
wealth to achieve the utility level that he could obtain if he had access to a real annuity market. These two findings can be combined to suggest that a retiree with access to a real annuity, who loses such access, would be made worse off by approximately the same amount as he would be if he lost ten percent of his wealth. Consumers also value access to variable-payout equity-linked annuities, although their demand for such products is quite sensitive to their degree of risk aversion. For moderately risk averse consumers, with coefficients of relative risk aversion of two or less, the annuity equivalent wealth for an equity-linked variable annuity may be greater than that for a real annuity. This finding obtains even when we assume that the average annual real return on equities is only 300 basis points higher than the real return on riskless bonds.

These findings bear on two concerns that are raised in connection with Social Security reform plans that include individual accounts. One is that insurers might not be able bring to market products providing inflation and longevity protection. Our evidence suggests that this is, in fact, not a concern in the two countries that we have examined. Both have government-issued inflation-indexed bonds that can be used to back the issuance of privately-sold inflation-indexed annuities.

A second concern is that, given a choice, retirees might use their individual account funds to purchase nominal rather than inflation-indexed annuities. This is perceived as a problem to the extent that it exposes retirees to the risk of consumption losses in old age. Our model suggests that the expected utility losses associated with purchase of a nominal rather than a real annuity are modest. It also implies that consumer demand for inflation-linked annuities in an individual accounts system would be positive, although the extent to which our stylized model describes actual consumer behavior is an open issue. The demand for real annuities is greatest among the most risk averse consumers. It is also increasing in the degree of persistence of inflation shocks.
When inflation is serially independent, the annuity equivalent wealth for a nominal annuity is higher than when inflation is highly persistent. This is because, conditional on the average inflation rate, the risk of experiencing high and persistent inflation poses a greater threat to real retirement consumption than the risk of a shorter-lived period of high inflation.

The demand for real annuities also tends to be lower for households with a substantial endowment of annuitized wealth. This would include any remaining real defined benefit promises offered to retirees under a restructured Social Security system. We estimate that the annuity equivalent wealth of a real annuity is about 5-8% less for a consumer holding half his wealth in Social Security as for one having no real annuity at all. Moore and Mitchell (1998) show that older Americans currently hold close to half their retirement wealth in real Social Security annuities. This may explain the limited current demand for real annuity products in the United States. If the Social Security system were changed in a way that reduced the importance of CPI-indexed real annuity payouts, the demand for privately-provided annuity products might increase substantially.

Our examination of the interplay between annuity choice, inflation protection, and portfolio risks raises a number of issues that could productively be explored in future work. One pertains to the use of more complex annuity products than the ones considered here. We have not investigated “graded nominal payout products” discussed by Biggs (1969) and King (1995). While graded policies do not offer inflation protection per se, they do provide annuitants with an opportunity to back-load their real annuity payouts. Annuity equivalent wealth values in graded policies, relative to that for fixed nominal or real annuities, would be straightforward to calculate in our framework.
A more difficult issue for future research concerns the set of portfolio options available to the individuals considering annuitization, and the extent to which such households have access to assets other than riskless bonds. One reason we find that investors find equity-linked annuities valuable is that our models assume investors can access the equity market only by using variable annuities. For some low-income and low-net-worth households accumulating retirement resources in an individual accounts system, it may be realistic to assume that they do not hold stock in any other way. For higher net worth households with greater financial sophistication, this assumption is less appropriate. Extending the current analysis to allow for a richer portfolio structure on the part of potential annuitants is an important direction for further work.
REFERENCES


Baxter, Marianne and Robert G. King. 1999. The role of international investment in a privatized social security system.


TIAA-CREF. 1997b. Introducing the CREF Inflation-Linked Bond Account, New York: TIAA-CREF.


Table 1: Summary Statistics on Nominal and Real Annuities Available in the Compulsory Annuity Market in the United Kingdom, 1998

<table>
<thead>
<tr>
<th>Annuity Buyer Characteristics</th>
<th>Average Monthly Payout For a £100,000 Annuity</th>
<th>Coefficient of Variation for Annuity Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal</td>
<td>Real</td>
</tr>
<tr>
<td>Man, 60 Years Old</td>
<td>666.20</td>
<td>476.35</td>
</tr>
<tr>
<td>Man, 65 Years Old</td>
<td>754.80</td>
<td>563.20</td>
</tr>
<tr>
<td>Man, 70 Years Old</td>
<td>872.94</td>
<td>679.50</td>
</tr>
<tr>
<td>Woman, 60 Years Old</td>
<td>602.99</td>
<td>416.81</td>
</tr>
<tr>
<td>Woman, 65 Years Old</td>
<td>666.88</td>
<td>482.70</td>
</tr>
<tr>
<td>Woman, 70 Years Old</td>
<td>760.50</td>
<td>575.06</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations based on data provided by U.K. annuity brokers. Reference date is August 21, 1998. Sample consists of fourteen large insurance companies that provide annuities. Data were provided by Annuity Direct, Ltd. All annuity products analyzed in this table offer a five year guarantee period.

Table 2: Expected Present Discounted Value of Annuity Payouts for Nominal and Real Annuities Available in the Compulsory Annuity Market, United Kingdom, August 1998

<table>
<thead>
<tr>
<th>Characteristics of Annuitant</th>
<th>Nominal Annuity</th>
<th>Inflation-Indexed Annuity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Payout</td>
<td>Highest Three</td>
</tr>
<tr>
<td>Male, Aged 60</td>
<td>0.921</td>
<td>0.953</td>
</tr>
<tr>
<td>Male, Aged 65</td>
<td>0.908</td>
<td>0.936</td>
</tr>
<tr>
<td>Male, Aged 70</td>
<td>0.889</td>
<td>0.917</td>
</tr>
<tr>
<td>Female, Aged 60</td>
<td>0.928</td>
<td>0.966</td>
</tr>
<tr>
<td>Female, Aged 65</td>
<td>0.907</td>
<td>0.942</td>
</tr>
<tr>
<td>Female, Aged 70</td>
<td>0.886</td>
<td>0.920</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations as described in the text. Sample consists of fourteen companies with data provided by Annuity Direct, Ltd. See notes to Table 1.
Table 3: Monthly Annuity Payouts on Single Premium Annuity Products Offered by ILONA in the United States Market, 1998

<table>
<thead>
<tr>
<th>Annuitant Age and Product</th>
<th>Male, Single Life Annuity</th>
<th>Female, Single Life Annuity</th>
<th>Joint and Survivor Annuity with Full Survivor Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 65, Unindexed</td>
<td>$7452</td>
<td>$6620</td>
<td>$6068</td>
</tr>
<tr>
<td>Age 65, Indexed</td>
<td>5149</td>
<td>4432</td>
<td>3849</td>
</tr>
<tr>
<td>Age 70, Unindexed</td>
<td>8520</td>
<td>7543</td>
<td>6663</td>
</tr>
<tr>
<td>Age 70, Indexed</td>
<td>6262</td>
<td>5332</td>
<td>4549</td>
</tr>
<tr>
<td>Age 75, Unindexed</td>
<td>10075</td>
<td>8825</td>
<td>7594</td>
</tr>
<tr>
<td>Age 75, Indexed</td>
<td>7833</td>
<td>6643</td>
<td>5552</td>
</tr>
</tbody>
</table>

Note: All payouts correspond to an initial purchase of $1 million. Data were provided by Irish Life of North America (ILONA). See text for further details.

Table 4: Expected Present Discounted Value of Annuity Payouts, Freedom Inflation Indexed Annuities Offered by ILONA, 1998

<table>
<thead>
<tr>
<th>Calculations Using Population Mortality Table</th>
<th>Male Annuitant, Age 65</th>
<th>Male Annuitant, Age 75</th>
<th>Female Annuitant, Age 65</th>
<th>Female Annuitant, Age 75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Annuity</td>
<td>0.864</td>
<td>0.830</td>
<td>0.889</td>
<td>0.887</td>
</tr>
<tr>
<td>Real Annuity</td>
<td>0.702</td>
<td>0.720</td>
<td>0.708</td>
<td>0.762</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculations Using Annuitant Mortality Table</th>
<th>Male Annuitant, Age 65</th>
<th>Male Annuitant, Age 75</th>
<th>Female Annuitant, Age 65</th>
<th>Female Annuitant, Age 75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Annuity</td>
<td>0.987</td>
<td>0.984</td>
<td>0.966</td>
<td>0.967</td>
</tr>
<tr>
<td>Real Annuity</td>
<td>0.822</td>
<td>0.872</td>
<td>0.782</td>
<td>0.841</td>
</tr>
</tbody>
</table>

Notes: Each entry shows the expected present discounted value of annuity payouts using the algorithm described in the text. See notes to Table 3.
Table 5: Total Return, January 1 1998-December 31 1998, By TIAA-CREF Account

<table>
<thead>
<tr>
<th>CREF Accounts:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation-Linked Bond Account</td>
<td>3.48</td>
</tr>
<tr>
<td>Growth Account</td>
<td>32.89</td>
</tr>
<tr>
<td>Stock Account</td>
<td>22.94</td>
</tr>
<tr>
<td>Equity Index Account</td>
<td>24.12</td>
</tr>
<tr>
<td>Social Choice Account</td>
<td>18.61</td>
</tr>
<tr>
<td>Global Equities Account</td>
<td>18.58</td>
</tr>
<tr>
<td>Bond Market</td>
<td>8.60</td>
</tr>
<tr>
<td>Money Market</td>
<td>5.45</td>
</tr>
<tr>
<td>TIAA Accounts</td>
<td></td>
</tr>
<tr>
<td>Traditional Annuity</td>
<td>6.71</td>
</tr>
<tr>
<td>Real Estate Account</td>
<td>8.07</td>
</tr>
<tr>
<td>Personal Annuity Stock Index Account</td>
<td>23.84</td>
</tr>
</tbody>
</table>

Source: www.tiaa-cref.org, various pages.

Table 6: Real Value of a One Dollar Investment after Various Periods, 1926-1997 Average

<table>
<thead>
<tr>
<th>Value After N Years:</th>
<th>Cash (No Investment Return)</th>
<th>Investment Portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treasury Bills</td>
<td>Treasury Bonds</td>
</tr>
<tr>
<td>5 Years</td>
<td>0.864 (0.150)</td>
<td>1.036 (0.163)</td>
</tr>
<tr>
<td>10 Years</td>
<td>0.729 (0.205)</td>
<td>1.047 (0.245)</td>
</tr>
<tr>
<td>20 Years</td>
<td>0.490 (0.160)</td>
<td>1.013 (0.285)</td>
</tr>
<tr>
<td>30 Years</td>
<td>0.356 (0.129)</td>
<td>1.033 (0.324)</td>
</tr>
</tbody>
</table>

Notes: Each entry shows the mean value of a one dollar initial investment, in real terms, and the (standard error) of this value. Calculations are based on authors’ computations using actual realizations of inflation, bill, bond, and stock returns over the 1926-1997 period, as reported in Ibbotson Associates (1998).
Table 7: Estimates of the Inflation Process for the United States, 1930-1997

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.008 (0.005)</td>
<td>0.010 (0.006)</td>
<td>0.009 (0.006)</td>
<td>0.005 (0.006)</td>
</tr>
<tr>
<td>Inflation (t-1)</td>
<td>0.706 (0.113)</td>
<td>0.666 (0.124)</td>
<td>0.647 (0.100)</td>
<td>0.566 (0.106)</td>
</tr>
<tr>
<td>Inflation (t-2)</td>
<td>-0.146 (0.142)</td>
<td>-0.086 (0.148)</td>
<td>-0.161 (0.119)</td>
<td>-0.127 (0.120)</td>
</tr>
<tr>
<td>Inflation (t-3)</td>
<td>-0.223 (0.142)</td>
<td>-0.208 (0.146)</td>
<td>-0.056 (0.118)</td>
<td>-0.066 (0.119)</td>
</tr>
<tr>
<td>Inflation (t-4)</td>
<td>0.436 (0.112)</td>
<td>0.447 (0.119)</td>
<td>0.302 (0.099)</td>
<td>0.280 (0.103)</td>
</tr>
<tr>
<td>Bill Yield (t-1)</td>
<td>0.370 (0.340)</td>
<td>0.370 (0.340)</td>
<td>0.549 (0.241)</td>
<td>0.549 (0.241)</td>
</tr>
<tr>
<td>Bill Yield (t-2)</td>
<td>-0.694 (0.470)</td>
<td>-0.694 (0.470)</td>
<td>-0.677 (0.328)</td>
<td>-0.677 (0.328)</td>
</tr>
<tr>
<td>Bill Yield (t-3)</td>
<td>0.129 (0.483)</td>
<td>0.129 (0.483)</td>
<td>0.218 (0.338)</td>
<td>0.218 (0.338)</td>
</tr>
<tr>
<td>Bill Yield (t-4)</td>
<td>0.108 (0.338)</td>
<td>0.108 (0.338)</td>
<td>0.053 (0.234)</td>
<td>0.053 (0.234)</td>
</tr>
<tr>
<td>Adjusted R2</td>
<td>0.507</td>
<td>0.500</td>
<td>0.544</td>
<td>0.571</td>
</tr>
</tbody>
</table>


Table 8: Unexpected Inflation and Real Asset Returns, United States, 1926-1997

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bills</td>
<td>Bonds</td>
<td>Stocks</td>
</tr>
<tr>
<td>Bills and Inflation Only</td>
<td>-0.827 (0.137)</td>
<td>-1.702 (0.389)</td>
<td>-1.582 (0.804)</td>
</tr>
<tr>
<td>Inflation Only</td>
<td>-0.864 (0.128)</td>
<td>-1.672 (0.378)</td>
<td>-1.560 (0.783)</td>
</tr>
<tr>
<td>5-Year Nonoverlapping Returns, Inflation Only</td>
<td>0.191 (0.437)</td>
<td>-1.522 (0.657)</td>
<td>-1.969 (0.670)</td>
</tr>
</tbody>
</table>

Note: Each entry corresponds to the coefficient $\lambda_i$ in the regression equation

$$R_{it} = \alpha + \lambda_i \pi_{it} + \epsilon_{it}$$

where $R_{it}$ denotes the real return on asset $i$ in period $t$ and $\pi_{it}$ denotes the unexpected inflation rate. Estimates are based on authors’ analysis of data in Ibbotson Associates (1998), as described in the text.
Table 9: Mean Real Returns, and Standard Deviations of Real Returns, 1926-1997

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Real</td>
<td>Standard</td>
</tr>
<tr>
<td></td>
<td>Return</td>
<td>Deviation</td>
</tr>
<tr>
<td>Treasury Bills</td>
<td>0.73%</td>
<td>4.17%</td>
</tr>
<tr>
<td>Long-Term</td>
<td>2.57%</td>
<td>10.53%</td>
</tr>
<tr>
<td>Treasury Bonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equities</td>
<td>9.66%</td>
<td>20.46%</td>
</tr>
</tbody>
</table>


Table 10: Annuity Equivalent Wealth for Real and Nominal Annuities

<table>
<thead>
<tr>
<th>Coefficient of Relative Risk Aversion</th>
<th>Individual with No Pre-Existing Annuity Wealth</th>
<th>Individual With Half of Initial Wealth in Pre-Existing Real Annuity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Real Annuity</td>
<td>Nominal Annuity: i.i.d. inflation</td>
</tr>
<tr>
<td>1</td>
<td>1.502</td>
<td>1.451</td>
</tr>
<tr>
<td>2</td>
<td>1.650</td>
<td>1.553</td>
</tr>
<tr>
<td>5</td>
<td>1.855</td>
<td>1.616</td>
</tr>
<tr>
<td>10</td>
<td>2.004</td>
<td>1.592</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations. The annuity equivalent wealth for the nominal annuity is calculated under the assumption that inflation takes one of six possible values, roughly capturing the distribution of inflation outcomes over the 1926-1997 period. Inflation shocks are independent across periods in the i.i.d. case, and follow a stylized AR(1) process in the persistent inflation case. See text for further discussion.
Table 11: Annuity Equivalent Wealth for Equity-Linked Variable Annuity Products

<table>
<thead>
<tr>
<th>Coefficient of Relative Risk Aversion</th>
<th>No Pre-Existing Annuities</th>
<th>Pre-Existing Annuity Equal to Half of Initial Wealth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Real Stock Return 6%</td>
<td>Real Stock Return 9%</td>
</tr>
<tr>
<td></td>
<td>1.623</td>
<td>2.024</td>
</tr>
<tr>
<td></td>
<td>1.499</td>
<td>1.901</td>
</tr>
<tr>
<td></td>
<td>0.921</td>
<td>1.355</td>
</tr>
<tr>
<td></td>
<td>0.331</td>
<td>0.622</td>
</tr>
<tr>
<td></td>
<td>Annuity Equivalent Wealth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.567</td>
<td>1.953</td>
</tr>
<tr>
<td></td>
<td>1.570</td>
<td>1.957</td>
</tr>
<tr>
<td></td>
<td>1.443</td>
<td>1.789</td>
</tr>
<tr>
<td></td>
<td>1.261</td>
<td>1.563</td>
</tr>
<tr>
<td></td>
<td>Annuity Equivalent Wealth Ratio, Variable Annuity/Real Annuity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.081</td>
<td>1.348</td>
</tr>
<tr>
<td></td>
<td>0.908</td>
<td>1.152</td>
</tr>
<tr>
<td></td>
<td>0.496</td>
<td>0.730</td>
</tr>
<tr>
<td></td>
<td>0.165</td>
<td>0.330</td>
</tr>
<tr>
<td></td>
<td>1.178</td>
<td>1.468</td>
</tr>
<tr>
<td></td>
<td>1.090</td>
<td>1.358</td>
</tr>
<tr>
<td></td>
<td>0.889</td>
<td>1.102</td>
</tr>
<tr>
<td></td>
<td>0.695</td>
<td>0.861</td>
</tr>
</tbody>
</table>

Source: Authors' calculations, as described in the text. The calculations in the bottom panel show the ratio of the annuity equivalent wealth from the upper panel to the analogous annuity equivalent wealth from holding a real annuity with an assumed real return of 3 percent. The underlying annuity equivalent wealth values for the real annuity case are shown in Table 10, columns 1 and 4. A ratio greater than 1 indicates that the variable annuity is more valuable than a real annuity. Ratios less than 1 indicate that the real annuity is more valuable.
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