THE HEALTH AND FINANCIAL DECISIONS OF THE ELDERLY

Morris A Davis

A DISSERTATION

in

Economics

Presented to the Faculties of the University of Pennsylvania in Partial

Fulfillment of the Requirements for the Degree of Doctor of Philosophy

1998

Supervisor of Dissertation

Graduate Group Chairperson

DEDICATION

To my friends that encouraged me throughout high school (Jason DiLullo, Mike Lehrer, Barry Linder, Ken Norman, and Dave Polen), college (Doug Eden, Rajeev Garside, Andrew Lazerow, Shannon Moffat, Jason Resnick, and Tom Vandever), and graduate school (Asif Ahmad, Jeremy Berkowitz, Peter Christoffersen, Susan “Toots” Christoffersen, Jon Heathcote, Kim Liddle, and Ken Rowles),

and to my family (Mom, Dad, Sally, Wendy, Ben, Harrison, and Kayla):

thanks.

ACKNOWLEDGEMENT

I wish to thank Dave Cass, Frank Diebold, Andrew Foster, Jinyong Hahn, Jose-Victor Rios-Rull, Richard Rogerson, John Rust, Petra Todd, and Randall Wright; they have all given me helpful advice at some point during my graduate career. For the countless hours we spent discussing my research, I wish to separately thank Sam Preston and Olivia Mitchell. Mark Rosenzweig and Mark Pauly, who are both on my dissertation committee, were fundamental to my development as an economist and a researcher: this dissertation happened because of their efforts. Robert Douglas provided computer support when I needed it and was unbelievably flexible in accommodating my computational needs; his computational accommodations in many ways made this dissertation feasible. Finally, I need to thank my good friend and professor at Georgia State, E. Michael Foster, who has been as supportive as a person can be both while I was an undergraduate and during graduate school.

And, as anyone who lingers on the 5th floor of the McNeil building knows, this dissertation would not have happened without the tireless efforts of Ken Wolpin, my dissertation advisor. Ken read every draft I gave him and commented on each iteration of this research. He was always there to help me.

ABSTRACT

THE HEALTH AND FINANCIAL DECISIONS OF THE ELDERLY

Morris A Davis

Supervisor: Kenneth I. Wolpin

This dissertation predicts how the health insurance, doctor service use, nursing home use, and assets of the current generation of elderly women living alone will change if Medicare and Medicaid substantially change. To make these predictions, the structural parameters of a dynamic model of the health, assets, and Medicare supplemental insurance (Medigap) decisions of the elderly are estimated using the AHEAD panel data set, and the model is simulated at different Medicare and Medicaid policies. In the first simulation, Medicare and Medicaid increase cost-sharing responsibilities: the out-of-pocket costs for doctor services of the elderly insured with only Medicare are increased by 50%, and, the Medicaid assets and income eligibility criteria for the elderly are lowered by 50%. In the second simulation, Medicare and Medicaid impose non price rationing: with 25% probability the elderly that do not purchase Medigap and were last diagnosed as healthy within a two year period can not use doctor services, and, with 25% probability entrance into a Medicaid funded nursing home is denied.

With increased cost-sharing, simulations show the elderly change their asset holdings, but minimally change their purchase of Medigap, use of doctor services, and use of nursing homes. As a result, relative to predicted age seventy life-expectancy at

current Medicare and Medicaid policies (13.43 years), predicted age seventy life-expectancy drops .02 years. With Medicare and Medicaid rationing, the elderly buy more Medigap to circumvent the doctor service rationing, but do not increase their assets to avoid the rationing of Medicaid nursing homes and enter private nursing homes. Therefore, doctor use marginally drops, but nursing home use declines by the rationed amount. However, Medicaid nursing homes have an ineffective impact on the life-expectancy of residents, so the predicted life-expectancy of a typical cohort of elderly women living alone falls .03 years with Medicare and Medicaid rationing policies compared to current policies. In conclusion, this dissertation predicts that if Medicare and Medicaid increase cost-sharing responsibilities or impose rationing, life-expectancy of the current generation of elderly will not significantly change.

TABLE OF CONTENTS

LIST OF TABLES

1. Introduction

The costs and coverage of the Medicare program (the program that subsidizes health care costs of the elderly and disabled) and the Medicaid program (the program that funds the health care costs of the poor) have changed dramatically over the past thirty years. The number of Medicare enrollees has increased from 19.5 million elderly in 1967 to 33 million elderly and 5 million disabled people in 1996[i] while the real average expenditure per Medicare enrollee (in $1996) has grown from $746 per enrollee in 1967 to $5,374 per enrollee in 1996. The enrollment and costs of the Medicaid program have similarly changed since its inception. In 1967, 10 million people received Medicaid benefits, while in 1996, 36.1 million people received Medicaid benefits. In 1996, 4.7 million elderly people received Medicaid benefits that, on average, subsidized (in $1996) $8,660 worth of health care costs. In 1996, the Medicare and Medicaid programs subsidized a total of 241 billion dollars of health care costs of 33 million elderly and 5 million disabled.

Government projections indicate that the enrollment and expenditure growth of the Medicare and Medicaid program will continue well into the 21st century. For example, real Medicare expenses (in $1996) are predicted to reach 337 billion dollars in 2006[ii], which is approximately 1.7 times greater than 1996 real Medicare expenses. The cost and demographic trends responsible for these large forecasted increases in program expenditures are expected to continue until at least 2030. Since Medicare and Medicaid financing sources are projected to grow at much slower rates than Medicare and Medicaid expenditures[iii], it is clear that both the Medicare and Medicaid programs will undergo substantial change in the near future.

This dissertation predicts how the assets, private health insurance holdings, use of doctor services, and use of nursing homes of the current generation of elderly women living alone will change if Medicare and Medicaid undergo large structural changes in order to reduce program costs. These predictions are made by comparing the simulated lifetime use of doctor services, nursing homes, asset holdings, and insurance purchases of a cohort of seventy year old women living alone at current Medicare and Medicaid policies with the simulated lifetime use of doctor services, nursing homes, asset holdings, and insurance purchases of this cohort of elderly women at less-generous Medicare and Medicaid policies. These simulations are based on the structural estimates of a multi-period model of behavior of elderly women living alone. In this model, each period elderly women living alone choose whether or not to buy supplemental Medicare insurance ("Medigap"), decide whether or not to see a doctor to obtain a diagnosis of their current state of health (receiving treatment that increases their survival probability if diagnosed as ill), and choose whether or not to enter a nursing home for a long-term spell if diagnosed as functionally disabled. They also choose a level of consumption of non-health goods, which along with the cost of their insurance and health care choices, determines the level of assets they carry forward to future periods (if they live to future periods). In addition to receiving a random contemporaneous utility flow from the consumption of non-health goods, the elderly receive random current utility or disutility from their current period insurance, doctor, and nursing home choices. Given the dynamic structure of the model and the set of public policies that affect current and future expected payoffs from decisions, each period these elderly make the insurance, doctor visit, nursing home, and assets decisions that maximize their appropriately discounted expected value of their lifetime utility.

The structural parameters of this model are estimated using the AHEAD data set. The AHEAD panel data set contains information on the insurance, doctor visit, nursing home, and assets decisions of a nationally representative sample of elderly (with an oversampling of African-American elderly and elderly living in Florida). The AHEAD data provide all the information necessary to estimate the structural parameters of the model posited in this paper; in fact, the structure of the model is designed to take advantage of the information available in the AHEAD data set. The structural parameters of the model are estimated using a procedure that directly embeds the solution of the model into a maximum likelihood framework. This estimation procedure allows that preferences, survival probabilities (conditional on health state), and costs, and thus the sequence of optimal decisions, may systematically differ among people in a way that is not directly observable. In other words, the estimation procedure allows for multiple "types" of people in the world (where a person's type is not directly observable), and types of people differ by preferences, survival probabilities, and costs of health care.

Estimates of the structural parameters of this model reveal that unobserved heterogeneity exists in the population in preferences, costs, and survival probabilities.

This unobserved heterogeneity explains phenomenon in survival probabilities, costs, and choice behavior in the data that cannot otherwise be explained conditional on the structure of the model. For estimation purposes, the number of different types of people is fixed at two; however, these two types of people differ significantly in estimated survival probabilities (type "twos" have higher survival rates than type "ones"), preferences over health care use (type twos gets less average utility from seeing a doctor and greater average disutility from entering a nursing home than type ones), and costs of health care.

Given the estimates of the type specific mortality, preference, and cost parameters, and given the estimated initial distribution of types across the state variables of the first wave of AHEAD data, simulations of the model reveal that according to two different definitions of adverse selection in the Medigap market, there is no evidence of adverse selection in the market for Medigap among elderly women living alone in 1995. In the first definition, elderly women living alone that purchase Medigap are defined as adversely selected if, conditional on their going to the doctor, their expected total cost of care[iv] is higher than the expected total cost of care of Medicare purchasers that go to the doctor. In the second definition, Medigap purchasers are defined as adversely selected if their unconditional expected total cost of care is larger than the unconditional expected total cost of care of those elderly insured only with Medicare. The unconditional total cost of care can vary if Medigap purchasers use more health services than Medicare purchasers (called "moral hazard" in the health care literature), or, Medigap purchasers require more expensive services than Medicare purchasers. As such, it appears that conditional on going to a doctor, the expected total cost of care of those insured with Medigap is *less* than the expected total cost of care of those insured with Medicare and go to a doctor. The probability of going to a doctor minimally varies by health insurance, so the unconditional expected total cost of care of those insured with Medigap is also less than the unconditional expected total cost of care of those insured with Medicare. The reason that the elderly insured with Medicare have higher expected total costs is that the elderly insured with Medicare are more likely to be diagnosed with the chronic condition than those insured with Medigap, and diagnosis and treatment of the chronic condition is more expensive than diagnosis and treatment of the other health states. Therefore, according to both definitions of adverse selection, elderly women living alone that purchased Medigap in 1995 were not adversely selected.

The model is simulated for a cohort of seventy year old women living alone (with characteristics similar to the seventy year old women living alone in the data) at current Medicare and Medicaid policies and at two substantially less generous sets of Medicare and Medicaid policies. At one simulated set of Medicare and Medicaid policies, Medicare and Medicaid cost-sharing is substantially increased: the out-of-pocket prices of all doctor services for those insured with only Medicare are 50% higher than their current levels (although Medigap out-of-pocket prices for doctor services stay at their current levels), the Medigap premium is 50% larger than its current level, and the Medicaid assets and income eligibility criteria are both set equal to half their current levels. Simulations of behavior reveal that the elderly facing increased cost-sharing do not change their purchase of Medigap, but they do choose different asset holdings relative to the elderly facing current Medicare and Medicaid policies. However, the elderly with increased cost sharing have an almost identical simulated pattern of use of doctor services and nursing homes as the elderly with current Medicare and Medicaid policies. As a result, the age seventy life-expectancy of this cohort of seventy year old women at current Medicare and Medicaid policies and at Medicare and Medicaid policies imposing increased cost-sharing are nearly identical at 13.43 years and 13.41 years respectively.

At the second set of simulated Medicare and Medicaid policies, the out-of-pocket price of all health services and the Medigap premium are the same as with current Medicare and Medicaid policies, however, non-price rationing of the use of health care is imposed. In this set of Medicare and Medicaid rationing policies, those that are insured with only Medicare and were last diagnosed as healthy one period ago cannot go to the doctor in the current period with 25% probability, although no such restrictions apply to those insured with Medigap. Furthermore, those who apply for nursing home residence and try to enter a Medicaid nursing home (they need Medicaid funding to pay any part of the cost of the nursing home) are refused entry with 25% probability. The elderly that are in the Medicare and Medicaid rationing regime choose to purchase substantially more Medigap insurance than the elderly who face the current set of Medicare and Medicaid policies in order to circumvent the Medicare rationing of doctor visits. However, the elderly facing Medicare and Medicaid rationing choose not to accumulate assets in order to pay for nursing home use themselves and avoid the

Medicaid rationing of nursing homes. As a result, the percentage of elderly that go to a doctor is only slightly lower, but the percentage of elderly that enter a nursing home is approximately twenty five percent lower than the elderly who face the current set of Medicare and Medicaid policies. Since it is estimated that Medicaid nursing homes only marginally increase the survival probabilities of those with a functional disability, and given that the use of doctor services does not fall by much, the age seventy life-expectancy of those elderly women living alone in the Medicare and Medicaid rationing regime is 13.40 years, which is only .03 years lower than the life-expectancy of those elderly with the current set of Medicare and Medicaid policies.

In conclusion, simulations of behavior at the base set of Medicare and Medicaid policies, Medicare and Medicaid policies that impose substantially more cost-sharing than current policies, and Medicare and Medicaid policies that impose rationing, reveal that in all three sets of Medicare and Medicaid policies, the age seventy life-expectancy of a typical cohort elderly women living alone varies by no more than .03 years. As a result, policy makers do not need to worry that reductions in the generosity of the Medicare and Medicaid programs will substantially alter the life-expectancy of the current generation of elderly women living alone.

1.1 Previous Literature

The life-cycle model of behavior that this paper most closely resembles is the model of Hubbard, Skinner, and Zeldes (1994, 1995). In the Hubbard, Skinner, and Zeldes model, agents die probabilistically until a terminal period. Each period while alive, agents in their model receive an exogenously determined income and an exogenously determined medical expense; these agents receive Medicaid assistance if their health care expenses are large enough to reduce their assets to Medicaid eligibility levels. Given their income, expenses, and probability of dying, each period agents choose assets to carry forward to the next period. However in their model, and unlike the model of this dissertation, medical expenses are exogenous and not related to the probability of dying. Furthermore, many health authors, including Pauly (1990), believe Medicaid use and "spend down" of assets is directly related to entrance into a nursing home. Nursing home use (and thus "spend down") is the outcome of a choice process in this paper; in Hubbard, Skinner, and Zeldes, the nursing home choice is captured by the exogenous medical expense.

This dissertation also builds on the empirical work that tries to identify the marginal impact of economic variables on the probability of nursing home entry. The papers in this literature, as typified by Headen (1993) and Reschovsky (1996), regress nursing home entry on a number of covariates, including price, assets, income, measures of disability, and number of non-nursing home caretakers (family members) for which the elderly have access. The results in this literature do not account for the possibility that there may be unobserved heterogeneity in observable health states, meaning there may be multiple "types" of people in the world and conditional on observed health state and other observed covariates, different types of people may systematically differ in their costs, benefits, and preferences over nursing home use. If unobserved heterogeneity of this sort exists (as the research in this dissertation suggests), it introduces a severe endogeneity bias between observed economic covariates and the propensity to enter a nursing home. The research in this dissertation suggests that the "type" of person more likely to enter a nursing home (type 1) also has a lower life expectancy than the type of person less likely to enter a nursing home (type 2). Given the differences in life-expectancy, and (more importantly) given that Medicaid pays for nursing homes, we expect that the type of person more likely to enter a nursing home will deplete assets at a faster rate than the type of person less likely to enter a nursing home, which implies that at any given age, the type of person more likely to enter a nursing home will have lower asset holdings than the type of person less likely to enter a nursing home. Thus, with two types of people, the regressors in this literature (specifically assets) and dependent variable (nursing home entry) are jointly endogenously determined by type, and the typical claims of this literature, like "Wealth significantly reduces the hazard of nursing home entry," (Headen, 1993) are incorrect in their interpretation of the data. Since the estimation procedure used in this dissertation accounts for the fact that there may be multiple types of people in the sample of data, the estimates of the structural parameters of the model of this dissertation provide insight as to the type-specific importance of economic variables on the propensity to enter nursing homes.

Finally, this paper builds on the literature that tries to understand the relationship between economic covariates, the purchase of Medigap, and the utilization of health care services. Although there is still considerable debate as to whether or not Medigap purchasers are adversely selected (see Hurd, 1997, and Ettner, 1997, for two recent papers from the same journal that have conflicting conclusions), the RAND Health Insurance Experiment (RHIE) established that demand for health services (in 1977) changed with health insurance coverage, although measured health outcomes did not change with health insurance coverage (see Manning, et. al., 1987, for details and conclusions from the RHIE). There are compelling reasons why studies based on the RHIE may not provide reliable estimates of the change in health care use and health outcomes of the elderly if Medicare and/or Medicaid change in 1998 or beyond. First, the RHIE did not include people age 65 and over, and the elderly may behave differently with respect to their health than the rest of the population. Perhaps more importantly, studies using the RHIE estimate the relationship between the demand for health care and economic covariates using “reduced form” techniques. These techniques do not explicitly model the relationship between the use of health care, economic covariates, public policy and medical technology; rather, they regress health care utilization on a set of economic covariates, implicitly conditioning on current and future expected public policies and current and future expected medical technology. Unexpected changes in public policy or changes in medical technology may change the relationship between observed economic covariates and health care use, and if this relationship changes the regression coefficients on the economic covariates in these reduced form regressions correspondingly change. If the regression coefficients of reduced form techniques change with public policy change, reduced form regression estimates will not provide accurate public policy forecasts. In contrast, this dissertation uncovers the structural parameters of a model that explicitly accounts for the relationship of income, assets, public policy (Medicare, Medicaid, and Medigap rules), and medical technology (which is defined as the set of mortality rates both with and without various health care services across different health states). Estimates of these structural parameters uncover the relationship between economic covariates, purchase of supplemental health insurance, and health care use at varying levels of medical technology and different sets of public policies.

Endnotes

[i] The 1997 Medicare and Medicaid enrollment and expenditure data are not yet available. The historical and current enrollment and costs for Medicare and Medicaid come from the 1997 Annual Report of the Board of Trustees for the HI and SMI programs and the 1994 Green Book.

[ii] This estimate adds forecasted “Total Expenditures” of the HI Trust Fund to forecasted “Total Expenditures” of the SMI Trust Fund under the “Intermediate” set of forecasting assumptions of the Trust Fund Advisory Board. This estimate also assumes the inflation rate is 3.2% a year between 1996 and 2006, which is consistent with the “Intermediate” set of assumptions used by the Trust Fund Advisory Board. See the 1997 Annual Report of the Board of Trustees of the Federal Hospital Insurance Trust Fund and the 1997 Annual Report of the Board of Trustees of the Federal Supplemental Medical Insurance Trust Fund for details.

[iii] See the 1997 Annual Report of the Board of Trustees of the Federal HI Trust Fund for details.

[iv] The total cost of care includes insurers’ costs and out-of-pocket costs of the insured, some of which may be subsidized by Medicaid.

2. Model

2.1 Introduction

The elderly are assumed to make four choices each period that allow them to partially control both the cost of their health care and their life-expectancy. The elderly can control the cost of their health care by purchasing Medigap and depleting their assets. Since Medigap plans pay Medicare deductibles and coinsurance, Medigap plans lower current health care expenses. However, some elderly with low expected health care expenses purchase Medigap to guarantee future access to Medigap (and future lowered health care costs) due to Medigap's "guaranteed renewable" clause. The elderly can also partially control the cost of their future health care by depleting their assets. If the elderly deplete their assets on current consumption, and if their income is low enough, the elderly make themselves eligible for Medicaid. Once the elderly are eligible for Medicaid, their health care is free.

In addition to controlling the cost of their health care, the elderly control their expected life span through their health care utilization choices. If the elderly go to a doctor and are diagnosed as not healthy, they get treatment and this treatment increases their probability of survival to the future. Those that go to a doctor and are diagnosed with a functional disability also then have the option of entering a nursing home. For those that are functionally disabled, a nursing home increases the probability of survival to the next period. Given that the elderly choose whether or not to enter a nursing home and whether or not to go to a doctor, the elderly affect their life expectancy through their health care choices.

Each period, the elderly are assumed to make the insurance, assets, and health care utilization decisions that maximize their discounted expected lifetime utility.

2.2 Structure

In each period the elderly first choose a health insurance plan. All elderly are insured with Medicare and some have the option of purchasing Medicare supplemental insurance, called "Medigap;" others have Medigap provided to them for free by an ex-employer. Define $d_t^{1,i}$ as a dummy variable that indicates the type of health insurance the elderly are covered with in period *t*. $d_t^{1,1} = 1$ if the elderly are insured with only Medicare ($d_t^{1,1} = 0$ otherwise), $d_t^{1,2} = 1$ if the elderly purchased Medigap insurance, *0* otherwise, and $d_t^{1,3} = 1$ if the elderly have Medigap provided for free by an ex-employer (sometimes denoted "free" Medigap), *0* otherwise.

After choosing a health insurance plan, the elderly must then choose whether or not to go to a doctor for a diagnosis of their current state of health. Denote the period *t* decisions on whether the elderly go to a doctor as the dummy variable d_t^2: if the elderly go to a doctor, $d_t^2 = 1$, while if they choose not to go to a doctor, $d_t^2 = 0$. After deciding whether or not to go to a doctor for a diagnosis, the elderly jointly decide on a level of consumption of market goods and (only if diagnosed as functionally impaired) whether or not to enter a nursing home for the duration of the period. Denote the period *t* consumption decision as C_t and the period *t* decision on whether or not to enter a nursing home as d_t^3 (where if the elderly choose to enter a nursing home,

$d_t^3 = 1$, $d_t^3 = 0$ otherwise). Note that if the elderly do not go to a doctor, or go to a doctor and are not diagnosed as functionally disabled, then they can not enter a nursing home and $d_t^3 = 0$.

The current period utility the elderly receive in any period after having made their insurance choice, doctor choice, nursing home choice, and consumption choice is:

$$U\left(C_t, d_t^{1,2}, d_t^2, d_t^3\right) = u\left(C_t; e_t^c\right) + b_t^{ins} d_t^{1,2} + b_t^{doc} d_t^2 + b_t^{nh} d_t^3 \tag{2.1}$$

In (2.1), $u\left(C_t; e_t^c\right)$, the utility the elderly receive from choosing consumption C_t, includes a random variable e_t^c that affects the marginal utility of consumption. In addition, the elderly are assumed to get utility (or disutility) from the purchase of Medigap insurance, from seeing a doctor, and from residing in a nursing home. Specifically, $b_t^{ins} = \overline{b}^{ins} + e_t^{ins}$ is a random variable that affects utility if Medigap insurance is purchased; $\overline{b}^{ins}$ is always known by the elderly and e_t^{ins} is a random "insurance shock," or shock to the marginal utility from purchase of Medigap. Similarly, $b_t^{doc} = \overline{b}^{doc} + e_t^{doc}$ is a random variable that affects the utility of the period if the elderly see a doctor, and $b_t^{nh} = \overline{b}^{nh} + e_t^{nh}$ is a random variable that affects the utility of the period if the elderly enter a nursing home, where $\overline{b}^{doc}$ and $\overline{b}^{nh}$ are known and e_t^{doc} and e_t^{nh} are random shocks to the marginal utility from seeing a doctor and entering a nursing home; sometimes these shocks are denoted as "doctor shock" and "nursing home shock" respectively. All of the preference shocks are assumed to be contemporaneously and serially independent.

In each period the elderly are assumed to make the choices that maximize the sum of discounted expected lifetime utility subject to a set of constraints. Although the elderly make all four decisions within each period, these choices are not made simultaneously at the beginning of a period, but rather sequentially. The elderly are assumed to first choose a health insurance plan, then decide whether to go to a doctor, then jointly decide a level of consumption and (if applicable) whether or not to enter a nursing home. The sequential nature of choices implies that state variables evolve both between periods and within periods.

Given this sequential framework, the decisions the elderly make in any period can be thought of as occurring in three distinct "stages." All three stages occur immediately at the beginning of each period, but there is a sense of a small time interval between stages: stage three occurs immediately after stage two, which occurs immediately after stage one. In the first stage, the elderly choose a health insurance plan. Some elderly have Medigap provided to them for free by an ex-employer. These elderly make no insurance choice per-se. Other elderly are institutionally constrained from purchasing Medigap, and these elderly are insured with only Medicare. The remaining elderly can choose to be either insured by Medicare or to purchase Medigap. Before the insurance decision is made, the elderly know the value of the random variable that affects their payoff if they purchase Medigap, e_t^{ins}. They do not know, however, the values of the random variables that affect the payoffs of their remaining doctor, nursing home, and consumption decisions (e_t^{doc}, e_t^{nh}, and e_t^{c}). The assumption that the health insurance decision is made first allows for adverse selection of Medigap purchasers on the permanent components of the direct utility from health care ($\bar{b}^{doc}$ and $\bar{b}^{nh}$) but avoids adverse selection of Medigap purchasers on the basis of the idiosyncratic (within-period) shocks to doctor, nursing home, and consumption preferences.

After the elderly choose their health insurance, they enter the second stage of the period, in which they observe e_t^{doc} and must choose whether or not to see a doctor. Visiting a doctor results in a diagnosis of their current health state, *h*. The elderly are either diagnosed as healthy ($h=1$), as having a chronic condition called "CR" ($h=2$), as sick with the chronic condition and a functional impairment "CR+ADL" ($h=3$), or afflicted with only the functional impairment "ADL" ($h=4$). Health states do not evolve within a period, however, they probabilistically evolve between periods according to a known Markov process. This implies that even if the elderly get a diagnosis of their health state in period $t-1$, they do not know their health state in period t unless they go to a doctor for a diagnosis in period t; otherwise, they remain uncertain as to their current health state.

The value of a doctor's visit has three components in addition to its direct (dis)utility. The first component is that the doctor identifies the health state of the elderly. The second component is that the doctor provides treatment to all those that are diagnosed as not healthy: for those that are not healthy, treatment increases the probability of survival from period t to period $t+1$. The third component of the value of a doctor visit is that those diagnosed as functionally impaired (they are diagnosed either in the "ADL" state or the "CR+ADL" state) can choose in the third stage of the period whether or not to reside in a nursing home for the remainder of the period. For these elderly, residence in a nursing home increases the probability of survival from period *t* to period *t+1*. Although at the stage of the doctor choice the elderly know their average (dis)utility from entering a nursing home $\bar{b}^{nh}$, the values of the remaining random utility shocks of the period, b_t^{nh} and e_t^c, are not known at the time of the doctor choice. This ensures that the incentives over visiting a doctor are unaffected by potentially atypical preferences over entering a nursing home or consumption.

In the third and final stage of a period the consumption (e_t^c) and nursing home (e_t^{nh}) shocks are revealed, and the elderly choose consumption. Those elderly that went to a doctor and were diagnosed as in health state CR+ADL or health state ADL (diagnosed with a functional disability) simultaneously choose whether or not to enter a nursing home for the remainder of the period. Those elderly that did not go to a doctor, or, went to a doctor and were diagnosed as healthy or in health state CR do not make a nursing home decision. After the consumption and nursing home decisions are made, the elderly wait to the end of a period, at which point some of them die. The survivors have their health state evolve and then repeat the same decision process in the new period. Although survival is probabilistic, no elderly person lives longer than *T* periods: death is certain by period *T+1*.

Specification Issues:

There are two aspects of the model and the contemporaneous payoff function listed in (2.1) that may be considered unusual. First, the elderly receive direct additive random utility or disutility from the purchase of Medigap. Second, in a model about health, health nowhere directly enters the utility function: (as will be shown) health states and health care only determine current out-of-pocket costs and the rate of discounting on utility in future periods. These two points are actually closely related. First consider the problem of including both a random payoff to purchasing Medigap and a random shock to the marginal utility of consumption that determines future assets. Given the structure of the model, the elderly must differ in their payoffs from purchasing Medigap in an unobserved way: in the data, the elderly with identical state variables make different Medigap decisions. One natural way to allow variation in the payoffs of Medigap purchase of the elderly is to include a random shock to risk aversion in the first stage of a period. However, this shock to risk aversion is also a shock to the marginal utility of consumption, and another shock to the marginal utility of consumption is needed in the model to explain the variation in assets behavior conditional on insurance purchase. So this model would have two shocks to the marginal utility of consumption each period, where the first shock occurs in the first stage of the period and determines the insurance decision, and the second shock occurs in the third stage of the period and determines future assets conditional on the insurance decision (and the use of health care, among other things). This does not seem any more natural or realistic than the current structure of the model, which has additive random marginal utility from purchase of Medigap.

Consider next the difficulty of including health directly into the utility function. The way that health enters the utility function determines what, if anything, the elderly know about their health at the start of a period. If the current state of health directly enters the utility function at the first stage of a period, then the elderly exactly know the current state of their health at the start of each period, and the doctor provides no information to the elderly. It seems reasonable that the elderly are not omniscient about the state of their health, which eliminates this as a modeling possibility. As modeled in this paper, at the beginning of each period the elderly receive no new information on the state of their health, and in this case the current health state cannot enter the utility function: in cases where the elderly do not go to a doctor, they do not know (with certainty) their current health state, and so they do not know the value of their utility (which is a function of their current state of health). However, one reasonable alternative to these specifications is to allow the elderly to receive a random signal that provides information on the current state of their health each period: this signal, realized in the first stage of each period, could be an additive random shock to the utility function and the mean of the signal would be allowed to vary by current health state. This shock (signal) may then serve two purposes: first, health and "quality of life" would be incorporated directly into the utility function (shocks from the chronic and functionally disabled health states would almost certainly be drawn from a distribution with a low or negative mean), and second, this health signal would provide random incentives and disincentives to the purchase of Medigap (thus possibly eliminating the need for a separate Medigap shock). However, there are problems with adding an informative health signal to the utility function. First, given data on Medigap purchases by health state transitions, it does not appear that people adjust their purchase of Medigap when they switch health states; if signals are truly informative, and the elderly have different incentives to purchase Medigap in different health states, then a separate Medigap shock will almost certainly still be needed to explain the variation in Medigap purchases[i], and the problem of including a random payoff to Medigap purchase somewhere in the model will still exist. More importantly, however, the elderly that do not go to a doctor will use their observed sequence of health signals to form Bayesian probabilities over the current states of their health. This dramatically increases the computational burden in solving the model: since signals are informative, a continuous state variable (the value of the physical signal) must be added to the model for each period the elderly wait before they visit a doctor. In the computational implementation of the current framework, the elderly are allowed to wait up to three periods before they must visit the doctor; in this case, three continuous state variables must be added to the feasible state space to fully solve the model, and this extra computational burden will make estimation of the structural parameters of the model infeasible. In conclusion, given the problems with including health in the utility function and allowing the payoffs to Medigap purchase to randomly vary, the contemporaneous utility function listed in (2.1) seems quite reasonable.

Period T:

Given the finite horizon, the easiest way to show the solution for the decision rules of the model is to solve the terminal period problem first and “work backwards” through time. Suppose, for expository purposes only, that the terminal period is different from the other periods of the model: in the terminal period there is only one stage, and in this stage the elderly only choose consumption. Denote the vector of state variables relevant to the terminal period as S_T. In the terminal period, these state variables include non-housing assets carried over from the previous period (A_T), the random variable that affects the utility from consumption e_T^c, and non-market income W. The elderly are assumed not to work and thus have no market earnings, so W is time invariant and consists of Social Security and pension income.

Given that the elderly are assumed to bequest their illiquid housing assets and have no other bequest motives, and given that death is certain by the next period (*T+1*), the elderly optimally consume all remaining non-housing assets and their period *T* income. Letting $V_T\left(S_T\right)$ be maximal utility[ii] at *T*,

$$V_T\left(S_T\right) = u\left(A_T + W, e_T^c\right) \tag{2.2}$$

Period T-1, Stage 3 - Consumption and Nursing Home Choice:

Next, consider the optimal consumption decision of period *T-1* (which, as mentioned, occurs in the third stage of the period). Given the relevant set of state variables in the third stage[iii], denoted as S_{T-1}^3, the optimal consumption and nursing home choices in *T-1* must solve:

$$\begin{aligned} V_{T-1}^3\left(S_{T-1}^3\right) &= \max_{d_{T-1}^3, C_{T-1}} \left\{ u\left(C_{T-1}; e_{T-1}^c\right) + b_{T-1}^{nh} d_{T-1}^3 + bp_{T-1}^s E\left[V_T\left(S_T\right) | S_{T-1}^3\right]\right\} \\ s.t. \quad A_T &= (1+r)\left(A_{T-1} + W - oop_{T-1} - C_{T-1}\right) \\ A_T &\geq 0 \end{aligned} \tag{2.3}$$

where in (2.3), the value of the optimal consumption and nursing home decisions given third stage state variables S_{T-1}^{3} is denoted $V_{T-1}^{3}\left(S_{T-1}^{3}\right)$.

Consumption is constrained by the assumption that housing assets are completely illiquid (they serve as bequests) and non-housing assets must be non-negative: there is no borrowing against the value of the house or against future income. In (2.3), b is the subjective discount factor (assumed to be time-invariant) and *r* is the one period rate of return on assets. The out-of-pocket expenses the elderly pay for their health insurance, doctor, and nursing home choices is denoted oop_{T-1} and the subjective probability the elderly form of living to period *T* given they are alive at *T-1* is denoted p_{T-1}^{s}. The formulation of out-of-pocket costs and the subjective probability of survival is discussed below.

The elderly are constrained to consume only out of the resources that remain after they pay for their health insurance, doctor visit, and nursing home entrance (if they decide to enter a nursing home). Consider the health insurance costs of the elderly insured with health care plan *i* for *i=1* (Medicare), *i=2* (costly Medigap) or *i=3* (ex-employer provided Medigap) . The fixed one-period premium for health insurance plan *i* in period *T-1* is denoted as n_{T-1}^{i}. Since Medigap is insurance that supplements Medicare, people that receive Medigap must also pay the Medicare premium. This implies that the cost of health insurance of those insured with "costly" Medigap is larger than the health insurance cost of those insured with only Medicare, $n_{T-1}^{2} > n_{T-1}^{1}$. Those that have ex-employer provided Medigap are assumed to pay for the Medicare premium themselves, implying $n^3_{T-1} = n^1_{T-1}$.

Given health insurance plan *i*, if the elderly do <u>not</u> use Medicaid their out-of-pocket cost for their insurance, doctor, and nursing home choices in period *T-1* is:

$$n^i_{T-1} + d^2_{T-1} doc^{i,h}_{T-1} + d^3_{T-1} m^{i,h}_{T-1} \tag{2.4}$$

where $doc^{i,h}_{T-1}$ is the out-of-pocket cost of a doctor visit[iv] when in health state *h* and insured with health insurance *i*, and $m^{i,h}_{T-1}$ is the out-of-pocket cost of a one period stay in a nursing home with health insurance *i* when in health state *h*[v]. However, the elderly do not have to pay (2.4) if they have low assets and low income because of Medicaid: the Medicaid program will pay Medicare premiums, the cost of a doctor visit, and the cost of a one period nursing home stay as long as the elderly have non-housing assets less than $\overline{A}$ and per-period income less than $\overline{W}$.

Consider the expenses of those elderly who only have Medicare health insurance. For those elderly insured with Medicare who have $A_{T-1} \le \overline{A}$ and $W \le \overline{W}$, the out-of-pocket cost of health insurance and health care is *0*. However, those elderly who have $A_{T-1} > \overline{A}$ or $W > \overline{W}$ can "spend down" their assets and/or income on health insurance and health care until they become eligible for Medicaid. The amount the elderly insured only with Medicare have to spend down on health insurance and health care expenses before becoming eligible for Medicaid can be written as:

$$\max\left\{\left(A_{T-1} - \overline{A}\right), 0\right\} + \max\left\{\left(W - \overline{W}\right), 0\right\} \tag{2.5}$$

The elderly with Medicare insurance are assumed to apply for Medicaid benefits as soon as they are eligible. They incur out-of-pocket expenses (oop_{T-1}) equal to the amount specified in equation (2.5) for their health insurance and health care as long as $\left[\max\left\{\left(A_{T-1}-\overline{A}\right),0\right\}+\max\left\{\left(W-\overline{W}\right),0\right\}\right]<n_{T-1}^{1}+d_{T-1}^{2}doc_{T-1}^{1,h}+d_{T-1}^{3}m_{T-1}^{1,h}$. Medicaid does not subsidize any costs if the opposite is true: if $\left[\max\left\{\left(A_{T-1}-\overline{A}\right),0\right\}+\max\left\{\left(W-\overline{W}\right),0\right\}\right]>n_{T-1}^{1}+d_{T-1}^{2}doc_{T-1}^{1,h}+d_{T-1}^{3}m_{T-1}^{1,h}$, then the elderly pay all of their health insurance and health care costs themselves, which implies $oop_{T-1}=n_{T-1}^{1}+d_{T-1}^{2}doc_{T-1}^{1,h}+d_{T-1}^{3}m_{T-1}^{1,h}$.

The elderly with Medigap must apply for Medicaid differently. By assumption the Medicaid program will not pay any health insurance premiums of the elderly insured with Medigap, even if this Medigap coverage is provided by an ex-employer[vi]. *After* the elderly insured with Medigap pay their health insurance premiums (they either pay n_{T-1}^{2} or n_{T-1}^{3}, whichever is appropriate), the elderly can apply for Medicaid coverage, and the Medicaid spend down criteria subtracts the amount that the elderly have already paid for their health insurance. The amount that the elderly with Medigap have to spend down on health insurance and health insurance costs before becoming eligible for Medicaid is:

$$n_{T-1}^{i}+\max\left[\left(\max\left\{\left(A_{T-1}-\overline{A}\right),0\right\}+\max\left\{\left(W-\overline{W}\right),0\right\}-n_{T-1}^{i}\right),0\right] \qquad (2.6)$$

It is assumed that the elderly with Medigap apply for Medicaid benefits as soon as they are eligible (so once (2.6) is paid, the elderly with Medigap pay no more health care costs). Therefore, if (2.6) is less than (2.4) the elderly apply for Medicaid as soon as possible, and their out-of-pocket expenses on their insurance, doctor, and nursing home choices equals

$oop_{T-1} = n^{i}_{T-1} + \max\left[\left(\max\left\{\left(A_{T-1} - \overline{A}\right),0\right\} + \max\left\{\left(W - \overline{W}\right),0\right\} - n^{i}_{T-1}\right),0\right]$. If (2.6) is greater than (2.4), the elderly do not apply for Medicaid (they pay for their insurance and health care entirely out-of-pocket) and their out-of-pocket expenses on their insurance, doctor, and nursing home choices equals

$oop_{T-1} = n^{i}_{T-1} + d^{2}_{T-1} doc^{i,h}_{T-1} + d^{3}_{T-1} m^{i,h}_{T-1}$.

The optimal consumption and nursing home decisions of period *T-1* not only consider the period *T-1* utility received from consumption (and direct (dis)utility from a nursing home stay), but also the future discounted value of remaining assets in the terminal period. The effective discount rate on the future period is the product of the time discount factor b and the subjective probability of survival to period *T*, p^{s}_{T-1}. The true probability of survival to period *T* depends on the health state of the elderly in period *T-1*, whether or not the elderly went to a doctor, whether or not the elderly entered a nursing home, and, if the elderly enter a nursing home, whether or not the elderly entered a Medicaid nursing home[vii]. The probability of survival from period *T-1* to period *T* for those in Medicaid nursing homes is not necessarily the same as the probability of survival to period *T* for those in privately funded nursing homes. As mentioned, those elderly that go to a doctor, are diagnosed in state CR+ADL (*h=3*) or state ADL (*h=4*), and enter a nursing home in period *T-1* have a higher probability of survival to period *T* than if they do not enter a nursing home; this remains true regardless if the elderly enter a Medicaid nursing home or a privately funded nursing home. Let *mcaid* be a dummy variable that equals one if the elderly enter a Medicaid nursing home and zero if the elderly do not enter a Medicaid nursing home. Given the elderly are in health state *h* in period *T-1*, the true probability that the elderly survive to period T is $p_{T-1}^{h}\left(d_{T-1}^{2}, d_{T-1}^{3}, mcaid\right)$.

Since health states do not evolve within a period, at the stage when the elderly jointly choose consumption and whether or not to enter a nursing home, those elderly that went to a doctor in period *T-1* know their health state (*h*) with certainty, and know (from the formation of oop_{T-1} detailed in the previous paragraphs) if they choose to enter a nursing home whether or not they will be in a Medicaid nursing home. This implies that the elderly who went to a doctor know the true probability that they will survive to period *T* at the stage of the consumption choice and they set their subjective probability of survival equal to the true probability of survival, i.e. for them:

$$p_{T-1}^{s} = p_{T-1}^{h}\left(d_{T-1}^{2}, d_{T-1}^{3}, mcaid | d_{T-1}^{2} = 1\right) \qquad (2.7)$$

The true probability of survival of those elderly that do not go to a doctor and are in health state *h* at period *T-1* is $p_{T-1}^{h}\left(d_{T-1}^{2}, d_{T-1}^{3}, mcaid | d_{T-1}^{2} = 0, d_{T-1}^{3} = 0\right)$ (those who do not have a current diagnosis by assumption can not enter a nursing home). For those elderly that did not go to the doctor and are in the healthy state (*h=1*) at *T-1*, the probability of survival to *T* is the same as the probability of survival if they went to a doctor. However, those that did not go to a doctor and are not healthy survive to period *T* with a lower probability than if they had gone to a doctor (regardless of the nursing home choice for those with a functional disability) because the doctor automatically gives treatment to the elderly that are not healthy and this treatment increases the probability these elderly live to the next period[viii].

The elderly who choose not to see a doctor will not have a current diagnosis of their health state and so will not know their true mortality probability. These elderly use the number of periods since their last doctor's diagnosis L_{T-1} and their last diagnosed health state H_{T-1} (which is a diagnosis that occurred L_{T-1} periods ago) to form subjective probabilities over the current states of their health. The elderly then use these subjective probabilities over the states of their health to formulate a subjective probability of dying. Denoting the self-assessed probabilities of the elderly of being in health state *h* in period $T-1$ as q_{T-1}^{h}. The subjective probability of survival to period *T* among the elderly that do not go to a doctor in period *T-1* is:

$$p_{T-1}^{s} = \sum_{h=1}^{4} q_{T-1}^{h} p_{T-1}^{h}\left(d_{T-1}^{2}, d_{T-1}^{3}, mcaid \mid d_{T-1}^{2} = 0, d_{T-1}^{3} = 0\right) \tag{2.8}$$

The set of q_{T-1}^{h} (*h=1,…,4*) are formed in a fully Bayesian way. Suppose that the elderly last went to the doctor one period ago ($L_{T-1} = 1$), and the last diagnosed health state of the elderly is $H_{T-1} = h'$. Given that health states evolve according to a known Markov process between periods, denote the true probability the elderly are in health state *h* (for *h=1,…,4*) at *T-1* given they were in health state h' at *T-2* as $g_{T-2}^{h,h'}$. The elderly know the probabilities that govern the intertemporal stochastic movements of health states and set them equal to their subjective probabilities over health states, i.e. the elderly that last went to the doctor one period ago and were diagnosed in health state h' set $q_{T-1}^{h} = g_{T-2}^{h,h'}$ for *h=1,…,4*.

The elderly who last had a diagnosis of h' two periods ago ($L_{T-1} = 2$, $H_{T-1} = h'$) use a recursion to calculate their subjective probability distribution over health states *h=1,…,4* in period *T-1*. This recursion (which follows) accounts for the fact that the elderly survived to period *T-1* without going to the doctor in period *T-2*:

$$q_{T-2}^{h''} = g_{T-3}^{h'',h'} \quad \text{For } h'' = 1,\ldots,4$$

$$q_{T-1}^{h} = \sum_{h''=1}^{4} \left\{ \frac{q_{T-2}^{h''} p_{T-2}^{h''}\left(d_{T-2}^{2}, d_{T-2}^{3}, mcaid | d_{T-2}^{2} = 0, d_{T-2}^{3} = 0\right)}{\sum_{h'''=1}^{4} q_{T-2}^{h'''} p_{T-2}^{h'''}\left(d_{T-2}^{2}, d_{T-2}^{3}, mcaid | d_{T-2}^{2} = 0, d_{T-2}^{3} = 0\right)} \right\} g_{T-2}^{h,h''}$$

where the fraction in the above equation updates the subjective probabilities over health states formed in period *T-2* with the information that the elderly lived to period *T-1* (even though the elderly did not go to a doctor in *T-2*). The elderly who last went to the doctor more than two periods ago use the same recursion to update their set of subjective probabilities over states of their health.

To summarize, the complete vector of state variables S_{T-1}^{3} that influence the payoff from consumption and entrance into a nursing home (if applicable) at the time of the third stage include the consumption and nursing home shocks shock (e_{T-1}^{c} and e_{T-1}^{nh}), the insurance purchased for the period $d_{T-1}^{1,i}$, the doctor decision, d_{T-1}^{2}, the prices of all possible insurance, doctor, and nursing home choices ($\{n_{T-1}^{r}\}_{r=1}^{3}$, $\left\{\{doc_{T-1}^{i,h}\}_{i=1}^{3}\right\}_{h=1}^{4}$, $\left\{\{m_{T-1}^{i,h}\}_{i=1}^{3}\right\}_{h=3}^{4}$), the Medicaid eligibility limits ($\overline{A}$ and $\overline{W}$), non-housing assets (A_{T-1}), per-period income (W), the number of periods since last seeing the doctor (L_{T-1}), and the last diagnosed health state (H_{T-1}). Given these state variables, $V_{T-1}^{3}\left(S_{T-1}^{3}\right)$ is the value of the optimal consumption and nursing home decisions as detailed in (2.3).

Period T-1, Stage 2 - Doctor Choice:

In the second stage of period *T-1*, the elderly decide whether or not to go to the doctor. The elderly go to a doctor if it solves the following maximization problem:

$$\begin{aligned} &V_{T-1}^{2}\left(S_{T-1}^{2}\right)= \\ &\max\left\{\left(E\left[V_{T-1}^{3}\left(S_{T-1}^{3}\right)|S_{T-1}^{2},d_{T-1}^{2}=1\right]+b_{T-1}^{doc}\right),E\left[V_{T-1}^{3}\left(S_{T-1}^{3}\right)|S_{T-1}^{2},d_{T-1}^{2}=0\right]\right\} \end{aligned} \tag{2.9}$$

where the first term in the maximization operator is the payoff from seeing the doctor, the second term in the maximization operator is the payoff from not seeing the doctor, and the value of the optimal doctor decision is denoted $V_{T-1}^{2}\left(S_{T-1}^{2}\right)$. The expectation over the value of the third stage in (2.9) is over the consumption shock, (and for the doctor decision) the nursing home shock and the doctor's diagnosis of the current period's health state. S_{T-1}^{2} is the relevant state space at stage two, which is identical to the state space at stage three except that the consumption and nursing home shocks are not known, and L_{T-1} and H_{T-1} may change between stage two and stage three (depending on whether or not the elderly go to a doctor in stage two). If the elderly do not go to a doctor, both the number of periods since their last diagnosis and their last diagnosed health state do not change from S_{T-1}^{2} to S_{T-1}^{3}. If the elderly go to a doctor, the values of L_{T-1} and H_{T-1} change from S_{T-1}^{2} to S_{T-1}^{3}: the number of periods since last seeing the doctor L_{T-1} and the last diagnosed health state H_{T-1} are both updated from S_{T-1}^{2} to S_{T-1}^{3}.

Period T-1, Stage 1 - Insurance Choice:

In the first stage of period *T-1*, the elderly make their health insurance choice for the period. The elderly that have Medigap provided for free make no insurance choice[ix]. Some of the remaining elderly can not purchase Medigap because of institutional constraints. If the elderly have financial resources less than the cost of health insurance premiums ($A_{T-1} + W < n_{T-1}^{2}$), they can not buy Medigap because Medicaid will not subsidize the cost of health insurance premiums for those insured with Medigap. Also, the elderly who had Medicare health insurance in period *T-2* and have a "pre-existing condition" are also not allowed to buy Medigap. The elderly are defined as having a pre-existing condition if their last doctor's diagnosis, H_{T-1} (which occurred no later than stage 2 of period *T-2*), is either CR, CR+ADL, or ADL. Since Medigap plans are "guaranteed renewable," pre-existing conditions clauses do not apply to those elderly that had Medigap health insurance in period *T-2*; the elderly with Medigap insurance in period *T-2* can buy Medigap in period *T-1* as long as their financial resources are greater than the cost of Medigap.

The pre-existing conditions and guaranteed renewable clauses in Medigap provide additional incentives for the elderly to maintain their Medigap coverage. If the elderly forecast that their period *T-1* health care expenses will be high enough then they purchase Medigap[x]. However, those elderly that do not think their current health care expenses will be high may nevertheless purchase Medigap in the event that they develop a pre-existing condition and wish to have access to Medigap in the future. This argument is not particularly relevant to the Medigap decision in period *T-1* (we have assumed for expository purposes that the elderly make no health care choices in period *T*), but does affect the value of Medigap in periods *1* through *T-2*.

For those elderly that have a choice, the type of health insurance the elderly choose in period *T-1* solves the following maximization problem:

$$\begin{aligned} &V_{T-1}^{1}\left(S_{T-1}^{1}\right)= \\ &\max\left\{\left(E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)\mid S_{T-1}^{1}, d_{T-1}^{1,2}=1\right]+b_{T-1}^{ins}\right), E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)\mid S_{T-1}^{1}, d_{T-1}^{1,1}=1\right]\right\} \end{aligned} \tag{2.10}$$

The first term of the maximization operator in (2.10) is the value of purchasing Medigap, while the second term is the value of being insured with only Medicare; the maximal value of the insurance decision is denoted $V_{T-1}^{1}\left(S_{T-1}^{1}\right)$. S_{T-1}^{1} is the relevant state space at stage one, and the expectation in both of the terms of the maximization operator in (2.10) is over the value of the random utility shock from seeing the doctor that occurs in stage two of the period. The state variables at the first stage (the insurance choice stage) are the same as the state variables in the second stage except that the value of the random utility shock from seeing the doctor (e_{T-1}^{doc}) is not known at the first stage, and because of Medigap's pre-existing conditions and guaranteed renewable clauses, S_{T-1}^{1} must include the type of health insurance coverage of the elderly in period *T-2*, $\left\{d_{T-2}^{1,i}\right\}_{i=1}^{3}$. If $d_{T-2}^{1,1} = 1$, the elderly were insured with only Medicare in period *T-2*. If $d_{T-2}^{1,2} = 1$, the elderly were insured with self-purchased Medigap and if $d_{T-2}^{1,3} = 1$, the elderly were insured with ex-employer provided Medigap in period *T-2*. As mentioned, along with non-housing assets, income, and the last doctor's diagnosis $H_{T-1}, \left\{d_{T-2}^{1,i}\right\}_{i=1}^{3}$ determines what type of health insurance the elderly can purchase in period *T-1*.

Period T-2, Stage 3 - Consumption and Nursing Home Choice:

If we go back one more period, to period *T-2*, the problem of the elderly in the third stage of *T-2* (the stage of the consumption and nursing choice) is exactly analogous to the optimal problem of the elderly in the third stage of period *T-1*. The optimal consumption and nursing home decisions in the third stage of period *T-2* must satisfy:

$$
\begin{aligned}
V_{T-2}^{3}\left(S_{T-2}^{3}\right) &= \max_{d_{T-2}^{3}, C_{T-2}} \left\{u\left(C_{T-2}; e_{T-2}^{c}\right) + b_{T-2}^{nh} d_{T-2}^{3} + bp_{T-2}^{s} E\left[V_{T-1}^{1}\left(S_{T-1}^{1}\right) | S_{T-2}^{3}\right]\right\} \\
s.t. \quad & A_{T-1} = (1+r)\left(A_{T-2} + W - oop_{T-2} - C_{T-2}\right) \qquad (2.11) \\
& A_{T-1} \geq 0
\end{aligned}
$$

The expectation in the above equation is with respect to the random component of S_{T-1}^{1}, which is the utility shock associated with purchasing Medigap in period *T-1*, e_{T-1}^{ins} [xi]. In a fashion identical to that described for period *T-1*, we can derive the optimal decisions (at each stage) for period *T-2* and then "move backwards" to period *T-3*. Continuing recursively in this way, we can calculate the optimal decision at each stage of each period at all periods for all possible relevant values of the state variables. The set of optimal decisions for all possible state variables in all stages of all periods completely describes the solution to the model for the elderly.

2.3 Solution

2.3.1 Computation

The model will in general have no analytical solution. However, it can be solved numerically using an algorithm that essentially matches the exposition of the model. First, the value of optimal consumption decision at terminal period is calculated at all values of the state space elements. To make these calculations, feasible assets and income in the terminal period are discretized and the expected value $V_T\left(S_T\right)$ at these different discrete asset and income values is evaluated via Monte-Carlo integration. The value of optimal consumption is then calculated for each of a set of randomly drawn consumption shocks (from the appropriate distribution) and for each discrete element of the state space. The average value of $V_T\left(S_T\right)$ at each discretized state space element is set equal to the expected value, $E\left[V_T\left(S_T\right)\right]$, which is needed for the calculation of the stage 3 period *T-1* value function. A cubic spline that preserves monotonicity is passed through the calculated expected values as a function of assets; this cubic spline is then considered the true expected value function for *any* feasible assets in period *T*.

At this point, the optimal consumption and nursing home decisions in period *T-1* are calculated for all possible state variables S_{T-1}^3 at the third stage of period *T-1*. As before, assets and income are discretized, and the discretization of income in *T-1* is the same as the discretization of income in T (because income is time-invariant). Given a value of the consumption shock e_{T-1}^{c} and nursing home shock e_{T-1}^{nh} and the values of the other discretized state variables, the value of optimal consumption is calculated first without and then with nursing home entry (for those that can enter nursing homes). Optimal consumption (both with and the without nursing home entry) is calculated by forcing feasible consumption to be one of a discrete number of points on a grid and then performing a grid search to find the feasible consumption point that yields the highest value. The feasible consumption grid consists of evenly spaced points bounded by 0 and the financial resources that remain after the out-of-pocket expenses on the insurance, doctor, and nursing home choices have been paid. These bounds enforce the no-borrowing constraint on consumption and they also let the points of the consumption grid change with the nursing home choice (since out-of-pocket expenses may differ with the different nursing home choices)[xii]. The optimal value for the third stage at a particular value of the consumption shock and nursing home shock is the maximum of the value of optimal consumption with entrance in a nursing home (if applicable) and the value of optimal consumption without entrance in a nursing home. Given the procedure for finding the optimal value for the third stage at a particular value of the consumption shock and nursing home shock, $E\left[V_{T-1}^{3}\left(S_{T-1}^{3}\right)\right]$ is calculated by Monte Carlo integration over the set of consumption and nursing home shocks at all (discretized) S_{T-1}^{3}.

At this point, the expected value over the second stage (the doctor choice) at all discretized S_{T-1}^{2} is evaluated using Gaussian Quadrature[xiii]. This procedure computationally approximates the following one dimensional expectation[xiv] and is derived from equation (2.9):

$$\begin{aligned}&E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)\right]=\\&E\left[\max\left\{\left(E\left[V_{T-1}^{3}\left(S_{T-1}^{3}\right)|S_{T-1}^{2},d_{T-1}^{2}=1\right]+b_{T-1}^{doc}\right),E\left[V_{T-1}^{3}\left(S_{T-1}^{3}\right)|S_{T-1}^{2},d_{T-1}^{2}=0\right]\right\}\right]\end{aligned} \tag{2.12}$$

where the outside expectation in the above equation is over the doctor shock.

Similarly, the expectation over the first stage (the insurance choice) at all discretized S_{T-1}^{1} of period *T-1* is calculated using Gaussian Quadrature (if a one-dimensional integral needs to be evaluated). For those that are eligible to purchase Medigap, this expectation over the insurance shock is derived from (2.10) and equals:

$$\begin{aligned}&E\left[V_{T-1}^{1}\left(S_{T-1}^{1}\right)\right]=\\&E\left[\max\left\{\left(E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1},d_{T-1}^{1,2}=1\right]+b_{T-1}^{ins}\right),E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1},d_{T-1}^{1,1}=1\right]\right\}\right]\end{aligned} \tag{2.13}$$

For those that are institutionally prohibited from purchasing Medigap (these elderly have pre-existing conditions or not enough financial resources on hand to afford the Medigap premium), the expectation over the first stage of period *T-1* is simply:

$$E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1},d_{T-1}^{1,1}=1\right] \tag{2.14}$$

The expectation over the first stage is more complicated for those with ex-employer provided Medigap, since with probability p_{T-1} these elderly lose their ex-employer provided Medigap and then must choose to purchase Medigap or be insured with only Medicare. Even though these elderly are not subject to pre-existing conditions clauses, they must have enough resources on hand to purchase the Medigap premium. If this is the case, the expectation over the first stage equals p_{T-1} times (2.13) plus $(1-p_{T-1})E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1}, d_{T-1}^{1,3}=1\right]$. For those that can not afford Medigap if they lose their ex-employer provided Medigap, the expectation over the first stage equals $(1-p_{T-1})E\left[V_{T-1}^{2}\left(S_{T-1}^{2}\right)|S_{T-1}^{1}, d_{T-1}^{1,3}=1\right]$ + p_{T-1} times (2.14).

Once the expectation over the first stage, $E\left[V_{T-1}^{1}\left(S_{T-1}^{1}\right)\right]$, has been calculated at all discretized S_{T-1}^{1}, a cubic spline that preserves monotonicity is passed through $E\left[V_{T-1}^{1}\left(S_{T-1}^{1}\right)\right]$ at the discretized set of assets and treated as the true expected value function over continuous assets. At this point, the period *T-2* optimal consumption and nursing home decision at all discretized S_{T-2}^{3} can be calculated. This entire process is repeated recursively from period *T-2* to period *1* to yield the full set of decision rules implied by the model.

2.3.2 Shock Sorting

The FORTRAN 90 code developed to solve the model draws all consumption shocks simultaneously and sorts them from high to low. This shock sorting greatly reduces the computation time associated with calculating the set of optimal decisions at any given set of parameters: it can be shown that given some relatively weak assumptions about the local properties of the derivative of the expected value functions in assets, and given the value of the risk aversion parameter is greater than zero, (conditional on the nursing home choice) as the value of the consumption shock increases, optimal consumption must increase. To see this, consider the following necessary condition for an interior optimal consumption decision[xv]:

$$\frac{\partial u\left(C_t;\varepsilon_t^c\right)}{\partial C_t}+\frac{\partial \beta \pi_t^s E\left[V_{t+1}\left(S_{t+1}^1\right)|S_t^3\right]}{\partial A_{t+1}}\frac{\partial A_{t+1}}{\partial C_t}=0 \qquad (2.15)$$

The utility function used in this dissertation is $u\left(C_t;\varepsilon_t^c\right)=\frac{\varepsilon_t^c\left(C_t\right)^{1-\sigma}}{1-\sigma}$, which implies:

$$\frac{\partial u\left(C_t;\varepsilon_t^c\right)}{\partial C_t}=\varepsilon_t^c\left(C_t\right)^{-\sigma} \qquad (2.16)$$

$$\frac{\partial^2 u\left(C_t;\varepsilon_t^c\right)}{\partial C_t \partial \varepsilon_t^c}=\left(C_t\right)^{-\sigma} \qquad (2.17)$$

and

$$\frac{\P^2 u\left(C_t ; e_t^c\right)}{\P C_t \P C_t} = -s e_t^c \left(C_t\right)^{-s-1} \tag{2.18}$$

The consumption shock is drawn from a distribution with positive support (the lognormal distribution) and by construction consumption is constrained to always be greater than zero. This implies that in (2.16) the marginal utility from consumption is always positive, that in (2.17) the derivative of marginal utility with respect to the consumption shock is always greater than zero, and that in (2.18) the derivative of marginal utility with respect to consumption is always less than zero (for $s > 0$). From the budget constraint in (2.3), we know $\frac{\P A_{t+1}}{\P C_t} = -1$. We also know that b is fixed and (conditional on a given nursing home choice) p_t^s is fixed. All of the above imply that an interior optimal consumption decision must satisfy:

$$e_t^c \left(C_t\right)^{1-s} = b p_t^s \frac{\P E\left[V_{t+1}\left(S_{t+1}^1\right) | S_t^3\right]}{\P A_{t+1}} \tag{2.19}$$

at all periods $t \neq T$.

Consider what happens to optimal consumption if the consumption shock increases slightly. According to (2.17), the left hand side of (2.19) will increase, but due to the serial independence of all utility shocks, the right hand side of (2.19) will not change: thus, if the consumption shock increases, at the old level of optimal consumption, the left hand side of (2.19) becomes larger than the right hand side of (2.19). To reconcile (2.19), suppose consumption is increased slightly. From (2.18), with $s > 0$ we know the left hand side of (2.19) will decrease. We also know that if we increase period *t* consumption, from the budget constraint (2.3), period *t+1* assets must fall. As long as $\frac{\partial E\left[V_{t+1}\left(S_{t+1}^{1}\right)|S_{t}^{3}\right]}{\partial A_{t+1}}$ locally increases as assets decrease, this means that $\frac{\partial E\left[V_{t+1}\left(S_{t+1}^{1}\right)|S_{t}^{3}\right]}{\partial A_{t+1}}$ is locally increasing in C_t. Thus, the right hand side of (2.19) increases and the left hand side of (2.19) decreases with an increase in period *t* consumption. Therefore, if the consumption shock increases, optimal consumption must increase as long as $\frac{\partial E\left[V_{t+1}\left(S_{t+1}^{1}\right)|S_{t}^{3}\right]}{\partial A_{t+1}}$ is locally decreasing in assets. Recognition of this fact greatly reduces computation time since optimal consumption is found with a grid search over discrete levels of consumption: if the consumption shock is sorted from low to high, as the consumption shocks increase in value, optimal consumption must not decrease in value, and the number of elements of the grid necessary to search for optimal consumption falls[xvi].

Endnotes

[i] Of those elderly that have the same observed health state in both waves of the data used to estimate this model, eight percent of those insured with Medicare switch to Medigap, while sixteen percent of those insured with Medigap switch to Medicare. Of those elderly with different health states in both waves of the observed data, six percent switch from Medicare to Medigap and twenty four percent switch from Medigap to Medicare.

[ii] Since housing assets are illiquid in all periods, and the value of the bequest of the housing stock is additive, housing assets are not kept as a separate state variable because they do not affect any of the decisions in the model. The only financial state variables that affect decisions are non-housing assets and income. The terms “non-housing assets” and “assets” are used interchangeably throughout this section and the rest of this dissertation.

[iii] These state variables will be defined later in this section.

[iv] Note that $doc_{T-1}^{i,h}$ includes both a diagnosis cost and a treatment cost if $h=2$, 3, or 4.

[v] By definition, the cost of visiting the doctor (given a diagnosis h) or entering a nursing home (given a diagnosis of $h=3,4$) while insured with Medigap is not larger than the cost of visiting the doctor or entering a nursing home while insured with only Medicare: $doc_{T-1}^{i,h} \leq doc_{T-1}^{1,h}$ and $m_{T-1}^{i,h} \leq m_{T-1}^{1,h}$ for $i=2$ (costly Medigap) and $i=3$ (ex-employer provided Medigap).

[vi] This implies that all would be Medigap purchasers in period *T-1* must have income and period *T-1* assets greater than the cost of the period *T-1* Medigap premium.

[vii] The elderly are defined as entering a Medicaid nursing home if Medicaid pays any health insurance or health care expenses in the period.

[viii] The assumption here is that the elderly that are not healthy cannot receive treatment unless they first go to a doctor.

[ix] With probability p_{T-1}, the elderly with ex-employer provided Medigap lose this type of health insurance immediately before the first stage of the *T-1* period. Those elderly that lose this insurance must subsequently choose to be insured with Medicare or pay for Medigap plan they once had. These elderly are not subject to the pre-existing conditions clauses discussed later in this section, but must be able to purchase the Medigap plan themselves.

[x] The elderly must forecast these expenses at the stage of the insurance choice because they have not yet made their doctor and nursing home choices for the period.

[xi] For those insured with ex-employer provided Medigap in period *T-2*, the expectation is also over the shock that determines whether or not they keep this insurance in period *T-1*.

[xii] The cubic spline through the expected value of assets in the terminal period allows evaluation of the value of consumption points in period *T-1* that do not necessarily correspond to the discretization of assets for which the expected value in the terminal period is calculated.

[xiii] The set of discrete asset and income points that constitute S_{T-1}^{3} is the same as the set of discrete asset and income points that constitute S_{T-1}^{2} and S_{T-1}^{1}.

[xiv] To limit the number of feasible states in any given period, the elderly are forced to go to the doctor if they haven't been to the doctor in 3 periods, i.e. if $L_{T-1} = 3$ then $E\left[V\left(S_{T-1}^{3}\right) | S_{T-1}^{2}, d_{T-1}^{2} = 0\right]$ equals minus infinity.

[xv] Due to the no-borrowing constraints of the model, optimal consumption does not have to satisfy (2.15) (the elderly can choose to consume all remaining non-housing assets and income). If this is the case, the logic that follows simply implies that optimal consumption does not change as the consumption shocks increase in value.

[xvi] Extensive Monte-Carlo testing has shown that the solution to the model with "shock-sorting" is identical to the solution of the model when optimal consumption can assume any point on the consumption grid for any shock.

3. Data

The parameters of the model are estimated using the AHEAD (Asset and Health Dynamics of the Oldest Old) data set. The AHEAD data set obtains information from a sample of older Americans on non-housing and housing assets, income, health insurance, health utilization, and health care costs at every interview. There are two waves of AHEAD data, collected in 1993 and 1995, that are currently publicly available. The primary AHEAD respondents are elderly (age 65 and over) and are drawn from a nationally representative sample, with the exception that African-Americans and the elderly living in Florida are oversampled. The initial wave of AHEAD respondents are also drawn only from a non-institutionalized population; however, those respondents that enter nursing homes over time are kept in the AHEAD sample.

The model presented in the previous section pertains only to the elderly living alone. Thus, the elderly residing in multiple person households are excluded from the sample used to estimate the model. Since elderly men face different mortality probabilities than elderly women, the model has to be separately estimated for men and for women. In this dissertation, the parameters of the model are estimated using just data on women. Of the 5,000 elderly women interviewed by the AHEAD survey in Wave 1, approximately 40% live alone. After imposing other sample restrictions, 741 people remain in the working sample in Wave 1. Of these 741 people, 651 survive to the Wave 2 interview[i]. The two waves yield information on one decision period of the model: respondents' answers to Wave 1 questions provide data on the state variables and respondents' answers to Wave 2 questions provide data on the choice variables of this period. This implies that one period of the model is two years long.

Choice Variables:

Table 3.1 (see next page) reports the unconditional choice distribution for the elderly in the remaining sample by 5 year age intervals, from age 67 to age 90[iiiii]. If respondents visited a medical doctor about their health at least once between Wave 1 and Wave 2, stayed overnight in a hospital as a patient between Wave 1 and Wave 2, or stayed overnight in a long-term health care facility at least once between Wave 1 and Wave 2, then they are classified as having chosen to see a doctor, $d_t^2 = 1$. From this table, it is evident that almost all elderly women living alone (from 93 to 98 percent) go to the doctor at least once in a two year period. Furthermore, in Wave 2 if respondents respond that their primary residence is a nursing home facility, $d_t^3 = 1$; otherwise $d_t^3 = 0$[iv]. As seen in Table 3.1, very few elderly (no more than six and one-half percent) enter a nursing home and declare the nursing home as the place of primary residence.

Respondents are classified as having chosen Medigap insurance if they report that they have privately provided (non Medicaid) insurance that supplements Medicare[v]. If the cost of this insurance was \$0 in Wave 1 and Wave 2, respondents are classified as

Table 3.1 Distribution of Choices by 5 Year Age Intervals

	Age	67-72	73-78	79-84	85-90
	(# of observations)	(47)	(246)	(231)	(127)
$d_t^{1,i}$	% Medicare	61.7	45.9	42.4	44.1
	% Self-Purchased Medigap	36.2	50.4	52.4	51.2
	% Ex-Employer Medigap	2.1	3.7	5.2	4.7
d_t^2	% Do not go to Doctor	6.4	2.4	3.9	2.4
	% Go to Doctor	93.6	97.6	96.1	97.6
d_t^3	% Do Not Enter Nursing Home	97.9	97.6	95.2	93.7
	% Enter Nursing Home	2.1	2.4	4.8	6.3
$\frac{A_{t+1}}{1+r}$	Median Non-Housing Assets	\$800	\$1,550	\$2,000	\$5,000

having chosen ex-employer provided Medigap, $d_t^{1,3} = 1$. If the cost of this supplemental insurance was non-zero in Wave 1 or Wave 2, respondents are classified as having chosen to purchase Medigap ($d_t^{1,2} = 1$). The remaining elderly are classified as having only Medicare insurance, $d_t^{1,1} = 1$. With the exception of the youngest cohort of elderly, approximately one-half of the elderly in the sample, as shown in Table 3.1, choose to purchase Medigap, and this proportion does not vary much by age for those older than age 73. Finally, although consumption is not directly observable, in Wave 2 respondents report non-housing assets and out-of-pocket expenses on health care and health insurance. Given income and initial (Wave 1) non-housing assets, the consumption choice C_t can be imputed.

State Variables:

As mentioned, responses to Wave 1 questions provide information about the state variables: income (W)[vi], non-housing assets (A_t), number of periods since last seeing the doctor (L_t), last diagnosed health state (H_t), and last type of health insurance ($d_{t-1}^{1,i}$). Table 3.2 (see next page) depicts the distribution of initial state variables by five year age intervals. Note that approximately half the elderly in the working sample have initial non-housing assets and per-period income low enough to qualify for Medicaid at the beginning of a period. The assets ($\overline{A}$) and income ($\overline{W}$) eligibility levels that determine Medicaid eligibility are specified by the "Qualified Medicare Beneficiary" (QMB) criteria. For the elderly to be QMB recipients of

Table 3.2 Distribution of States by 5 Year Age Intervals

	Age (# of observations)	67-72 (47)	73-78 (246)	79-84 (231)	85-90 (127)
$d_{t-1}^{1,i}$	% Medicare	46.8	38.2	34.6	32.3
	% Self-Purchased Medigap	48.9	54.5	58.4	58.3
	% Ex-Employer Medigap	4.3	7.3	6.9	9.4
L_t	% 1 pd. since Doctor Visit	91.5	94.3	93.5	92.9
	% 2 pds. since Doctor Visit	8.5	5.7	6.5	7.1
H_t	% Last diagnosed as Healthy	42.5	50.4	52.8	48.8
	% Last diagnosed as CR	51.1	38.6	38.1	39.4
	% Last diagnosed as CR+ADL	6.4	9.4	5.2	5.5
	% Last diagnosed as ADL	0	1.6	3.9	6.3
W	Median Yearly Income	$7,968	$9,000	$8,450	$8,725
A_t	Median Assets	$300	$1,000	$850	$1,000
	% Eligible for Medicaid (at start of period)	61.7	44.7	48.5	50.4

Medicaid assistance, they must have non-housing assets no greater than twice the allowable amount for SSI eligibility and yearly income no greater than the federal poverty line, although these rules vary by state (see the 1994 Green Book for details). The cutoff assets and income levels used to determine Medicaid eligibility in this dissertation are a non-housing assets limit of $\overline{A} = \$12{,}000$ and yearly income limit of \$7,890 (the 1997 federal income poverty line for people living alone): this yearly income limit implies a *per-period* income limit of $\overline{\mathrm{W}} = \$15{,}780$. Approximately 93% of the elderly went to the doctor at least once in a twelve month period prior to the Wave 1 interview[vii]; these elderly have L_t set equal to one period. The remaining elderly (about 7%) have L_t set to two periods[viii]. If the elderly have privately provided supplemental Medicare insurance in Wave 1 and they list the Wave 1 cost of this supplemental insurance as \$0, then $d_{t-1}^{1,3} = 1$. If the elderly have supplemental Medicare insurance and pay for it, $d_{t-1}^{1,2} = 1$; the remaining elderly are defined as having only Medicare, $d_{t-1}^{1,1} = 1$. Notice that between 50% and 60% of the elderly have privately provided supplemental Medicare insurance in Wave 1, and that this proportion increases with age.

What is not directly observable from Table 3.1 and Table 3.2 is that both the doctor choice and the insurance choice are persistent between waves. Of the elderly that saw a doctor within 12 months of the Wave 1 interview, only 2% (12 out of 609) choose not to go to a doctor by the Wave 2 interview. However, of the elderly that did not see a doctor within 12 months of the Wave 1 interview, 21% (9 out of 42) choose not to go to a doctor by the Wave 2 interview. Similarly, of the 237 people insured with only Medicare in Wave 1, 219 are insured with only Medicare in Wave 2 (92%), while of the 366 people insured with (privately purchased) Medigap in Wave 1, 299 are insured with privately purchased Medigap in Wave 2 (82%)[ix].

The elderly are defined as having last been diagnosed in the chronic condition CR if they report in Wave 1 that they have ever been diagnosed with diabetes, lung disease, or heart disease, or some combination of these diseases. These conditions are assumed to be permanent as the AHEAD interview implicitly assumes those diagnosed with diabetes, lung disease, or heart disease in Wave 1 automatically have these conditions in Wave 2 (regardless of any treatments or lifestyle changes the elderly undertook between the Wave 1 interview date and Wave 2 interview date). These conditions comprise CR because they represent most major causes of death in national statistics: diabetes, lung disease, and heart disease combined account for between 50% and 60% of all listed causes of death of the elderly (Death and Death Rates …, 1992). Those elderly that report they ever had cancer as of Wave 1, or developed cancer between Wave 1 and Wave 2, were excluded from the working sample. Even though cancer accounts for approximately another 20% of the listed causes of death of the elderly (Death and Death Rates …, 1992), cancer is not in the model (and those that ever had cancer are excluded from the sample) because cancer would have to be modeled as an additional health state (different from healthy or CR) and only 16 people develop cancer between Wave 1 and Wave 2[x].

In this model, functional disability is defined to be a "nursing home disease." If the elderly have this nursing home disease, they can seek treatment, which is residence in a nursing home; if the elderly do not have the nursing home disease they cannot get treatment (enter a nursing home). An open questions remains as to what set of observable conditions constitutes the best "nursing home disease," i.e. with what set of observable conditions do nursing homes realistically increase survival probabilities. The true "nursing home disease" is the set of conditions the elderly must have such that a doctor says the elderly with these conditions would benefit from entering a nursing home. However, this set of conditions is not directly observable in the data. The criteria used in this paper to determine the nursing home disease is arbitrary - most elderly in a nursing home have to have the condition(s) while few outside nursing homes can have the condition(s). Although arbitrary, these criteria try to capture the set of elderly that can substantially increase their survival probabilities by entering a nursing home. Although in theory the elderly can enter a nursing home for many different reasons, including various cognitive difficulties and functional impairments, the elderly are defined here as having the functional disability (the nursing home disease) only if they have difficulty bathing.

This choice was determined by looking at the relationship of all possible combinations of Wave 2 Activities of Daily Living questions and Wave 2 nursing home usage[xi]. The AHEAD questionnaire has many different Activities of Daily Living questions that determine whether the elderly have various functional impairments. Assigning the elderly a value of 1 if they had a particular functional impairment and a 0 if they did not have a particular functional impairment for each of the Activities of Daily Living questions, the sum of these values was calculated and compared to whether or not the elderly were in a nursing home. This procedure was carried out one impairment at a time (for all Activities of Daily Living questions), two impairments at a time (pairwise over all Activities of Daily Living questions), three impairments at a time, …, up to five impairments at a time. The Activities of Daily Living question (among all possible sets or combinations of Activities of Daily Living questions) that was the best predictor of nursing home usage was the bathing question: 64% of those in nursing homes (16 out of 25) had trouble bathing, while only 17% of those not in nursing homes (108 out of 625) had trouble bathing. By adding other functional impairments to the nursing home criteria, at most 20 out of the 25 elderly in nursing homes have one of this set of functional impairments; however, nearly 2/3 of those not in nursing homes also has at least one of these impairments. It remains to be seen as to whether bathing difficulty coupled with these additional functional impairments is a better "nursing home disease" than just difficulty bathing. However, this choice of the "nursing home disease" is also consistent with previous research (see Headen, 1993) which shows that the inability to bathe oneself is the most important health-condition correlate of nursing home entry[xii].

Probabilities:

Table 3.3 (displayed on the next page) shows the transitions among health states between the two waves as well as the unconditional death probabilities by Wave 1 diagnosed health state (for those elderly that went to the doctor in Wave 1). Although the unconditional probability of dying for those last diagnosed in CR or CR+ADL is higher than the unconditional probability of dying for those diagnosed as healthy in Wave 1, the unconditional probability of dying for those diagnosed with ADL in Wave 1 is lower than the unconditional probability of dying for those diagnosed as healthy. It is also interesting (not reported in Table 3.3) that those elderly that did not go to the doctor within 12 months of the Wave 1 interview and were last diagnosed as healthy die with the same (if not lower) probability than those diagnosed as healthy within 12 months of the Wave 1 interview. The model, however, implies that the longer it has been since seeing the doctor, the higher the probability that the elderly last diagnosed as healthy die: some elderly that were healthy get sick and these elderly die with higher probability given they do not go to the doctor for treatment. Although it is hard to draw any conclusions from these facts given the small number of people diagnosed with ADL in Wave 1 (20) and the small number of people diagnosed as healthy outside of 12 months of the Wave 1 interview (39), these two facts suggest that there may be unobserved heterogeneity of survival probabilities among diagnosed health states. In other words, those that are diagnosed as in health states ADL or CR+ADL and do not enter a nursing home (the Wave 1 population is non-institutionalized) and those that do not go to the doctor in Wave 1 may be inherently healthier than the rest of the sample, regardless of last diagnosed health state. This inherent healthiness, and its correlation to last diagnosed health state and number of periods since last getting a doctor's diagnosis, may reconcile the two facts mentioned above.

Table 3.3 Health State Transitions

			Wave 2[xiii]			
		Died	Healthy	CR	CR+ADL	ADL
Wave 1	Healthy (330 obs.)	11.2	74.5	11.0	1.4	13.1
	CR (290 obs.)	13.1	0	80.5	19.5	0
	CR+ADL (55 obs.)	18.2	0	40.0	60.0	0
	ADL (20 obs.)	5.0	47.4	5.3	10.5	36.8

Table 3.4 Doctor's Visit Cost by Diagnosis

Health State	Median reported total cost[xiv]	Median out-of-pocket cost (Medicare)[xv]	Median out-of-pocket cost (Medigap)
Healthy	$3,000	$836	$1,100
CR	$15,000	$2,164	$1,720
CR+ADL	$15,000	$3,640	$2,885
ADL	$15,000	$680	$1,980

Table 3.3 shows that healthiness is a persistent state; 75% of those diagnosed as healthy in Wave 1 are diagnosed as healthy again in Wave 2. However, unlike the healthy state and the CR state, the ADL condition is quite transitory: most people diagnosed with a functional disability in Wave 1 were not diagnosed as having this disability in Wave 2, although part of this may be attributable to the fact that the bathing question changed between waves (the Wave 2 bathing question asks about a less serious functional difficulty than the Wave 1 bathing question)[xvi].

Transition probabilities between health states are assumed to be exogenous to health behavior. Because the CR condition is permanent by the way the AHEAD asks questions, treatment for CR in the model does not change whether or not the person will be diagnosed with CR in the future. Similarly, given the Wave 1 population of elderly is non-institutionalized, transitions into and out of the ADL state for those in nursing homes are not observed and cannot be compared to transitions into and out of the ADL state for those not in nursing homes. As a result, nursing homes are modeled as only affecting survival probabilities (and not transition probabilities); given both deaths of those in nursing homes and transitions into and out of the ADL state of those in nursing homes are not observed, it would be difficult to identify both survival and transition effects of nursing homes from the available data[xvii].

Costs:

Both the total cost of a doctor's visit (conditional on a diagnosis) and the out-of-pocket cost of a doctor's visit, conditional on health insurance and a diagnosis, are shown in Table 3.4[xviii]. The data suggest that Medicare subsidizes somewhere between

80% and 95% of the cost of a doctor's diagnosis. Although the out-of-pocket cost of a two year nursing home stay is not reported by the elderly, the total cost of a two year stay in a nursing home and a doctor's diagnosis is reported by the elderly; the median reported total cost of care for those whose primary residence in a nursing home is $65,000 for both those in the ADL and CR+ADL state.

The fact that Medigap is supplemental Medicare insurance implies that, conditional on a diagnosis, if the total cost of care is the same for the elderly with Medicare and with Medigap, the out-of-pocket costs for those elderly that go to a doctor and are insured with Medigap should be less than the out-of-pocket costs for those elderly that go to a doctor and are insured with only Medicare. However, as Table 3.4 reveals, the median reported out-of-pocket expense for the elderly that are healthy (or are in the ADL state), go to a doctor, and are insured with Medicare is lower than the median out-of-pocket expense for the elderly that are healthy (or in the ADL state), and go to a doctor[xix]. This suggests that perhaps Medigap purchasers are adversely selected; those with higher total costs of care (conditional on a diagnosis) may be more likely to purchase Medigap than those with lower total costs of care. To account for the possibility that Medigap purchasers are adversely selected on the basis of costs, the estimation procedure, which is detailed in the next section, allows for unobserved heterogeneity in the cost of a doctor's visit.

Endnotes

[i] Those elderly with missing information that is used to determine choices or states are not included in the sample. Also, the elderly with non-housing assets larger than $150,000 or yearly income larger than $37,500 are not included in the working sample, those elderly without Medicare insurance or with long-term care insurance are not in the sample, and the elderly with cancer or who ever had cancer are excluded from the sample. The elderly with large assets and income in either Wave 1 or Wave 2 of the data are excluded from the sample because the increase in computational burden associated with solving the model and calculating the likelihood for the elderly at large values of assets and income makes estimation nearly infeasible. Note that the cutoff value of yearly income seems low, but due to the assets restriction only 20 people otherwise eligible to be in the sample earn yearly income between $37,500 and $75,000. The elderly without Medicare or with long-term care insurance (in Wave 1 or Wave 2) are excluded because the prices they face for health care are different than the prices the rest of the sample faces for health care. Finally, those that report they "ever had cancer" in Wave 1 or report getting a cancer from Wave 1 to Wave 2 are excluded from the sample for reasons that will be discussed later.

[ii] The listed age is the age of the respondent at the Wave 2 interview date.

[iii] Since assets are reported in the AHEAD and not consumption, I report assets as the choice rather than consumption in this table.

[iv] A nursing home is defined as a facility that provides 24 hour nursing assistance and supervision, provides room and meals, and dispenses medication.

[v] The elderly with only non-Medicare government health insurance programs, like CHAMPUS, are not considered insured by Medigap.

[vi] Since each period of the model is two years, per-period income is two times the yearly income listed in Wave 1.

[vii] The AHEAD Wave 1 questionnaire asks if the elderly consulted with a doctor, entered a hospital overnight, or entered a long-term care facility at least once in a twelve month (not twenty four month) period prior to the Wave 1 interview.

[viii] The percentage of elderly with $L_t = 2$ is too high because it includes all elderly that visited the doctor between 12 and 24 months of the Wave 1 interview, and the model implies that the elderly that saw the doctor between 12 and 24 months of the Wave 1 interview have $L_t = 1$.

[ix] Of the 48 people insured with ex-employer provided Medigap in Wave 1, 28 are insured with the same insurance in Wave 2 (58%).

[x] Cancer has to be a different health state from healthy because those with cancer that do not go to a doctor to get treatment (may) die with higher probability than those that do. Cancer has to be a different health sate than CR because (unlike CR) it is possible to become healthy after getting treatment.

[xi] As mentioned, the Wave 1 population of the AHEAD is non-institutionalized, so only Wave 2 questions are considered.

[xii] Headen (1993) also shows that senility is an important predictor of nursing home entry, however all of the Wave 2 respondents in nursing homes that were capable of bathing themselves did not respond to the cognition questions. Because of these non-responses, senility (or some combination of cognition questions that determines cognitive functioning) is not a condition that comprises the nursing home disease in this dissertation.

[xiii] The numbers reported in this table are percentages. The Wave 2 health transition percentages are conditional on survival to Wave 2.

[xiv] Respondents are never directly asked questions as to how much the total cost of their health care was; they are asked questions that bound the total cost of health care. The median of the midpoint of these bounds is reported in this column.

[xv] The median reported out-of-pocket costs do not include costs of the elderly that have costs subsidized by Medicaid.

[xvi] It is assumed that the change in the bathing question between Wave1 and Wave 2 did not affect the reported transitions among health states.

[xvii] Given that survival probabilities differ for the functionally disabled for those in and not in nursing homes, optimal consumption should vary with the nursing home decision, and different mean asset levels conditional on either being in or not being in a nursing home should be observed. These different asset levels can be used to either identify survival probabilities or transition probabilities, but not both.

[xviii] Total cost includes both what the insurers pay and what the elderly pay out-of-pocket.

[xix] The out-of-pocket expenses of the elderly that use Medicaid are not included in the calculation of the median out-of-pocket expense.

4. Estimation

4.1 Likelihood

Denote individual *j*'s observed insurance choice, doctor choice, nursing home choice, and consumption[i] choice as $d_t^{1,j}$, $d_t^{2,j}$, $d_t^{3,j}$, and C_t^j, and the relevant set of state variables used to make these choices as $S_t^{1,j}$, $S_t^{2,j}$, and $S_t^{3,j}$. Given the model detailed in the previous section, the probability that individual *j*'s observed set of choices occurs can be written as:

$$\sum_{k=1}^{2} \Pr\left(t^k | S_t^{1,j}\right) \Pr\left(d_t^{1,j} | S_t^{1,j}, t^k\right) \Pr\left(d_t^{2,j} | S_t^{2,j}, t^k\right) \Pr\left(d_t^{3,j}, C_t^j | S_t^{3,j}, t^k\right) \tag{4.1}$$

For the reasons already mentioned, survival probabilities $\left\{p_t^h\left(d_t^2, d_t^3, mcaid\right)\right\}_{h=1}^4$ (for d_t^2, d_t^3, and $mcaid$ equal both one and zero) and out-of-pocket costs of health care conditional on diagnosed health state and insurance ($\left\{\left\{doc_t^{i,h}\right\}_{i=1}^3\right\}_{h=1}^4$ and $\left\{\left\{m_t^{i,h}\right\}_{i=1}^3\right\}_{h=1}^4$) may systematically vary in the population along a dimension that is not directly observable. Preferences over insurance, visiting the doctor, and entering a nursing home ($\overline{b}^{ins}$, $\overline{b}^{doc}$, and $\overline{b}^{nh}$) may also vary along the same unobserved dimension. t^k represents this potential unobserved heterogeneity of costs, probabilities, and preferences in the population. It is assumed that there are only two "types" of people in the population, t^1 and t^2, and each type has its own distinct set of costs, probabilities, and preferences[ii]. Since costs, probabilities, and preferences vary with type, the set of decision rules of the model and the probabilities over choices (which depends on the decision rules of the model) change with the "type" of person that solves the model. This also implies that probabilities over types must be correlated with the first observable set of state variables $S_t^{1,j}$, as long as $S_t^{1,j}$ is formed as the outcome of the decision process implied by the model in unobserved period *t-1*. Thus, the likelihood equation (4.1) integrates out the probability that the data occurs given an individual's type is unobserved but possibly correlated with initial state variables.

Given the contemporaneous and serial independence of the additive insurance and doctor utility shocks, and given the binomial nature of the insurance and doctor choice, $\Pr\left(d_t^{1,j} | S_t^{1,j}, t^k\right)$ and $\Pr\left(d_t^{2,j} | S_t^{2,j}, t^k\right)$ are (at most) one dimensional integrals in the distribution of e_t^{ins} and e_t^{doc} respectively[iii]. For example, the probability that person *j* goes to the doctor given state variables $S_t^{2,j}$ and type t^k is given from (2.9) and is simply:

$$\Pr\left(b_t^{doc} > \left(E\left[V_t^3\left(S_t^{3,j}\right) | S_t^{2,j}, d_t^{2,j} = 0, t^k\right] - E\left[V_t^3\left(S_t^{3,j}\right) | S_t^{2,j}, d_t^{2,j} = 1, t^k\right]\right)\right) \tag{4.2}$$

This probability is calculated using Gaussian Quadrature given the solution to the model[iv].

$\Pr\left(d_t^{3,j}, C_t^j | S_t^{3,j}, t^k\right)$ is evaluated using a Monte-Carlo method that smoothes the joint consumption choice and nursing home probability. $\Pr\left(d_t^{3,j}, C_t^j | S_t^{3,j}, t^k\right)$ is not evaluated using a more direct integration method because the consumption choice can adopt one of a multiple number of values, the utility shock for consumption is multiplicative, and for those that make a nursing home choice, the consumption shock and nursing home shock are jointly drawn. For those that make a nursing home choice, denote the value at a particular consumption shock and nursing home shock from nursing home choice $d_t^{3,j}$ and discrete consumption choice C_t^j as $V\left(d_t^{3,j}, C_t^j\right)$. Given there are only two possible nursing home choices and C feasible consumption choices for each nursing home choice[v], the smoothed simulated probability particular nursing home choice $d_t^{3,j}$ and discrete consumption choice C_t^j is calculated via Monte-Carlo integration, and is set equal to the average value of

$$\frac{\exp\left\{\dfrac{V\left(d_t^{3,j}, C_t^j\right) - \max\limits_{d_t^3, C_t^c}\left[V\left(d_t^3, C_t^c\right)\right]}{l}\right\}}{\sum_{j'=0}^{1}\sum_{c'=1}^{C}\exp\left\{\dfrac{V\left(d_t^3 = j', C_t^{c'}\right) - \max\limits_{d_t^3, C_t^c}\left[V\left(d_t^3, C_t^c\right)\right]}{l}\right\}} \tag{4.3}$$

over multiple nursing home and consumption shocks when these nursing home and consumption shocks are drawn from their appropriate distributions[vi][vii]. The nursing home and consumption probabilities are smoothed in this manner to allow the parameters of the model to be estimated with the BHHH method (see Quandt for details on this method) for reasonable numbers of draws of the consumption and nursing home shocks[viii].

However, reported consumption is not constrained to equal one of the discretized consumption values for which a smoothed simulated probability is calculated. Therefore, I.I.D. measurement error is incorporated into the likelihood in reported consumption. If people can report an exact value of their period *t* consumption[ix], the likelihood over period *t* consumption is calculated as the sum over all discrete consumption values (for which there is a smoothed probability) of the smoothed probability of that discrete consumption choice occurring times the measurement error density of the distance between reported consumption and the discrete value of consumption. If people can only report a range of values that contain their period *t* consumption, the likelihood calculations for consumption are the same, except the measurement error density of the distance between reported consumption and the discrete value of consumption is replaced with the cumulative measurement error density of the reported range of consumption and the discrete value of consumption.

I.I.D. measurement error is also incorporated in the likelihood function for reported out-of-pocket expenses and Wave 1 income and assets. Out-of-pocket expenses are assumed to be measured with error because given type, assets, income, and insurance, doctor, and nursing home choices, out-of-pocket expenses are exactly determined by the model. The discrepancy between reported out-of-pocket expenses and the out-of-pocket expenses determined by the model are attributed to measurement error. Income is assumed to be measured with error because the model is only solved for a discrete number of income values, but there is nothing in the data that restricts income to assume one of these values. Assets as a period *t* state variable are constrained to be one of a discrete number of values to reduce the computation time necessary for calculating the likelihood; the discrepancy between Wave 1 reported assets and the discrete values of assets as a state variable for which the likelihood is calculated is accounted for by measurement error. Denote the likelihood (4.1) for person *j* at particular asset level A_t^l and particular income level W^m (as part of $S_t^{1,j}$) as $l^j\left(A_t^l, W^m\right)$. If person *j* has *reported* state variable assets of A_t^j and income W^j, then the likelihood for person *j* is set equal to:

$$\sum_l \sum_m f\left(A_t^j, A_t^l\right) f\left(W^j, W^m\right) l^j\left(A_t^l, W^m\right) \tag{4.4}$$

The summations over *l* and *m* are summations over the set of all discretized assets A_t^l and discretized income W^m for which the likelihood is calculated. $f\left(A_t^j, A_t^l\right)$ is the density of measurement error in reported assets A_t^j given assets A_t^l for which the likelihood is calculated, and $f\left(W^j, W^m\right)$ is the density of measurement error in reported income W^j given income W^m at which the likelihood is calculated[x]. For all individuals in the data set, the assets A^l (comprising $S_t^{1,j}$) at which the likelihood is calculated are \$3,000, \$10,000, \$20,000, \$45,000, and \$90,000, while the one-period (two year) income W^m (comprising $S_t^{1,j}$) at which the likelihood is calculated are \$15,000, \$25,000, and \$50,000.

Finally, note that $S_t^{1,j}$, $S_t^{2,j}$, and $S_t^{3,j}$ include year of birth as a state variable (and this state variable is distinct from age). The costs and efficacy of health care of the current generation of ninety year olds is probably very different from the costs and efficacy of health care that the current generation of seventy year olds will face when they are ninety. To accommodate this factor, year of birth is included as a state variable[xi].

4.2 Functional Forms and Parameter Estimates

4.2.1 Survival Probabilities

Survival probabilities are modeled for each health state as logistic functions of age[xii] (age_t is defined as the respondent's age minus 70 years) and heterogeneity "type." For those in the CR, CR+ADL, and ADL states, survival probabilities are also a function of whether or not the elderly went to a doctor. Finally, entrance into a nursing home (and whether or not the nursing home was a Medicaid nursing home) affects survival probabilities for those in the CR+ADL and ADL states. For all health states *h*, the probability of dying (given doctor choice d_t^2, nursing home choice d_t^3, and type of nursing home *mcaid*, is the following:

$$\left(1-p_t^h\left(d_t^2, d_t^3, mcaid\right)\right) = \frac{\exp(z)}{1+\exp(z)} \tag{4.5}$$

For those in the healthy state (*h=1*):

$$z = a_1^h t^1 + a_2^h t^2 + a_3^h age_t$$

where t^k is a dummy variable that equals one if the person is type *k* and zero otherwise. For those in the CR state (*h=2)*:

$$z = a_1^h t^1 + a_2^h t^2 + a_3^h age_t + \left(1-d_t^2\right)a_4^h$$

and for those in the CR+ADL (*h=3*) and ADL states (*h=4*):

$$z = a_1^h t^1 + a_2^h t^2 + a_3^h age_t + \left(1 - d_t^2\right) a_4^h + d_t^3 \left(a_5^h + a_6^h mcaid\right)$$

In the estimation procedure, a_5^h and $a_5^h + a_6^h$ are forced to be less than zero to ensure that nursing homes decrease the probability of dying. Given these restrictions, the parameter estimates and associated standard errors are listed in Table 4.1[xiii].

It can be seen that type twos have lower mortality probabilities than type ones in all health states except ADL, that the doctor decreases mortality probabilities in the CR, CR+ADL, and ADL health states, that Medicaid nursing homes are ineffective, and private nursing homes decrease mortality probabilities for the functionally disabled. However, the standard errors on all of the type specific mortality parameters, doctor parameters, and nursing home parameters are all very high, and in some cases these parameters are fixed simply because they are unidentifiable. The reasons for the high standard errors on these parameters are straightforward: type specific parameters are hard to identify because type is unobserved, the increase in mortality probability associated with not going to the doctor is hard to identify because only 7 people that were not healthy did not go to the doctor in Wave 1, and the decrease in mortality probability associated with not entering a nursing home is hard to identify because the Wave 1 AHEAD respondents were all non-institutionalized. However, the lack of precision with which these parameters are estimated call into question the reliability of the public policy simulations run in this dissertation. When the third wave of AHEAD data is released, these parameters will be estimated again and the public policy simulations will be redone.

Table 4.1 Survival Probability Parameter Estimates

	Healthy (*h=1*)	CR (*h=2*)	CR+ADL (*h=3*)	ADL (*h=4*)
a_1^h	-2.8059	-1.9294	-0.8346	-1.7965
	(0.4523)	(0.3140)	(0.5598)	(2.6685)
a_2^h	-3.9466	-4.4294	-2.8648	-0.5426
	(2.7721)		(10.9128)	(4.0038)
a_3^h	0.0825	0.0359	-0.0043	0.0755
	(0.0358)	(0.0286)	(0.0558)	(0.1793)
a_4^h		1.1999	0.6267	0.8823
		(5.5934)	(27.4374)	(5.3803)
a_5^h			-3.8098	-2.7183
			(1.2878)	
a_6^h			3.8096	2.3504

Estimated Standard Errors are in Parentheses

4.2.2 Health Transition Probabilities

Transition probabilities among health states are modeled as multinomial logistic functions of only age. For the elderly that were healthy or in the ADL state (*h'*=1 or 4) at period *t-1*, the probability that they are in health state *h* (for *h=2*, *3*, or *4*) at period *t* is:

$$g_t^{h,h'} = \frac{\exp\left(v_1^{h,h'} + v_2^{h,h'} age_t\right)}{1 + \sum_{h'=2}^{4} \exp\left(v_1^{h,h'} + v_2^{h,h'} age_t\right)} \tag{4.6}$$

For *h=1*,

$$g_t^{h,h'} = \frac{1}{1 + \sum_{h'=2}^{4} \exp\left(v_1^{h,h'} + v_2^{h,h'} age_t\right)} \tag{4.7}$$

For those elderly in the CR or ADL+CR state (*h'=2* or 3) at time *t-1*, (4.6) and (4.7) are in general correct except that *h* cannot equal *1* or 4 (healthy or ADL), so $g_t^{1,h'} = g_t^{4,h'} = 0$ for *h'=2,3*. The transition probability parameter estimates are listed in table 4.2 on the next page.

Table 4.2 Transition Probability Parameter Estimates

Period t Health State		Period t-1 Health State: Healthy ($h'=1$)	CR ($h'=2$)	CR+ADL ($h'=3$)	ADL ($h'=4$)
CR ($h=2$)	$v_1^{h,h'}$	-1.8286		0.9207	-4.5347
		(0.3556)		(0.5771)	(49.4008)
	$v_2^{h,h'}$	-0.0372		-0.1674	0.1585
		(0.0404)		(0.0723)	(3.0843)
CR+ADL ($h=3$)	$v_1^{h,h'}$	-5.5197	-2.1895		-2.3640
		(1.0129)	(0.3306)		(3.1857)
	$v_2^{h,h'}$	0.1395	0.0702		0.1241
		(0.0920)	(0.0315)		(0.2328)
ADL ($h=4$)	$v_1^{h,h'}$	-3.3310			-0.2379
		(0.5092)			(1.3243)
	$v_2^{h,h'}$	0.1526			-0.0116
		(0.0435)			(0.1173)

Estimated Standard Errors are in Parentheses

4.2.3 Utility Function

The utility from consumption used throughout is:

$$u\left(C_t ; e_t^c\right) = \frac{e_t^c \left(C_t\right)^{1-s}}{1-s} \tag{4.8}$$

The per-period discount factor b is fixed at 0.9606. All of the utility shocks in the model, e_t^{ins}, e_t^{doc}, e_t^{nh}, and e_t^c are all drawn independently of each other and drawn independently over time. e_t^{ins}, e_t^{doc} and e_t^{nh} are drawn from the normal distribution with mean zero and standard deviations sd^{ins}, sd^{doc} and sd^{nh}. e_t^c is drawn from the lognormal distribution with mean $\bar{b}^c$ (which varies by type) and standard deviation sd^c, which is fixed at 1.0 for both types.

From the table of utility parameter estimates found on the next page, we can see that the risk aversion parameter, s, is estimated to be 3.3, which is consistent with previous studies (see Hubbard, Skinner, and Zeldes, 1994). Both the type specific average preferences over seeing a doctor, entering a nursing home, and buying Medigap insurance and the standard deviations of these average preferences are estimated with high standard errors. However, the point estimates of these mean type specific preferences reveal that both types of elderly like going to the doctor and dislike entering nursing homes. It is also clear that type twos like going to a doctor less and dislike

Table 4.3 Utility Parameter Estimates

	Type t^1	Type[xiv] t^2
s	3.2982	3.2982
	(1.6146)	
$\bar{b}^{ins}$	0.2600	-0.0034
	(0.2732)	(0.2332)
$\bar{b}^{doc}$	9.1160	2.4551
	(0.0017)	(3.1951)
$\bar{b}^{nh}$	-20.9573	-28.1994
	(18.8678)	(35.9438)
$\bar{b}^{c}$	5.5885	6.1407
	(4.3132)	(5.0652)
sd^{ins}	1.1833	1.1833
	(0.7819)	
sd^{doc}	4.7793	4.7793
	(5.7280)	
sd^{nh}	34.2162	34.2162
	(40.2973)	

Estimated Standard Errors are in Parentheses

nursing homes more than type ones. Type twos also like purchasing Medigap less than type ones. If costs and survival probabilities are ignored, and preferences over purchasing Medigap, going to the doctor, and entering a nursing home are compared, it is reasonable to believe that Medigap purchasers may be adversely selected. As will be shown in a later section, there is persuasive evidence that the elderly who purchase Medigap are not adversely selected.

4.2.4 Unobserved Heterogeneity

Probabilities over unobserved heterogeneity types are modeled as logistic functions of initial state variables S_{t-1}^{1}. Since $S_t^{1,j}$ is the outcome of the decision process implied by the model in period *t-1* (which is unobserved), and this decision process varies by type, we expect that the distribution of S_t^1 varies with type, i.e., S_t^1 is not an exogenous initial condition except when conditioned on type. The probability individual *j* is type t^1 is modeled as:

$$\Pr\left(t^1\right) = \frac{\exp(z)}{1+\exp(z)} \tag{4.9}$$

where

$$\begin{aligned} z = x_1 + x_2 I\left(L_t = 2\right) + x_3 I\left(H_t = 2\right) + x_4 I\left(H_t = 3\right) + x_5 I\left(H_t = 4\right) \\ + x_6 I\left(d_{t-1}^{1,1} = 1\right) + x_7 A_t + x_8 W + x_9 age_t \end{aligned} \tag{4.10}$$

In the above, *I(.)* is the indicator function: the expression in parenthesis equals one if it is true and zero otherwise. Estimates of the parameters over type probabilities are listed in the table on the next page. From this table, (even though standard errors are high) certain Wave 1 characteristics serve as a clear signal of type: those that did not go to the doctor in Wave 1 and were last diagnosed as healthy are almost certainly type twos and those that were last diagnosed as CR+ADL or ADL within one period are almost certainly type ones. The other type correlates appear to be less significant predictors of

Table 4.4 Type Parameter Estimates

x_1	-1.7752 (8.8125)
x_2	-9.4432 (17.3068)
x_3	2.9626 (2.5269)
x_4	8.5735 (31.0903)
x_5	8.5107 (34.1957)
x_6	-1.2959 (1.8097)
x_7	-0.0232 (0.0231)
x_8	0.2401 (0.4994)
x_9	0.0276 (0.2145)

type. However, given that type twos have lower mortality probabilities than type ones, we would expect that the probability of being type two must increase with age, and this is not the case[xv]. Finally, those that last had Medicare insurance are estimated to be more likely to be type twos and this is consistent with simulations of the model at the estimated parameters that make it appear that type twos are less likely to buy Medigap than type ones.

4.2.5 Costs and Miscellaneous

The estimated costs of insurance, and the costs of seeing the doctor and entering a nursing home conditional on insurance are listed at the tables on the next two pages. For both types, the cost of Medicare insurance (and the cost of ex-employer provided Medigap) is fixed at $1,106 (which equals 24 times the 1995 published Medigap Part B monthly premium of $46.08) and the cost of Medigap is fixed at $3,241, which is the cost of Medicare plus the median reported price of Medicare supplemental health insurance (for those that purchased Medicare supplemental health insurance). Notice that even though the out-of-pocket costs of doctor services differ by type, the estimation procedure, which (conditional on type) forces Medigap costs to be lower than Medicare costs, has difficulty estimating the costs of those insured with Medigap. It appears that Medigap does not reduce the cost of doctor services. The tables reporting the out-of-pocket cost of a nursing home show that Medigap reduces the cost of entering a nursing home. However the Medigap reduction in nursing home costs is imposed on the data: nursing home residents only report their total costs of health care and their out-of-pocket cost of health care is not observed. The out-of-pocket cost for nursing homes for those insured with Medigap is set to be $10,000 less than the out-of-pocket cost for nursing homes for those insured with Medicare. The $10,000 reduction is imposed because all Medigap plans pay the $100 Medicare deductible on the first 100

Table 4.5 1995 Out-of-Pocket Cost of a Doctor Visit

		Type t^1	Type t^2
Medicare	Healthy (*h=1*)	$1,574	$696
		($698)	($805)
	CR (*h=2*)	$2,277	$2,434
		($121)	($623)
	CR+ADL (*h=3*)	$2,759	$6,979
		($598)	($56,201)
	ADL (*h=4*)	$1,944	$43
		($2,033)	($1,855)
Costly Medigap and Ex-Employer Medigap	Healthy (*h=1*)	$1,574	$696
	CR (*h=2*)	$2,019	$2,434
		($114)	
	CR+ADL (*h=3*)	$2,584	$6,979
		($357)	
	ADL (*h=4*)	$1,944	$43

Estimated Standard Errors are in Parentheses

Table 4.6 1995 Out-of-Pocket Cost of a One-Period (2 Year) Nursing Home Stay

	Medicare	Medigap[xvi] Ex-Employer Medigap
CR+ADL (*h=3*)	\$62,114 (\$1,551)	\$52,114
ADL (*h=4*)	\$57,658 (\$7,811)	\$47,658

Estimated Standard Errors are in Parentheses

days of a nursing home stay and it is assumed that Medigap does not subsidize any other nursing home costs (see Waid, 1997 for details).

All costs are assumed to grow at a constant real rate of h percent a year. The growth rate in all costs is estimated to be 7% a year (see the table on the next page). The probability that the elderly lose ex-employer provided Medigap is fixed at p per period for all elderly, where p is estimated to be 0.4143. The real rate of return on assets is fixed at two percent a year, and the inflation rate from 1993 to 1995 is fixed at two percent a year as well. Finally, measurement error in assets, income, and out-of-pocket expenses is drawn from a distribution whose variance varies with "true" assets, income, and out-of-pocket expenses, i.e. if y_t^r is the true but unreported value of assets, income, or out-of-pocket expenses and y_t^o is the observed (reported) value, $y_t^o = y_t^r + e_t$, where $e_t \sim N\left(0,\left(u_1 + u_2 y_t^r\right)^2\right)$. This formulation of the variance of measurement error allows the reported variable to vary when y_t^r is close to zero ($u_1 \neq 0$) but also allows the range of error to grow with y_t^r ($u_2 \neq 0$). As can be seen, u_1 and u_2 are estimated at 1.005 and 0.7789 respectively.

Table 4.7 Miscellaneous Parameters

h	1.0718
	(0.0324)
p	0.4143
	(0.0758)
u_1	1.0050
	(0.0554)
u_2	0.7789
	(0.0101)

Estimated Standard Errors are in Parentheses

4.3 Fit

This section tries to evaluate how well the model fits the data. The maximized log-likelihood value at the estimated parameters is -9315.064, but this number (by itself) does not reveal whether or not the model captures the key features of the data. Although the fit of a model can be evaluated in many ways, this section reports the fit of the choice distributions by age. This particular way of evaluating fit is chosen to ensure that the model accurately captures the inherent dynamic, age-varying nature of the choices specified in the model.

The tables on the next few pages compare the observed insurance choice, doctor choice, and nursing home distribution by age with the model's predicted insurance, doctor, and nursing home choice distributions by age. These predictions are made by simulating the choices of a sample of people that have the same initial characteristics as the data. This simulated sample of people is generated by simulating the outcomes of 100 sub-people for each of the 741 people alive in Wave 1 of the data set. First, each of these 100 sub-people are assigned the same initial number of periods since last doctor's visit, last diagnosed health state, last type of health insurance coverage, and age (which is constrained to be either 70, 76, 82, or 88[xvii]) as the particular person in the data on which they are based. Then, each of these 100 simulated sub-people draw measurement error on income and assets, and these draws, in conjunction with reported assets and income for the original person on which the sub-person's characteristics are based, determine each sub-person's initial income (which is constrained to be either $15,000, $25,000, or $50,000) and assets (which is constrained to be either $3,000, $10,000, $20,000, $45,000, or $90,000). Once income, assets, last diagnosed health state, number of periods since last diagnosis, and age have been determined for each sub-person, probabilities over types are known, and a sub-person's type is randomly drawn. Given type, last diagnosed health state, and number of periods since last diagnosis, the probability of death is determined, and each sub-person draws a shock that determines whether or not they survive. Then, for all sub-people that survive, an insurance shock is drawn and they make an insurance choice, a doctor shock is drawn and they make a doctor choice, and finally consumption and nursing home shocks are drawn and they make consumption and (if applicable) nursing home choices. These choices are recorded, and the entire process is repeated for all 741 people in the working data set.

Tables 4.8 and Table 4.9 at the end of this section show the unconditional distribution of insurance and doctor choices among survivors (both observed and predicted) by age. From these table, and from the reported chi-squared statistics, it is clear that the model closely matches the observed distribution of the insurance choice and the doctor choice by age, with the possible exception of the age seventy choices: the model predicts that seventy year olds have Medigap with higher probability than observed, and, that seventy year olds go to the doctor with higher probability than is observed. However, because there are so few seventy year olds in the sample (47), the discrepancy between these simulated probabilities and observed probabilities may be more due to sampling error than model mis-prediction. The low values of the chi-squared statistics for seventy year olds indicates that sampling error may be responsible for the difference between observed and simulated probabilities for these seventy year olds.

Tables 4.10 and 4.11 at the end of this section show two different ways of evaluating the model's fit of the nursing home choice. Table 4.10 at the end of this section shows the unconditional distribution of the nursing home choice among survivors (both observed and predicted) by age. According to this table, the model predicts probabilities over nursing home use accurately, except at the oldest age, at which the model over-predicts nursing home use. Even at the oldest age, the chi-square statistic shows an insignificant difference between the predicted probability of nursing home entry and observed probability of nursing home entry, after accounting for sampling error. However, Table 4.11 shows the conditional distribution of the nursing home choice (both observed and predicted) by age, conditional on having a nursing home choice (conditional on going to the doctor and getting a diagnosis of CR+ADL or ADL). This table shows that the model consistently over-predicts nursing home use by between seven and ten percent for those that have a nursing home choice. This difference may be attributed to the small sample sizes in this table, as the relevant chi-squared statistics show no significant difference between predicted probability over nursing home use and observed probability of nursing home use.

Finally, Table 4.12 at the end of this section shows the unconditional distribution of the assets (consumption[xviii]) choice among survivors by age, when observed assets[xix] are lumped into four discrete bins. According to this table, the model does a terrible job of predicting the assets choice, both within an age and across ages. However, some caveats apply to interpreting the results of this table. First, some people can not directly report assets: they can only report the bounds in which their assets lie. For these people, the midpoint of the bound is used to lump their reported assets into the appropriate bin. The midpoint may be the incorrect statistic to use to sort assets into bins. Furthermore, the bounds on each bin were determined by dividing observed assets (as a choice) unconditional on age into quartiles, and taking the boundary of the quartile as the bound of each bin. Changing these bounds on the bins (while keeping the number of bins constant) will surely change the observed fit statistics on the assets choice. Finally, the number of bins was chosen arbitrarily. This is problematic, because the goodness of fit statistics must change with the number of bins (with two bins and appropriately chosen bounds, the chi-squared p value must be near 1.0), but the appropriate number of bins to use is not known a-priori. The reader is left to his or her own discretion in evaluating the goodness of fit of the assets choice.

Table 4.8 Health Insurance Probabilities (Observed and Predicted) by Age

	observed age	67-72	73-78	79-84	85-90
	(# observations)	(47)	(246)	(231)	(127)
	model age	70	76	82	88
Medicare	observed	.6170	.4593	.4242	.4409
	predicted	.5449	.4440	.4029	.4411
Medigap[xx]	observed	.3830	.5407	.5758	.5591
	predicted	.4551	.5560	.5971	.5589
chi-squared statistic (p value)	d.f.=1	0.9852 (0.3209)	0.2333 (0.6291)	0.4357 (0.5092)	0.0000 (0.9964)

Table 4.9 Doctor Probabilities (Observed and Predicted) by Age

	observed age	67-72	73-78	79-84	85-90
	(# observations)	(47)	(246)	(231)	(127)
	model age	70	76	82	88
Go to Doctor	observed	.9362	.9756	.9610	.9764
	predicted	.9658	.9698	.9744	.9846
Do Not Go to Doctor	observed	.0638	.0244	.0390	.0236
	predicted	.0342	.0302	.0256	.0154
chi-squared statistic (p value)	d.f.=1	1.2467	0.2826	1.6628	0.5632
		(0.2642)	(0.5950)	(0.1972)	(0.4530)

Table 4.10 Nursing Home Probabilities #1 (Observed and Predicted) by Age

	observed age	67-72	73-78	79-84	85-90
	(# observations)	(47)	(246)	(231)	(127)
	model age	70	76	82	88
Enter	observed	.0213	.0244	.0476	.0630
Nursing Home	predicted	.0168	.0335	.0531	.0871
Do Not Enter	observed	.9787	.9756	.9524	.9370
Nursing Home	predicted	.9832	.9665	.9469	.9129
chi-squared	d.f.=1	0.0576	0.6292	0.1390	0.9277
statistic		(0.8103)	(0.4277)	(0.7093)	(0.3355)
(p value)					

Table 4.11 Nursing Home Probabilities #2 (Observed and Predicted) by Age

	observed age	67-78[xxi]	79-84	85-90
	(# observations)	(39)	(55)	(38)
	model age	70, 76	82	88
Enter Nursing Home	observed	.1795	.2000	.2105
	predicted	.2802	.2708	.2795
Do Not Enter Nursing Home	observed	.8205	.8000	.7895
	predicted	.7198	.7292	.7205
chi-squared statistic (p value)	d.f.=1	1.9608 (0.1614)	1.3962 (0.2374)	0.8939 (0.3432)

Table 4.12 Asset Choice Probabilities (Observed and Predicted) by Age

	observed age	67-78[xxii]	79-84	85-90
	(# observations)	(159)	(122)	(60)
	model age	70, 76	82	88
$A_{t+1} \leq \$1,000$	observed	.3333	.2869	.2000
	predicted	.1819	.2015	.2292
$\$1,000 \leq A_{t+1} \leq \$10,000$	observed	.2201	.1393	.1167
	predicted	.3159	.3202	.2974
$\$10,000 \leq A_{t+1} \leq \$50,000$	observed	.2264	.3443	.3833
	predicted	.3247	.3241	.2994
$\$50,000 \leq A_{t+1}$	observed	.2201	.2295	.3000
	predicted	.1775	.1542	.1740
chi-squared statistic (p value)	d.f.=3	31.0206 (0.0000)	21.5239 (0.0001)	13.6959 (0.0033)

4.4 Selection of Medigap Purchasers

The simulation procedure detailed in the last section used to evaluate the fit of the choice distribution can also be used to determine the extent (if any) of the adverse selection of Medigap purchasers in 1995 (the year for which simulations of the model apply). Two alternate definitions of adverse selection in the market for Medigap are examined. In the first definition, the elderly women that live alone and purchase Medigap are defined as adversely selected if their expected total cost of their care (including insurers' costs and out-of-pocket costs of the insured), conditional on going to the doctor, is higher than the expected total cost of care of Medicare purchasers that go to the doctor[xxiii]. In the second definition, Medigap purchasers are defined as adversely selected if their unconditional expected total cost of care is larger than the unconditional expected total cost of care of those insured with only Medicare. According to this definition, adverse selection of Medigap purchasers can occur because either Medigap purchasers use more services (they go to the doctor or enter nursing homes more) than those insured with Medicare, or, (conditional on use) Medigap purchasers require more expensive care. Although this definition of adverse selection combines the classic notions of moral hazard and adverse selection in the market for health insurance, it is a useful summary statistic of the significant differences (if any) between those that purchase Medigap and those that choose to remain insured only with Medicare: both those with a higher propensity to visit a doctor and those that require more expensive health care (conditional on use) have incentives to buy Medigap. As such, it is interesting to know the net effect of differences in both use and cost on the total expected health care costs of those insured with Medigap compared to those insured only with Medicare.

The simulated type proportions by insurance and health service rendered (doctor visit by diagnosis and nursing home use) are listed on Table 4.13 on the next page. From this table, it can be seen that those insured with Medigap go to the doctor slightly more than those insured with only Medicare (97.59% vs. 96.94%)[xxiv]. Since doctor visits trivially vary by insurance, the extent of adverse selection (if any) of Medigap purchasers will be similar according to both definitions listed earlier. However, from Table 4.13, it can also be seen that the diagnoses rendered by the doctor vary by insurance. Those insured with Medigap are less likely to be diagnosed with the chronic condition (more likely to be healthy or only functionally disabled) than those insured with Medicare. This is an important observation, because as will be shown in Table 4.14 (see the page after next) the chronic condition turns out to be the most costly condition to treat. From Table 4.13 it can also be seen that, conditional on a diagnosis, the distribution of types by insurance does not substantially vary except for those diagnosed as healthy and those diagnosed with ADL (but choose not to enter a nursing home).

Table 4.14 shows the total cost of health services by type under two different assumptions. AHEAD respondents are asked questions that bound the total cost of

Table 4.13 Use of Health Services by Service, Insurance, and Type

	Medicare		Medigap	
Choice	Percent Choose	Percent t^{1} [xxv]	Percent Choose	Percent t^{1}
$d_t^2 = 0$	3.03%	7.92%	2.31%	15.84%
$d_t^2 = 1$, Healthy	35.17%	77.20%	42.39%	85.46%
$d_t^2 = 1$, CR	42.98%	94.17%	38.14%	95.52%
$d_t^2 = 1$, CR+ADL, $d_t^3 = 0$	9.19%	95.97%	7.35%	96.01%
$d_t^2 = 1$, CR+ADL, $d_t^3 = 1$	3.38%	97.21%	2.82%	97.51%
$d_t^2 = 1$, ADL, $d_t^3 = 0$	4.53%	80.06%	5.00%	93.29%
$d_t^2 = 1$, ADL, $d_t^3 = 1$	1.72%	86.74%	1.99%	90.21%
Total	100.00%		100.00%	

Table 4.14 Total Cost of Health Services, by Service, Assumption, and Type

	Assumption #1		Assumption #2	
Choice	Total Cost, Type t^1	Total Cost, Type t^2	Total Cost, Type t^1	Total Cost, Type t^2
$d_t^2 = 0$	\$0	\$0	\$0	\$0
$d_t^2 = 1$, Healthy	\$8,316	\$7,235	\$3,000	\$3,000
$d_t^2 = 1$, CR	\$21,845	\$7,706	\$15,000	\$3,000
$d_t^2 = 1$, CR+ADL, $d_t^3 = 0$	\$51,718	\$35,650	\$15,000	\$15,000
$d_t^2 = 1$, CR+ADL, $d_t^3 = 1$	\$113,832[xxvi]	\$97,764	\$77,114	\$77,114
$d_t^2 = 1$, ADL, $d_t^3 = 0$	\$12,247	\$14,787	\$15,000	\$15,000
$d_t^2 = 1$, ADL, $d_t^3 = 1$	\$69,905	\$72,445	\$72,658	\$72,658

their health care, but the width of the bounds varies with the lower bound, and, some people can not report an upper bound to the total cost of their care (so an upper bound is imposed for them). Under total cost "Assumption #1," the type specific average of the midpoint of these bounds is reported by health service, and under total cost "Assumption #2" the type specific median of the midpoint of these bounds is reported. Although the magnitude of total costs varies by assumption, type specific differences in total costs do not differ much except for those diagnosed with CR and possibly those diagnosed with CR+ADL.

From Table 4.13 and Table 4.14 it is possible to calculate both the total expected cost of care (conditional on going to the doctor) and the unconditional total expected cost of care in 1995 by health insurance purchased. Under both definitions of adverse selection and both total cost assumptions, there is no evidence that Medigap purchasers (among elderly women that live alone) are adversely selected. Under total cost Assumption #1, the expected total cost of health care of Medigap purchasers that go to a doctor is $21,017, which is $1,861 *less* than the expected total cost of health care of Medicare purchasers that go to a doctor. As was thought to be the case, the increase in use of doctor services of Medigap purchasers is not large enough to offset the fact that those insured with Medicare use more expensive services: under total cost Assumption #1, the unconditional expected total cost of health care of those insured with Medicare purchasers is $22,184, which is $1,653 larger than the unconditional expected total cost of health care of Medigap purchasers. Qualitatively similar results are obtained using total cost Assumption #2: the expected total cost of health care of

Medigap purchasers that go to a doctor is $12,551 while the expected total cost of health care of Medicare purchasers that go to a doctor is $13,525, and the unconditional expected total cost of health care of Medigap purchasers is $12,261, which is $855 less than the unconditional expected total cost of health care of Medicare purchasers.

The reasons that those insured with Medicare have higher expected total costs of care (both conditional on going to the doctor and unconditionally) than those that purchase Medigap are straightforward. Those elderly insured with Medigap go to the doctor with nearly the same propensity as those elderly insured with Medicare, so conditioning on doctor use does not affect any selection statistics. So given the structure of the model, there are only two ways that Medigap purchasers can have different expected total costs of care than those insured with Medicare: either Medigap purchasers receive systematically different diagnoses than those insured with Medicare, or, there is variation in both the type specific total cost of a diagnosis and variation in the distribution of types by diagnosis and health insurance. Only the CR and CR+ADL health states have substantial type specific differences in the total cost of a diagnosis, and the percentage of type ones and type twos diagnosed with CR and CR+ADL are basically the same for those elderly with Medicare and those purchasing Medigap. Therefore, any systematic difference in the costs of Medigap purchasers and the costs of those insured with only Medicare must come from differences in diagnoses. Since those insured with Medicare are more likely to be diagnosed with the chronic condition (in health state CR or CR+ADL) than those insured with Medigap, and diagnosis and treatment of the chronic condition (the cost of a diagnosis and treatment in health states

CR and CR+ADL) is more costly than diagnosis and treatment of any other health state, those insured with Medicare have higher total costs of care (both conditional and unconditional on a doctor's diagnosis) than those that purchase Medigap. Unfortunately, the estimated type specific total expected cost of health services varies quite a lot by assumption, but under both assumptions Medigap purchasers have a lower expected total cost of health care than those elderly insured with only Medicare. From this analysis, it is possible to conclude that there is no adverse selection in the market for Medigap insurance[xxvii].

Finally, note that from Table 4.13, Table 4.14, and Table 4.5 it is also possible to conclude that Medigap is an unusually bad deal: Medigap insurers only expect to pay \$592 for each person enrolled, while they charge \$2,135 for enrollment. Table 4.5, which reports the estimated out-of-pocket doctor costs by type of person and insurance, shows that it is estimated that Medigap does not reduce the out-of-pocket doctor costs of type twos at all and only trivially reduces the out-of-pocket doctor costs of type ones. Therefore, Medigap insurers' biggest expense is the \$10,000 they must pay when an elderly person chooses to enter a nursing home. However, nursing home entry is a rare enough event that selling Medigap insurance is still estimated to be very profitable.

Endnotes

[i] For now, assume that consumption is directly observable. The likelihood with consumption not directly observable is derived later in this section.

[ii] By assumption, a person's "type" does not change over time.

[iii] As noted, some people are given free Medigap, while others that were insured with Medicare and have a pre-existing condition are not allowed to purchase Medigap. These people make no insurance choice per-se, so the probability over their observed insurance choice equals one.

[iv] The probabilities over the insurance choice are similarly given from (2.10).

[v] Remember from the model solution section that consumption can only adopt one of a discrete number (denoted C) of values. Although C is the same for both nursing home choices, the set of feasible consumption points may differ with the nursing home choice (because the nursing home may be costly). See the model solution section for details on how the feasible consumption grid is formed conditional on assets, income, and out-of-pocket expenses on insurance, doctor, and nursing home costs.

[vi] For those that do not make a nursing home choice $d_t^3 = 0$ always, and the summation in the denominator of (4.3) is only over consumption.

[vii] In (4.3), l is the smoothing parameter; for the joint consumption and nursing home probability estimate listed in (4.3) to be consistent, l must approach 0 as the sample size gets large. At the current sample size (741), lambda is set to 0.1.

[viii] If the consumption and nursing home probabilities are not smoothed, then small changes in the parameters may yield no change in the consumption and nursing home probabilities. This will confound derivative based likelihood optimization methods, such as BHHH.

[ix] Given out-of-pocket expenses, which are determined by the three discrete choices of the period and Wave 1 income and assets, consumption can be imputed as long as Wave 2 assets are exactly reported.

[x] As with consumption, some elderly can only report a range of values where their assets and income lie. For these elderly, $f(.)$ is the cumulative density of measurement error in equation (4.4).

[xi] To minimize the computational burden of solving the model calculating the likelihood, respondents are grouped together into four different ages (and four different corresponding years of birth) based on their Wave 2 age. Respondents that are 67-72 are labeled as 70 years old (which implies a birth year of 1925); similarly respondents aged 73-78 are labeled as 76 years old (birth year 1919), elderly age 79-84 are labeled as 82 years old (birth year 1913), and respondents age 85-90 are labeled age 88 (birth year 1907).

[xii] Year of birth does not enter survival probabilities distinctly from age because only one wave of deaths is observed, so no age/cohort variation in deaths is observed. This implies (among other things) that there is no systematic variation in cohorts in inherent

healthiness, and, that health care technology (as captured by the reduction in mortality probabilities from seeing the doctor when ill) does not change over time.

[xiii] In the following table, and all parameter tables in the sections that follow, parameters in shaded boxes (and without standard errors) have been fixed outside the estimation procedure because these parameters can not be identified.

[xiv] s , sd^{ins}, sd^{doc}, and sd^{nh} are restricted to be the same for both types.

[xv] Given there is no age/cohort variation, both the age and the cohort correlation with type are captured by x_9. That said, survival probabilities at each age have been increasing over cohorts (Lee and Carter, 1992), and this suggests we should observe an even stronger relationship between age and probability of being type two. Type specific differences in the increase of cohort survival probabilities by age hopefully reconcile this observation.

[xvi] The two types are restricted to have the same total cost.

[xvii] As with the likelihood calculations, those elderly with reported Wave 2 age of 67-72 are listed as having age of 70. Similarly, the elderly with reported age of 73-78 are listed as age 76, 79-84 as age 80, and 85-90 as age 88.

[xviii] Although consumption is the choice in the model, assets are reported as the choice in this table because assets are reported in the data. (Given out-of-pocket expenses, there is a one-to-one correspondence of the consumption choice and the assets choice. For details, see the likelihood chapter of this dissertation).

[xix] Not everyone in the working sample can report assets (as a choice) at all, which explains why the number of observations in the assets table is smaller than the number of observations in the insurance, doctor, and nursing home tables.

[xx] This includes both the elderly that pay for their own Medigap and the elderly that have Medigap provided for free. These choices are combined because of the low number of observations of elderly with free Medigap.

[xxi] Ages 67-72 and 73-78 are combined because there are only 5 observations of elderly age 67-72.

[xxii] Ages 67-72 and 73-78 are combined because there are only 20 elderly capable of reporting Wave 2 assets age 67-72.

[xxiii] Since Medicaid is a payer of last resort, Medicaid only pays the out-of-pocket expenses that the elderly can not pay themselves. As a result, the total cost of care for those using Medicaid equals the out-of-pocket costs the elderly have to pay (some, if not all, paid for by Medicaid) plus the insurers' cost.

[xxiv] It also appears that those insured with Medigap are slightly less likely enter a nursing home than those insured with Medicare.

[xxv] The percent of purchasers that are type t^2 is 100 minus the percent of purchasers that are type t^1.

[xxvi] This includes the total cost of a diagnosis for those type t^1 in the CR+ADL state plus the out-of-pocket expense of a two year stay in a nursing home for those diagnosed

in the CR+ADL state (it is assumed that Medicare does not pay any nursing home costs).

[xxvii] It can be argued that the appropriate statistic for adverse selection is total cost of doctor services, non total cost of health care, since Medicare does not pay for long term nursing homes. In all cases, the total expected cost of doctor services is approximately $3,000 less than the total cost of all health care, so the conclusions are identical.

5. Public Policy Simulations

Table 5.1 on the next page reports the simulated remaining lifetime health insurance, doctor visits, nursing home entrance, and assets[i] of a typical cohort of seventy year olds at current Medicare and Medicaid policies. As reported, the predicted life-expectancy of this cohort of age seventy elderly women living alone is 13.43 years. This cohort was constructed by simulating 125 sub-people for each of the 47 people age 67-72 in the sample[ii]. Each of the 125 sub-people have the same number of periods since the last doctor's visit, last diagnosed health state, and last type of health insurance coverage as the particular person in the data on which they are based, however, each sub-person randomly draws age seventy assets, income, and then type in a procedure identical to that described in the last section. Once all of the age seventy state variables are established, the elderly in the simulations make their decisions according to the structure of the model until death.

Simulations of the model at the current set of Medicare and Medicaid policies show that the elderly reduce their purchase of Medigap steadily throughout their lifetime, keep their doctor visits constant at approximately 96% throughout their lifetime, and steadily increase their use of nursing homes: according to these simulations, nearly 20% of the elderly at age 98 are in a nursing home. Simulations of the model at the current set of Medicare and Medicaid policies also show that average

Table 5.1 Base Case Predicted Outcomes of Elderly age 70 in 1995

Age	Alive	Mean Initial Assets	% Buy Medigap	% Go to Doctor	% Enter Nursing Home
70	5875	$20,737	44.87%	96.61%	1.79%
72	5258	$23,587	40.74%	96.18%	2.42%
74	4662	$25,625	36.89%	95.67%	3.07%
76	4116	$26,666	33.02%	96.26%	4.01%
78	3596	$24,412	28.75%	95.69%	4.48%
80	3103	$20,146	24.59%	96.10%	5.83%
82	2649	$15,352	19.78%	96.04%	7.02%
84	2237	$11,786	16.00%	95.75%	8.81%
86	1881	$9,255	14.19%	95.00%	9.46%
88	1543	$7,480	9.79%	96.44%	11.73%
90	1267	$5,817	7.26%	95.66%	12.47%
92	1036	$4,778	4.25%	95.85%	13.71%
94	852	$3,695	2.23%	94.48%	16.31%
96	729	$3,146	1.37%	94.38%	18.11%
98	639	$2,070	0.78%	93.11%	19.09%

Life expectancy of sample at age 70: 13.43 years

assets of the sample rise until age 76, then steadily decline until age 100. This interesting life-cycle asset behavior is not due to selection effects (the elderly with high probability of dying deplete their assets at a faster rate), but rather a direct result of the estimated efficacy of private nursing homes and ineffectiveness of Medicaid nursing homes. Average assets increase until age 76 because some elderly save quite a lot in case they wish to enter a private nursing home; after age 76 the cost of this saving (foregone consumption) outweighs the increase in life-expectancy from entrance in a private nursing if functionally disabled, and the elderly steadily deplete their assets. This hypothesis is confirmed by simulating the model at parameters such that neither private nursing homes nor Medicaid nursing homes increase the survival probabilities of the functionally disabled: in these simulations, the elderly steadily deplete their assets throughout their lifetime.

It should be noted that both the predicted age 85-90 distribution of assets and the predicted age 85-90 Medigap behavior of the current generation of seventy year olds is very different from the distribution of assets and Medigap behavior of current elderly age 85-90. This result comes from two sources: first, all health insurance and health care costs are estimated to be increasing at the real rate of seven percent a period (approximately three and one-half percent a year), while the real rate of return on savings is only two percent a year. So, the incentives to save and incentives to purchase Medigap correspondingly change with calendar year. Second, the estimated distribution of types of current 85-90 year olds is very different from the simulated age 85-90 distribution of types of the current generation of seventy year olds: the estimated percentage of the current generation of 85-90 year olds that are type twos is only 11%, but the predicted age 85-90 percentage of type twos of the current generation of seventy year olds is 38%. The differences in Medigap and assets behavior of current 85-90 year olds and the current generation of seventy year olds when they are 85-90 is directly attributable to the fact that different types receive different benefits from savings and Medigap purchase.

These simulations of the remaining lifetime behavior of a typical cohort of seventy year olds are also run at Medicare and Medicaid policies that impose substantially more cost-sharing than current Medicare and Medicaid policies[iii]. The type specific out-of-pocket costs of doctor services for those insured with Medicare and those insured with Medigap of this alternate Medicare policy are reported in Table 5.2 on the next page. As can be seen, the out-of-pocket costs of doctor services of those insured with Medicare are 50% higher than current levels, while the Medigap out-of-pocket costs do not change. The cost of Medicare does not change, but the extra cost of Medigap insurance is increased by 50%, so the total cost of Medigap becomes $4,308.50. Nursing home costs do not change, but Medicaid eligibility criteria are fixed at 50% of their current levels: $\overline{W}$ is set equal to $7,890 and $\overline{A}$ is set equal to $6,000.

The simulated outcomes with these Medicare and Medicaid policies, listed in Table 5.3 (on the page after Table 5.2), show that the elderly maintain a nearly identical pattern of health care use as the elderly with current Medicare and Medicaid policies, and as a result the life-expectancy of the cohort of elderly facing increased cost-sharing

Table 5.2 Alternate Policy #1 1995 Out-of-Pocket Cost of a Doctor Visit

		Type t^1	Type t^2
Medicare	Healthy (*h=1*)	\$2,361	\$1,044
	CR (*h=2*)	\$3,416	\$3,651
	CR+ADL (*h=3*)	\$4,139	\$10,469
	ADL (*h=4*)	\$2,916	\$64.5
Costly Medigap and Ex-Employer Medigap	Healthy (*h=1*)	\$1,574	\$696
	CR (*h=2*)	\$2,019	\$2,434
	CR+ADL (*h=3*)	\$2,584	\$6,979
	ADL (*h=4*)	\$1,944	\$43

Table 5.3 Alternate Policy #1 Predicted Outcomes of Elderly age 70 in 1995

Age	Alive	Mean Initial Assets	% Buy Medigap	% Go to Doctor	% Enter Nursing Home
70	5875	$20,737	43.90%	96.48%	1.79%
72	5258	$24,670	40.30%	95.85%	2.38%
74	4665	$27,499	37.15%	95.31%	3.00%
76	4120	$29,282	33.88%	95.56%	3.98%
78	3598	$29,318	30.04%	94.89%	4.45%
80	3108	$25,896	23.58%	95.43%	5.95%
82	2652	$21,289	18.10%	95.25%	7.01%
84	2238	$15,691	12.47%	94.15%	8.40%
86	1878	$11,903	10.97%	93.50%	9.48%
88	1536	$8,825	8.20%	94.92%	11.46%
90	1257	$5,505	6.36%	94.11%	12.41%
92	1024	$3,657	3.52%	94.53%	13.28%
94	839	$1,843	1.55%	93.56%	16.33%
96	717	$1,151	0.84%	93.17%	17.57%
98	627	$704	0.48%	92.66%	18.66%

Life expectancy of sample at age 70: 13.41 years

is 13.41 years, which is almost identical (only .02 years lower) to the life-expectancy of the elderly facing current Medicare and Medicaid policies. Under the new Medicare and Medicaid policies, the elderly do not adjust their purchase of Medigap, but they maintain higher mean assets until age 88. This is a particularly interesting result, as the elderly must pay more for their health care and still save more than at the baseline set of Medicare and Medicaid policies. This interesting asset behavior is driven by incentives to enter private nursing homes and the assumption that the elderly apply for Medicaid as soon as they are eligible. At the Medicare and Medicaid policies imposing increased cost sharing, the elderly must spend more to become eligible for Medicaid. Given that they must spend more to become eligible for Medicaid, some choose to save more to afford a private nursing home, and this saving increases mean assets. Table 5.4 (on the next page) shows different asset profiles when both Medicare and Medicaid impose increased cost sharing, when only Medicare imposes increased cost sharing (the Medicaid asset and income criteria equal their baseline levels), and when only Medicaid imposes increased cost sharing (the Medicare out-of-pocket expenses and the price of Medigap equal their baseline levels). From this table, it can be seen that the increase in mean assets stems from the Medicaid cost-sharing: when only Medicare imposes cost sharing, mean assets decrease relative to the baseline assets profile until age 90.

In the second set of simulations, Medicare and Medicaid impose non-price rationing of doctor visits and nursing homes. In these rationing simulations, those elderly that apply to enter a Medicaid nursing home are refused entrance with 25%

Table 5.4 Mean Assets by Age, Alternate Policy #1 and Variants

	Mean Assets			
Age	Baseline	Medicare, Medicaid change	only Medicare change	only Medicaid change
70	$20,737	$20,737	$20,737	$20,737
72	$23,587	$24,670	$23,019	$24,983
74	$25,625	$27,499	$24,502	$28,252
76	$26,666	$29,282	$25,279	$30,517
78	$24,412	$29,318	$23,001	$30,971
80	$20,146	$25,896	$19,033	$27,349
82	$15,352	$21,289	$14,549	$22,361
84	$11,786	$15,691	$11,404	$16,438
86	$9,255	$11,903	$9,134	$12,788
88	$7,480	$8,825	$7,430	$9,794
90	$5,817	$5,505	$5,698	$6,446
92	$4,778	$3,657	$4,617	$4,486
94	$3,695	$1,843	$3,624	$2,363
96	$3,146	$1,151	$3,046	$1,406
98	$2,070	$704	$2,014	$749

probability; this non-price rationing of nursing home use has the interpretation of an institutionalized “waiting list” for entrance into Medicaid nursing homes. Also, those elderly that are insured with Medicare and were last diagnosed as healthy one period ago cannot visit a doctor with 25% probability (although this restriction does not apply to Medigap patients). This form of rationing is intended to capture a more subtle rationing that Medicare may impose. Note that in the data, twenty five percent of the elderly women living alone insured with Medicare and last diagnosed as healthy within a two year period go to the doctor 22 times or more in a two year period. Suppose Medicare were to impose a rationing scheme that limited the number of doctor visits of the elderly that were last diagnosed as healthy to 24 in a two year period (but those purchasing Medigap were subject to no such restrictions). Given the structure of the model, this form of rationing is similar to a rationing scheme imposing that the elderly last diagnosed as healthy one period ago insured with Medicare cannot go to the doctor with 25% probability. In the model, an elderly person either goes or does not go to the doctor in a two year period and the elderly all learn about their health and get treatment if sick at this one visit, if they choose to go. However, in the data, we do not know the precise visit at which the elderly learn the current state of their health and get treatment if ill. If twenty five percent of the elderly learn about changes to their health and get treatment if ill after 24 visits to the doctor in a two year period, then the two forms of rationing are equivalent.

As shown in Table 5.5 at the end of this section, the elderly in the rationing regime choose to save slightly more, but choose to purchase quite a lot more Medigap than the elderly with current Medicare and Medicaid policies. By purchasing Medigap, these elderly circumvent the Medicare rationing of doctor visits, and so the percentage of elderly that visit the doctor falls by less than one percent compared to the baseline Medicare and Medicaid policies. The elderly do not choose to save enough, however, to pay for their own nursing homes, and as a result the use of nursing homes drops by about twenty five percent due to Medicaid rationing. Still, under rationing the life-expectancy of the sample is only .03 years lower than the life expectancy of the sample with current Medicare and Medicaid policies. This decrease in life-expectancy is not larger because doctor visits decrease only slightly, and even though the use of Medicaid nursing homes falls by quite a lot, Medicaid nursing homes at best marginally increase the survival probabilities of the functionally disabled.

In conclusion, at the baseline set of Medicare and Medicaid policies, Medicare and Medicaid policies imposing substantially more cost-sharing than current policies, and Medicare and Medicaid policies imposing non-price rationing of doctor services and nursing home entry, the age seventy life-expectancy of a typical cohort of elderly women living alone only varies from 13.43 years to 13.40 years. At all policies, these elderly try to not to change their utilization of doctor services, although the elderly vary their assets with the increased cost-sharing policies, and with Medicare and Medicaid rationing Medigap purchases and nursing home use vary relative to baseline Medicare and Medicaid policies. By keeping their doctor visits constant, the elderly maintain their age seventy life-expectancy at approximately 13.43 years across all different Medicare and Medicaid policies. In conclusion, these simulations show that policy makers can substantially decrease the generosity of the Medicare and Medicaid programs and the age seventy life-expectancy of the current generation of elderly women living alone will not substantially change.

Table 5.5 Alternate Policy #2 Predicted Outcomes of Elderly age 70 in 1995

Age	Alive	Mean Initial Assets	% Buy Medigap	% Go to Doctor	% Enter Nursing Home
70	5875	$20,737	57.24%	95.90%	1.24%
72	5257	$24,146	54.06%	95.43%	1.85%
74	4662	$26,674	49.96%	94.92%	2.64%
76	4116	$28,041	45.21%	95.14%	3.11%
78	3595	$26,256	40.50%	94.74%	3.42%
80	3101	$21,360	35.28%	95.07%	4.13%
82	2651	$16,536	30.93%	94.95%	5.17%
84	2237	$12,784	25.57%	94.05%	6.21%
86	1880	$10,131	21.91%	93.19%	6.91%
88	1541	$8,104	15.25%	94.35%	8.44%
90	1260	$6,309	10.79%	93.33%	9.68%
92	1022	$5,084	6.75%	94.42%	9.98%
94	836	$4,067	4.90%	93.18%	11.24%
96	714	$3,298	2.66%	92.44%	12.75%
98	626	$2,258	1.44%	90.73%	13.10%

Life expectancy of sample at age 70: 13.40 years

Endnotes

[i] In the tables that follow, assets are reported without measurement error.

[ii] This construction explains why the age seventy simulated sample size is 5,875.

[iii] The simulated cohort of seventy year olds is only “typical” if the Medicare and Medicaid policies imposing increased cost-sharing come as a completely unexpected surprise to these seventy year olds. If the elderly had anticipated the cost-sharing earlier in their life, their asset holdings (and thus the distribution of types by assets), would necessarily be different.

6. Conclusions

This paper has specified a dynamic programming model of the health and financial decisions of elderly women living alone. In this model, the elderly choose whether or not to purchase Medigap, visit the doctor, and enter a nursing home if diagnosed as functionally disabled; in addition, they also choose non-housing assets to carry to future periods. The elderly partially control their health care expenses by choosing whether or not to purchase Medigap, which lowers out-of-pocket expenses of entrance into a nursing home and the out-of-pocket expenses of some doctor services as well. The elderly also affect their health care expenses by choosing a level of assets to carry forward to future periods; if the elderly deplete their assets and have low enough income, they become eligible for Medicaid, which pays all health care costs. The elderly control their use of health care by choosing whether or not to visit the doctor for a diagnosis of their current health state (receiving treatment that increases their one period survival probability if diagnosed as not healthy) and choosing whether or not to enter a nursing home if diagnosed as functionally disabled. Thus, the four choices of the model allow the elderly to simultaneously (partially) endogenously determine their health care expenses and their health care use.

The structural parameters of this model are estimated using the AHEAD data set, a nationally representative panel data set with two waves of data currently available. The estimation procedure embeds the solution to the model (which is a set of optimal choices given all relevant state variables and values of the utility shocks) directly into a maximum likelihood framework. The BHHH method is employed to search for the structural parameters that maximize the model's predicted probability of the observed choices occurring given the solution to the model, given that there is measurement error in assets, income, and out-of-pocket expenses, and given that people may systematically differ in costs, preferences, and survival probabilities in an unobserved way. The likelihood is thus a complicated non-analytic function of the structural parameters of the model. Each time a parameter is perturbed, the model must be computationally resolved in order to calculate a new likelihood. Therefore, speed for computing the solution at any given set of parameters is critical to finding a set of parameters that maximize the likelihood; this paper uses the structure of the problem to employ a shock-sorting method that expedites the solution of the model.

Estimates of the structural parameters of the model reveal four observations about the costs, preferences, and probabilities of the elderly. First, the elderly have strong preferences in their use of health care services: in addition to any survival benefits the elderly get from going to the doctor, elderly women living alone receive high average utility from going to the doctor, while on average, these same elderly women living alone strongly dislike entering a nursing home. Second, estimates of the survival benefits of health care show that doctor services increase survival probabilities for those elderly that are not healthy, show that private nursing homes increase survival probabilities for those that are functionally disabled, and also show that Medicaid nursing homes at best marginally increase the survival probabilities for those that are functionally disabled. However, these parameters are imprecisely measured: classification of who can benefit from nursing home use is chosen using an arbitrary method, and deaths of nursing home residents are not observed because the first wave of AHEAD data includes only non-institutionalized residents (so the effect of nursing homes on survival probabilities must be inferred from asset behavior). Third, conditional on type, it is estimated that Medigap only marginally lowers the out-of-pocket costs of doctor services. It is simply not clear, aside from pure receiving pure utility or disutility from the purchase itself, why the elderly purchase Medigap. Finally, the inclusion of different types of people into the estimation procedure explains choice phenomena in the data that the model cannot otherwise explain. Estimates of type specific parameters reveal that certain Wave 1 variables are strong signals of type, and that types substantially differ in costs, preferences, and survival probabilities.

Given the estimates of the structural parameters of the model, the model is simulated to evaluate how well it fits the observed choice distribution. The model appears to fit the insurance choice by age, doctor choice by age, and nursing home choice by age all well. However, the model simply cannot fit the assets choice by age distribution at all. These same simulations are used to determine the extent (if any) of the adverse selection of Medigap purchasers in 1995. Under two different definitions of adverse selection, it appears that Medigap purchasers were not adversely selected in 1995. Both the total expected cost of care (conditional on going to the doctor) and the unconditional total expected cost of care of those insured with Medigap were less than the total expected cost of care (conditional on going to the doctor and unconditionally) of those insured with only Medicare. As it turns out, Medicare patients tend to be more likely diagnosed with the chronic condition that those insured with Medigap, and diagnosis and treatment of the chronic condition is more expensive than diagnosis and treatment of those that are healthy or only functionally disabled.

Finally, the life-cycle behavior of a typical cohort of seventy year old elderly women living alone is simulated at the current set of Medicare and Medicaid policies, at Medicare and Medicaid policies that impose substantially more cost-sharing than current, and at Medicare and Medicaid policies that impose non-price rationing of health care services. These simulations serve as predictions of the effect that various Medicare and Medicaid changes will have on the assets, insurance, doctor, and nursing home behavior of the current generation of elderly. These simulations show that relative to the current set of Medicare and Medicaid policies, the elderly vary their assets, but do not change their insurance, nursing home, and doctor behavior when Medicare and Medicaid impose increased cost-sharing. However, when Medicare and Medicaid impose non-price rationing of health services, relative to the current set of Medicare and Medicaid policies, the elderly purchase substantially more Medigap to avoid the Medicare rationing of doctor visits, but do not adjust their assets behavior to afford a private nursing home and avoid the Medicaid rationing of nursing homes. As a result, with rationing, the percentage of elderly that visit a doctor decreases by less than one percentage point, but the percentage of elderly that enter a nursing home decreases by approximately the rationed amount. However, under all three sets of Medicare and Medicaid policies (current, increased cost-sharing, and rationing) life-expectancy varies by only .03 years: age seventy life-expectancy is highest under current Medicare and Medicaid policies (13.43 years) and lowest under rationing Medicare and Medicaid policies (13.40 years). In conclusion, policy makers that wish to reduce Medicare and Medicaid program costs do not need to worry that the life-expectancy of the elderly will substantially decrease after Medicare and Medicaid change.

7. Bibliography

[1] *1994 Green Book*. Committee on Ways and Means, U.S. House of Representatives.

[2] *1997 Annual Report of the Board of Trustees of the Federal Hospital Insurance Trust Fund. Communication from The Board of Trustees, Federal Hospital Insurance Trust Fund.*

[3] *1997 Annual Report of the Board of Trustees of the Federal Supplemental Medical Insurance Trust Fund. Communication from The Board of Trustees, Federal Hospital Insurance Trust Fund.*

[4] *1997 Physician Payment Review Commission Annual Report to Congress*.

[5] *Actuarial Study No. 107. Life Tables for the United States Social Security Area 1900-2080.* U.S. Department of Health and Human Services, Social Security Administration, Office of the Actuary. August, 1992. SSA Pub. No. 11-11536.

[6] Arrow, Kenneth J. *Uncertainty and the Welfare Economics of Medical Care*. The American Economic Review, 1963, vol. 53, no. 5, pp. 941-973.

[7] Bellman, Richard. *Dynamic Programming*. Princeton University Press, 1957. Princeton, New Jersey.

[8] Dick, Andrew, MaCurdy, Thomas, and Garber, Alan M. *Forecasting Nursing Home Utilization of Elderly Americans*. NBER Working Paper 4107, June, 1992.

[9] Eckstein, Zvi, and Wolpin, Kenneth I. *Youth Employment and Academic Performance in High School.* Unpublished Manuscript, University of Pennsylvania, 1997.

[10] Ettner, Susan L. *Adverse Selection and the Purchase of Medigap Insurance by the Elderly*. Journal of Health Economics, October1997, vol. 16, no. 5, pp. 543-562.

[11] Fritsch, F.N., and Carlson, R.E. *Monotone Piecewise Cubic Interpolation*. SIAM Journal of Numerical Analysis, 1980, vol. 17, no. 2, pp. 238-246.

[12] Gilleskie, Donna Lynn. *A Dynamic Stochastic Model of Medical Care Use and Work Absence*. Ph. D. Thesis, University of Minnesota, 1994.

[13] Grossman, Michael. *The Demand for Health: A Theoretical and Empirical Investigation*. Columbia University Press, 1972. New York.

[14] Headen, Alvin E., Jr. *Economic Disability and Health Determinants of Nursing Home Entry*. Journal of Human Resources, 1993, vol. 28, no. 1, pp. 80-110.

[15] Himes, Christine L., Preston, Samuel H., and Condran, Gretchen A. *A Relational Model of Mortality at Older Ages in Low Mortality Countries*. Population Studies, 1994, vol. 48, pp. 269-291.

[16] Hubbard, R. Glenn, Skinner, Jonathan, and Zeldes, Stephen P. *The Importance of Precautionary Motives in Explaining Individual and Aggregate Saving*. Carnegie-Rochester Conference Series on Public Policy, 1994, vol 40, pp. 39-125.

[17] Hubbard, R. Glenn, Skinner, Jonathan, and Zeldes, Stephen P. *Precautionary Saving and Social Insurance*. Journal of Political Economy, 1995, vol. 103, no. 2, pp. 360-399.

[18] Hurd, Michael D., and McGarry, Kathleen. *Medical Insurance and the Use of Health Care Services by the Elderly*. Journal of Health Economics, 1997, vol. 16, no. 2, pp. 129-154.

[19] Kannisto, Vaino, Lauritsen, Jens, Thatcher, A. Roger, and Vaupel, James W. *Reductions in Mortality at Advanced Ages*. Population Studies of Aging \#4, Dec. 1993. Center for Health and Social Policy, Odense University.

[20] Keane, Michael P., and Wolpin, Kenneth I. *The Solution and Estimation of Discrete Choice Dynamic Programming Models by Simulation and Interpolation: Monte Carlo Evidence*. Review of Economics and Statistics, 1994, vol. 76, no. 4, pp. 648-672.

[21] Kotlikoff, L.J. *Health Expenditures and Precautionary Savings*. MIT Press, 1989. Cambridge, Massachusetts.

[22] Lee, Ronald D., and Carter, Lawrence R. *Modeling and Forecasting U.S. Mortality*. Journal of the American Statistical Association, 1992, vol. 87, no. 419, pp. 659-675.

[23] Manning, Willard G., Newhouse, Joseph P., Duan, Naihua, Keeler, Emmett B., and Leibowitz, Arleen. *Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment*. American Economic Review, 1987, vol. 77, no. 3, pp. 251-277.

[24] Page, Harriet S., and Asire, Ardyce J. *Cancer Rates and Risks*. National Institutes of Health, NIH Publication No. 85-691.1985.

[25] Pauly, Mark V. *The Rational Nonpurchase of Long-Term-Care Insurance*. Journal of Political Economy, 1990, vol. 98, no. 1, pp. 153-168.

[26] Preston, Samuel H. *American Longevity: Past, Present, and Future*. Maxwell School of Citizenship and Public Affairs - Center for Policy Research Policy Brief. Syracuse University, No. 7/1996.

[27] Quandt, Richard E. "Computational Problems and Methods," in Zvi Griliches and Michael D. Intriligator, eds., *Handbook of Econometrics*, Vol. 1, Amsterdam: North-Holland.

[28] Reschovsky, James D. *Demand for and Access to Institutional Long-Term Care: The Role of Medicaid in Nursing Home Markets* Inquiry, 1996, vol. 33, spring, pp. 15-29.

[29] Smith, James P., and Kington, Raynard. *Demographic and Economic Correlates of Health in Old Age*. Demography, 1997, vol. 34, no. 1, pp. 159-170.

[30] Snir, Marc, Otto, Steve W., Huss-Lederman, Steven, et. al. *MPI: The Complete Reference*. MIT Press, 1996. Cambridge, Massachusetts.

[31] Trick, Michael A., and Zin, Stanley E. *Adaptive Spline Generation: A New Algorithm for Solving Stochastic Dynamic Programs*. Unpublished Manuscript, Carnegie Mellon University, 1995.

[32] Waid, Mary Onnis, of the Health Care Financing Administration. *Brief Summaries of Medicare and Medicaid, Title XVIII and Title XIX of the Social Security Act*. July, 1997. Available at the following web site: `http://www.hcfa.gov/`

[33] *Death and Death Rates for the 10 Leading Causes of Death in 5-year Age Groups, by Race, Hispanic Origin, and Sex: United States, 1992 - Con*. Available at the following web site: `http://www.hcfa.gov/`