Resolving the Annuity Puzzle:

Estimating Life-Cycle Models without (and with) Behavioral Data *

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Abstract

Why do so few retirees purchase private annuities? Recent research suggests that bequest motives, precautionary savings motives, and actuarially-unfair pricing can explain the lack of demand for annuities. The degree to which these forces can explain the annuity puzzle depends crucially on retiree preferences, which can be challenging to properly identify. In this paper, we build an incomplete markets model of heterogeneous retirees, who save precautionarily when faced with health risks, the potential need for long term care, and an uncertain life span and who value consuming, leaving a bequest, and receiving long term care if they need it. Expenditures on long term care can be valued differently than typical consumption, depending on estimates of a health-state dependent utility function, and retirees can choose the amount to spend on LTC on the intensive margin, subject to a minimum cost of private LTC that captures the reality that this state is associated with large and lumpy costs. Additionally, since small, but important, changes in model specification can significantly change preference parameter estimates, we develop Strategic Survey Questions (SSQs) that identify preference parameters using a novel application of stated-preference methodology. The model is estimated using data from our newly created Vanguard Research Initiative Panel, allowing for heterogeneous preference parameter types, using moments from the wealth distribution alone, SSQs alone, and both wealth and SSQs. We explore retiree demand for different financial products, including annuities, and how these demand functions vary across the population and depend on prices and preferences.

*The views expressed herein are those of the authors and do not necessarily reflect the views of The Vanguard Group, Inc. or of Ipsos SA.

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1 Introduction

The annuity puzzle refers to the apparent contradiction of low retiree interest in private annuities and model predictions of high demand for annuities. More specifically, in simple life cycle models in which the only risk retirees face is the uncertainty of the timing of their death, full annuitization is the optimal policy, as it is perfect insurance against retirees' sole risk of outliving their assets. Much has changed in the literature since Yaari's pioneering work and there are roughly three major schools of thought on the annuity puzzle. Some economists believe there is still an annuity puzzle and explain the lack of demand due to some behavioral or informational barrier that prevents individuals from valuing these products correctly. There are economists who believe the bequest motive explains the lack of desire for annuities, as individuals do not want to annuitize away the wealth they would rather bequeath. Finally, there are those who believe the lack of annuity demand is driven by late in life precautionary savings motives—predominantly associated with health and long term care (LTC) needs.[1]

This paper studies retiree saving and spending behavior, with a focus on quantifying the relative strength of the precautionary savings and the bequest motives in determining annuity demand. To do this, we build a heterogeneous agent incomplete markets model of retirees, who save precautionarily when faced with health risks, the potential need for long term care, and an uncertain life span. Retirees value consuming, leaving a bequest, and receiving long term care if they need it. Retirees can either save so that they can purchase private LTC, or they can rely on a government that provides a means tested public care option.[2]

Understanding the true determinants of annuity demand is extremely important, as it has wide-ranging impacts on the optimal design of social security, medicare, medicaid, retirement savings plans, and private insurance products. These issues are especially important currently, given the demographic changes America is experiencing. Although there is broad agreement on the importance of the issue, the debate is ongoing because it is hard to discriminate between theories in the existing data. Often studies of behavioral impediments to annuity demand are based on case studies and small scale experiments

[1]Kopecky and Koreshkova (2009) show how LTC risk is the predominant old age risk, contributing substantially to saving and expenditure patterns of the elderly.

[2]It is certainly true that important family dynamics affect late in life savings and consumption decisions and the desire for financial products, as is well documented in the literature (for recent work see, for example, Braun, Kopecky, and Koreshkova (2013), Skira (2013). Properly modeling family interactions is certainly an important line of research, but is beyond the scope of the current paper.

that can be difficult to generalize to the US at large. Descriptions that rely solely on health related precautionary savings motives are hard to square with observed consumption and wealth patterns over the lifecycle, as the wealthy be should be consuming more rapidly since they have enough wealth to alleviate all precautionary concerns. To explain the lack of annuity demand as an optimal response to the desire to leave a bequest is hard to square with level of inter-vivos giving and often implies an implausibly small aversion to receiving public care. Furthermore, a long life without annuities necessarily draws down a retiree's wealth to pay for at least a subsistence level of expenditures.

In this paper we develop new theory and complementary new sources of data to help quantify the contribution of the bequest motive, the precautionary savings motive, and government programs in determining annuity demand. The model that we construct is very much in the spirit of the recent literature, which allows for both precautionary and bequest motives to potentially play a strong role, depending on the data. In our model, expenditures on long term care can be valued differently than typical consumption, depending on estimates of a health-state dependent utility function. Furthermore, retirees can choose the amount they spend on LTC on the intensive margin, subject to a minimum cost of private LTC that captures the reality that this state is associated with large and lumpy costs. This will enable the model to generate a non-degenerate LTC expenditure distribution and better match the cross-sectional wealth distribution by age. Furthermore, allowing expenditures to be valued differently when a retiree needs long term care changes the incentives for retirees to save. Specifically, if a retiree has strong PCA and highly values being able to spend on high quality LTC, he will save more than otherwise. Since the retiree can decide how much to spend on LTC, as opposed to modeling LTC as a fixed mandatory expenditure, this may raise the savings of the middle-wealth individuals who are the consumers with strong precautionary savings motives. This richer model of LTC expenditure, with health-dependent utility, may let the model match the empirical cross-sectional distribution of wealth by age with very different estimated parameters for the bequest utility function than the model that treats LTC as traditional health cost shocks.

In this class of models, small, but important, changes in model specification can significantly change preference parameter estimates. Thus, a major contribution of this paper is the development of Strategic Survey Questions (SSQs) that identify preference parameters using a novel application of stated-preference methodology. The model is estimated using data from our newly created Vanguard Research Initiative Panel, allowing for heterogeneous preference parameter types, using moments of the wealth distribution alone, SSQs alone, and both wealth and SSQs.

With the model estimated, we turn to an analysis of annuity demand. In particular, we are interested in how the demand for annuities varies across the population and how different features of preferences and the economic environment interact to determine annuity demand. Estimates suggest bequest motives and precautionary savings motives contribute to the lack of demand for annuities in an environment in which the government provides means-tested public care. Ultimately, there is almost no demand for annuities similar to those that are typically available in the US private market. This holds for almost all individuals—across incomes from \$5,000 to \$120,000 per year and across wealth from \$0 to \$500,000—with much more demand to deannuitize than to annuitize. Savings motives driven by LTC are active for the lower income and wealth individuals (the majority of the US population), while higher wealth individuals' annuity demand is primarily driven by bequest motives. This strong lack of desire for annuities, when estimated using direct evidence on individual preferences and in the absence of information and non-rational "frictions" is strong evidence that there is no annuity puzzle. Most individuals don't want to buy annuities because they are not good financial products given people's preferences and the economic environment in which retirees live.

The paper is organized as follows. Section 2 develops the model, Section 3 describes the data in the VRIP with a focus on the design of the Strategic Survey Questions, Section 4 describes the estimation methodology that allows us to estimate the structural life cycle model without (and with) data on observed behavior and describes the estimated parameters, and finally Section 6 uses the estimated model to analyze the annuity demand of retirees.

1.1 Relation to the Literature

Many policy recommendations about annuity purchases draw on the insight of early research that developed lifecycle models of retired agents. The main force at work in these classic models is that agents have a desire to smooth consumption over the life cycle, given an initial stock of wealth and an uncertain time of death (see, for example, the foundational paper Yaari (1965)). The focus of more recent work has been to model and estimate richer environments that better reflect the risks retirees face. The major extensions to the simple framework usually deal with stochastic health and associated expenditures and the bequest motive. Recent research has also focused on the importance of LTC in determining the consumption, saving, and insurance demand of retirees. We will focus on this aspect of the lifecycle and enhance the traditional model by allowing for voluntary levels of expenditure in the LTC state that may be valued differently than standard consumption. Some papers, such as De Nardi, French, and Jones (2010), allow for an intensive margin of spending when the retiree is in need of LTC, valued using the standard consumption utility function. Other papers, such as the baseline model in Lockwood (2013), treat utility in the LTC state as a binary outcome—either a retiree pays the expensive health cost and obtains the associated level of utility, or he uses government provided LTC and obtains a different level of utility. We allow for an intensive margin of LTC expenditure that is valued using the health-state utility (HSU) function. Additionally, we model a minimum cost to obtain private LTC, reflecting that a retiree in need of LTC can not survive without some significant minimum level of provided care, and that this care is costly to obtain.

From at least as early as Arrow 1973, economists have postulated that utility may be state dependent and that health may be an important state that determines utility. Furthermore, Eisner and Strotz (1961) suggest that state dependent utility could significantly affect an individuals demand for insurance.[3] Considering death as an absorbing health state, using a warm glow bequest utility function that differs from the standard consumption utility function is an extension of this line of thought. Although there have been many papers that focus on the theoretical implications of state-dependent preferences, there have been far fewer empirical papers that estimate state-dependent utility functions. There have been two primary empirical strategies used to identify health state-dependent utility. The first, is to use panel data to analyze health profiles over time and the corresponding levels of consumption (Lillard and Weiss (1997)) or utility proxies (Finkelstein, Luttmer, and Notowidigdo (2009)). The primary alternative has been to use a compensating differentials approach (Viscusi and Evans (1990); Evans and Viscusi (1991)), asking survey respondents how much they would need to be paid to compensate for hypothetical health risks, often in the context of physically dangerous jobs. In this paper, we take a different approach, developing new stated preference methods and employing them in the design of detailed Strategic Survey Questions that identify parameters of a long term care state-dependent utility function. The closest paper to ours in this dimension is Brown, Goda, and McGarry (2013), who also use a related survey methodology to study the degree to which there exists state dependent utility.[4] To our knowledge, we are the first to estimate a state-dependent utility

[3]See Kremslehner and Mürmann (2009) for a survey of the state-dependent utility literature.

[4]As in our paper, they do find evidence of state dependence and they also find evidence of heterogeneity in preferences. They do not attempt to estimate a state-dependent utility function.

function for the LTC state. Furthermore, a common difficulty in the literature is that the degree of an individuals risk aversion crucially affects estimates of other utility function parameters. One of our main contributions is a joint estimation of risk aversion, LTC utility parameters, and bequest utility parameters that are heterogeneous across the population.

Whether there exists an annuity puzzle is fundamentally a quantitative question, as we have multiple theories that potentially explain why consumers do not purchase private annuities. Thus, data, model, and estimation strategy must be the essential ingredients in providing an answer. Unfortunately, similar but different models, using similar but different data have provided somewhat dissimilar results. For example, Ameriks, Caplin, Laufer, and Van Nieuwerburgh (2011) and Lockwood (2013) both conclude that some combination of precautionary savings induced by public care aversion and utility from bequests are enough to explain the lack of demand for private annuities. However, Lockwood (2013) estimates a near linear bequest utility function, and ascribes most of the lack of demand for annuities to the fact that bequests are a good way to obtain utility with little decreasing marginal utility in bequest size. This near-linear bequest motive allows end-of-life bequests to easily explain the high savings rates of the elderly. Ameriks, Caplin, Laufer, and Van Nieuwerburgh (2011) find that bequests are valued by a large fraction of the population, but also that public care aversion explains to a large degree the lack of demand for annuities. While Lockwood (2013) uses a MSM estimator to match moments of the cross-sectional wealth distribution by cohort, Ameriks, Caplin, Laufer, and Van Nieuwerburgh (2011), use a maximum likelihood estimator, with parameter identification coming from Strategic Survey Questions. It is important to distinguish the relative contributions of bequest and precautionary savings motives in determining the lack of demand for annuities, as they have different implications for the optimal policies of governments and insurers. In this paper we develop an estimation methodology that is well suited to jointly estimate all important preference parameters, as well as investigate whether the estimates of previous studies were the result of subtle but important model misspecification or whether they reflected the true underlying preferences.

We develop a MSM estimator that can jointly use moments of the wealth distribution and moments based on responses to Strategic Survey Questions. The methodology builds on previous work, such as De Nardi, French, and Jones (2010), French and Jones (2011), Lockwood (2013), Gourinchas and Parker (2002), and Laibson, Repetto, and Tobacman (2007). Our use of stated choices is related to work by van der Klaauw and Wolpin (2008) and van der Klaauw (2012) that use moments derived from subjective expectations data to estimate structural model parameters. In addition to jointly estimating risk aversion, LTC utility parameters, and bequest utility parameters, a main contribution is our estimation methodology. Our estimation procedure draws on the stated-preference methodology, in which data on stated choices are often used to estimate models—often featuring random utility functions—in the same manner as are data on actual choices. For a recent example that highlights the similarities and differences of the classic stated-preference and our strategic survey methodologies, see Blass, Lach, and Manski (2010).

This is the first paper to use stated-preference survey methods to develop moments and to jointly estimate preference parameters of a structural life-cycle model without (and with) behavioral data.

2 The Model

2.1 Consumers

Consumers are heterogeneous over wealth ($a \in [0, \infty)$), income age-profile ($y \in \{y_1, y_2, \ldots, y_5\}$), age ($t \in \{55, 56, ..., 100\}$), gender ($g \in \{m, f\}$), health status ($s \in \{0, 1, 2, 3\}$), and health cost ($h \sim H(t, s)$ with support $\Omega_H(t, s)$). Time is discrete and the lifecycle horizon is finite. Consumers start at age t_0 and live to be at most T-1 years old, where in our parameterization t_0 corresponds with age 55 and T corresponds with age 101. Each period, consumers choose consumption ($c \in [0, \infty)$), savings (a'), expenditure on long term care, ($e_{LTC} \in [\chi_{LTC}, \infty)$), and whether to use government care ($I^G \in \{0, 1\}$). Each consumer has a perfectly forseen deterministic income sequence and receives a risk free rate of return of $(1 + r)$ on his savings. The only uncertainty a retiree has is over health/death.

2.2 Government

The consumer always has the option to use a means-tested government provided care program. The cost of using government care is that a consumers wealth is set to zero, while the benefit is that the government provides predetermined levels of expenditure, which depend on the health status of the retiree as described below. $I^G = 0$ if the consumer chooses to use government care and $I^G = 1$ if the consumer chooses not to use government care.

2.3 Health and Death

There are 4 health states: $s = 0$ represents good health, $s = 1$ represents poor health, $s = 2$ represents the need for long term care (LTC), and $s = 3$ represents death. The health state evolves according to a markov process, where the probability matrix, $\pi(s'|t, s)$ is age and health state dependent. h is a stochastic health expenditure that must be paid—essentially a negative wealth shock.

Each period the consumer is not in good health he has to pay a health cost, h, where, $h \sim H(t, s)$ and H is the CDF of the health cost random variable with support $\Omega_H(t, s)$.

If a consumer chooses to use government care when he does not need long term care (i.e., when $s = 0, 1$), then the government provides a consumption floor, $c = C_f$, that is designed to represent welfare.

A consumer needs long term care if he needs help with the activities of daily living (ADLs), such as bathing, eating, dressing, walking across a room, or getting in or out of bed. Thus, state 2 is interchangeably referred to as the LTC or ADL state. If a consumer needs LTC ($s = 2$), then he must either purchase private long term care or use government care. Capturing the fact that LTC provision is essential for those in need and private long term care is expensive, there is a minimum level of expenditure needed to obtain private LTC, i.e., $e_{LTC} \geq \chi_{LTC}$ for those not using government care.[5] Treatment of government provided care is related to the institution of Medicaid. If the consumer needs LTC and uses government care, the government provides $e_{LTC} = LTC^{PC}$. The value LTC^{PC} is a measure of the consumers public care aversion, since that parameter essentially determines the utility of a retiree who needs LTC and chooses to use government care.

In addition to affecting health costs and survival probabilities, health status affects preferences. There is a health-dependent utility function, such that spending when a consumer needs LTC ($s = 2$) is valued differently than spending when a consumer does not need LTC.

$$U(e_{LTC}) = \frac{\theta_{LTC}}{1 - \sigma} \left(e_{LTC} + \kappa_{LTC}\right)^{1-\sigma}. \tag{1}$$

Upon death ($s = 3$), the agent receives no income and pays all mandatory health costs. Any

[5] We are taking the stand that all empirical heterogeneity in LTC expenditure is from voluntary additional spending, as opposed to heterogeneous necessary expenditure. In future survey work, we are collecting information on the subjective expectations of the cost of LTC.

remaining wealth is left as a bequest, b, which the consumer values with warm glow utility function

$$\nu(b) = \frac{\theta_{beq}}{1-\sigma} \left(b + \kappa_{beq}\right)^{1-\sigma} \tag{2}$$

Utility Functions. When an individual is healthy or sick, his utility is given by a power utility function of consumption. Bequests are valued using the industry standard warm glow utility function developed in De Nardi (2004). When an individual needs long term care, utility is given by a similar formula, which treats LTC and bequests symmetrically in theory, allowing differences in preferences to be determined empirically through estimated parameter differences. Two key parameters are θ and κ; θ affects the marginal utility of an additional dollar spent and κ controls the degree to which an expenditure is valued as a luxury good or a necessity, in the sense that it provides a utility floor. Increases in θ increase the marginal utility of a unit of expenditure, while increases in κ indicate the expenditure is valued as more of a luxury good. Negative κ can be interpreted as the expenditure being a necessity.

2.4 The Consumer Problem

The consumer takes r as given and chooses a', c, e_{LTC}, and I^G to maximize his welfare. The consumer problem, written recursively, is

$$V(a,y,t,s,h,g) = \max_{a',c,e_{LTC},I^G} I^G \mathbb{I}_{s\neq 3}\left\{U_s(c,e_{LTC}) + \beta E[V(a',y,t+1,s',h')]\right\}$$
$$+ \left(1-I^G\right)\mathbb{I}_{s\neq 3}\left\{U_s(C^f, LTC^{PC}) + \beta E[V(0,y,t+1,s',h')]\right\} + \mathbb{I}_{s=3}\{\nu(b)\}$$

s.t.

$$a' = I^G[(1+r)a + y - c - e_{LTC} - h]$$

$$a' \geq 0$$

$$e_{LTC} \geq \chi_{LTC} \text{ if } (I^G = 1 \ \&\ s = 2)$$

$$e_{LTC} = LTC^{PC} \text{ if } (I^G = 0;\ s = 2)$$

$$C = C^f \text{ if } (I^G = 0;\ s = 0,\ s = 1)$$

$$b = max\{(1+r)a - h' \ ,\ 0\}$$

$$U_s(c,e_{LTC}) = \alpha_c \frac{1}{1-\sigma}(c)^{1-\sigma} + \alpha_{LTC}\frac{\theta_{LTC}}{1-\sigma}(e_{LTC}+\kappa_{LTC})^{1-\sigma}$$

$$\nu(b) = \frac{\theta_{beq}}{1-\sigma}(b+\kappa_{beq})^{1-\sigma}$$

Where $\alpha_c = 0$ if $s = 2$, $\alpha_c = 1$ if $s \in \{0,1\}$, $\alpha_{LTC} = 0$ if $s \in \{0,1\}$, and $\alpha_{LTC} = 1$ if $s = 2$.

The value function has three components, corresponding to the utility plus expected continuation value of a living individual who does not use government care, that of one who does choose to use government care, and the warm glow bequest utility of the newly deceased retiree. Note that a retiree using government care has expenditure levels set to predetermined public care levels and zero next period wealth. The budget constraint shows that wealth next period is equal to zero if government care is used, and equal to the return on savings plus income minus expenditures on consumption and LTC minus health costs. The retiree can not borrow, private expenditure on LTC must be at least χ_{LTC}, and a retiree can not leave a negative bequest.[6]

[6] Technically, there is a fifth health state that is reached (with certainty) only in the period after death and is the absorbing state, so that the consumer only receives the value of a bequest in the first period of death.

2.5 Describing Optimal Retiree Behavior

The model does not permit analytic solutions and must be solved numerically, with details of the solution algorithm presented in Technical Appendix A. In this section, we explore key properties of optimal retiree behavior to illustrate how each force in the model contributes to consumption and savings patterns over the life cycle and across the wealth distribution. The retiree's savings behavior is largely determined by the confounding influence of the precautionary savings motive and bequest motive in the presence of government policies.

Long term care is an event that occurs with non-trivial probability and is very costly to obtain privately. The fact that the government offers a means tested public care option induces interesting retiree behavior. Because the retiree has the option to choose government care, the value function is non-convex and the optimal savings policy is discontinuous.[7] Roughly speaking, high wealth individuals have enough savings to ensure they will obtain a high level of personal consumption and leave a large bequest, regardless of whether or not they need to pay for private long term care. For low wealth individuals, even if they saved almost all of their money and consumed very small amounts each year, they would not be able to save enough to make it optimal for them to purchase private long term care if they eventually needed it. Thus, it is the middle-wealth retirees whose actions are predominantly affected by precautionary savings motives. If these middle-wealth individuals are frugal and save, they will have enough wealth to purchase private LTC if they need it late in life. If they do not save, but rather consume at a high rate over their lifecycle, they will have higher utility along the lifecycle path, but will forgo a bequest and rely on public provision of LTC if they need it later in life. There exists some threshold wealth level, conditional on all idiosyncratic state variables, such that it is optimal for all agents with more wealth to follow the frugal path and for all agents below to follow the spendthrift path, with a discrete difference in their savings policy for a tiny difference in their wealth state. To illustrate optimal consumer behavior we present model simulations at certain parameter values. Parameters will be estimated and discussed further in Section 4.

The discontinuity of the savings policy is demonstrated in Figure 1 by plotting the value function across savings policies for different wealth states. In the left figure $a = 60$, in the right figure $a = 64$

[7]The non-convexity of the value function and the discontinuity in the optimal savings policy introduce computational complications. We use a modified endogenous grid method, building on insights from Fella (2014). The model solves approximately ten times faster when using the modified endogenous grid algorithm compared to value function iteration, which is esential since estimation of the model requires computational efficiency.

and in the bottom figure $a = 69$.

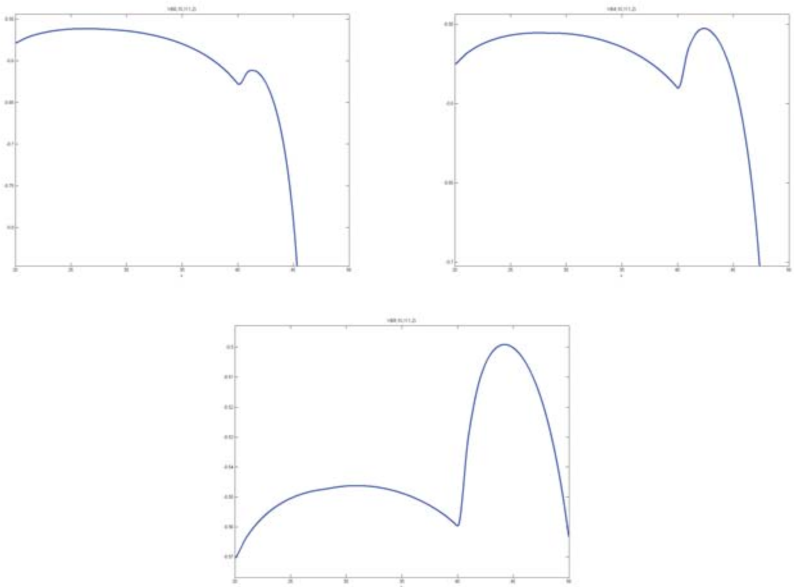


Figure 1: In all graphs the x axis is a' with range $[20, 50]$ and the y axis is $V(a, y, t, s, h, a')$.

Thus, for low wealth individuals, the value of saving a small amount is higher than the value of saving a higher amount. The opposite is true for higher wealth individuals as shown in the bottom panel. As presented in the right panel, the maximum value jumps from the lower to the higher savings maxima, and it is around this wealth level where there will be a discrete jump in the optimal savings policy (although the value function will remain continuous).

As was highlighted by Dynan, Skinner, and Zeldes (2002), a dollar saved today is fungible in its future use. Savings early in the retiree's life could be made to insure against future uncertain events like LTC as well as to ensure suitable savings remain at end of life to leave a desired bequest. If the bequest motive is weak, over saving for an uncertain late in life event that never occurs is costly, as the retiree would much rather have had a smooth higher consumption path over his life. However, with a strong bequest motive, "extra" savings at the end of life are highly valued, which reduces the cost over oversaving. To demonstrate how savings are influenced by bequest and LTC-induced savings motives, we plot the wealth age-profile for a VRIP sample median wealth male in Figures 2 and 3.[8]

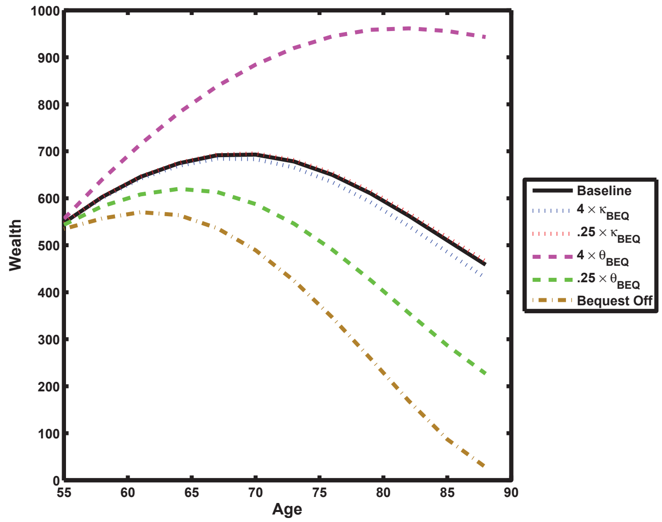


Figure 2:
Wealth Profiles Across Bequest Parameters at 50th Wealth Percentile

As expected, an increase in the marginal utility of a bequest greatly increases savings over the lifetime, as individuals want to enter late in life with much wealth to obtain high levels of utility from bequests when they die. Setting the marginal utility of a bequest to be a quarter of the baseline value significantly reduces savings over the lifecycle, and turning bequests off completely does so even further. Changes in κ_{beq} that determine the degree to which bequests are viewed as a luxury good do not have a significant effect on savings for such high wealth individuals, as they are already well above the minimum necessary expenditure to obtain utility from a bequest.

Figure 3 documents how wealth profiles are affected by parameters of the LTC utility function. Note that the baseline κ_{LTC} is negative, which indicates that LTC is viewed as a necessary good. Making κ_{LTC} even more negative greatly increases the savings rates, as retirees want to have more wealth available to spend if they need long term care. Note that a more negative κ_{LTC}, holding all other things equal, increases the marginal utility of a unit of expenditure in the LTC health state, as it is valued at a lower point in the utility function domain where the function has higher curvature.

[8] To generate these figures, we first sample (with replacement) 10000 individuals from our working data set. We then take their observed initial state variables (age, gender, assets, income quintile, and health) and initialize agents at these points. We then simulate these agents forward until their simulated death date. This provides a simulated cross-sectional distribution of assets, that we then aggregate into moments (10/25/50/75/90 percentiles) and display. We repeat this for the different combinations of parameter sets we display in the figures. Note that this is the same algorithm that we use to generate the asset profiles we match in estimating the model.

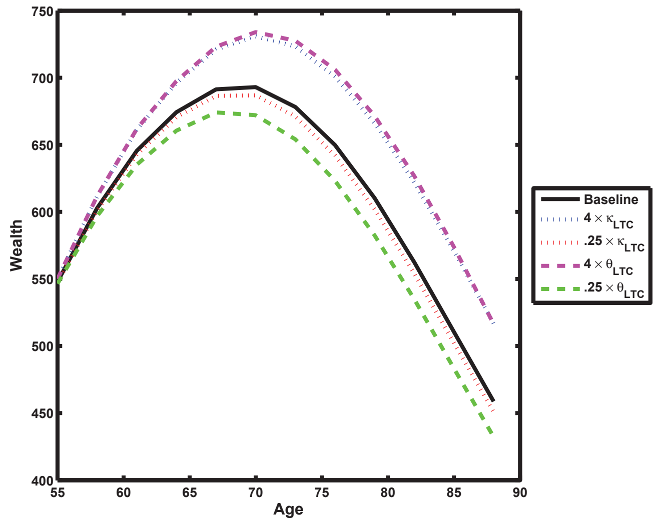


Figure 3:
Wealth Profiles Across LTC Parameters at 50th Wealth Percentile

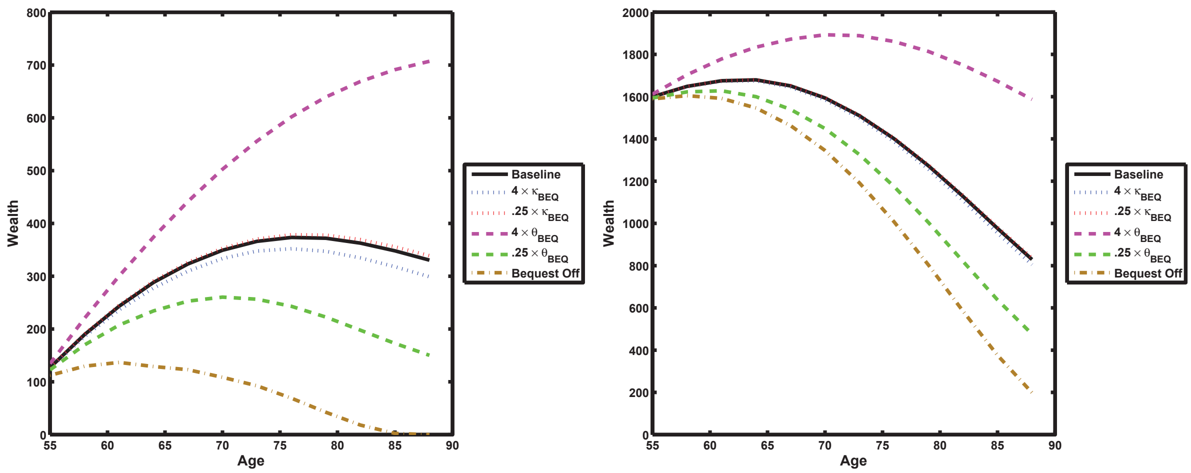
Similarly, decreasing κ_{LTC} decreases savings, as LTC is less of a necessary good. Increasing the marginal value of expenditures on private long term care also increases optimal savings, as retirees want to have more wealth available to spend if they need LTC.

Savings profiles and the effects of these parameters on savings behavior vary across the state space, as demonstrated in Figures 4(a), 4(b), 5(a), and 5(b).[9] At the baseline parameters, individuals who are in the 10th wealth percentile at age 55 actually save and increase their wealth until ages 75-80. Individuals who are in the 90th wealth percentile at age 55 steadily decummulate assets starting around age 65.

Figure 4(a) shows that for low wealth individuals, a high θ_{beq} induces asset accumulation throughout the entire lifecycle. Even though they have little wealth, with a high θ_{beq} bequests deliver so much utility that retirees save instead of consume. With no utility from bequests, low wealth individuals spend down their assets over the life cycle to such a degree that they eventually reach zero wealth at age 85. As show in Figure 4(b), at baseline, high wealth individuals have around $800,000 in assets at age 90. When there is no utility from bequests, they consume much more of their assets over their life and arrive at age 90 with $200,000—a huge change in savings and consumption behavior induced by different bequest motives. If θ_{beq} is large enough, even very wealthy individuals do not run down their assets and reach age 90 with the same amount of wealth they had at age 55.

As can be seen in Figures 5(a) and 5(b), changes in LTC parameters influence the savings behavior

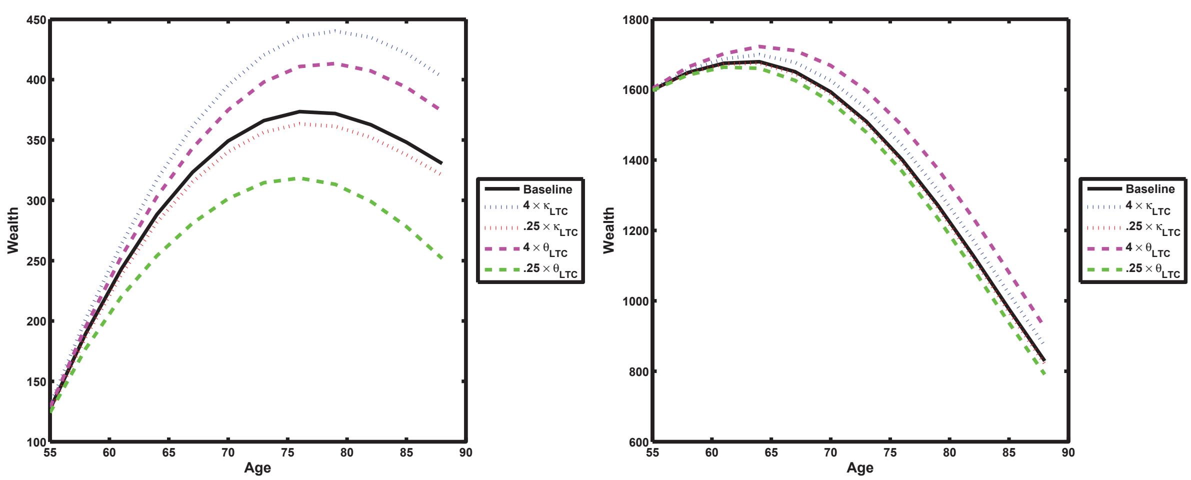
[9] We create figures



(a) 10th Wealth Percentile

(b) 90th Wealth Percentile

Figure 4: Wealth Profiles Across Bequest Parameters



(a) 10th Wealth Percentile

(b) 90th Wealth Percentile

Figure 5: Wealth Profiles Across LTC Parameters

of low wealth individuals much more than that of high wealth individuals. High wealth individuals barely change their savings behavior as LTC parameters are varied. However, low wealth individuals are very sensitive to such changes. As expected, when θ_{LTC} is low, retirees save less, as it is less valuable for them to have wealth available to spend when in need of LTC. The opposite is true for high θ_{LTC}. Just as with the median savings profile, a more negative κ_{LTC} means LTC is viewed as more of a necessary good, and retirees significantly increase their savings as a precaution, to be able to purchase private LTC in case they need it.

With an understanding of the key features of optimal savings behavior in the model and how it relates to important state and parameter values, we turn to a description of the data, from which these parameter values will be estimated.

3 Data

In order to examine annuity demand, it is essential to have data on a population that has wealth it might want to annuitize. This paper draws on the newly developed Vanguard Research Initiative Panel (VRIP) which combines survey and administrative account data. In this section we briefly describe the VRIP, highlighting the advantages of the sample population for addressing the question at hand, and also documenting the Strategic Survey Questions that we developed that are used to estimate the preference parameters of our model.

The VRI Panel consists of approximately 10,000 individuals drawn from Vanguard account holders who are at least 55 years old.[10] The sample is partitioned into pilot and production samples, with the pilot sample approximately one-tenth the total sample size. Surveys are administered over the internet and ask respondents about their and their spouse's or partner's household-level wealth, income, and decision-making motives.

A sample drawn from Vanguard account holders is, of course, not random or representative of the US population. For example, by construction, the sample is drawn from individuals who have positive financial wealth. Hence, we exclude the large fraction of households who approach or reach retirement age with little or no financial assets. Furthermore, the sample is drawn from two groups of account

[10]As a point of comparison, the VRIP is cross-sectionally about the same size as the HRS and around 4 times larger than the SCF.

holders—employer-sponsored account holders and individual account holders.[11] Though individuals in both the employer-sponsored and individual accounts are selected samples, we suspect that the selection process in the two groups may be quite different. For example, the employer-sponsored account subsample looks to be a much closer match to the U.S. population.

Overall, the VRIP sample is wealthier, healthier, and more educated than the US population, also containing more white and more married individuals. These facts are demonstrated in Tables 1–4.

Table 1: Age Distribution Across Surveys

	VRIP	**HRS**			**SCF**		
Age groups	Total	Total	$< \$10,000$	$> \$10,000$	Total	$< \$10,000$	$> \$10,000$
All Ages 55+	8,950	9,396	5,063	4,333	2,630	1,877	753
55-59	1,549	622	273	349	761	515	246
60-64	1,788	1,444	668	776	601	438	163
65-69	1,931	1,242	688	554	442	323	119
70-74	1,907	1,936	1,049	887	306	217	89
75-100	1,775	4,152	2,385	1,767	520	384	136

HRS data are from the 2012 interview. SCF data from 2010 interview. HRS wealth is the sum of household total net financial wealth and IRA. SCF wealth is total financial wealth, which is total financial asset net of non-mortgage debts. The last two columns for HRS and SCF panels give corresponding subsamples for wealth greater than or less than $10,000.

Table 2: Demographics Across Surveys

		VRIP	**HRS**			**SCF**		
		Total	Total	$< \$10,000$	$> \$10,000$	Total	$< \$10,000$	$> \$10,000$
Education	College	32.18%	12.86%	7.81%	16.57%	16.08%	10.10%	19.70%
	Post College	38.45%	14.44%	6.14%	20.55%	15.18%	5.00%	21.34%
Health	Poor	0.84%	8.24%	13.38%	4.44%			
	Fair	4.77%	19.69%	27.40%	14.01%			
	Good	21.77%	31.96%	32.66%	31.44%			
	Very Good	41.84%	31.28%	21.14%	38.76%			
	Excellent	30.78%	8.83%	5.41%	11.35%			
Marital Status	Coupled	67.21%	50.98%	40.01%	59.08%	54.38%	42.02%	61.85%
	Single	32.79%	49.02%	59.99%	40.92%	45.62%	57.98%	38.15%

HRS data are from the 2012 interview. SCF data from 2010 interview.

Tables 1, 2, 3, and 4, taken from Ameriks, Caplin, Lee, Shapiro, and Tonetti (2014), give a quick comparison of the VRIP to the Health and Retirement Study and to the Survey of Consumer Finance

[11] Employer-sponsored accounts derive from choices made by employers to administer their retirement savings—e.g., 401(k) and 403(b) accounts—through Vanguard, and decisions of the employees to take up these accounts by electing to participate and by electing Vanguard if the employer offers multiple account providers. Individual accounts derive from decisions of individuals to open and maintain accounts with Vanguard.

Table 3: Income Distribution Across Surveys

		Mean	10p	25p	50p	75p	90p
VRIP	All	121,481	27,004	50,000	82,017	125,000	191,616
HRS	All	57,422	8,400	14,600	27,305	61,670	126,000
	Wealth $> \$10,000$	77,170	12,348	20,000	37,512	83,520	170,888
	Wealth $< \$10,000$	30,678	6,000	10,800	17,676	33,527	70,300
SCF	All	86,458	14,173	23,986	44,701	83,950	153,727
	Wealth $> \$10,000$	117,426	22,895	35,979	63,235	112,297	196,247
	Wealth $< \$10,000$	35,220	10,685	15,264	26,166	43,610	69,777

VRIP Income is total household income—comparable to Adjusted Gross Income.

Table 4: Wealth Distribution Across Surveys

		Mean	10p	25p	50p	75p	90p
VRIP	All	944,557	17,700	137,100	437,900	997,500	1,918,128
HRS	All	208,255	-2,900	0	26,500	187,000	563,000
	Wealth $> \$10,000$	365,678	22,000	50,000	140,000	400,000	835,000
	Wealth $< \$10,000$	-4,965	-11,900	-2,000	0	1,000	4,500
SCF	All	388,305	-5,363	719	38,773	240,789	789,400
	Wealth $> \$10,000$	626,402	20,110	49,338	154,973	491,101	1,248,668
	Wealth $< \$10,000$	-7,862	-25,098	-6,403	0	1,673	5,363

In this comparison, VRIP wealth is defined to be the sum of total financial wealth and other financial assets, net of pension and debt.

data. To study the annuity puzzle, it is valuable to have observations on individuals who are in the age group when annuity purchases are typically made and who have wealth to potentially annuitize. As is apparent from Table 1, the HRS and SCF have very small numbers of such individuals. The HRS in particular has a small fraction of individuals aged 55-75 with more than $10,000 in financial wealth. The 2010 SCF has 753 people aged 55+ with at least $10,000. Thus, our sample is well positioned to complement existing samples with a highly relevant but previously under-sampled population.

Tables 3 and 4 show that people in the VRIP sample have higher incomes and wealth than the U.S. population. Although the income levels are high, they are not all to different from the levels seen in the SCF population of individuals with at least $10,000. However, the VRIP sample contains much wealthier individuals than the HRS or SCF, even after conditioning on having this small, but positive, amount of wealth.

In Ameriks, Caplin, Lee, Shapiro, and Tonetti (2014) we provide complete details on the VRIP, both on the survey methodology and on the resulting collected data. Of particular interest is information on portfolio allocations, both from the recent survey and linked to historical administrative data.

However, for the purposes of this paper, it is important to note that the VRIP contains information on individuals' wealth and income, information on life expectancy, expected need for long term care, and, crucially, responses to SSQs that were specifically designed to identify parameters of the model just developed. Since we do not explicitly model the family in this paper, we restrict our sample to the single individuals present in the VRIP, who are oversampled to ensure a large single subsample. In the remainder of this section, we focus on describing the SSQs.

3.1 Strategic Survey Questions

Strategic Survey Questions ask survey respondents to state choices they would make in hypothetical scenarios that are designed to achieve identification of structural preference parameters. SSQs build on the stated preference methodology, although our applications differ in design and use. Though necessarily incomplete per se, our scenarios are significantly more detailed than those typically designed and the parameters identified with these questions are not those of a random utility model, as is typically the case. Questions are designed to provide the survey respondent precise detail on all relevant individual states of the world, from the perspective of the life cycle heterogeneous agent incomplete market structural model, and parameters are of deterministic utility functions. SSQs ask the respondent to comprehend and imagine complex scenarios. To make these tasks as easy as possible, we pay close attention to the presentation of the material. To ease respondent comprehension these questions are presented in four parts, with the implementation detailed below.

In the first screen, we begin by telling the respondent explicitly what tradeoff we are asking them to think about. This is done to prompt the respondent to weigh the relevant risks we are interested in, and to alleviate their concern over not understanding the point of the question and guessing about the motives of the survey designers. This was a recommendation from consulting psychologists that read our question, and is carefully worded to not lead the respondent towards any specific answer. Next, the question presents the specific scenario and details the choices that the respondent must make. This screen is the complete scenario, and will be made available to the respondents as they are giving their final answers if they would like to check any features of the scenario. Although ultimately the model is estimated on responses from four types of SSQs, we illustrate the key features of SSQs by detailing a particular SSQ related to LTC.

3.2 Example SSQ

We are interested in how you trade off your desire for resources when you do and when you do not need help with activities of daily life (ADLs).[12] This scenario is hypothetical and does not reflect a choice you are likely ever to face.

Suppose you are 80 years old, live alone, rent your home, and pay all your own bills. Suppose that there is a chance that you will need help with ADLs in the next year. If you need help with ADLs you will need long-term care.

- There is a **25%** chance that you **will** need help with ADLs for all of next year.
- There is a **75%** chance that you **will not** need any help at all with ADLs for all of next year.

You have **$100,000** to divide between two plans for the next year. This choice will affect your finances for next year alone. At the end of next year you will be offered the same choice with another $100,000 for the following year.

- Plan C is hypothetical ADL insurance that gives you money if you **do** need help with ADLs.
  - For every $1 you put in Plan C, you will get **$4** to spend if you need help with ADLs.
  - From that money, you will need to pay all your expenses including long-term care at home or in a nursing home and any other wants, needs, and discretionary purchases.
- Plan D gives you money only if you **do not** need help with ADLs.
  - For every $1 you put in Plan D, you will get **$1** to spend if you **do not** need help with ADLs.
  - From that money, you will need to pay for all of your wants, needs, and discretionary purchases.

Presenting the Rules of the Scenario. Immediately after the scenario is presented, the respondents are provided with a recap of the specific rules that govern their choice. This recaps the previous screen but is presented in a bulleted, easy to read format. In addition, some features which were

[12] Although not presented here, in previous sections of the survey the definition of "needing help with ADLs" is given and understanding is verified. Further, a reminder of this definition appears if respondents move their mouse over the word "ADLs."

hinted at in the first screen, e.g., that there is no public care option and that determination of which plan pays out is made by an impartial third party, are stated explicitly. Other factors that are not accounted for in our structural model are omitted, as we will analyze the data through the lens of our model.

Here are the rules for this scenario.

- You can only spend money from Plan C or Plan D next year. You do not have any other money.
- If you want to be able to spend whether or not you need help with ADLs, you need to put money into both plans.
- If you need help with ADLs, all money in Plan D is lost.
- If you do not need help with ADLs, all money in Plan C is lost.
- Any money that is not spent at the end of next year cannot be saved for the future, be given away, or be left as a bequest.
- You must make your choice before you know whether you need help with ADLs. Once you make your choice, you cannot change how you split your money.
- Regardless of whether or not you need help with ADLs, your hospital, doctor bills, and medications are completely paid by insurance.
- Other than Plan C, you have no other resources available to help with your long-term care. **You** have to pay for any long-term care you may need from Plan C.
- There is **no public-care option or Medicaid** if you do not have enough money to pay for a nursing home or other long-term care.
- An impartial third party that you trust will verify whether or not you need help with ADLs immediately, impartially, and with complete accuracy.

Verification Questions In order to reinforce details of the scenario and measure comprehension, we ask the respondents a sequence of questions about the specifics of the scenario, including payoffs in different states, potential uses of money, potential expenses, and rules regarding the payouts. When answering these questions the respondents do not have access to the screens describing the scenario, but have a chance to review the information before retrying any missed questions a second time. If the respondents fail to answer questions correctly a second time, they are presented the correct answers. Two examples of these questions are presented below.

1. Money in Plan C is available

   (a) Only if you do not need help with ADLs

   (b) Only if you do need help with ADLs

   (c) Whether or not you need help with ADLs

   (d) Neither if you need help with ADLS or do not

2. Who will determine whether or not you need help with ADLs, and thus are eligible to receive payment from Plan C?

   (a) Yourself

   (b) The underwriting company

   (c) An impartial third party that you trust

Recording the Response Having reinforced and measured understanding, we are finally prepared to ask the question: how would respondents split their wealth between the two plans. After again presenting them with the original scenario, we present them the following screen with a link in the top right corner to the full scenario. To record responses, we utilize an interactive slider, which displays the payoff in different states of the world for the current allocation. This allows the respondents to dynamically see the marginal trade-off they are making as they alter their portfolio by moving the slider. Furthermore, before recording a respondent's answer, we force them to move the slider at least once to ensure that they understand how the answer mechanism works and so that they internalize the answer they are providing. This dampens issues related to anchoring and status quo bias, and we observe little effect of a respondents first click on their final answer.[13] The survey response page is as

[13]To alleviate anchoring and stats quo bias concerns, the initial screen starts without the slider in any position and the slider is first positioned at the first click of the respondent. Furthermore, the axis is not labeled with dollar amounts. Instead it contains indications that moving the slider right places more money in Plan D and moving to the left places more money in Plan C.

follows:

“Please make your decision on splitting money into Plan C and Plan D by clicking on the scale below. To put more money in Plan C, move the slider to the left. To put more money in Plan D, move the slider to the right. The numbers in the box will change as you move the slider to let you know how much you will receive if you need long term care and if you do not.

Please move the slider to see how it works. When you are ready, place the slider at the split you want and click NEXT to enter your choice.”

Following this initial question, we ask two variations of this SSQ with different wealth levels, probabilities, and payouts. This provides further information about how they value having wealth in different states and provides us with a consistency check of individual choices. By comparing individual choices across iterations of the same question, we can measure the information vs. noise components of their answers.

3.3 Survey Design: Incorporating Feedback

Our SSQ design process provides two sources of feedback that provide us an opportunity to improve the survey prior to fielding to the production sample. First, we obtain feedback from a team of psychologists on how to structure, present, and word the questions. Their recommendations are guided by cognitive interviews: live discussions with a small pre-sample who verbalize their thoughts while taking an early version of the question. In response to this feedback, we adapted the survey in several ways:

- Included an introductory paragraph before each SSQ that tells respondents specifically what tradeoffs we are interested in understanding

- Reformulated comprehension check questions to directly target issues that were identified as confusing

- Clarified timing at which the respondent invests in the plan and the plan pays out

- Altered wording to ensure that we are always clearly referring to the hypothetical situation to discourage respondents from thinking about their own situation

- Reduced repetition in presenting different iterations of the same scenario to address respondents claim that seeing the same information multiple times caused them to worry that they were taking a "reading comprehension test" and needed to search for changes that in reality weren't present

In addition to survey desing feedback obtained as a result of cognitive interviews, we also gathered feedback from scripted "iModerate" pop-up interviews with a subset of the pilot sample. The psychologist team also provided valuable guidance on the questions we should ask in these live post-survey chats when fielding our survey to the Pilot sample. The iModerate chats are an important component of the SSQ methodology and provide feedback in free response form that permit us to obtain information on what issues trouble respondents prior to fielding the survey to the production sample. At the recommendation of the psychology team, we asked specifically for each question:

- Overall, what are your reactions to this survey?
- What, if anything, did you find hard to understand about this scenario?
- Did you feel any needed information was missing from this specific hypothetical scenario?
- How easy or difficult was it for you to decide how you would divide the money between plans?

These questions are designed to reveal how well respondents understood the scenarios, were able to place themselves in the scenarios, and provide answers as if they were in these scenarios. However, the questions are structured to prompt respondents to provide specific information that was unclear and specific difficulties they had in responding to the questions, as well as specific suggestions for improvement. In reading the transcripts of these chats, several patterns emerge. First, as expected, respondents found the SSQs challenging. Many felt that such scenarios were unrealistic given their current situation, and thus found it challenging to think entirely in the hypothetical world.

Despite the acknowledgment that these scenarios are difficult, most respondents reported that they were able to successfully place themselves in the scenario. First, in regards to missing information that rendered the scenario incomplete, several respondents claimed that they thought about the situation and reported what seemed to them to be most appropriate. For instance, costs of assistance with ADLs were not given, but respondents frequently claimed to have mentally accounted for such costs.

The iModerate chats suggest that while respondents found placing themselves in the hypothetical scenarios difficult, the self-reported assessment of their performance on the survey suggests that respondents did succeed in understanding and answering the question we posed. Furthermore, many individuals specifically mentioned their preferences towards ADL spending vs. bequests when prompted to describe what influenced their allocations in to Plan C and Plan D, leading us to conclude that the iModerate chats are a strong validation of the SSQ data.

3.4 Overview of other SSQs

In addition to the SSQ presented above that examines the tradeoff between wealth when in need and not in need of assistance with ADLs, our survey presents three other SSQs that examine tradeoffs that are relevant to understanding the late in life savings motives. Like the previously presented SSQ, these questions present situations which individuals may be unlikely to ever face. However, the decisions that individuals make when confronted with these hypothetical situations provide information regarding the relative value of having wealth in different states of the world.

The first type of SSQ posed was a modified version of the Barsky, Juster, Kimball, and Shapiro (1997) style question which examines an individuals willingness to trade a certain lifetime income for a lottery over lifetime income that has a higher expected payoff. This original question measured tolerance for risk, and has been used frequently to identify the coefficient of relative risk aversion parameter in a power utility function. In our formulation, we develop this question further by specifying a richer environment in which age, health expense, labor income, unexpected expenses, and outside sources of wealth are all controlled for. We also make the risky income decision a static choice, by allowing the individuals to only bet over a single year's income. This is a significant departure from the standard BJKS formulation, but necessary to avoid contamination with late in life health state utility and bequest preferences. Specifically, in our question we present individuals an option of choosing between two plans that affect their consumption for the upcoming one year. The first plan guarantees \$100,000 for certain, and the second plan will with 50% probability double the income to \$200,000 and with 50% probability reduce income by some fraction. The individuals are then asked a series of questions that categorize them into ranges of fractions they would be willing to risk, and then prompted to provide a point estimate of the largest fraction for which they would choose the lottery over the certain income option. This question is then repeated for an individual with \$50,000 in income.

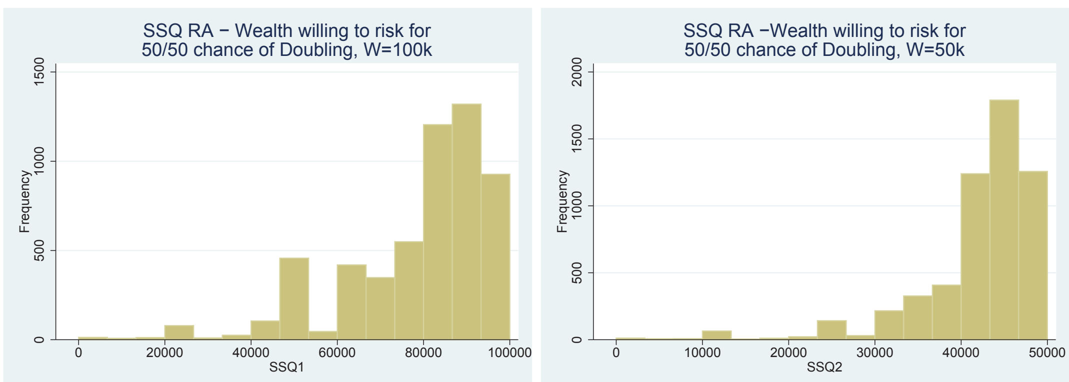
In the third type of SSQ that we posed (the second being described in the previous section), we ask individuals to make an irreversible portfolio decision that allocates money between bequests and expenditure while alive, when the individuals does need help with ADLs. This question, which is similar to one posed in Ameriks, Caplin, Laufer, and Van Nieuwerburgh (2011), removes the possibility of an incidental bequest and thus allows us to focus on an intentional bequest motive. Because bequests observed in standard data sources also include unused precautionary savings, it is difficult to identify how strong the bequest motive is. However, by removing the option of saving money usable for both precautionary and bequest purposes, we are able to separately identify the relative strength of the two motives. To formulate this question, we present individuals with $100,000 and tell them that they have exactly one year left to live. Furthermore, during this year they will need help with ADLs for the entire year. They then must allocate money between two plans, the first which is available for them to spend during the coming year but can not be left as a bequest, and the second which is only accessible as a bequest upon their death. This response is then recorded and the individuals are asked how their portfolio allocation would change if they had $150,000 and $200,000 of wealth.

In the final SSQ, we focus on an individual's willingness to utilize public LTC. The environment is similar to the third SSQ in that the respondents are told they only have one year to live, told they will need help with ADLs for the entire year, and the only two spending channels accessible to them are spending on themselves during the year and leaving money as a bequest. However, in this scenario there is a publicly funded care option that is available to them. Using the public care option will allow them to leave all of their wealth as a bequest, but they are forced to accept the level of care that a typical public care facility would provide. We then ask for the level of wealth at which they would be indifferent between taking public care and paying for their own. Intuitively, for extremely low levels of wealth the respondents are likely to utilize public care, as they are unable to adequately fund their own care and a bequest. However, for wealth levels sufficiently high, they are likely to fund their own care as the value of public care becomes small compared to the value private care and the total expenditures on LTC become small relative to their desired bequest level. This suggests there will be an interior response that provides a measure of the equivalent dollar amount an individual assigns to receiving public care.

3.5 Quantitative Analysis of SSQ Responses

Before utilizing the survey responses in formal estimation, it is useful to examine the responses to the SSQs to ensure that individuals answer the questions in ways that are economically reasonable. Ultimately, parameters are estimated jointly, so there is no simple mapping between a particular parameter and a particular SSQ response. However, as we vary wealth and probabilities, respondents should adjust their answers in response to the new environments. Respondents adjusting their answers in ways that are compatible with economic intuition is informal evidence that they understood the scenario and that their answers provide useful information. The SSQ responses presented here suggest strongly that individuals understood the questions and internalized different changes to the environment when responding to questions.

The first two SSQs presented in the survey asked respondents how much of a guaranteed income stream they would risk losing with 50% probability for a 50% probability of doubling. Thus, if the initial income stream was valued at $100,000, an answer of $80,000 would imply that they would be indifferent between a lottery that provided payouts $80,000 and $200,000 with equal probability and a lottery that provided $100,000 for certain. Furthermore, under the maintained assumption of CRRA utility, a response of $80,000 would imply that the individual answering the question had a risk aversion parameter of approximately 3.7.

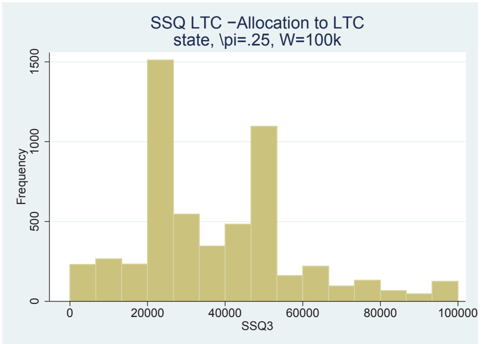


(a) SSQ 1

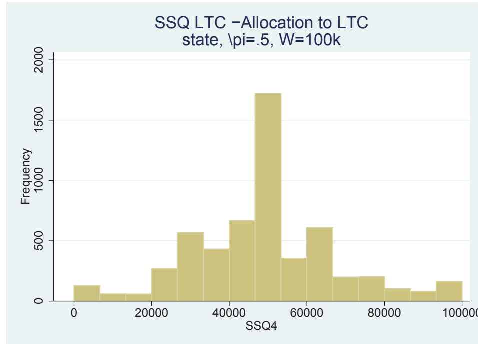
(b) SSQ 2

Figure 6: Risk Aversion SSQs

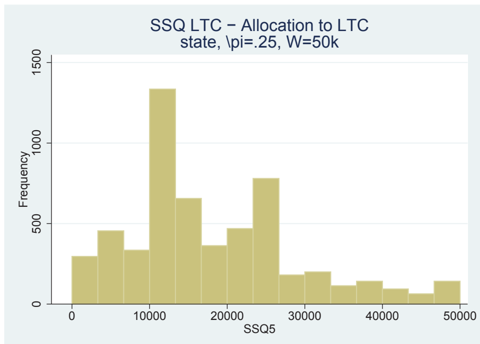
Figure 6(a) presents the minimum income at which respondents would still be willing to accept the lottery described above. Here we see that the majority of these individuals are clustered between $60,000 and $100,000, with a peak about $90,000. A response of $90,000 implies a risk aversion parameter of approximately 7.8 and any lower response implies a lower risk aversion. These responses are similar to those to the standard Barsky, Juster, Kimball, and Shapiro (1997) question from which this question was derived. Finally, in examining responses to the second iteration of the question which was posed with a base income of $50,000 (presented in Figure 6(b)), we find that the response distribution is very similar to that of the first SSQ with a $100,000 base income. This wealth-level invariance lends support to our assumption of CRRA preferences which are modeled with a homothetic utility function. Thus, these response distributions suggest that individuals were responding to this SSQ in reliable ways that are consistent with our model.



(a) SSQ 3



(b) SSQ 4

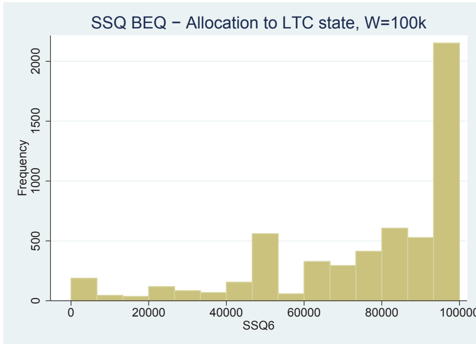


(c) SSQ 5

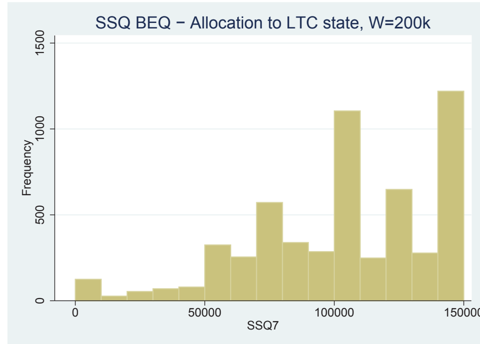
Figure 7: LTC SSQs

Figures 7(a), 7(b), and 7(c) present the distribution of responses to the second type of SSQ that essentially asks individuals to purchase Arrow securities that pay off in the healthy state, which occurs with probability π, and the ADL state, which occurs with probability $1-\pi$. Furthermore, for each dollar that they allocate to the ADL state, they receive $1/(1-\pi)$ in the event that this state occurs.

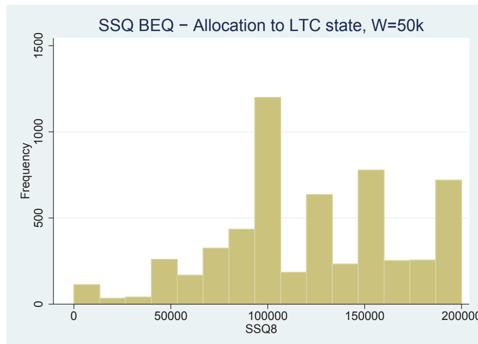
Compared to the third SSQ, in the fourth SSQ the probability of finding oneself in the ADL state has increased while the return to saving for the ADL state has decreased, while the wealth level is the same. Figures 7(a) and 7(b) depict the different distribution of responses. We would expect an unambiguous increase in the portfolio share allocated to the ADL state in response to these changes. In comparing the distributions, we notice a notable rightward shift in the distribution, signifying a higher portfolio allocation toward the LTC state. Thus, the respondents' decisions are at first glance consistent with economic theory. In comparing the third and fifth SSQs, which specify the same probabilities of entering the LTC state but vary the wealth level from \$100,000 to \$50,000. We do not observe significant changes in the reported portfolio shares.



(a) SSQ 6



(b) SSQ 7



(c) SSQ 8

Figure 8: Bequest SSQs

In Figures 8(a), 8(b), and 8(c) we observe how individuals trade off leaving money as a bequests and having wealth when in the ADL state, across wealth levels of \$100,000, \$150,000, and \$200,000, respectively. In each figure, we observe the amount that the individual would allocate towards the ADL state. Here, we clearly see that individuals react to the wealth level, as we note that most respondents allocate almost all of their portfolio to the ADL state when wealth is \$100,000, about 2/3 to the ADL state when wealth is \$150,000, but only about half when wealth is \$200,000. This is suggestive that individuals view LTC as the primary reason to save late in life at lower wealth levels, with bequest motives becoming more important at higher wealth levels. Given that bequests are estimated to be a luxury good, these patterns are consistent with the economic behaviors one would expect and signify an understanding of the scenario presented in the question.

Finally, we present in Figure 9 respondents' answers to the ninth SSQ. In SSQ 9, respondents are in need of LTC, and can either accept free public care and leave all of their wealth as a bequest, or spend to obtain private care, leaving the remainder of their wealth as a bequest. In this question we observe significant heterogeneity, including masses around \$100,000, \$200,000, and \$300,000.[14] Despite

[14]For exposition, we truncate the data at the 95th percentile.

the tendency for some respondents to require extremely high wealth levels before they funded their own care, we observe a large mass of individuals between \$0 and \$100,000. These are reasonable values, especially when one considers that an individual with \$100,000 could both provide \$50,000 for their own care and leave \$50,000 as a bequest. Thus, we generally view this response distribution as economically reasonable, while acknowledging that there seems to exist significant heterogeneity in the population regarding the attitude toward publicly funded LTC.

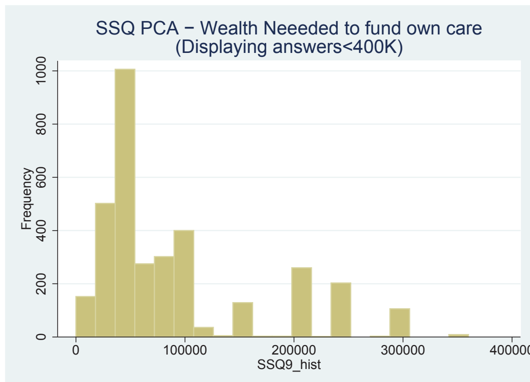


Figure 9: SSQ 9: PCA

In short, an initial analysis of the SSQ responses leads us to believe that individuals interpreted the questions correctly and responded in an economically meaningful way. This, combined with our understanding checks and iModerate responses provides support for the validity of the SSQ data. Thus, we proceed to develop an estimation strategy that utilizes this data to identify preference parameters.

4 Estimation Methodology

We develop a two stage Method of Simulated Moments (MSM) estimator that is similar to those used in De Nardi, French, and Jones (2010), French and Jones (2011), Lockwood (2013), Gourinchas and Parker (2002), and Laibson, Repetto, and Tobacman (2007) to estimate parameter set Γ. $\Gamma = [\Xi, \Theta]$ is divided into two subsets, with the first subset, Ξ, consisting of parameters externally estimated without the use of the structural model (e.g., survival probabilities, health transitions, etc.) and the second parameter subset, Θ, consisting of underlying preference and preference type assignment parameters that are estimated using moments generated by simulating the structural model. After calibrating the first stage estimates at their estimated values, the second stage parameters will be estimated using MSM procedure by minimizing the distance between model implied moments and their empirical counterpart.

4.1 First Stage Estimates

4.1.1 Income

Income profiles are estimated from VRIP Survey 1. In Survey 1, respondents report their income flows as the sum of labor income, pension and disability payments, and social security payments. For each age, we assign respondents to an income quintile based on their current rank amongst individuals the same age. Using this cross-section of income, we use a quintile regression to estimate the age profile of earnings as a polynomial of age and gender. We then assume that an individual's income process follows a deterministic process as determined by the estimated coefficients, and do not allow for quintile mobility. This allows us to capture income changes during retirement, but abstract from income fluctuations as a source of uncertainty. The estimated age profiles of income for each quintile are presented in Appendix A.1.

4.1.2 Health Transitions

Health Transitions were estimated using HRS waves 3 through 10, with the defined health states constructed from two sets of questions. The first utilizes self-reported subjective health status questions to classify individuals into good or bad health ($s = 0$ or $s = 1$).[15] The second set of questions is used to determine whether an individual is in the LTC/ADL state ($s = 2$). This set of questions presents 5 Activities of Daily Living and asks whether respondents receive help with any of the 5 activities. If the respondent answers yes to any of these questions, then we define that respondent to be in the ADL health state. Although alternative LTC/ADL state definitions, such as having spent time in a nursing home, are feasible given the available data, we choose this state definition since it is most consistent with the ADL definition presented in our survey. The questions necessary to make this health state assignment are not available in the 1992 and 1994 surveys, so we exclude these surveys from our health transition estimates.

Using these health state definitions we estimate a sequence of health transition matrices conditional on a vector $x_{i,t}$ which includes individual i's age, t, and gender, g. The HRS only records 2 year health state transitions which we use to identify the one-year transition probabilities in a manner similar to

[15] This classification is done according to the criteria presented in the RAND HRS.

De Nardi, French, and Jones (2010). To do this, we write the two year transition probabilities as

$$\begin{aligned}
Pr(s_{t+2} = j | s_t = i) &= \sum_{k=0}^{3} Pr(s_{t+2} = j | s_{t+1} = k) Pr(s_{t+1} = k | s_t = i) \\
&= \sum_{k=0}^{3} \pi_{kj,t+1} \pi_{ik,t}
\end{aligned}$$

where,

$$\pi_{ik,t} = \frac{\gamma_{ik,t}}{\sum_{m=0}^{3} \gamma_{im,t}} \text{ and } \gamma_{ik,t} = exp(x_{i,t}\beta_k).$$

We then estimate the β_k using a maximum likelihood estimator, and use these estimates to fill in the corresponding cells in the health transition matrices. More information on health transition matrices are included in Appendix A.2.

4.1.3 Health Expense

Health expenses, as implied by current health state (s) and idiosyncratic health cost state (h) are estimated from the 2010 HRS distribution. Because we do not allow for persistence in the idiosyncratic cost state in our model, a single year of cross-sectional data is sufficient. To estimate the mean ($\mu(t, g, s)$) of health costs conditional on health state (s), we regress log out-of-pocket medical expenditures on age, gender, health state, and interaction terms.

Using the residuals from this first regression, we regress the squared residuals on the same set of state variables as in the first regression to find the conditional variance ($\sigma^2(t, g, s)$) of medical expenses. Finally, discretizing the error term $\epsilon_t \sim N(0, 1)$ into separate health cost states fully determines the medical expense process. For more information regarding this estimation, including visual representation of the age profiles of health expenditures, please see Appendix A.2.

4.2 Second Stage Estimates

In the second stage, we apply our MSM estimation procedure. Specifically, we define moments as the difference between statistics generated by the structural model ($m(\hat{\Xi}, \Theta, X)$) and empirical data ($s(X)$) as $g(\hat{\Xi}, \Theta, X) = \mathbb{E}\left[m(\hat{\Xi}, \Theta, X) - s(X)\right]$, and estimate second stage parameters $\hat{\Theta}$ that minimize a GMM quadratic objective function with moments $g(\hat{\Xi}, \Theta, X)$. Here and throughout the paper, we define $X = (X_i)_{i=1}^{I}$ as the collection of measurements for all individuals, including behavioral responses, SSQ responses, and state variables. Furthermore, $x_i \subseteq X_i$ will be used to denote relevant subsets of the individual i data set.

Empirical moments are defined by our data and taken as given. To generate simulated moments, we first solve our model to generate optimal decision rules as function of all relevant state variables. Next, we sample (with replacement) a large number of individuals N from our observed data X. We then draw relevant shocks, drawn from our $\hat{\Xi}$ parameterized stochastic processes, and simulate the behavior of each individual in our initial X distribution as implied by the computed optimal policies (conditional on a given parameter set $\theta \subset \Theta$). We then aggregate these individual decisions to construct simulated population moments $m(\hat{\Xi}, \Theta, X)$. If our model is correctly specified, then $g(\hat{\Xi}, \Theta_0, X) = 0$ exactly by the LLN, for the simulated moments should replicate the observed empirical actions. Our second stage estimator is thus formally defined as

$$\hat{\Theta} = \arg\min \frac{N}{N+I} g(\hat{\Xi}, \Theta, X)' W g(\hat{\Xi}, \Theta, X). \tag{3}$$

As is standard, asymptotically,

$$\begin{aligned}
\sqrt{N}\left(\hat{\Theta} - \Theta_0\right) &\to \mathbb{N}(0, \Psi) \\
\Psi &= \left(\frac{N+I}{N}\right)(D'WD)^{-1}(D'W\Omega WD)(D'WD)^{-1} \\
D &= \left.\frac{\partial g(\hat{\Xi}, \Theta, X)}{\partial \Theta'}\right|_{\Theta=\Theta_0}.
\end{aligned}$$

with Ω defined as the empirical covariance matrix. This holds generally for every estimation exercise we conduct in this paper.

We explore three specific estimation procedures that utilize different data to estimate the parameters that control the various savings motives active in our model.

1. Estimate the model solely matching behavioral data moments

2. Estimate the model solely matching strategic survey response moments

3. Estimate the model matching both strategic survey response and behavioral data moments

Estimation method 1 uses a set of moment conditions frequently used to estimate life-cycle savings models, age-conditional wealth percentiles. Estimation method 2 estimates all preference parameters of the structural model using only moments based on the SSQs. Finally, estimation method 3 will combine the moments used in the previous two methods, using a weighting factor that determines the relative weight placed on SSQ and behavioral moments in the estimation. In addition, splitting our data into SSQ and behavioral data permits out of sample model verification, as we can examine the behavioral estimates implied by SSQ responses and the SSQ responses implied by behavioral patterns.

The construction of the moment conditions used in estimation strategies 1, 2, and 3 are specified in subsections 4.2.1, 4.2.2, and 4.2.3 respectively. Finally, in all estimations we allow for heterogeneous preferences across the population, with individuals assigned probabilistically to an estimated preference type. This reflects the idea that preferences towards bequests or LTC may vary significantly across people and may be an important determinant of generating the behavioral and SSQ data.[16] In Section 4.2.4 we discuss the variables used in assignment to preference sets. This assignment is necessary given the heterogeneity we allow in our model, and the estimation procedure must simultaneously identify assignment coefficients when identifying underlying structural parameters.

4.2.1 Behavioral Moments

As is common with many life cycle studies of retirement savings (e.g., De Nardi, French, and Jones (2010), Gustman and Steinmeier (1986), Lockwood (2013)), our first estimation exercise will target asset percentile levels, a_x^p, conditional on a set of state variables x. In our baseline case $x = t$ so that we are matching wealth percentiles conditional only on age, while in other cases we expand x to include health (h), discretized income level (y), and gender (g), in addition to age. For a full specification of other moment conditions conditional on behavioral data, we refer to Technical Appendix B.

The empirical moment conditions for wealth percentile p conditional on state variables x are denoted a_x^p, while $a_i(\hat{\Xi}, \Theta, X_i)$ denotes simulated individual i's wealth holdings when he has state variables X_i and the model is specified with parameters $\hat{\Xi}$ and Θ. We also denote $a^p(\hat{\Xi}, \Theta, X)$ as the simulated wealth percentile from aggregating all $\left(a_i(\hat{\Xi}, \Theta, X_i)\right)_{i=1}^{N}$. Then, we denote our wealth

[16] We can imagine one type of person who very much wants to receive high quality convenient care while in need of LTC and is willing to consume a bit less while healthy to self-insure. It is also plausible that another type of individual might rather accept lower quality LTC to be able to spend more while healthy and more capable of enjoying consumption.

moments conditional on x as

$$g_x(\hat{\Xi}, \Theta, X) = \mathbb{E}\left[\hat{a}_x^p(\hat{\Xi}, \Theta, X_i) - a_x^p | x_i = x\right], \tag{4}$$

an expression which can easily be converted to an unconditional expectation through the Law of Iterated Expectations. For more information on this, and formal derivation of the asymptotics, please see Technical Appendix B.

In our baseline estimation, we define the moment conditions as the level of the 25^{th}, 50^{th} ,and 75^{th} percentiles (a_t^p) conditional on age t. We aggregate the age profiles into disjoint three year intervals, so that $t \in \{55-57, 58-60, ..., 88-90\}$. We thus define a_t^p as the empirical p^{th} percentile for those aged t,$t+1$, or $t+2$, with the simulated percentile defined accordingly. This aggregation is done to smooth noise in the empirical asset profile that we observe in the cross-sectional data. Given that generally the number of moment conditions in the estimation with behavioral data will be given as $\|p\| \times \|x\|$, this provides us with 36 moment conditions to target.

4.2.2 Strategic Survey Moments

In our second estimation exercise, we estimate the model solely using strategic survey question responses. We are unaware of any existing study that has undertaken a similar estimation. Our estimation strategy is most similar to van der Klaauw (2012) and Blass, Lach, and Manski (2010), due to the use of non-behavioral data to identify parameters in a structural model. However, unlike these studies, we do not utilize subjective expectations data that require specification of an expectation formation process, but instead estimate the model from stated strategies in hypothetical situations. In addition, we have collected sufficient non-behavioral data to identify (almost) all preference parameters solely from our SSQ responses, and thus, unlike other studies, do not need to augment our non-behavioral data with observed behaviors to gain identification. Finally, we use deterministic utility functions, as opposed to the random utility specifications frequently made in this literature to obtain a closed form likelihood function convenient for estimation.

Estimation of preference parameters without any behavioral data requires design of SSQs to ensure identification. In our proposed structural model there exist 8 preference parameters: relative risk aversion parameter, σ, LTC state utility parameters, θ_{LTC} and κ_{LTC}, bequest utility parameters, θ_{beq} and κ_{beq}, public care aversion, LTC_{PC}, healthy state consumption floor, C_F, and intertemporal discounting, β. Using responses to the four types of SSQs described in Section 3.4 and their iterations at different wealth levels and state probabilities, we are able to identify all parameters except for the discount factor, β, and the consumption floor, C_F. Restrictions on survey length prevented us from fielding questions that would allow us to estimate these parameters.[17] Thus, when examining results from this estimation exercise through the lens of our life-cycle savings model we calibrate β to .98 and C_F to \$6,000.[18]

For the remaining parameters, we rely on our parameterized model estimation from our SSQs to identify individual parameters. In each situation, we ask individuals to make a trade-off between certain states, and record their decisions. Because different utility functions are active in different states, different preference parameters control the marginal utility tradeoffs that determine the decisions in each state of the world (see Table 5 to see which parameters influence optimal decisions in each SSQ). For instance, SSQ 1 asks individuals to make a risky bet regarding consumption when healthy and explicitly rules out the potential that this decision could influence consumption in other states. Since relative risk aversion parameter σ is the only parameter which determines marginal utilities in the active states, this question identifies risk aversion. This strategy was first developed in Barsky, Juster, Kimball, and Shapiro (1997), from which this question is derived. SSQ 2 examines the tradeoff between having wealth when healthy and when in need of help with ADLs. This tradeoff is optimally determined (abstracting from corner solutions for the moment) by equating marginal utility in the healthy state as determined by σ with marginal utility when in need of help, as determined by θ_{LTC} and κ_{LTC}. Utilizing the observed tradeoffs at different wealth levels and state probabilities, we thus are able to identify the θ_{LTC} and κ_{LTC} necessary to align the model with SSQ responses. SSQ 3 examines a similar tradeoff between wealth when in need of help with ADLs and wealth for a bequest, while SSQ 4 examines how the existence of a government LTC consumption floor effects the tradeoff. In both of these question, the model implied optimal strategy is dictated by the marginal value of wealth in the ADL state (again, determined by θ_{LTC} and κ_{LTC}) and the marginal value of wealth allocated towards a final bequest (determined by θ_{beq} and κ_{beq}), while in the fourth the respondent must also take into account how the existence of a public care option affects this tradeoff by determining how

[17] Additionally, the consumption floor that is designed to represent welfare is not an active margin for the sample we are studying.

[18] Lockwood (2013) estimates this to be \$7800 and Ameriks, Caplin, Laufer, and Van Nieuwerburgh (2011) finds this to be \$4,700.

much he values public care (PC_{LTC}). Because these tradeoffs vary with wealth levels, we are able to use these questions to identify the underlying parameters that map survey responses to parameters.

As an example of this identification, we present the optimization problem and optimal decision rule of each individual that corresponds to SSQ 2:

$$\begin{aligned}\max_{x_1,x_2} \quad & \pi_1 \frac{(x_{i,1})^{1-\sigma}}{1-\sigma} + (1-\pi_1)\frac{\theta_{LTC}(x_{i,2}+\kappa_{LTC})^{1-\sigma}}{1-\sigma} \\ \text{s.t. } & x_{i,1} + \frac{1}{\pi_1} x_{i,2} \le W \\ & x_{i,2} \ge 0\end{aligned}$$

where the optimal policy is given by

$$x_{i,2} = \begin{cases} 0 & if \quad W^{-\sigma} - (1-\pi_1)\theta_{LTC}(k_{LTC})^{-\sigma} > 0 \\ W \frac{\left(\frac{1}{(1-\pi_1)\theta_{LTC}}\right)^{\frac{-1}{\sigma}}}{1+\frac{1}{\pi_1}\left(\frac{1}{(1-\pi_1)\theta_{LTC}}\right)^{\frac{-1}{\sigma}}} - \frac{k_{LTC}}{1+\frac{1}{\pi_1}\left(\frac{1}{(1-\pi_1)\theta_{LTC}}\right)^{\frac{-1}{\sigma}}} & otherwise. \end{cases}$$

In the above expressions, π_1 and W are specified in the survey question, and we will rely on varying these values in different question iterations to ensure identification. In addition, SSQ1 provides a measure of individuals relative risk aversion, so this question is needed primarily to measure θ_{LTC} and κ_{LTC}. The optimal SSQ 2 decision rule is linear in wealth:

$$x_{i,2} = \begin{cases} 0 & if \quad (W)^{-\sigma} - (1-\pi_1)\theta_{LTC}(k_{LTC})^{-\sigma} > 0 \\ W B_{\theta_{LTC},\sigma,\pi_1} - C_{\theta_{LTC},\kappa_{LTC}\sigma,\pi_1} & otherwise. \end{cases}$$

Thus, by obtaining responses for 2 different combinations of W and π_{LTC} for which allocations to both states are positive, we are able to identify $B_{\theta_{LTC},\sigma,\pi_1}$ and $C_{\theta_{LTC},\kappa_{LTC}\sigma,\pi_1}$. Furthermore, there exists a unique mapping from $(\theta_{LTC},\kappa_{LTC})$ to $(B_{\theta_{LTC},\sigma,\pi_1}, C_{\theta_{LTC},\kappa_{LTC},\sigma,\pi_1})$ conditional on σ, so θ_{LTC} and κ_{LTC} are conditionally identified. Combining these with the results of SSQ 1 we are thus able to identify all three parameters from responses to these questions. Finally, since our survey poses 3 different iterations of SSQ 2 (as well as 2 iterations of SSQ 1), we have an overidentified system suitable for estimation. The conditional identification of $(\theta_{beq},\kappa_{beq})$ and LTC_{PC} by SSQ 3 and SSQ 4

	σ	θ_{LTC}	κ_{LTC}	θ_{beq}	κ_{beq}	LTC_{PC}	C_F	β
SSQ 1	X							
SSQ 2	X	X	X					
SSQ 3	X	X	X	X	X			
SSQ 4	X	X	X	X	X	X		

Table 5: **Link between Parameters and Each SSQ**

respectively can similarly be shown, thus ensuring that all parameters are jointly identified from our set of SSQ responses.

By design, the strategic survey questions remove all state dependence from the answers, so our model predicts the only heterogeneity in responses should be the result of heterogeneous preferences. Thus, for a single SSQ, the model predicts a single response implied by each of the H parameter sets, with the the number of simulated individuals assigned to each response determined by the preference assignment function coefficients, λ. Our MSM estimation strategy thus matches the population means of these SSQ responses to the empirical means by varying the preference parameters which determine response values and assignment coefficients which determine assignment of individuals to these responses.

Formally, in our second estimation exercise, we match the empirical mean of each SSQ ($m = 1...9$) conditional on a set of variables x, denoted $\bar{z}_{m,x} = \mathbb{E}\left[z_{i,m}|x_i = x\right]$, with the mean of the simulated SSQ responses conditional on x. To generate our simulated means, we denote simulated individual i's response to SSQ m as $s_m(\theta_i)$, $\theta_i \in \{\theta_1, ..., \theta_H\}$. We then write the conditional moment as

$$g_{m,x}(\hat{\Xi}, \theta, X) = \mathbb{E}\left[s^i_m(\theta_i) - \bar{z}_{m,x}|x_i = x\right], \tag{5}$$

where in the simulation we can express this as

$$g_{m,x}(\hat{\Xi}, \theta, X) = \left(\frac{1}{N_x}\sum_{i|x_i=x} s_m(\theta_i)\right) - \bar{z}_{m,x}$$

In practice, the above conditional moment conditions are converted to unconditional moment conditions by applying the Law of Iterated Expectations. For more information regarding the formal derivation of moment conditions, we refer the reader to Technical Appendix B.3. Finally, given that we have 9 SSQs, the above moment conditions will yield $9 \times \|x\|$ where $\|x\|$ denotes the number of conditioning states we use.

In our baseline case for SSQ estimation, we define the moment conditions as the the SSQ means conditional on gender and an indicator variable that groups individuals based on their responses to SSQs. This SSQ group indicator variable $k_i \in \{1, ..., K\}$ is defined in detail in Technical Appendix B.1.2, but utilizes a clustering algorithm to optimally group individuals by minimizing the dispersion of answers within groups. In general we will allow for $K = H$ possible groups as we anticipate that k_i will be a significant predictor of preference assignment. Similarly, we elect to condition on gender because it is the only modeled state variable that we do not control for in posing our SSQ, and we expect it to predict preference type. Because for both of these we expected notable differences in the preference assignments conditional on these variables, we expect the SSQ response distributions to differ and thus condition on these variables. Finally, since $M = 9$ (number of SSQs) and $H = 2$ (number of preference types) and there are 2 genders, there are 36 moment conditions.

4.2.3 Behavioral and SSQ Combined Estimation

In the previous two sections we described the specification of wealth and strategic survey moments and the estimation procedures using these as separate inputs. In this section we describe a third estimation procedure using both SSQ and behavioral data that combines these moments into a single moment vector that will be used to estimate the model. Utilizing both sources of information disciplines our estimator to match behavioral data and SSQ data, with each source of data likely containing unique information. To do this, we concatenate the two moments sets and allow the econometrician to control the relative weight given to each. This allows us to examine how our estimates vary with weights, and nests the previous two estimation specifications in the limits. It is important to note that it is not necessary that this estimation procedure yields estimates that are a convex combination of or are contained within the interval defined by the first and second estimates due to the non-linearity of our model. In general however, the resulting parameter estimates should not differ starkly from our first and second estimation exercises if we have a well specified model.

Let $g_V(\hat{\Xi}, \Theta, X)$ denote the set of moments constructed from behavioral data, $g_S(\hat{\Xi}, \Theta, X)$ denote a set of moments constructed from SSQ data, and $\eta \in [0, 1]$ denote the econometrician-specified weight given to behavioral moments. Denote the combined set of moments as

$$g(\hat{\Xi}, \Theta, X) = \begin{bmatrix} \sqrt{\eta}\times & g_V(\hat{\Xi}, \Theta, X) \\ \sqrt{1-\eta}\times & g_S(\hat{\Xi}, \Theta, X) \end{bmatrix} \tag{6}$$

$$= \begin{bmatrix} \sqrt{\eta} & 0 \\ 0 & \sqrt{1-\eta} \end{bmatrix} \begin{bmatrix} g_V(\hat{\Xi}, \Theta, X) \\ g_S(\hat{\Xi}, \Theta, X) \end{bmatrix}. \tag{7}$$

$$\tag{8}$$

Substituting the above expression into equation 3 and assuming a block diagonal weighting matrix, W, yields

$$\hat{\Theta} = \arg\min \frac{N}{N+I} \begin{bmatrix} g_V(\hat{\Xi}, \Theta, X) \\ g_S(\hat{\Xi}, \Theta, X) \end{bmatrix}' \begin{bmatrix} \eta W_1 & 0 \\ 0 & (1-\eta) W_2 \end{bmatrix} g \begin{bmatrix} g_V(\hat{\Xi}, \Theta, X) \\ g_S(\hat{\Xi}, \Theta, X) \end{bmatrix}. \tag{9}$$

From the above expression, it is apparent that our specification of η results in a linear weighting scheme in the GMM objective functions used in the first two estimation cases. Formal derivation of the asympotic properties of this distribution and implementation of the simulation procedure are presented in Technical Appendix B.

For the baseline case of this estimation, we let $g_V(\hat{\Xi}, \Theta, X)$ be the same as the baseline estimation using behavioral moments, and $g_S(\hat{\Xi}, \Theta, X)$ be the same as the baseline using SSQ moments. Therefore, our moment conditions in this estimation consist of the age conditional wealth percentiles (a_t^p), with $p \in \{25, 50, 75\}$ for each of the 12 age groupings, and the mean to each of the 9 SSQs asked, conditional on the group variable $k \in 1, 2$ and gender. This provides us with 72 total moment conditions which we match in this exercise.

4.2.4 Preference Heterogeneity

To accommodate a wide variety of preferences and savings motivations, especially as reported by SSQs, we allow for preference heterogeneity. In all three estimation exercises we assign individuals to one of a finite number of preference sets according to a logistic assignment function. A preference set contains values for each parameter, i.e., a $\theta \in \Theta$. We express assignment coefficients as the vector λ, so that the probability of being assigned to preference type h conditional on individual variables x_i

is denoted $p(\theta_h|x_i) = f(x_i;\lambda)$ where $f(x_i;\lambda)$ is either a logistic function ($H = 2$ types) or a set of weighted logistic functions ($H > 2$ types). We focus on the case when $H = 2$, indicating that there are 2 preference types in our model, but the following generalizes to allow for a set of $\{\lambda_h\}_{h=1}^{H-1}$ coefficients. When $H = 2$, we can denote the probability of preference type as

$$p(\theta_1|x_i) = f(x_i;\lambda) \tag{10}$$
$$= \frac{exp(\lambda x_i)}{1 + exp(\lambda x_i)} \tag{11}$$

and

$$p(\theta_2|x_i) = 1 - f(x_i;\lambda) \tag{12}$$
$$= \frac{1}{1 + exp(\lambda x_i)} \tag{13}$$

Individuals are assigned a preference type probabilistically, and the preference type is time invariant. However, simulated individuals with the same observables can be assigned different preference sets due to the stochastic assignment procedure.

Generally x_i can be any subset of individual i's data set, X_i. In practice we only want to include variables that we believe are likely to be predictive of an individuals underlying preference type. In addition, in our estimation using behavioral data, we include wealth at age t_0 as an assignment variable. Similarly, in our estimation using SSQ data, we utilize a group indicator, the construction of which is described below. In the estimation exercises that combine behavioral and SSQ data, we define the set of assignment variables as the union of the assignment variables used in the behavioral and strategic survey estimations.

An SSQ indicator variable used to predict preference types is constructed to aid in preference type assignment. To construct this variable, we use a clustering algorithm that assigns data into groups according to a minimal distance criteria. Given $(Z_i)_{i=1}^{I}$, where $Z_i = \{z_{i,1}, z_{i,2}, ..., z_{i,M}\} \subset X_i$ denotes the set of individual i's SSQ answer set, we assign individuals into a group $k_i = \{1, ..., K\}$ that minimizes the sum of each individual's response distance from its assigned group's response centroid.[19]

[19] Recall, in our applicatoin, M=9. The SSQ set consists of 2 iterations of SSQ 1, 3 iterations each of SSQs 2 and 3, and 1 iteration of SSQ 4.

We normalize each question z_m to be contained in the unit interval and utilize the Euclidean distance metric, with formal specification of the variables' construction presented in Technical Appendix B.1.2. Intuitively, an individual's group assignment corresponds to the group that minimizes the total distance of all individuals' response sets to their respective group's mean. Thus, because different underlying parameters would imply different SSQ responses, we would expect this indicator variable to be predictive of underlying preference type.

Similarly, we expect the other variables included in our estimation, including wealth, to be predictive of preference type. For our wealth moments, identification will largely be driven by the initial asset level from which we initialize our simulation. Because certain preference types are more likely to be associated with different asset holding levels, we expect this to predict preference types. Similarly, gender, age, marital status, and education may be correlated with preference types and thus are included in the assignment regression.

5 Parameter Estimates

Following the process presented in the previous section, we obtain estimation results for each of the three estimation methods.[20] To aid in exposition, we will often present results for males of preference type 1. However, we will explore how parameters vary across types and gender and the resulting economic importance of these different parameter estimates when analyzing the demand for annuities. Figure 10 illustrates the mean response for each SSQ, in both the data and in our model simulations at the estimated parameter values. Model simulated and empirical moments match closely for question 1 related to risk aversion and questions 2-5 related to the health-state utility function. In the model, questions 6-8, which are related to bequests, are lower than in the data, suggesting, holding all other things equal, that agents in our model value bequest less on the margin and view them more as luxury goods. Finally, the match on question 9 is not very good, suggesting a wide dispersion between model and empirical responses to this question about public care aversion. Agents in our model seem to have lower public care aversion than empirical responses to SSQ 9 would seem to suggest. It is important to note that all parameters are jointly estimated, so there is no simple bijective mapping between the

[20] Estimation jointly using both sources of data is to be added in future versions of the paper.

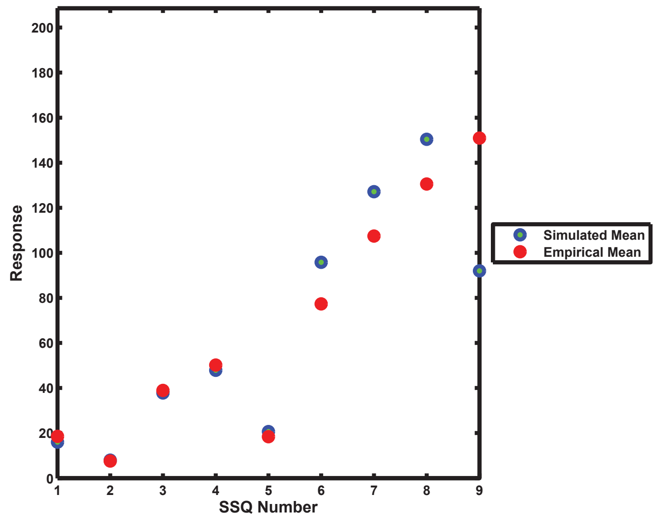


Figure 10:
SSQ Moments: Model and Data

mean response to a single SSQ and a particular parameter.[21] For example, changes in risk aversion affect the health-state utility function, the value of a bequest, and the degree of public care aversion.

Figure 11 presents the model generated and empirical 25th percentile, 50th percentile, and 75th percentile of the wealth distribution across ages. These moments were not targeted in the estimation that used SSQ moments. Using the parameters estimated only on SSQ responses, we see that the model generally delivers lower levels of wealth at higher ages than the data. The model generated data matches the empirical 25th and 50th percentile wealth profiles quite well for most ages. However, the model output deviates from the data by generating much lower savings rates for the very wealthy starting around age 70. Even so, this is strong evidence that the SSQs seem to have important information to inform parameter estimates, as in and of themselves, they generate savings behavior consistent with the behavioral data for a large fraction of the population.

The baseline estimates for each estimation exercise are presented in Table 6. Of particular interest in our estimation are three groups of parameters. First, the estimates of health state utility presented are the first we are aware of to estimate this functional form applied to LTC. Second, our bequest parameters θ_{beq} and κ_{beq} have been measured in several other studies, enabling us to compare our estimates to the literature. Finally, LTC_{PC} has been previously estimated in Lockwood (2013) and Ameriks, Caplin, Laufer, and Van Nieuwerburgh (2011), and we thus similarly have a baseline to

[21] Also note that the PCA aversion parameter is identified through only question 9, whereas most other parameters are more directly informed by responses to multiple questions.

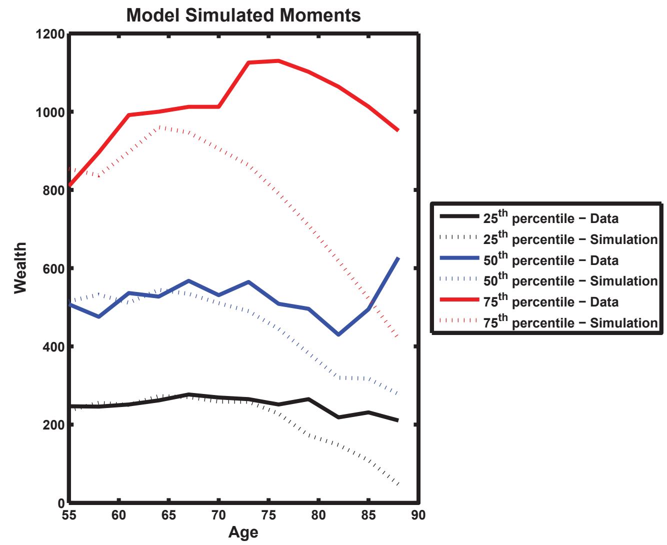


Figure 11:
Wealth Moments: Model and Data

compare our estimated values to.

In examining the estimated preferences towards LTC, it is most striking that across all specifications we observe that $\kappa_{LTC} < 0$, implying that LTC is viewed as a necessary good that requires a certain level of positive expenditure. In examining θ_{LTC} estimates, we observe significant heterogeneity across individuals. To interpret this, note that relative to normal consumption, $\theta_{LTC} < 1$ implies that LTC expenditures provide less marginal utility for each dollar expended while $\theta_{LTC} > 1$ implies a higher marginal utility for each dollar expenditure. Thus, conditional on having met the necessary expenditure implied by κ_{LTC}, we observe some individuals who have a strong preference for additional wealth in the LTC state while some who have very little desire for extra expenditure when in need of LTC.

Individuals with $\theta_{LTC} < 1$ and $\kappa_{LTC} < 0$ are likely to view LTC consumption as an indivisible cost and optimally desire to consume the consumption equivalent that this necessary expenditure provides but no more. Thus, the effect on precautionary savings annuity demand is similar to medical expenses such as those presented in De Nardi, French, and Jones (2010). For individuals with $\theta_{LTC} > 1$, LTC expenditure is viewed as a high source of utility, resulting in a desire to spend extra resources in this state. For these individuals, annuity demand will depend heavily on whether or not they can self-fund a reasonable consumption stream. Given our parameter sets, we observe both attitudes present in the population.

Table 7 presents a comparison of our bequest and public care aversion estimates to the literature. Our bequest estimates from SSQ estimations differ sharply from previous estimates. In particular, we estimate the lowest marginal intensity to leave a bequest of any study we are aware of. In addition, we find that bequests are only a slight luxury good through our estimation of κ_{beq}. This contradicts previous studies that have found that a near linear bequest motive is most compatible with savings patterns.

In addition, our estimate of public care aversion is far lower than previous estimates. In looking at the LTC_{PC} parameter estimate, we find that preference type 1 individuals assign a private expenditure equivalent of roughly \$33,000 to public care. While this seems in direct contradiction to the values found in Lockwood (2013) and Ameriks, Caplin, Laufer, and Van Nieuwerburgh (2011), we argue that in many aspects this number is a more reasonable assignment to the value of public care than their estimates of $\$4,700$ and $\$7,000$ respectively.

In comparing our estimates of type 1 and type 2 individuals as estimated from the SSQ data, we notice several things. First, we note that individuals of type 1 are less risk averse (and therefore less motivated to save due to precautionary motives) than individuals of type 2, as demonstrated by estimated relative risk aversion of 1.86 and 5.17 respectively. In addition, we see that individuals of type 1 have obtain less value from expenditures when in the LTC state—both because $\kappa_{LTC,1} > \kappa_{LTC,2}$ and $\theta_{LTC,2} > \theta_{LTC,1}$. Consistent with a lower value from expenditures when in the LTC state, we also find that preference type 1 individuals are much less averse to utilizing public care. Interestingly, type 1 individuals also have a significantly stronger bequest motive than type 2, as $\theta_{beq,1} > \theta_{beq,2}$ and $\kappa_{LTC,1} < \kappa_{LTC,2}$. This analysis suggests that the savings behavior of type 1 individuals are more motivated by a desire to leave a bequest, compared to the savings behavior of type 2 individuals, who are more motivated by precautionary motives related to LTC.

6 Annuity Demand

With the model estimated, we turn to an analysis of annuity demand. In particular, we are interested in how the demand for annuities varies across the population and how different features of preferences and the economic environment interact to determine annuity demand. To do this, we calculate the amount of wealth an individual would annuitize (or deannuitize) if given the one-time option to purchase an annuity at a particular age. An annuity is a financial product that provides a price to determine a

Strategic Survey Estimation								
Preference Parameters								
	σ	θ_{LTC}	κ_{LTC}	θ_{beq}	κ_{beq}	PC_{LTC}	C_F	β
Baseline								
Type 1	1.8564	.3119	-17.2754	11.6136	9.8730	16.0130	X	X
Type 2	5.1666	3.7475	-21.8066	5.0209	100.0000	4.0161	X	X
Preference Type Assignment Parameters								
Constant	Gender	Group Indicator	Type 1					
.1523	-2.8867	.2773	77%					

Behavioral Data Estimation								
Preference Parameters								
	σ	θ_{LTC}	κ_{LTC}	θ_{beq}	κ_{beq}	PC_{LTC}	C_F	β
Baseline								
Type 1	1.7495	7.8522	-29.9158	1.1249	13.862	39.5276	3.3401	.9484
Type 2	1.11	9.8719	35.8025	6.0466	45.8464	28.6599	5.6271	.9237
Preference Type Assignment Parameters								
Constant	Gender	Initial Wealth	Type 1					
2.75	-9.1	.055	95%					

Table 6: Estimated Parameter Sets: In this table we present the parameter estimates for the estimation targeting SSQ moments and the estimation targeting wealth moments.

Parameter Comparison			
Source	θ_{beq}	κ_{beq}	PC_{LTC}
This Paper (SSQ Type 1)	.80	2.53	33.28
This Paper (Wealth Type 1)	.52	12.96	69.44
Ameriks, Caplin, Laufer, and Van Nieuwerburgh (2011)	.94	5.3	4.7
Lockwood (2013)	.92	20.4	7.4

Table 7: Parameter Comparisons Across Studies: In this table we compare our estimated parameters with literature standards by transforming estimates to a common functional form. Our measure of PCA is the amount of money an agent would have to privately spend to obtain the same amount of instantaneous utility as receiving public care. That is, if a retiree in need of LTC spends $PC_{LTC} - \kappa_{LTC}$ he obtains utility equal to that of accepting public care.

mapping between wealth and income streams. An individual can increase the income he receives for the rest of his life by $X amount per year by spending the lump sum of $Y, with the annuity price determining the ratio of X to Y. Annuities are priced conditioning on the individuals age, gender, and health status, and is actuarially fair valued if an issuer of the asset would expect to make zero profit on the contract. For the purposes of this exercise, we treat individuals as if their future expected income was collateralizable, thus allowing individuals to pick their optimal ratio of wealth to income. This thought experiment allows us to determine if individuals actually wish to deannuitize, by decreasing their future income flow to gain some lump sump wealth. For exposition, unless otherwise noted, we will focus on the demand for a fair valued annuity by a male in good health at age 65. We also focus on individuals with preference type 1, which composes 77% of the population.

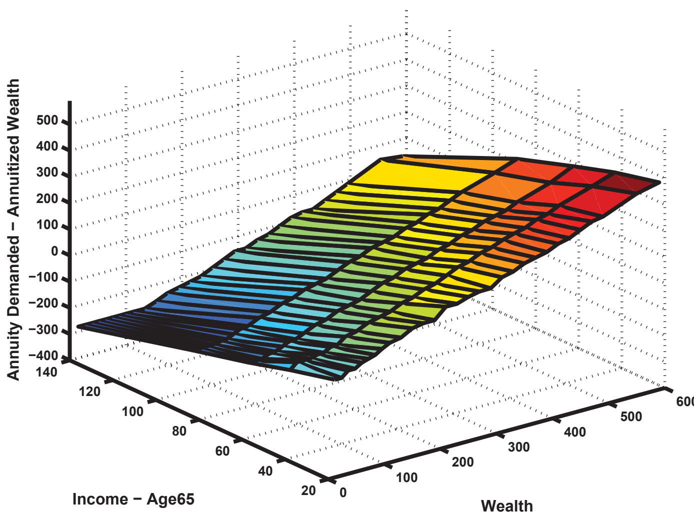


Figure 12:
Demand for Actuarially Fair-valued Annuities

Figure 12 presents our baseline annuity demand figure. The horizontal plane spans the income-wealth space, while annuity demand is graphed on the vertical axis. The wealth axis denotes the amount of wealth an individual has at age 65 and the income axis denotes the income an individual is receiving at age 65, even though annuity demand is a function of an individuals entire expected future income stream. The vertical axis denotes the amount of wealth an individual would spend to purchase an annuity.[22] First note the standard results that annuity demand is increasing in wealth and decreasing in income. Higher wealth individuals have more wealth to annuitize, so even if the fraction

[22]Given annuity prices, which are provided in **??**, the amount of annuitized wealth can easily be translated into the amount of yearly income purchased.

of wealth annuitized was constant across wealth levels, annuity demand would be increasing in wealth. The slope of the annuity demand function with respect to wealth is a measure of the differences in the fraction of wealth annuitized across wealth levels. Annuity demand is decreasing in income, as an annuity is a perfect substitute for income (given that we do not model stochastic income for retirees). There is a large fraction of the population that is over-annuitized and wishes to have more wealth and less income. Annuity demand is not positive for high-income individuals until wealth reaches around \$500,000, and around \$300,000 for low-income individuals.

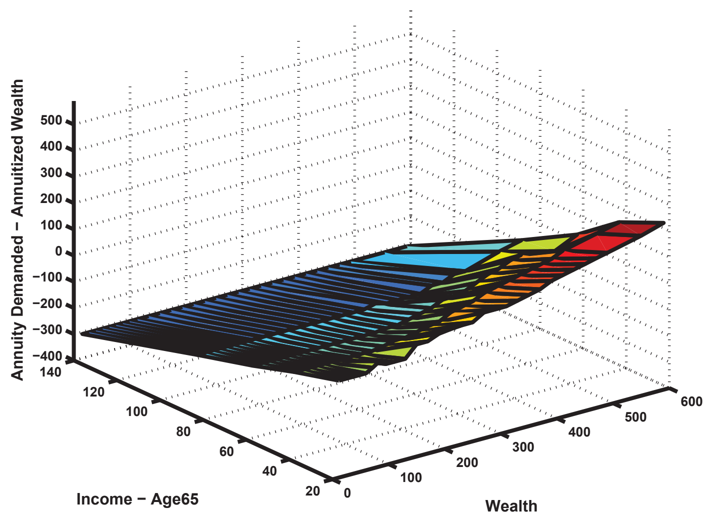


Figure 13:
Demand for 10 % Premium Annuities

Figure 13 presents demand for an annuity that has a 10 % premium, which is a representative loading for the US private annuity market as documented by Brown (2007). The demand for the typical annuity available in the US market is remarkably negative across incomes and wealth levels. Positive annuity demand is only present for individuals with greater than \$500,000 in wealth in the lowest income quintile. This is the main result of our analysis: From the perspective of our estimated model, there is no annuity puzzle, as there is almost no demand in the population for the private annuities that are available for purchase.

6.1 Decomposing Annuity Demand

Given our stark finding for such negative annuity demand, we want to use the model to better understand the forces that ultimately combine to determine annuity demand. To do so we will analyze annuity demand by agents in our model at different parameter values, isolating the role of the bequest motive, public care aversion, and the precautionary savings motive induced by the potential need for long term care. For the purposes of exposition, the following section will set all health cost shocks to zero and focus on lower income profiles than those of individuals in the VRIP.[23] This is to better graphically illustrate features of the model that generate annuity demand, but also because it is more representative of the US population and allows for possible positive annuity demand by analyzing individuals that are not already so over annuitized by their income streams.

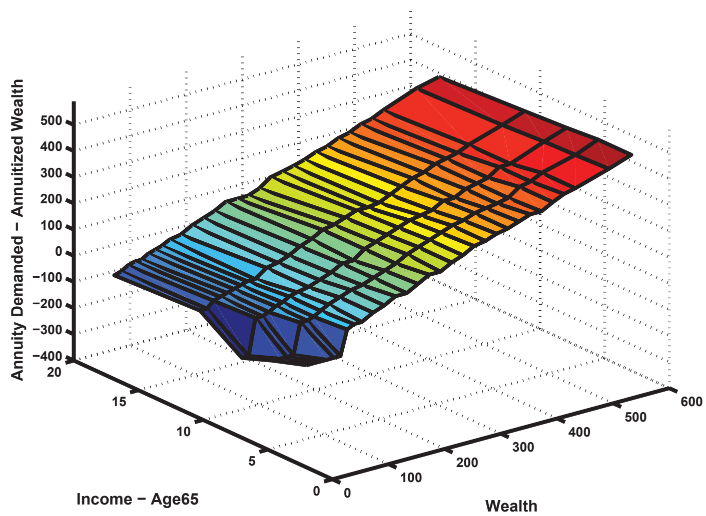


Figure 14:
Demand for Actuarially Fair-valued Annuities at Low Incomes

Figure 14 plots the baseline demand for annuities for our lower income population. Patterns similar to the high income baseline are present, in that annuity demand is higher for high-wealth and low-income individuals. However, a new feature of annuity demand is present. Note the sudden drop in annuity demand towards the income-wealth origin. These are individuals with strong precautionary savings motives induced by the potential need for LTC and the associated government policies. The existence of this discontinuity in annuity demand is driven by the same incentives that cause the optimal savings policy of a retiree to be discontinuous in wealth levels.

To highlight that the source of this severe demand for wealth is driven by LTC and the government, we plot in Figure 15 annuity demand in an environment in which the government does not provide a consumption floor, does not provide public care, there is no health care utility function, and there is no minimum LTC expenditure. As is evident, the annuity demand canyon disappears. Additionally, annuity demand for higher wealth levels and incomes are largely unaffected by these government

[23]Specifically, we divide all income profiles by 8.

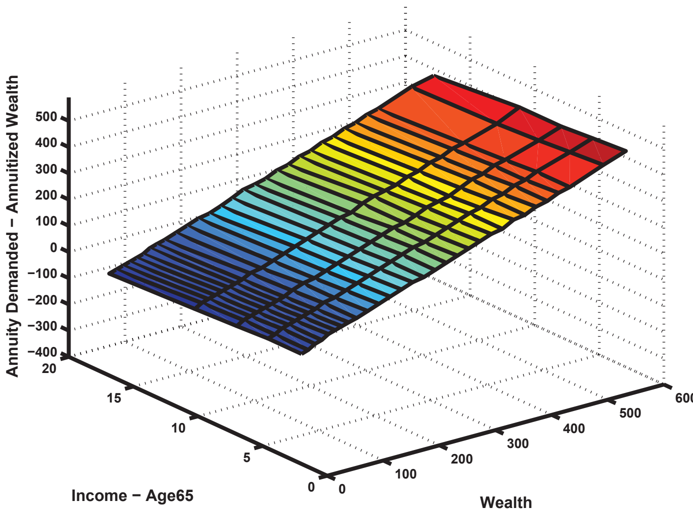
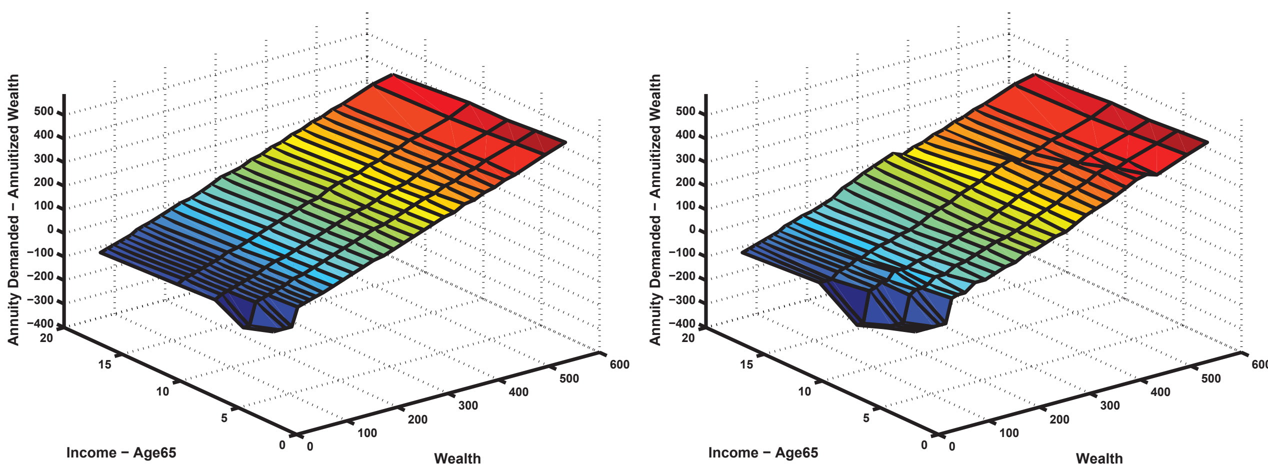


Figure 15:
Demand for Annuities with no Government, HSU, and $\chi_{LTC} = 0$

policies and minimum expenditure requirements.



(a) Annuity Demand with No Minimum Cost of LTC (b) Annuity Demand with Positive Minimum Cost of LTC

Figure 16: Demand for Annuities and Minimum Cost of Private LTC

As can be seen from Figures 16(a) and 16(b), increasing the minimum necessary expenditure for private long term care increases the region of extreme negative annuity demand. The fact that LTC has this discrete expenditure feature induces strong precautionary savings motives among the low wealth and low income populations. While this region does not appear large in the figure, a large fraction of the US population is similarly wealthy.

The degree to which individuals value public care has a strong influence on their demand for annuities. As seen in Figure 17, an increase in public care aversion decreases annuity demand. This

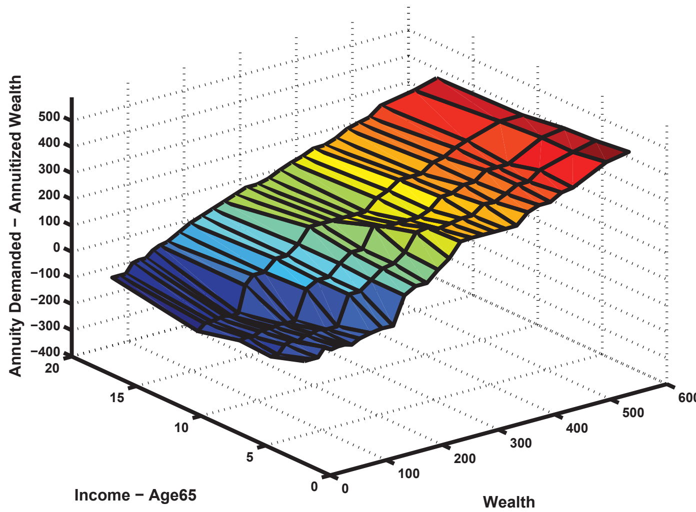


Figure 17:
Demand for Annuities and Strong Public Care Aversion

is especially so for low wealth individuals, as a decrease in the value of public care induces more individuals to desire private long term care and to save precautionarily in order to be able to afford it. Thus, real features of the world like government provided care and a minimum cost of private long term care combine with preferences to create strong deannuitization demand among low wealth and low income individuals.

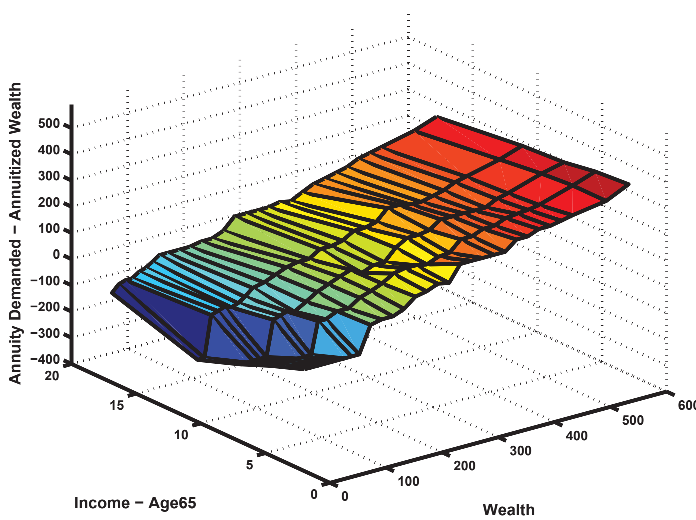
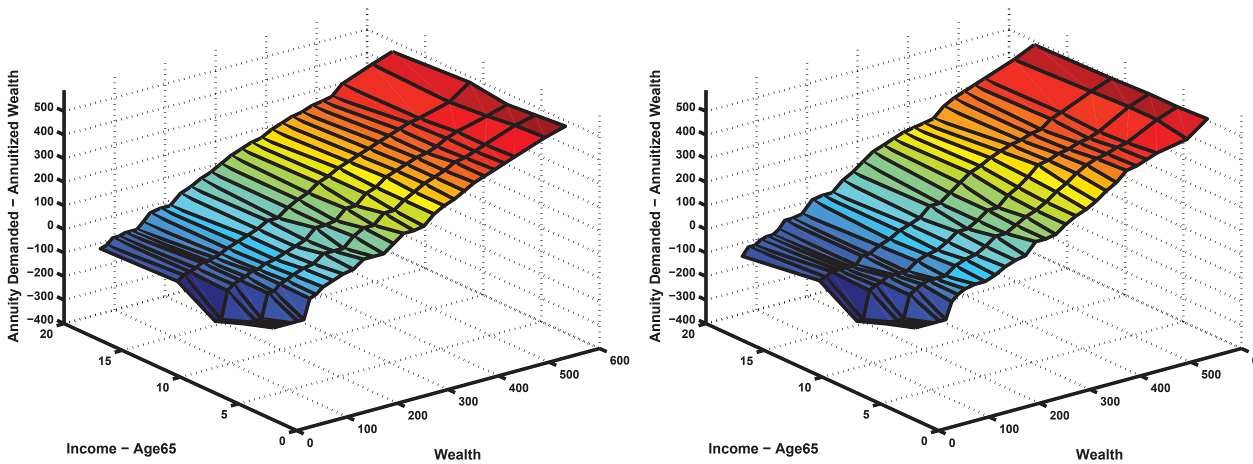


Figure 18:
Demand for Annuities with no Health-dependent Utility

In addition to modeling government care and a minimum cost of private LTC, a major innovation of our paper is to estimate a health-state dependent utility function that measures how individuals value expenditures when they are in need of LTC. Figure 18 plots annuity demand in a model where the utility functions are the same across all health states (other than death). Without the HSU function, annuity demand decreases for everyone, especially the wealthy. Since in our baseline parameter set $\theta_{LTC} < 1$, the HSU function decreases the marginal value of expenditure when the retiree needs LTC, and thus decreases the precautionary savings motive and increases annuity demand.



(a) $\theta_{LTC} = 10$

(b) $\theta_{LTC} = 20$

Figure 19: Annuity Demand with High Health-dependent Marginal Utility

However, as can be seen in Figures 19(a) and 19(b), increasing θ_{LTC} significantly has an interesting effect. It increases annuity demand for high wealth individuals and decreases annuity demand for low wealth individuals. This increase in annuity demand for high-wealth individuals is driven by the overall increase in utility obtained while alive, compared to the value of a bequest. This leads these high-wealth individuals to want to make sure they can consume more while they are alive, particularly when they need long term care, which is likely late in life. The decrease in annuity demand for low-wealth individuals is because the private long term care expenditures are now more highly valued on the margin, and thus they want to save precautionarily so that they have more wealth to purchase private LTC in case they need it.

Now that we have documented how LTC affects annuity demand, both through government policies, features of the private LTC market, and preferences, we document that bequest motives also significantly affect annuity demand. Figure 20 plots annuity demand in an environment where retirees receive no utility from leaving a bequest. Relative to baseline, there is a huge increase in annuity demand, even more pronounced at higher wealth levels. Note that most household are essentially

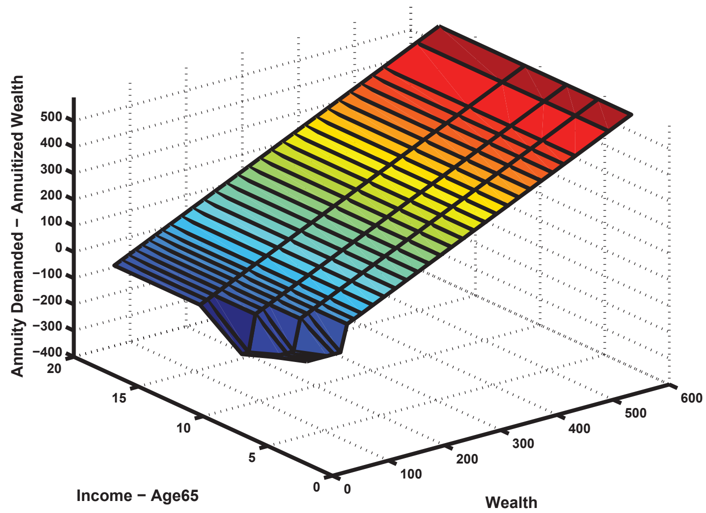


Figure 20:
Demand for Annuities with No Bequest Motive

annuitizing all wealth, aside from those low wealth and low income households who still have strong negative annuity demand for LTC-related reasons. We see that bequests can be a strong determinant of the wealthy individuals' annuity demand.

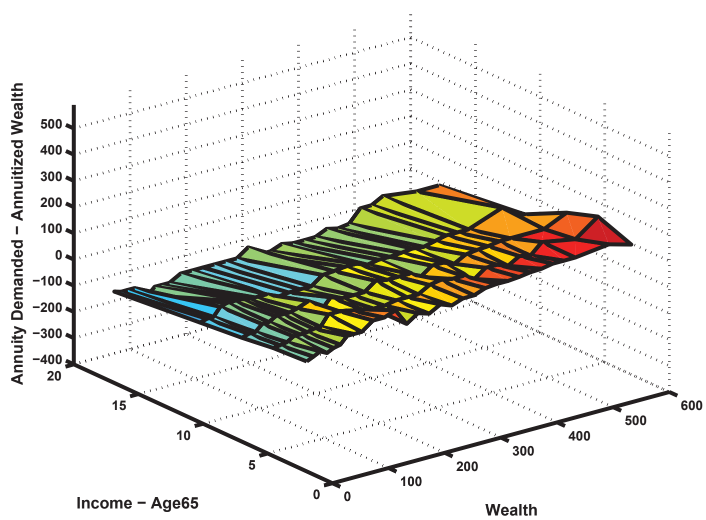


Figure 21:
Demand for Annuities with Strong Bequest Motive

The bequest motive can affect annuity demand for all retirees. In Figure 21 we plot the annuity demand when the bequest motive is very strong. There is a huge drop in annuity demand across all income and wealth levels. Note also, there still exists a discontinuity in annuity demand at low wealth and income levels, demonstrating that low wealth households have an extra concern related to LTC that determines their annuity demand that to a large degree does not affect high wealth households.

Finally, we end our annuity demand analysis by plotting annuity demand in the classic framework, without government care, without a health state utility function, and without valued bequests. As we see, the model predicts a strong demand for annuities across most wealth and income levels, with near full annuitization desired by many. This is the economic environment that originally gave birth to the "annuity puzzle," but in light of recent analysis, it does not seem so puzzling that the predictions from a model with such a simple and unrealistic economic environment do not accord with the data.

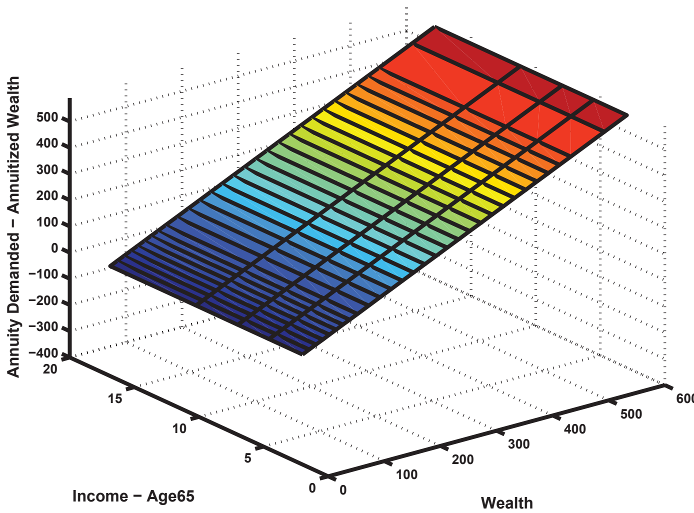


Figure 22:
Demand for Annuities in Classic Setup

7 Conclusion

There is no annuity puzzle. Most individuals don't want to buy annuities because they are not useful financial products given people's preferences and the economic environment in which retirees live.

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Appendix

A External Estimates

A.1 Income

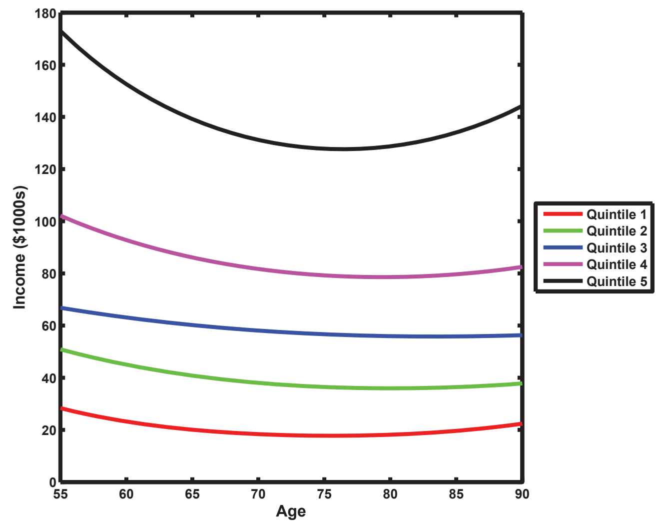


Figure 23:
Male Income Profile Quintiles

A.2 Health

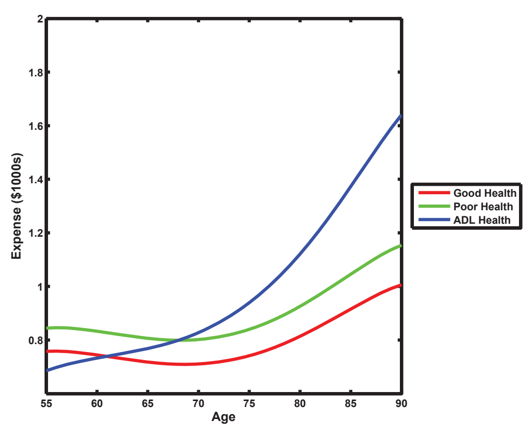
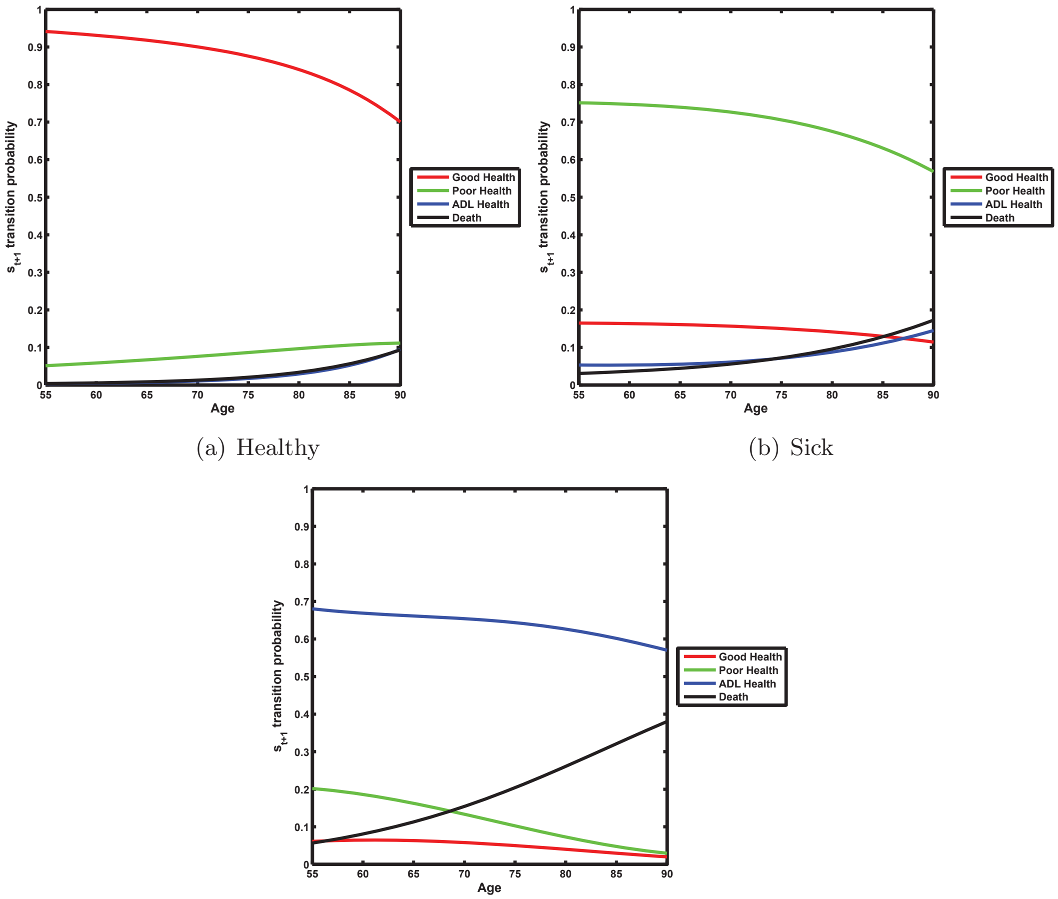


Figure 24:
Male Median Health Cost Profile

Figure 24 plots the mandatory health costs spent over the life cycle by men of different health status. Men in poor health spend around $100 more per year out of pocket for health costs than healthy individuals. Later in life, men in need of LTC spend about $600 more than health men for non-LTC health costs. Overall, out of pocket health costs are much smaller than LTC expenditures and are thus contribute little to the overall precautionary savings motive.



(a) Healthy

(b) Sick

(c) LTC

Figure 25: Male Health State Transition Profile

Figure 26 plots the fraction of the population that needs LTC by age.

Note in Figures 27(a) and 27(b) that preference type 2 has a much larger θ_{beq} and thus has more heterogeneity in LTC expenditures over the life cycle across wealth levels. The overall expenditure on LTC is also much higher for preference type 2, whose parameters suggest they value LTC more highly.

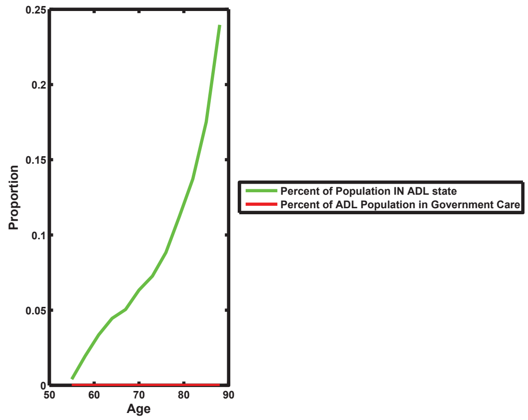
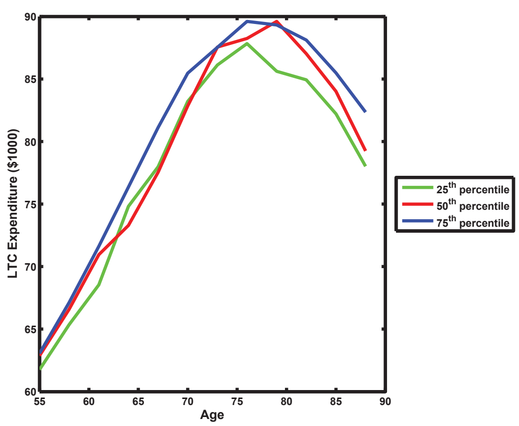
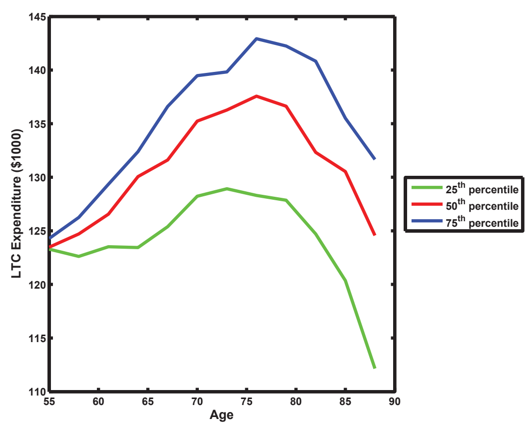


Figure 26:
Fraction of Population Needing LTC



(a) Preference Type 1



(b) Preference Type 2

Figure 27: Median Long Term Care Expenditures by Wealth Percentile