Old, Sick, Alone and Poor: A Welfare Analysis of Old-Age Social Insurance Programs *

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Abstract

All individuals face some risk of ending up old, sick, alone and poor. Is there a role for social insurance for these risks and, if so, what is a good program? A large literature has analyzed the costs and benefits of pay-as-you-go public pensions and found that the costs exceed the benefits. This paper, instead, considers means-tested social insurance programs for retirees such as Medicaid and Supplemental Security Income. We find that the welfare gains from these programs are large. Moreover, the current scale of means-tested social insurance in the U.S. is too small in the following sense. If we condition on the current Social Security program, increasing the scale of means-tested social insurance by 1/3 benefits both the poor and the affluent when a payroll tax is used to fund the increase.

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1 Introduction

All individuals face some risk of ending up old, sick, alone and poor. These risks are significant. Poverty rates of the elderly are large and increase with age. They rise from a level of 17% for those aged 75–79 to 19% for those aged 80 and over.[1] Important determinants of these poverty outcomes are lifetime earnings risk, longevity, sickness/disability and marital status risk. Some individuals enter retirement with low assets due to bad luck in the labor market. Medical and long-term care expenses are tightly connected with longevity because they increase with age and are highest in the final periods of life. Spousal death events are costly because large nursing home or hospital expenses often precede the death of a spouse.

Poverty among the aged is a particularly troubling problem for society. In contrast to younger individuals, the aged are often unable to self-insure against a medical or spousal death event by re-entering the labor force. Is there a role for social insurance for the aged and, if so, what is a good program?

The largest U.S. social insurance program for retirees is Social Security (SS).[2] SS outlays were 4.1% of GDP in 2013 and are predicted to increase to 4.9% of GDP by 2036.[3] A large macroeconomics literature has analyzed the role of SS and found that a pay-as-you-go SS program is a bad public policy. This result has been documented in models with dynastic households as in Fuster, İmrohoroğlu and İmrohoroğlu (2007) and also lifecycle OLG models starting with the research of Auerbach and Kotlikoff (1987). İmrohoroğlu, İmrohoroğlu and Joines (1999) show that this result holds in dynamically efficient economies. Conesa and Krueger (1999) find that this result holds when agents face lifetime earnings risk. Hong and Ríos-Rull (2007) show that this result holds when the economy is open and the pre-tax real interest rate is fixed. They also show that the result does not depend on the availability of private market substitutes such as private annuities and private life insurance. İmrohoroğlu, İmrohoroğlu and Joines (1995) reach the same conclusion in a model with catastrophic health risk but no Medicaid or any other means-tested transfers.[4]

It would be a mistake to conclude from these results that there is no role for society to provide insurance to retirees. We assess the welfare effects of means-tested social insurance

[1] For purposes of comparison, poverty rates for the general population are 16%. These numbers are based on the Bureau of Census Supplemental Poverty Measure which is designed to give a more comprehensive picture of the situation of the poor by including tax and other government benefits and accounting for out-of-pocket medical expenses. For more details see: http://www.ssa.gov/policy/docs/ssb/v73n4/v73n4p49.html.

[2] In the United States, this program is referred to as the Old-Age and Survivors Insurance Program.

[3] These figures are from "The 2014 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds." The GDP projections are from the Congressional Budget Office.

[4] These previous findings are based on a comparison of steady-states which is the same approach taken in this paper. Results in the literature pertaining to transitions are mentioned in Footnote 41.

(MTSI) programs for the aged and find that these programs are highly valued. MTSI programs that benefit the aged include Medicaid, Supplemental Security Income (SSI), food stamps and housing and energy assistance programs. MTSI provides good insurance against longevity risk and is a particularly effective way to insure against large medical expenses, spousal death events and poor lifetime earnings outcomes. MTSI works well because the transfers induced by the means test line up well with states where demand for the insurance is high. For example, large shocks are particularly costly at the end of life because agents cannot easily self-insure by re-entering the labor market and, absent a bequest motive, would like to keep their savings low. At the same time, the disutility of low consumption is very high. Thus, insurance for retirees that pays off when wealth is very low is highly valued.

We use a large quantitative model of the U.S. economy to demonstrate that removing MTSI for the elderly has a large negative effect on welfare. Our finding raises the question as to whether there is an opportunity to increase the scale of current MTSI programs. Indeed, we document broad-based welfare gains if the scale of these programs is increased by 1/3 and financed with a proportionate payroll tax.

Perhaps the most striking feature of MTSI is that its state-contingent nature delivers valuable insurance with programs that are much smaller than SS. Medicaid, which subsidizes medical costs, is the largest MTSI program for retirees. Yet, Medicaid expenditures for individuals 65 and over (65+) only constitute 0.6% of GDP. About 5% of 65+ receive assistance from SSI, the second largest program, and expenditures on this program are only about 0.3% of GDP.[5]

Our findings are surprising given that previous literature has shown that MTSI has large distortionary effects on incentives. Hubbard, Skinner and Zeldes (1995) find that means-testing results in a 100% tax on wealth in some states of nature. Feldstein (1987) shows that old-age MTSI programs can severely distort saving incentives, and induce some individuals to consume all of their income while working so that they can immediately qualify for MTSI when they retire. Estimates in Neumark and Powers (1998) suggest that these effects are quantitatively significant. Funding MTSI programs requires taxes which create further distortions. We start by illustrating the costs and benefits of MTSI in a two-period model. The model shows that the value of the insurance provided by MTSI against medical expense, longevity and lifetime earnings risks can outweigh the costs due to the negative incentive

[5]The Medicaid figure is taken from U.S. Centers for Medicare and Medicaid Services, Office of the Actuary, "National Health Expenditure Accounts" and is an average from 2000 to 2010. The SSI numbers are from CBO "Growth in Means-tested Programs and Tax Credits for Low-Income Households" (2013).

effects.[6]

Our principal objective is to assess U.S. MTSI programs for retirees, and this requires a quantitative model that captures the main risks retirees face. A large literature has already documented that individuals in the U.S. face significant lifetime earnings risk.[7] Individuals also face large risks after retirement. For example, De Nardi, French and Jones (2010) show that medical expenses are an important driver of precautionary saving by the elderly, and Kopecky and Koreshkova (2014) find that nursing home expense risks are particularly significant. Old-age risks are also an important driver of impoverishment. We provide new evidence that widowhood, poor health, and hospital and nursing home stays are all associated with more frequent transitions into the bottom wealth quintile and higher persistence of stays in that quintile. According to our results, even wealthy households can become impoverished by these events.

We capture these risks in a quantitative overlapping generations model. Individuals enter the economy with a given level of educational attainment and a spouse. Labor productivity evolves stochastically over the lifecycle and a borrowing constraint limits their ability to self-insure. Prime-age male labor supply is inelastic, but female participation and hours worked are optimally chosen by the household. To capture the decline in male participation at older ages, we assume that males make a participation decision in each period between ages 55 and 65.

Retired individuals 65+ are subject to survival, spousal death, health and out-of-pocket (OOP) medical expense risk, including the risk of a lengthy nursing home stay. These risks vary with age, gender and marital status of the retiree and are correlated with the retiree's education type. Thus, retired households are heterogeneous not only in the size of their accumulated wealth (private savings and pensions), but also in the life expectancies of their members, household OOP medical expenses and household composition. We assume that there are no private markets to insure against earnings, health, or survival risk. Partial insurance, however, is available to retirees through a progressive pay-as-you-go SS program that includes spousal and survivor benefits, and a MTSI program that includes both categorically and medically needy paths to Medicaid. Medicare is modeled in a simple way. Medical expenses are net of Medicare transfers and the payroll tax includes Medicare contributions.

The model is calibrated to a set of aggregate and distributional moments for the U.S. economy, including demographics, earnings, medical and nursing home expenses, as well

[6] We wish to emphasize that following Feldstein, we focus on MTSI for retirees. The costs and benefits of offering MTSI to workers are not the same, since social insurance programs for workers have been shown, for example, to have much larger effects on labor supply (Krueger and Meyer, 2002).

[7] See for example Heathcote, Storesletten and Violante (2008), Guvenen (2009), Heathcote, Perri and Violante (2010a) and Huggett, Ventura and Yaron (2011).

as features of the U.S. means-tested social welfare, SS and income tax systems. We then assess the model's ability to reproduce key facts observed in the data but not targeted in the calibration. The model generates patterns consistent with the data with regards to Medicaid recipiency rates, flows into Medicaid and OOP medical expenses by age and marital status. Moreover, the model delivers an increased likelihood of impoverishment for individuals who experience: large acute or long-term care OOP expenses; shocks to health status; or a spousal death event. These patterns of impoverishment in the model are in line with impoverishment statistics in our dataset obtained from the Health and Retirement Survey (HRS).

This economy is then used to investigate the welfare effects of MTSI. Removing MTSI from our baseline model of the U.S. results in large welfare *losses* for all types of households. Indeed, there is general support for increasing the scale of MTSI for retirees provided that it is financed by increasing the payroll tax. Both poor households and affluent households, as indexed by either educational attainment or lifetime earnings quintile of the male, prefer a larger scale of MTSI. In contrast, welfare of all types of households *increases* when SS is removed even though the fraction of retirees consuming at the MTSI consumption floor more than doubles. Interestingly, the welfare benefits of MTSI are even larger when SS is not available. When MTSI is available, SS is redundant in the following sense. MTSI provides meaningful insurance against longevity risk and other risks but at a lower social cost. Finally, we find important interaction effects between the two programs. In particular, the presence of SS alters saving patterns of poorer households, which lowers the fraction of households that roll-in to MTSI at retirement.

To our knowledge, our paper is the first to demonstrate that MTSI programs for U.S. retirees are welfare-enhancing. De Nardi, French and Jones (2013) in a complementary paper propose a detailed partial equilibrium model of Medicaid transfers to single retirees. Medical expenses are endogenous in their model, and they are able to estimate their model's parameters. They find that retirees value Medicaid transfers at more than their actuarial cost. Their model of single retirees is not suitable for measuring the overall welfare effects of MTSI. Neither the distortionary effects of MTSI on savings and labor supply of workers nor the tax burden born by workers in financing these programs are present.

Other recent research analyzes means tests in the context of public pension reform in OLG models where lifetime earnings risk and longevity are the only risks faced by retirees. Tran and Woodland (2012) compare Australia's current means-tested public pension system with an alternative economy with no means-tested public pension. They find that means-tested public pensions may be preferred to a universal public pension plan if means-tested benefits are tapered off in a suitable way. Sefton, van de Ven and Weale (2008) find that the Pension Credit program that was instituted in the UK in 2003 and that relaxed the public pension means test is preferred to both the previous program and a universal SS system.

In addition to transfers from MTSI programs, which are the subject of our analysis, U.S. retirees also receive entitlement transfers to cover acute medical expenses from the Medicare program. We model the Medicare program but do not alter its scale. Attanasio, Kitao and Violante (2011) consider Medicare reforms and explore how to fund Medicare as the baby boom generation retires. The main objective of Kopecky and Koreshkova (2014) is to demonstrate that nursing home expenses are important drivers of wealth accumulation in the U.S., but they also consider the welfare effects of replacing Medicaid coverage of nursing home expenses with Medicare coverage.

The remainder of the paper is organized as follows. In Section 2, we provide new evidence on sources of impoverishment for the elderly. Section 3 describes the two-period model. Section 4 develops our quantitative model of the U.S. economy. Section 5 reports how we estimate and calibrate the parameters and profiles that are needed to solve the model. In Section 5 we also assess the ability of the model to reproduce statistics not targeted in the calibration. Section 6 reports results from our welfare analysis. Finally, Section 7 concludes.

2 Sources of Impoverishment Among the Elderly

A large literature has analyzed earnings risk but much less is known about the importance of shocks that occur during retirement for impoverishment. Previous work by De Nardi et al. (2010) and Kopecky and Koreshkova (2014) on saving and wealth suggests that medical expenses may be an important source of old-age impoverishment. This section provides new empirical evidence supporting this view and shows that a range of other shocks also impoverish retirees. In particular, we find that longevity, widowhood, self-reported health status, hospital stays and nursing home stays are all associated with higher probabilities of transitions into the first (lowest) wealth quintile and longer durations in this quintile.

Table 1 reports probabilities of 2-year transitions from the five wealth quintiles to quintile 1 using a sample of 65+ retired individuals from the 1995–2010 waves of the HRS/AHEAD survey.[8] We will subsequently refer this data as 'our HRS sample.' The transitions are conditional on marital status, health status and nursing home status. For example, the first panel shows the probabilities of transiting to quintile 1 for married women and widowed women. To control for age, we computed the transitions separately for 65–74, 75–84 and 85+ year-old individuals and took a weighted average of the results to construct the table. Wealth consists of total wealth excluding the primary residence. More details on the construction of the wealth transitions can be found in Section 1.1 of the Online Appendix.

[8] More information on this sample is available in Section 1 of the Online Appendix.

Table 1: Percentage of retirees moving from each quintile of the wealth distribution to quintile 1 two years later by marital (women only), health and nursing home status

	Marital Status		Health Status		Nursing Home Status	
Quintile	**Married**	**Widowed**	**Healthy**	**Unhealthy**	**None**	**NH Stay**
1	72.4	77.9	72.4	77.9	74.3	87.4
2	18.7	22.7	18.7	22.7	17.4	39.4
3	4.4	7.4	4.4	7.4	4.1	25.0
4	1.4	2.5	1.4	2.5	1.4	15.3
5	0.7	1.1	0.7	1.1	0.6	3.9

The percentage of individuals moving down to quintile 1 from quintiles 2–5 in a 2-year period conditional on marital or health status in the initial period, or spending at least 90 days in a nursing home during the 2-year period. Marital status numbers are for women only. The first row is the percentage of individuals who stay in quintile 1. Source: Authors' computations using our HRS sample.

The table shows that widowhood, poor health and nursing home stays are all associated with higher transitions to wealth quintile 1 from other wealth quintiles and that low wealth is more persistent for those who experience these events. Notice that nursing home stays have the largest impact on impoverishment. The cost of a one year stay in a nursing home can easily exceed $60,000 and, while the average duration is only approximately two years, Brown and Finkelstein (2008) estimate that approximately 9% of entrants will spend more than five years there. Given the high cost and, for some, long duration of nursing home stays, it is not surprising that the percentage of individuals who transit to or stay in quintile 1 is significantly larger if such a stay has occurred. Hospital stays are also associated with a higher risk of impoverishment, but the differences are less pronounced.[9]

These results are robust. The same patterns arise for each of the three age groups separately and become more pronounced with age. Marital status patterns for males are also very similar to those for females.[10]

The pattern of correlations that emerges in these transitions yields a surprisingly consistent picture. Impoverishment is positively associated with age, widowhood, poor health and both acute and long-term medical events.

3 A Two-Period Model

We start by describing the insurance and incentive effects of MTSI in a simple two-period model. We show that MTSI can be welfare improving in the presence of medical expense,

[9] See Table 5 of the Online Appendix.

[10] See Tables 1–4 of the Online Appendix.

longevity and permanent earnings risks and that it is particularly valuable when multiple risks are present. This is accomplished by analyzing how welfare changes as we vary the scale of MTSI in the model.

3.1 Economy

Consider a small open economy such that the interest rate r is fixed and exogenous. Assume that the economy consists of a unit measure of individuals. A fraction θ receive a high endowment y_h and the remaining $1-\theta$ receive $y_l \leq y_h$ in period 1. A fraction, γ, survive to period 2 and the remaining agents die after they consume in period 1. Individuals who survive to the second period face high expenses m with probability ϕ. We omit private insurance markets for longevity and medical expenses in this model and also our baseline model. Our reasons for this modeling decision are discussed in Section 6.5.

3.1.1 Individuals

The individual chooses consumption c^y when young, consumption c^b when old if he experiences positive medical expenses, consumption c^g when old if he does not incur a medical expense shock and savings a that solve

$$V(y) = \max \left\{ \log(c^y) + \gamma\beta \big[\phi \log\left(c^b\right) + (1-\phi)\log(c^g) \big] \right\},$$

subject to

$$\begin{gathered} c^y = y(1-\tau) - a, \\ c^b = (1+r)a - m + TR^b, \\ c^g = (1+r)a + TR^g, \\ TR^j = \max\{0, \underline{c} + mI(j=b) - a(1+r)\}, \quad j \in \{b, g\}, \quad \text{and} \\ a \geq 0. \end{gathered}$$

Note that the subscripts denoting type have been omitted. Transfers to the old, TR^j, are subject to a means test. They are zero for those whose wealth net of medical expenses exceeds $\underline{c}$. Otherwise, they are large enough to provide the agent with $\underline{c}$ units of consumption. These transfers are funded by a tax τ on the endowment.

3.1.2 Government and Feasibility

The government can save at the same rate as individuals, r. It saves the revenue from taxing agents' endowments when young and uses it to finance means-tested transfers to them when old. Accidental bequests are taxed and consumed by the government. The government budget constraints and aggregate resource constraint are displayed in Section 2 of the Online Appendix.

3.2 The Welfare-Improving Effects of Means-tested Social Insurance

MTSI provides an insurance benefit to those who have long lives, high medical expenses and/or a low endowment. For instance, an individual with high medical expenses is more likely to receive a transfer than one with low expenses. In short, MTSI is a state-contingent transfer program. However, it is not obvious that MTSI is welfare improving as it distorts incentives in two ways. First, it is well known from Hubbard et al. (1995) that means testing creates non-convexities in agents' budget sets. These non-convexities are due to the fact that in certain states of nature the means test is a 100% tax on wealth. As a result, when MTSI is present, a small reduction in disposable income or a small increase in the consumption floor can produce a discrete fall in savings. Second, observe that MTSI is funded with a distortionary tax. In equilibrium, jumps in the saving policies due to a marginal increase in the consumption floor generate jumps in aggregate transfers which in turn produce a discrete increase in the equilibrium tax rate. We now show that the insurance benefit of MTSI can be large enough to offset the negative savings and tax distortions it creates.

Medical Expense Risk Only Consider first a situation where $y_l = y_h = 1$ and $\gamma = 1$ so that there is only medical expense risk. Under this assumption, introducing MTSI into a Laissez-Faire (LF) economy with no social insurance program may be welfare improving if medical risks are sufficiently large. The left panel of Figure 1, which plots compensating variations for different scales of MTSI as compared to LF, illustrates this point.[11] Welfare is not monotonically increasing in the scale of the MTSI program due a jump in the individual savings policy and the tax rate. But, it is welfare improving in two distinct regions. In region 1, private savings are positive and individuals receive a transfer only when they have medical expenses. In region 2, all individuals receive transfers and private savings are

[11] We set the endowment $y = 1$, $m = 0.5$ and $\phi = 0.05$. These choices imply that average medical expenses are 2.5% of the endowment and that there is a welfare enhancing role for MTSI. We also assume that $r = 1/\beta - 1 = 0$.

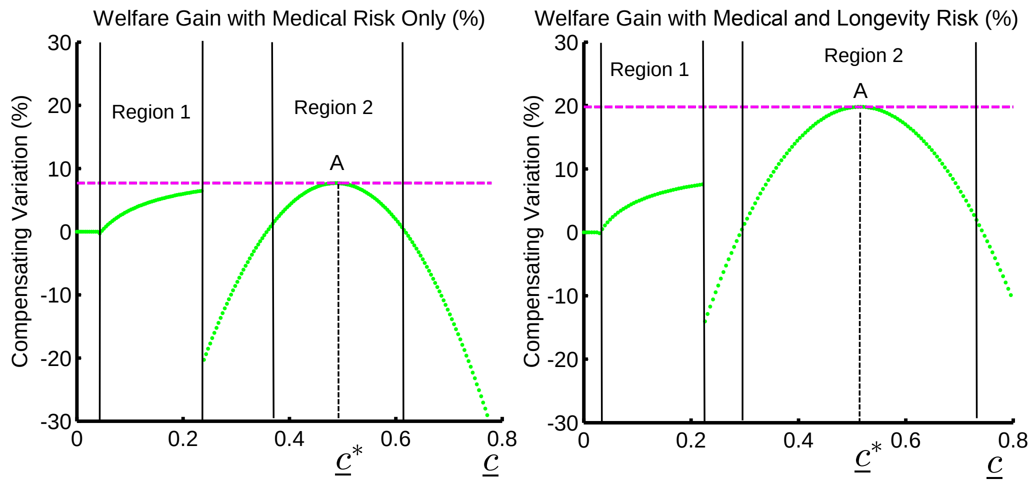

Figure 1: Welfare effects of MTSI for various levels of the consumption floor, $\underline{c}$, in the version of the two-period model with medical risk only and in the version with medical risk and longevity risk.

zero. Underlying the result that MTSI is welfare improving in the two regions is a positive insurance effect provided by the state-contingent nature of the program and a negative effect due to the saving distortions. The positive insurance effect is clearest in region 1. Increases in the consumption floor in this region reduce ex-post consumption inequality and this, in turn, reduces private savings. At a consumption floor of about 0.22, the negative incentive effect suddenly becomes dominant. The savings policy drops to zero, taxes discretely increase and welfare discretely falls. In region 2, the program fully insures against medical expense risk and the only reason why welfare varies is because the size of the consumption floor affects the time profile of consumption. With no private saving, the government can use the MTSI consumption floor to directly control consumption in each period. It follows that this tax and transfer scheme can implement the Pareto Optimal allocation, which occurs at point A in the figure.

The results illustrated in the left panel of Figure 1 assume a particular scale of expected medical expenses. As expected medical expenses are increased from this level, the sizes of regions 1 and 2 also increase and at some point all consumption floors less than $\underline{c}^*$ are Pareto preferred to LF.

Medical Expense and Longevity Risk The right panel of Figure 1 reports compensating variations for alternative scales of MTSI in comparison with LF for the case where both medical expense risk and longevity risk are present. The general shape of the welfare function in this panel is similar to that of the left panel. MTSI improves over LF in two regions, one with positive private savings and the second with zero private savings, and MTSI can

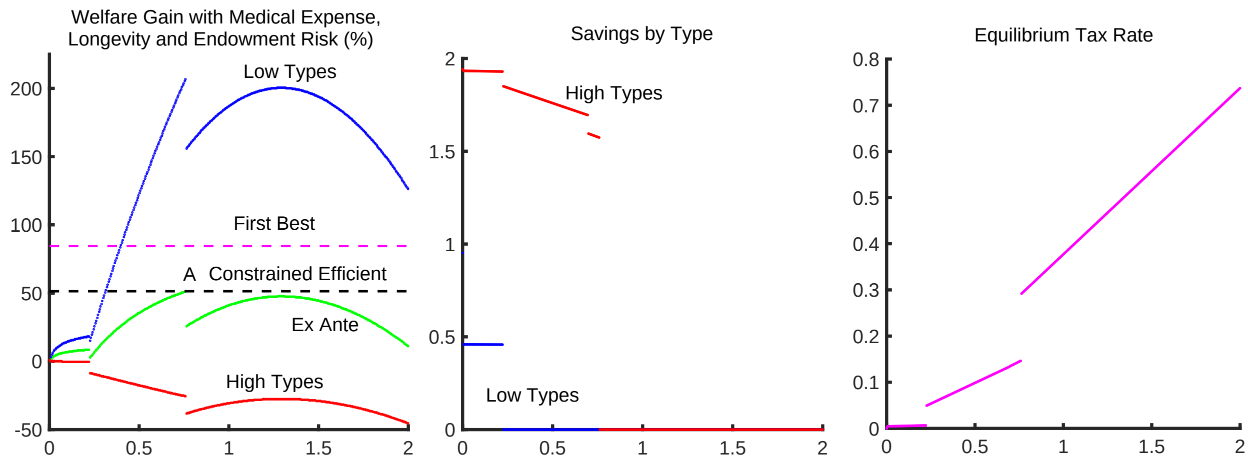

Figure 2: The left panel shows how the welfare effects of MTSI vary with the size of the consumption floor, $\underline{c}$, for the two-period model with medical expense, longevity and endowment risk. The middle graph shows the levels of savings of the two income types for each value of the floor and the right panel shows the tax rate at each value.

implement the PO allocation. The most significant new feature of the right panel of Figure 1 is that the welfare benefit of MTSI is now higher in both regions 1 and 2. The reason for this result is that the two risks are positively correlated. In other words, it is more costly to save for period 2 medical expenses when the probability of surviving to that period is less than one. Thus, a higher value is placed on insurance that reduces the need for savings.

Medical Expense, Longevity and Endowment Risk We now consider a parameterization where agents face the risk of a low endowment when young which we interpret as permanent earnings risk. MTSI can help insure against this risk as well, but the distortions we described above may also be larger. Figure 2 shows results for an economy with endowments of $y_l = 1$ and $y_h = 4$, an equal fraction of each type ($\theta = 1/2$), $m = 0.95$, $\gamma = 0.9$ and $\phi = 0.05$. The left panel of Figure 2 shows compensating variations relative to LF of newborn individuals before they know their endowment (ex-ante) and after.

Observe that the equilibrium with the optimal ex-ante consumption floor (point A) illustrates the claim of Feldstein (1987) that when MTSI is available to retirees, poorer households choose not to save. Instead they consume all of their earnings while working and rely on MTSI during retirement. In this equilibrium, high endowment types save and only receive transfers when they experience the medical expense event. The welfare of the poor is particularly high at point A, while the welfare of the rich is very low. The rich are paying taxes for insurance that they value but also financing old-age consumption of the poor. In fact, the rich prefer LF over having to fund transfers to poor individuals who have no medical expenses. In spite of these large distortions, the insurance benefits of MTSI are even larger and ex-ante welfare at point A is positive. Indeed, ex-ante welfare is positive for the entire range of consumption floors.

Taken together our results show that, despite its distortionary effects, MTSI can provide valuable insurance against a variety of risks faced by retirees. We now develop a quantitative model of the U.S that we will use to assess the welfare effects of old-age MTSI programs.

4 The Model

Our quantitative model is a rich overlapping generations model of the U.S. economy. Individuals differ by gender and level of educational attainment, and are matched with a spouse. Differences in educational attainment, in conjunction with stochastic shocks to labor productivity, mean that some households will reach retirement with high wealth and others with low wealth. Allowing for this form of cross-sectional heterogeneity is important for assessing the welfare effects of MTSI since this program is financed by a progressive income tax yet only the poor or medically needy receive benefits. Matching individuals with a spouse allows us to model the impoverishing effects of a spousal death event and to capture the variation in health, medical expenses and life expectancy by marital status, gender, and age in the data.

4.1 Demographics, Preferences and Endowments

Time is discrete. The economy is populated by overlapping generations of individuals who live at most J periods. The population grows at a constant rate n. Newborn individuals are endowed with a gender $i \in \{m, f\}$, a level of educational attainment $s^i \in \{hs, col\}$ and a spouse.[12] Until age R, individuals are workers. Individuals must retire at age $R + 1$. From retirement, the marital status of households changes to widow or widower as individuals die. Let d denote the marital status of a household: $d = 0$ for married, $d = 1$ for a widow and $d = 2$ for a widower.[13]

Individuals value consumption and leisure and are perfectly altruistic towards their spouses. We model labor supply decisions because we want to give individuals the opportunity to self-insure by adjusting their work effort in response to changes in social insurance. Our particular specification of preferences over leisure is designed to capture the variation in work hours and employment by gender and educational status. In U.S. data, most of the

[12]Table 12 contains a summary of the notation defined here, as well as other frequently used model notation.

[13]We distinguish between widows and widowers because they have different medical expenses and survival probabilities.

variation in labor supply of married households is due to changes in participation of the female and older male, as well as, in hours worked by the female (see e.g. Keane and Rogerson (2012) for a survey). Thus, we assume that females make labor force participation and hours decisions each period. However, males have no hours choice and only males older than age $\bar{j}$ have a participation choice. Our assumption that individuals are perfectly altruistic towards their spouse allows us to capture risk sharing within the household in a tractable way.

In light of these considerations, the utility function for an individual is

$$U(c, \mathbf{l}; d, \mathbf{s}, j) = N(d)\frac{c^{1-\sigma}}{1-\sigma} + \psi(\mathbf{s}, j)\frac{l_f^{1-\gamma}}{1-\gamma} - \phi_f(\mathbf{s}, j)\mathbf{I}(l_f < 1) \quad (1)$$
$$-\phi_m(\mathbf{s}, j)\mathbf{I}(j \geq \bar{j})\mathbf{I}(l_m < 1),$$

where c is consumption of each household member, $\mathbf{l} \equiv \{l_m, l_f\}$ is leisure of the male and female and $\mathbf{I}$ is the indicator function.[14] Utility is conditional on household marital status, age and the couple's schooling $\mathbf{s} \equiv (s^m, s^f)$. The function $N(d)$ maps the household marital status to the number of people in the household. In a two-member household $N(0) = 2$ and for widows and widowers $N(1) = N(2) = 1$. The parameters are such that $\sigma > 0$ and $\gamma > 0$.

For working-age individuals, $\psi(\mathbf{s}, j)$ and $\phi_i(\mathbf{s}, j)$ are positive and vary with the household's education type $\mathbf{s}$. For retirees, these parameters are set to zero and the utility function simplifies to

$$U^R(c; d) = N(d)\frac{c^{1-\sigma}}{1-\sigma}.$$

4.2 The Structure of Uncertainty

In our model, the sources of uncertainty change with age. Each member of a working-age household is exposed to earnings risk. During retirement, each household member faces individual-specific survival, spousal death and health risks, and households face household-specific medical expense risk. We now describe each of these risks in detail.

Productivity of an individual of gender i and schooling s^i evolves over the working period according to a function $\Omega^i(j, \boldsymbol{\varepsilon_e}, s^i)$ that maps his/her age j and household earning shocks $\boldsymbol{\varepsilon_e} \equiv (\varepsilon_e^m, \varepsilon_e^f)$ into efficiency units of labor. The vector of household earning shocks $\boldsymbol{\varepsilon_e}$ follows an age-invariant Markov process. Newborn households of all education types draw earning shocks from the same initial distribution.

Our model abstracts from some risks faced by working-age individuals in the real world.

[14] Under the assumption of perfect altruism and separable utility, both members of married households will have identical consumption in equilibrium. To save on notation we are imposing this directly.

In particular, some individuals lose their spouse before retirement through either death or divorce. In the model, we collapse these events into a single shock that occurs at age $R+1$. Specifically, at the beginning of age $R+1$, some individuals become widows or widowers and lose fraction ζ^m (ζ^f) of their spouse's lifetime earnings $\bar{e}^m$ ($\bar{e}^f$) which determines their SS benefits. This shock only occurs at age $R+1$ and is assumed to vary with male lifetime earnings. It allows us to reproduce the marital status distribution at age 65 and is discussed in more detail in Section 5.1.3.

During retirement, individuals face uncertainty about their health, survival and household medical expenses. An individual's health status, h^i, takes on one of two values: good ($h^i = g$) and bad ($h^i = b$). The probability of having good health next period, depends on age, gender, current health status and household marital status. The initial health status is drawn from a distribution conditional on education. We denote a household's health status by $\mathbf{h} \equiv (h^m, h^f)$. The probability of an individual surviving to age $j+1$, conditional on surviving to age j, is given by $\pi^i_j(h^i, d)$ and depends on age, gender, health status and marital status. Household marital status changes when individual household members die. Let $\pi_j(d'|\mathbf{h}, d)$ denote the probability of marital status d' at age $j+1$ for an age-j household with health status $\mathbf{h}$ and marital status d. The transition probabilities $\pi_j(d'|\mathbf{h}, d)$ are derived from $\pi^i_j(h^i, d)$ and are provided in Section 3.3 of the Online Appendix.

Medical and long-term care expenses, $\Phi(j, \mathbf{h}, \boldsymbol{\varepsilon_M}, d, d')$, are incurred at the household level.[15] They evolve stochastically and depend on household age j, household health status $\mathbf{h}$, the vector of medical expense shocks $\boldsymbol{\varepsilon_M} \equiv (\varepsilon^p_m, \varepsilon^t_m)$, marital status d, and death year (captured by a change in the marital status). The first medical expense shock follows an age-invariant Markov process. The largest realization of this persistent medical expense shock corresponds to a nursing home event and is denoted by $\bar{\varepsilon}^p_m$. The second shock is a transient, *iid* shock. The expense shocks' transitions and initial distributions are independent of marital and health status.

4.3 Social Insurance Programs

The government runs two social insurance programs: pay-as-you-go SS and MTSI.

4.3.1 Social Security

SS benefits in our model capture the following features of the U.S. Social Security system. First, married couples have the option of either receiving their own benefits or 1.5 times the benefit of the highest earner in the household. Second, widows/widowers have the choice

[15] The assumption that medical expense shocks are household level is made for reasons of tractability.

of taking their own benefit or their dead spouse's benefit. It follows that a household's SS benefits $S(\bar{\mathbf{e}}, d)$ depends on lifetime earnings of both household members, $\bar{\mathbf{e}}$, and the household's current marital status, d. The specific benefit formula is reported in Section 4.6 of the Online Appendix. SS benefits are financed by a capped, proportional tax on earnings that we denote by $\tau_{ss}(\cdot)$.

In addition to income transfers, the SS system covers some medical expenses through Medicare. Since the HRS only reports post-Medicare OOP medical expenses, we do not formally model the distribution of Medicare benefits. Instead, these benefits are included in government purchases G. The payroll tax used to finance them is given by $\tau_{mc}(\cdot)$. Total payroll taxes are thus $\tau_e(e) = \tau_{ss}(e) + \tau_{mc}(e)$.

4.3.2 Medicaid, SSI and Other Means-Tested Programs for the Elderly

By far, the largest means-tested social insurance program for the elderly in the U.S. is the health insurance program Medicaid. The second largest program is SSI, which provides a minimum income level to households irrespective of medical expenses. While the federal government determines general Medicaid and SSI eligibility rules, states establish and administer their own Medicaid programs and determine the scope of coverage. States also run other welfare programs for the elderly: subsidized housing, food stamps and energy assistance. Most states use the same means test to determine eligibility for Medicaid and other state-run welfare programs. Therefore, for the sake of simplicity, we refer to the entire system of these programs as MTSI.

De Nardi, French, Jones and Goopta (2012) provide an excellent description of eligibility rules for SSI and Medicaid programs for the elderly and argue that a good way to model U.S. Medicaid, SSI and other MTSI programs is to assume that there are two ways to qualify: a categorically needy path and a medically needy path. Households with low income and asset levels can qualify as categorically needy even if their medical expenses are negligible. Households with high income can qualify via the medically needy path if they have high medical expenses. Household MTSI transfers corresponding to each path are modeled as follows:

$$Tr^R \equiv \begin{cases} \max\left\{\underline{y}^d + \varphi M - S(\bar{\mathbf{e}}, d), \underline{c}^d + M - S(\bar{\mathbf{e}}, d)\right\}, & \text{if } S(\bar{\mathbf{e}}, d) < \underline{y}^d,\ a < \underline{a}^d \text{ and } \varepsilon_m^p \neq \bar{\varepsilon}_m^p, \\ \max\{0, \underline{c}^d + M - I^R\}, & \text{otherwise.} \end{cases} \tag{2}$$

where M is medical expenses, φM is the fraction of medical expenses paid for by Medicaid after copayments are made and I^R is cash-on-hand (assets plus after-tax income). The first line specifies the categorially needy path and the second line describes the medically needy path. Households not experiencing a nursing home event, i.e. those with shocks $\varepsilon_m^p \neq \bar{\varepsilon}_m^p$, can qualify for MTSI via the categorically needy path by demonstrating that their SS income $S(\bar{\mathbf{e}}, d)$ and assets a lie below the means test thresholds $\underline{y}^d$ and $\underline{a}^d$ as shown in the first line of Equation (2).[16] Most states require that categorically needy households make copayments if they incur medical expenses. The size of copayments, $(1-\varphi)M$, varies depending on the type and amount of the expense incurred and is capped. A result is that the categorically needy have significant OOP medical expenses. The term in the first argument recognizes these OOP expenses, and the second argument caps OOP expenses such that a household's total income is at least $\underline{c}^d$. Households who experience a nursing home event and households with higher income but also high medical expenses can qualify for MTSI via the medically needy path. This occurs when medical expenses are large relative to cash-on-hand I^R.

Equation (2) insures that total expenditure on household consumption is bounded below by $\underline{c}^d$ which, along with the income and asset thresholds, can vary by household marital status d. This transfer function also has the property that average consumption of categorically needy households exceeds average consumption of medically needy households, which De Nardi et al. (2012) show is a property of U.S. MTSI.

Medicaid and other means-tested social welfare programs are jointly financed by the states and the federal government using a variety of revenue sources. In the model, we assume that all funding for means-tested transfers comes out of general government revenues.

4.4 Household's Problems

The assumption of perfect altruism of married couples implies that the objective functions for an individual and a household coincide. We thus refer to the optimization problems as household problems.[17]

4.4.1 Working Household's Problem

A working household of age j with education type $\mathbf{s} \equiv (s^m, s^f)$ enters each period with assets a and average lifetime earnings of the male and female $\bar{\mathbf{e}} \equiv (\bar{e}^m, \bar{e}^f)$. It observes the current labor productivity shocks $\boldsymbol{\varepsilon_e} \equiv (\varepsilon_e^m, \varepsilon_e^f)$ and chooses consumption c, savings a', female non-market time l_f, and male non-market time l_m for males aged $j \geq \bar{j}$.[18]

[16] Our income test follows the Medicaid and SSI programs which exclude asset income.

[17] Alternatively, one can view the problems as those of individuals by designating either the husband or wife of married couples as the decision maker.

[18] Individuals have no option to purchase private insurance. The rationale for this assumption is discussed in Section 6.5.

Earnings of an individual of gender $i \in \{m, f\}$ are

$$e^i = w\Omega^i(j, \boldsymbol{\varepsilon_e}, s^i)\Big(1 - l_f \mathbf{I}_{i=f} - \big[\bar{l}\mathbf{I}_{j<\bar{j}} + l_m \mathbf{I}_{j \geq \bar{j}}\big]\mathbf{I}_{i=m}\Big), \tag{3}$$

and household income,

$$y^W \equiv e^m + e^f + (1 - \tau_c)ra, \tag{4}$$

consists of labor income and capital income net of a corporate tax τ_c. Household income is subject to a nonlinear income tax $\tau_y(\cdot)$ and a nonlinear payroll tax $\tau_e(\cdot)$

$$T_y^W \equiv \tau_y\big(y^W - \tau_e(e^m)e^m - \tau_e(e^f)e^f\big) + \tau_e(e^m)e^m + \tau_e(e^f)e^f. \tag{5}$$

It follows that the household budget constraint is

$$c(1 + \chi) + a' = a + y^W - T_y^W, \tag{6}$$

where $\chi \in [0, 1]$ captures returns to scale in consumption in the household. Thus, the first term in the budget constraint is the household's total expenditure on consumption.

A working-age household solves

$$V^W(j, a, \bar{\mathbf{e}}, \boldsymbol{\varepsilon_e}, \mathbf{s}) = \max_{c, l_f, l_m, a'} \Big\{U(c, \mathbf{l}; 0, \mathbf{s}, j) + \beta \mathbf{E}\big[V(j+1, a', \bar{\mathbf{e}}', \boldsymbol{\varepsilon}'_{\boldsymbol{e}}, \mathbf{s}) | \boldsymbol{\varepsilon_e}\big]\Big\}, \tag{7}$$

subject to (4)–(6), the law of motion for $\boldsymbol{\varepsilon_e}$, and

$$c \geq 0, \quad 0 \leq l_f \leq 1, \quad a' \geq 0, \quad l_m \in \{\bar{l}, 1\}, \tag{8}$$

$$\bar{e}^{i\prime} = (e^i + j\bar{e}^i)/(j+1), \quad i \in \{m, f\}, \tag{9}$$

where Equation (8) describes regularity conditions on consumption and leisure and imposes a borrowing constraint which rules out uncollateralized lending. Equation (9) specifies the evolution of average lifetime earnings which determine SS benefits.

4.4.2 Retired Household's Problem

Starting from age $R + 1$, all members of a household are retired and the household only makes consumption and saving decisions. Income of a retired household,

$$y^R \equiv (1 - \tau_c)ra + S(\bar{\mathbf{e}}, d), \tag{10}$$

consists of asset income and SS income. Its tax liabilities depend on income, marital status and medical expenses and are given by

$$T_y^R \equiv \tau_y^R\big((1-\tau_c)ar, S(\bar{\mathbf{e}}, d), d, M\big). \tag{11}$$

The tax function is non-linear and incorporates the following features of the U.S. tax code. First, SS benefits are subject to income taxation if the benefits exceed an exemption level. Second, medical expenses which exceed κ percentage of taxable income are tax deductible. The specific formulas used to compute income taxes are reported in the Online Appendix. The retired household may be eligible for MTSI transfers as specified by Equation (2), where cash-on-hand is given by

$$I^R \equiv a + y^R - T_y^R. \tag{12}$$

Finally, the household's budget constraint is

$$c(1+\chi \mathbf{I}_{d=0}) + M + a' = a + y^R - T_y^R + Tr^R, \tag{13}$$

where $c(1+\chi \mathbf{I}_{d=0})$ is total expenditure on household consumption and $M \equiv \Phi(j, \mathbf{h}, \boldsymbol{\varepsilon_M}, d, d')$ is household medical expenses.

A retired household solves

$$V^R(j, a, \bar{\mathbf{e}}, \mathbf{h}, \boldsymbol{\varepsilon_M}, d, d') = \tag{14}$$
$$\max_{c,a' \geq 0} \left\{ U(c, \mathbf{1}; d, \mathbf{s}, j) + \beta \mathbf{E}\Big[\sum_{d''=0}^{2} \pi_{j+1}(d''|\mathbf{h}', d') V(j+1, a', \bar{\mathbf{e}}, \mathbf{h}', \boldsymbol{\varepsilon'_M}, d', d'')|\mathbf{h}, \boldsymbol{\varepsilon_M}\Big]\right\}$$

subject to (10)–(13) and the laws of motion for $\mathbf{h}$ and $\boldsymbol{\varepsilon_M}$. The expectations operator $\mathbf{E}$ is taken over $\boldsymbol{\varepsilon'_M}$ and $\mathbf{h}'$.

As our state space shows, we assume that individuals observe their own and their spouse's death event one period in advance. It follows that bequests are zero for households with a single member. This assumption has the following motivations. First, there is considerable evidence that bequests and inheritances are low. One reason for this is that wealth is low in the final year of life. Using HRS data, Poterba, Venti and Wise (2011) find that 46.1% of individuals have less than $10,000 in financial assets in the last year observed before death and 50% have zero home equity. In a separate study of the Survey of Consumer Finances (SCF), Hendricks (2001) reports direct measurements of inheritances. He finds that most households receive very small or no inheritances. Fewer than 10% of households receive an inheritance larger than twice average annual earnings and the top 2% account for 70% of all inheritances.

The second reason for this assumption is that it allows us to capture the fact that both OOP and Medicaid medical expenses are large in the final year of life. In our HRS sample of retirees, OOP expenses in the last year of life are 3.43 times as large as OOP expenses in other years. Medicaid expenses are not available in our dataset. However, Hoover, Crystal, Kumar, Sambamoorthi and Cantor (2002) report that Medicaid expenses in the final year of life account for 25% of total Medicaid expenses for those 65+. This result is based on Medicare Beneficiary Survey data from 1992–1996.

Third, previous research has found that changes in the size and distribution of accidental bequests due to changes in government policy muddle analysis of the welfare effects of policy reform. For examples of this see Hong and Ríos-Rull (2007) and Kopecky and Koreshkova (2014). We avoid this problem because under our assumption accidental bequests are zero.

To maintain tractability we assume that for retirees the household's education type is no longer a state variable. Education does enter indirectly since the initial distribution of individual health status varies with educational attainment. Health, and thus education, affect both individual survival probabilities and household medical expenses as described in Section 4.2.

4.4.3 Problem for a Household about to Retire

The previous two cases cover all situations except that of a household in its last working period, R. Such a household enters the period with the state variables of a working household and chooses consumption, savings, female labor supply and male labor supply, recognizing that in period $R+1$ it will face the problem of a retired household. Consequently, when evaluating next period's value function, it forms expectations using the initial distributions for health, medical expense and marital status shocks.

4.5 Closing the Model

To complete the description of our model, we now specify the government budget, the production technology and the notion of equilibrium. The government budget is balanced period-by-period. Revenues from the corporate tax τ_c, income taxes T_y^W and T_y^R, and payroll tax $\tau_e(\cdot)$ finance SS benefits, means-tested transfers and government expenditures G.[19] Perfectly competitive firms rent capital K and labor L and combine them to produce a single

[19] For simplicity, we do not explicitly model the Social Security trust fund but instead assume that the Social Security program is part of the total government budget.

Table 2: Key structural parameters in the baseline economy

Parameter	β	σ	χ	$\bar{l}$	γ	r	α	δ
Value	0.97	2	0.67	0.55	2	5.6%	0.3	7%

Note that r is the annual pre-tax interest rate. The average post-tax rate is 4.1%.

good using the constant-returns-to-scale production technology

$$Y \equiv F(K, L) = AK^{\alpha}L^{1-\alpha},$$

where A is fixed.

Some of the policy reforms we will consider will have a large effect on private savings. Even though the U.S. is a large economy, capital markets are integrated and thus it is not clear how important changes in domestic savings are for determining the real interest rate. We thus assume that the interest rate and, consequently, the wage rate are exogenous. We consider a steady-state competitive equilibrium of our economy. All of the results we report below are based on a comparison of steady-states. The definition of a steady-state competitive equilibrium for our economy can be found in Section 3.5 of the Online Appendix.

5 Calibration and Assessment

The model is parameterized to match a set of aggregate and distributional moments for the U.S. economy, including demographics, earnings, medical and nursing home expenses, as well as features of U.S. social insurance programs for retirees and the U.S. tax system. Some of the parameter values can be set directly, others are formally calibrated so that moments generated by the model reproduce corresponding moments in the data.[20] Table 2 reports the value of some of the standard structural parameters.[21] The remainder of this section discusses the most novel aspects of the calibration and assesses our parameterization of the model by reporting statistics that were not targeted.

[20] Solving the quantitative model takes over 45 minutes on a computer with 16 cores due to the computational complexity. For this reason, it is not feasible to implement a formal method of moments estimation strategy.

[21] Details on the calibration of these parameters as well as other preference parameters, income tax functions, and contribution and benefit formulas for SS can be found in Section 4 of the Online Appendix.

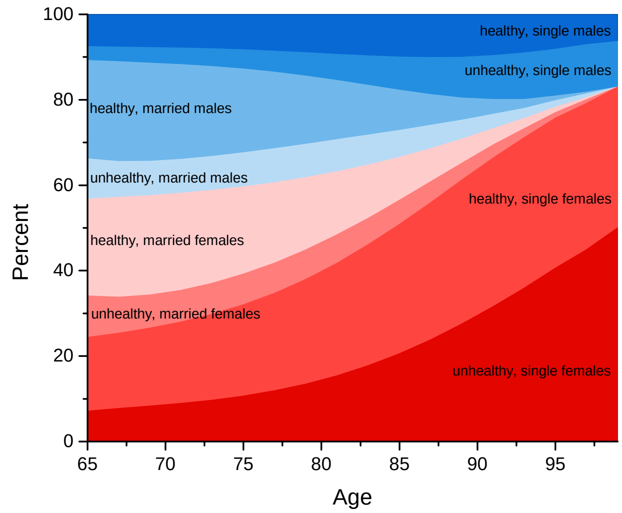

Figure 3: The population distribution of retirees by age. Individuals are classified by gender, health and marital status. The data for this figure is our HRS sample.

5.1 Demographics

Given that the focus of our analysis is on retirees, we want to reproduce the demographic structure of the 65+ population. Figure 3 reports the evolution of this distribution by marital status, health and gender estimated from our HRS sample. At the beginning of retirement, half of the population is healthy and married. As individuals age, three things happen: the fraction of singles increases, the fraction of unhealthy increases and males die faster than females. Below we will describe how we estimate this demographic structure and reflect it in our model.

5.1.1 Age Structure

Agents are born into our economy at age 21 and can live to a maximum age of 100. We set the model period to two years because the data on OOP medical expenses is only available bi-annually. Thus the maximum life span is $J = 40$ periods. Agents work for the first 44 years of life, i.e. the first 22 periods. At the beginning of period $R + 1 = 23$ (age 65), they retire and begin to face survival risk.

According to the U.S. Census Bureau the old-age dependency ratio (the 65+ population over the 21+ population) was 0.18 in the year 2000.[22] The old-age dependency ratio determines the tax burden on workers, which is an object of primary interest in our policy analysis. Thus, we choose the population growth rate n to reproduce this ratio. The

[22]We frequently use 2000 as a reference year because it is the only census year that falls in the range of our HRS sample.

Table 3: Marital status distribution of households with 65–66 year-old household heads by Social Security benefit quintiles

Quintile	1	2	3	4	5
Married	0.19	0.24	0.36	0.67	0.95
Single Female	0.56	0.55	0.45	0.21	0.03
Single Male	0.25	0.21	0.20	0.12	0.02

The fraction of households in each SS income quintile who are married, single female or single male households. Source: Authors' computations using our HRS sample.

resulting population growth rate is 1.8% per annum.

5.1.2 Education

In our HRS sample, both spouses have college degrees in 14% of 65–66 year-old households; only the male has a college degree in 14% of households; only the female has a college degree in 5% of households; and neither spouse has a degree in 67% of households. In the model, the educational attainment of newborn individuals is fixed throughout their working life. Thus, we set the distribution of educational attainment in the model to reproduce these percentages.

5.1.3 Marital Status

In our HRS sample, 48% of 65–66 year-old households are married couples, 36% are single females and 16% are single males. For the most part, these figures reflect the cumulative effects of divorce and spousal death in the ages prior to age 65. Since our primary objective is to model retirees, we summarize these effects with a spousal death event and associated loss in spousal lifetime earnings at age 65. This event, which is distinct from the health-related survival risk agents face throughout retirement, ensures that the model reproduces the marital status distribution of 65 year-olds. An important feature of our HRS data is that there are very large differences in SS benefits across the three types of households. Married households have the highest benefits and single males receive higher benefits than females. In order to reproduce the empirical magnitudes of these differences, we assume that the spousal death shock is negatively related to average lifetime earnings of the male. We then calibrate the death shock so that it reproduces the fractions of married, single male and single female households by SS benefit quintiles shown in Table 3. The loss of spousal earnings associated with the age 65 death event helps the model to replicate the left tail of the SS income distribution conditional on marital status and hence Medicaid recipiency rates in the data, as we explain below in Section 5.4.2.

Table 4: Expected additional years of life at age 65 by health, marital status and gender

	Female	**Male**	**All**
	19.5	16.6	18.2
By health			
good	20.5	17.6	19.2
bad	15.8	12.2	14.3
By marital status			
married	20.1	17.2	18.6
single	18.4	14.3	17.0

Source: Authors' computations using our HRS sample. Note that life expectancies in our HRS sample are lower than those in the 2000 U.S. Census. We thus scaled up the survival probabilities to match Census life expectancies at age 65.

5.1.4 Survival Probabilities and Health Status

Survival probabilities for males and females, $\pi^i_{j+1}(h^i, d)$, are estimated using our HRS sample. They are assumed to be a logistic function of age, age-squared, health status, marital status, health status interacted with age and marital status interacted with age. Transition probabilities for health status are also estimated separately for males and females, using the same logistic functions. The initial distributions of individuals across health status at age 65 are set to match the distribution of health status by education in the HRS sample for 65–66 year-olds. Expected years of life by marital status, health and gender generated by these objects are reported in Table 4. All three factors have a large effect on longevity. Having a spouse at age 65 is particularly beneficial for males as it extends their longevity by 2.9 years, compared to 1.7 years for females. Good health extends life by about five years for both genders. Finally, females live on average 2.9 years longer than males.

5.2 Earnings Process

Our strategy for calibrating the labor productivity process follows Heathcote, Storesletten and Violante (2010b), who also consider earnings for married households. However, their earnings process cannot account for the fact that some households in our HRS sample receive very little SS income during retirement. To address this problem, we augment their earnings process to allow for a low-earnings state for males and set the value of earnings in this state to reproduce the SS income Gini coefficient. We assume that this state has the same persistence as other states. The resulting earnings process is non-Gaussian.[23] Table 5 reports the Gini

[23]In order to make this process consistent with the estimates of Heathcote et al. (2010b), we use a simulated method of moments strategy described in Section 4.4 of the Online Appendix.

Table 5: Social security income distribution in the data and the model.

	Quintiles					*Top Percentiles*			*Gini*
	Q1	Q2	Q3	Q4	Q5	10	5	1	
					share of total, %				
Data	7.3	14.2	18.8	24.7	35.0	13.6	10.7	2.5	0.28
Model	7.8	13.3	18.1	25.6	35.2	18.7	9.5	2.1	0.28

Source: Authors' computations using our HRS sample. Data is adjusted for cohort-effects.

and other moments of the SS income distribution in the model and the data. Notice that the model does a good job of reproducing the bottom tail of this distribution. This specification of the earnings process also improves the model's implications for the bottom tail of the earnings distribution.

5.3 Medical Expense Process

Medical expenses vary systematically with age, gender, health and marital status. We assume that medical expenses have a deterministic and stochastic component and describe each of these components in turn.

5.3.1 Deterministic Medical Expense Profiles

Medical expenses are household-specific in the model. We start by estimating deterministic medical expense profiles for individuals and then sum these expenses over spouses for married couples. The shape of the medical expense profiles is determined by regressing individual medical expenses on a quartic in age and a quartic in age interacted with gender, marital status, mortality status (a dummy variable that takes on the value of one if death occurs in the next period) and health status using a fixed-effects estimator.[24]

Our HRS data reports OOP household medical expenses but not expenses covered by Medicaid. However, when solving the model, we need to specify *pre-Medicaid* medical expenses, defined as the sum of OOP and Medicaid payments. To resolve this issue, we exploit the fact that individuals in the top lifetime earnings quintile (or who have/had spouses in the top lifetime earnings quintile) are unlikely to qualify for means-tested Medicaid transfers, and hence their OOP medical expenses are, on average, very close to their pre-Medicaid expenses. Thus, the control variables in our medical expense regression include permanent income quintile dummies and their age interaction terms. These latter controls reduce the

[24] As pointed out by De Nardi et al. (2010), the fixed effects estimator overcomes the problem with the variation in the sample composition due to differential mortality and also accounts for cohort effects.

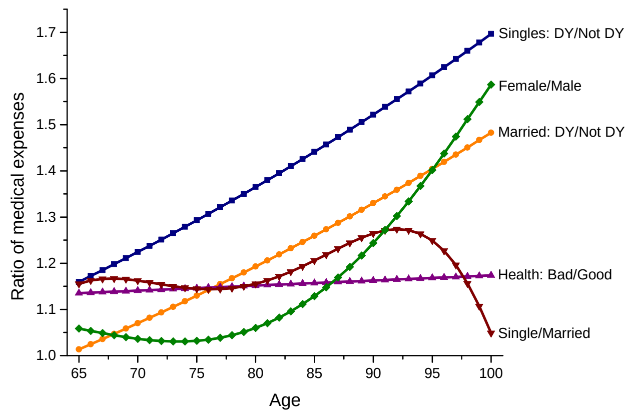

Figure 4: Estimated effects of marital status, health and death year (DY) conditional on marital status on individual medical expenses by age. The vertical axis is the ratio of estimated medical expenses for each type pair. Source: Authors' computations using our HRS sample.

estimation bias arising from the fact that Medicaid transfers increase with age. The estimated coefficients from this regression for permanent earnings quintile 5 pin down the shape of the deterministic age-profile of the pre-Medicaid medical expense process.[25]

The obtained medical expense profiles are similar to profiles reported in De Nardi et al. (2010) and Kopecky and Koreshkova (2014) for single individuals. OOP expenses increase with permanent income and age. Moreover, OOP medical expenses are higher for females relative to males and higher if self-reported health status is poor.

Our estimated medical expense profiles provide new information about how medical expenses vary by marital status and death year. Figure 4 shows the effects of marital status and death year on medical expenses. For purposes of comparison, we also report how medical expenses vary with gender and health. The most striking feature of the figure is that death year has a very large effect on medical expenses and its importance increases with age. At age 65, medical expenses for singles in their death year are 15% higher than for singles not in their death year. By age 85, the difference has risen to 45%. The effect of death year is smaller for married individuals but still important. Notice also that the effect of marital status on medical expenses is as large as or larger than the effect of health for those under age 95.

[25]All of the coefficients documented here are significant at conventional significance levels. Estimated coefficients and standard errors from these regressions are available from the authors.

5.3.2 Stochastic Structure of Medical Expenses

The stochastic component of medical expenses has a persistent and a transitory component. The standard deviation of the transitory component is 0.816 and the persistent component is assumed to follow an AR(1) at annual frequencies with an autocorrelation coefficient of 0.922 and a standard deviation of 0.579. These values are taken from French and Jones (2004).[26] The initial distribution of the persistent medical expense shock is set to the distribution of OOP expenses at age 65–66 in our HRS data sample.

Previous work has found that an important source of variation in retirees medical expenses is long-term care needs.[27] To capture long-term care risk, we approximate the persistent shock with a five state Markov chain and assume that the fifth state is associated with nursing home care. This calibration of the Markov chain captures both the small variation in medical expenses due to acute costs and the large variation due to long-term care costs. In particular, we target data facts pertaining to the cost of nursing home care for a Medicaid recipient, the expected duration of nursing home stays, the distribution of age at first entry and the overall size of nursing home expenses. The resulting Markov process recovers the serial correlation and standard deviation of the AR(1) process but is not Gaussian. More details on this aspect of the calibration are reported in Section 4.1 of the Online Appendix.

Finally, we scale the medical expense profiles so that aggregate medical expenses in the model are 2.1% of GDP. This target corresponds to the average total medical expenses paid OOP or by Medicaid during the period 1999 to 2005.[28]

5.4 Government

The government has three sources of funds: a proportionate corporate profits tax, and nonlinear income and payroll taxes. And it has three principal uses of funds: it pays SS benefits to retirees, provides means-tested social welfare benefits, and purchases goods and services from the private sector.

5.4.1 Sources of Government Revenue

In U.S. data, government tax revenue from corporate profits averaged 2.8% of GDP between 1950–2008, and revenue from the income tax averaged 8% of GDP.[29] We choose the corporate

[26]Their estimates are based on individuals. We use these values for the household but assume that the medical expense shocks to husbands and wives are independent.

[27]See for example Kopecky and Koreshkova (2014) who find that nursing home expenses are important drivers of wealth accumulation over the lifecycle.

[28]Total medical expenses paid OOP or by Medicaid are taken from the "National Health Expenditure Accounts," U.S. Centers for Medicare and Medicaid Services and include payments for insurance premia.

[29]See Table 11 of "Present Law and Historical Overview of the Federal Tax System."

Table 6: Medicaid recipiency rates by age and marital status

	65+	65–74	75–84	85+
Married				
data	0.07	0.07	0.07	0.11
model	0.07	0.07	0.07	0.10
Widows				
data	0.22	0.22	0.19	0.24
model	0.22	0.22	0.21	0.22
Widowers				
data	0.17	0.19	0.15	0.19
model	0.17	0.18	0.16	0.14

The fraction of individuals receiving Medicaid transfers by age group and marital status in the data and the model. Data source: Authors' computations using our HRS sample.

tax rate and level of income taxes in the model to hit these targets.

U.S. income tax schedules vary with marital status. Using the IRS Statistics of Income Public Use Tax File for the year 2000, Guner, Kaygusuz and Ventura (2012) estimate effective income tax functions for both married households and singles following the methodology of Kaygusuz (2010). We use their estimates. See Section 4.5 of the Online Appendix for more details.

Contributions for SS and Medicare are financed by the payroll tax, $\tau_e = \tau_{ss} + \tau_{mc}$. In the year 2000, the SS component of this tax, τ_{ss}, was 12.4%, and subject to a cap of \$72,000. The Medicare component, τ_{mc}, was 2.9%.

5.4.2 Uses of Government Revenue

Benefits under the U.S. Social Security system are nonlinear in an individual's lifetime earnings and have special provisions for spouses and survivors. The SS benefit function in our model reproduces these features of the U.S. system. Our calibration is standard and can be found in Section 4.6 of the Online Appendix.

Medicaid and SSI are the two largest MTSI programs in the U.S., but Medicaid has less stringent eligibility rules. Eligibility rules for other means-tested programs, such as food stamps, and energy and housing assistance, are usually based on either Medicaid or SSI rules to keep administrative costs low. MTSI expenditures in the model are derived from Equation (2) and represent all of these programs. Since Medicaid is the least stringent, we set model asset and income thresholds using its program rules for the years 2009–10. The asset thresholds, $\underline{a}^d$, $d \in \{0, 1, 2\}$ are set to 14% of average earnings of full-time, prime-age, male workers.[30] The income thresholds, $\underline{y}^d$, are set to 43% and 33% for married and single households.[31]

We choose the consumption floors, $\underline{c}^d$, to reproduce Medicaid recipiency rates by marital status of retirees but restrict them to fall in an interval ranging from 10 to 20% of male average earnings. This interval is consistent with previous estimates.[32] The first column of Table 6 shows Medicaid recipiency rates in the model and the data. The resulting consumption floor for married households is 14% of average male earnings. For widows and widowers, recipiency rates from the model are too low even at the upper end of the interval. This is because widows and widowers in our model have too much SS income. We use the low-earnings state to reproduce the average distribution of SS income but not the distribution by marital status. In order to bring this distribution, and ultimately Medicaid recipiency rates, more in line with the data, we fix the consumption floors for widows and widowers at 20% of average male earnings and adjust ζ^i, $i \in \{m, f\}$ introduced in Section 4.2. The resulting loss of spousal income of a widow is 20% of the spouse's average lifetime earnings and the corresponding figure for widowers is 90%.

In our HRS sample, average OOP expenses of individuals on Medicaid are 46% of average OOP expenses of all retirees. Setting the Medicaid copay rate, $1 - \varphi$, to 13% allows the model to reproduce this data fact.[33]

Finally, we adjust government purchases of goods and services, G, to close the government budget constraint. This results in a G/Y ratio of 0.11 for our baseline parameterization of the model.

5.5 Assessment

We assess our parameterization by comparing some key model statistics that were not calibration targets with the data. Here we document the model's implications for the share of wealth held by retirees, Medicaid recipiency rates, OOP medical expenses and impoverishment transitions. Section 5 of the Online Appendix contains additional model assessment

[30] According to the Social Security Administration, average earnings for full-time, prime-age, male workers was $47,552 in the year 2000.

[31] There are alternative types of Medicaid beneficiaries. Our choices of the income and asset thresholds ensure that the following groups qualify under the categorically needy criterion: individuals who receive SSI transfers, qualified Medicare beneficiaries, specified low-income beneficiaries and qualified income beneficiaries. See our data source: the Kaiser Commission on Medicaid and the Uninsured, "Medicaid Financial Eligibility: Primary Pathways for the Elderly and People with Disabilities," (February, 2010) for more details.

[32] See Kopecky and Koreshkova (2014) for a discussion of the literature on consumption floors.

[33] Given the variation in OOP expenses across the two paths to MTSI one might be concerned that we are overstating copayments by the poor (categorically needy). However, as Figure 5 shows the model understates OOP expenses of this group.

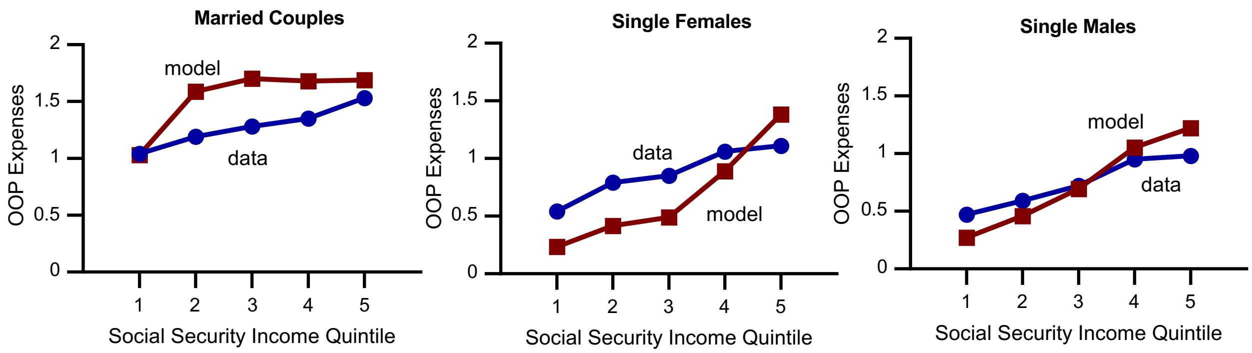

Figure 5: Out-of-pocket medical expenses of married couples (left panel), single females (middle panel) and single males (right panel) relative to mean OOP expenses of all households by SS income quintile in the model (red squares) and the data (blue circles).

results. To summarize these results, we find that the model does a reasonable job reproducing a range of statistics from U.S. data, and thus is a good platform for studying the welfare-enhancing role of MTSI.

In our model, individuals accumulate precautionary savings and hold on to their wealth late in life to self-insure against old-age risks. Is the share of wealth held by retirees in the model reasonable? In U.S. data the share of wealth held by individuals 65+ ranges from 0.25 to 0.33.[34] The share in our baseline model at 0.25 lies in the low end of this interval. Given that we have not modeled all risks faced by retirees nor bequest motives, the fact that we are on the low end is not surprising.

Medicaid recipiency rates by age were not calibration targets and thus are another way to assess the model's performance. The last three columns of Table 6 compare Medicaid recipiency rates by age for the three household types in the model and the data. The model does a good job of reproducing recipiency rates for each age group. The worst fit is for 85+ widowers. However, the number of individuals in this situation is very low in our HRS sample.

Figure 5 reports OOP medical expenses of households in the data and the model by marital status and SS income quintile. De Nardi et al. (2010) show that OOP medical expenses of single individuals are increasing by permanent income quintile.[35] Consistent with these findings, Figure 5 shows that households' OOP expenses increase with SS income in the data. Observe that OOP expenses also increase with SS income in the model. The primary reason for this is that, as income increases, the fraction of medical expenses covered

[34]These numbers are taken from Kopecky and Koreshkova (2014).

[35]De Nardi et al. (2010) use annuitized income to proxy for permanent income. Constructing annuitized income for households is subtle. So we use SS income instead. It is the largest component of annuitized income and we can observe it at the household level in both the model and the data.

Table 7: Conditional transitions into, and persistence of, low wealth

	Model			Data		
Cohort	65–74	75–84	85+	65–74	75–84	85+
Marital Status (Women)						
married	3.57	9.05	9.63	5.49	5.76	10.64
widow	8.58	7.11	10.01	8.01	7.59	12.11
Health Status						
good	4.23	6.42	7.89	5.06	5.16	7.76
bad	4.90	7.01	8.72	7.94	8.68	10.78
Nursing Home						
no NH stay	4.35	6.21	6.12	5.79	5.67	7.16
NH stay	7.57	17.22	27.86	23.19	18.64	18.49
Marital Status (Women)						
married	68.4	51.2	63.2	72.5	69.6	80.2
widow	76.6	73.4	60.7	80.0	75.9	76.1
Health Status						
good	81.4	73.1	68.4	69.7	70.8	67.8
bad	85.3	75.3	65.2	80.9	79.3	73.1
Nursing Home						
no NH stay	82.2	71.9	58.9	75.8	74.4	67.5
NH stay	97.6	99.9	99.2	90.7	85.2	80.2

The upper (lower) panel numbers are the percentage of individuals in wealth quintiles 2–5 who move to (stay in) quintile 1 two years later conditional on their status. Wealth quintiles are determined from an individual wealth distribution specific to each age group. Married individuals are assigned half of the household wealth.

by Medicaid falls.

Table 7 shows that our model reproduces the differentials in downward mobility discussed in Section 2. The upper panel of this table reports conditional transitions into the lowest wealth state, and the lower panel reports the persistence of the low wealth state over a period of two years. Singles have a higher incidence of transitions to the lowest wealth state as compared to married individuals. Poor health status and nursing home expenses also increase the likelihood of a low wealth outcome. The model also reproduces the magnitudes of the persistence of the bottom wealth quintile by marital and health status but overstates the magnitudes by nursing home status. This is due to our assumption that nursing home residents can only qualify for MTSI via the medically needy path.[36]

[36] In Section 8 of the Online Appendix, we show that if nursing home residents can qualify for MTSI via either path the model understates the magnitudes by nursing home status though our welfare results are essentially unchanged.

6 Welfare Analysis

We now document the welfare effects of MTSI in our quantitative model. The analysis of the two-period model in Section 3 demonstrates that MTSI can improve welfare by insuring medical expense, life expectancy and lifetime earnings risks. However, the welfare benefits depend on the pattern of endowments, the extent of the risks and the specification of the means tests. Our quantitative model has a rich specification of these primitives and captures many features of the U.S. economy. We are now in a position to ascertain whether the welfare-enhancing effects of MTSI documented in our stylized two-period model are empirically relevant.

6.1 The Value of Means-Tested Social Insurance for Retirees

Table 8 reports the welfare effects from removing MTSI in our baseline economy and two other versions of our quantitative model. The 'no medical expenses' economy has no medical expenses whereas the 'no earnings risk' economy has no idiosyncratic shocks to earnings. The latter two scenarios, which are designed to ascertain the role of these two factors, are not recalibrated and the government budget constraint is closed by adjusting government purchases. Welfare effects of removing MTSI are computed by comparing welfare of newborn households across steady states. Welfare is measured as an equivalent consumption variation — a constant percentage change in consumption of each household in every period of its life that makes the household indifferent between the economy with MTSI and an alternative economy with no MTSI. The top rows of Table 8 display ex-ante welfare of newborn households before education is known, welfare of newborn households after educational status but before initial earnings is known, and ex-post welfare by male permanent earnings quintiles.[37] The bottom two rows of the table report recipiency rates of MTSI by retirees in each economy when this insurance is provided and the size of the associated government transfers expressed as a percentage of output.

To remove MTSI we set the consumption floors for all types of households to 0.001% of average prime-age male earnings or about $0.50 per year. When reducing the scale of MTSI to this level the asset thresholds are held fixed and the income thresholds are adjusted down proportionately. We use the same level of the consumption floor in all 'no MTSI' economies we consider and subsequently refer to it as the 'no MTSI' consumption floor.[38]

[37] We use permanent earnings of males aged 21 to 55 because they are exogenous. This makes it possible to compare the same households across economies.

[38] We could also set the 'no MTSI' consumption floor to zero and the welfare results for the baseline economy would not change. Our 'no MTSI' consumption floor is so low that virtually nobody is on it in the

Table 8: Welfare effects of removing MTSI from three economies

Economy	Baseline	No Medical Expenses	No Earnings Risk
Welfare			
Ex-ante	-4.31	0.40	2.85
By HH education type (female, male):			
high school, high school	-5.36	0.26	2.99
high school, college	-2.27	0.72	1.73
college, high school	-1.74	0.62	4.91
college, college	0	0.93	2.31
By male permanent earnings:			
quintile 1	-7.02	0.04	2.99
quintile 2	-4.93	0.30	2.99
quintile 3	-3.89	0.45	2.99
quintile 4	-2.95	0.58	2.95
quintile 5	-1.21	0.83	2.11
Initial levels of MTSI			
recipiency rates, %	13.1	8.1	1.0
outlays, % of GNP	1.02	0.41	0.12

The welfare effects of removing MTSI from the baseline (first column), an economy with no medical expenses (second column) and an economy in which each household faces the average earnings profile conditional on its education type (third column). Welfare is measured as the percentage change in consumption in every period of life that makes a household indifferent between the reference economy with MTSI and the economy with no MTSI. The bottom two rows show the recipiency rates and total outlays to retirees of MTSI in each reference economy before MTSI is removed.

In comparison, Hubbard et al. (1995) set their 'no MTSI' consumption floor to \$1 per year with a relative risk aversion coefficient of 3. Recall that we assume agents are less risk averse by setting the relative risk aversion coefficient to 2. In our 'no MTSI' version of the baseline economy, only 0.07% of all retirees and less than 1% of those aged 90+ are on the floor. To satisfy government budget constraints when removing MTSI, we hold the ratio of government purchases to GDP fixed and adjust the proportional tax coefficient in the income tax schedule.

The first column of Table 8 shows that MTSI provides valuable insurance against old-age risks in the quantitative model. The fall in ex-ante welfare when MTSI is removed is equivalent to a 4.3% decrease in consumption. Notice next that the insurance benefits of MTSI are broadly based. All newborn households experience welfare losses when welfare

'no MTSI' economy. Setting the floor to zero creates problems solving the model when both MTSI and SS are absent. To avoid these problems, we need to set the 'no MTSI' floor to a positive number. The specific value we use makes households with two college-educated members indifferent between the baseline and the 'no MTSI' economy.

is indexed by permanent earnings quintile. This result may be surprising given that the high permanent earnings types preferred no MTSI in our two-period model. The insurance benefits of MTSI are so strong here that they overwhelm the higher income taxes that households in quintile 5 are paying to subsidize the consumption and medical expenses of poor retirees. If welfare is indexed by educational attainment instead, all but the household with college-educated females and males benefit from MTSI. This final group is indifferent between the current scale of MTSI and the 'no MTSI' floor.

Removing MTSI leads households to provision for their retirement by saving more and on aggregate working more. The first two columns of Table 9 display output (GNP), private consumption net of medical expenses, private wealth and various labor market indicators in the baseline economy and the baseline economy with no MTSI. Removing MTSI increases economic activity but also exposes households to more risk during retirement. With less insurance, households save more and aggregate wealth goes up by 45%. Aggregate labor input also goes up, albeit slightly, from 1.00 to 1.002. The small increase in labor input may be surprising because social insurance programs for workers, such as unemployment insurance and workers' compensation, are known to have significant negative incentive effects on labor supply, as described in the survey Krueger and Meyer (2002). However, our result is consistent with other research cited in their survey that finds that social insurance *for retirees* has much smaller effects on labor supply of working-age individuals.

Interestingly, the increase in aggregate labor when MTSI is removed is due to a rise in female labor input; male labor input actually declines. The decline in male labor is due to a positive wealth effect because income taxes fall. Females, in contrast, compensate for the loss of social insurance by working more. Working-age females have lower earnings on average but face less earnings risk than males. Thus having females work more helps to insure the household against the higher level of old-age risk it now faces. The insurance benefit of higher female earnings is particularly valuable to poorer households absent MTSI. Not surprisingly, we find that the increases in female participation and hours reported in Table 9 are concentrated among the poorest households. Labor supply of females in more affluent households does not change or falls slightly.

Columns 2 and 3 of Table 8 provide welfare results for two counterfactuals that are designed to help understand why the welfare gains from removing MTSI are so large and broadly based. In order to provide a common reference point, we use the same 'no MTSI' consumption floor values as before when removing MTSI in each counterfactual. Column 2 shows that medical expenses significantly increase the benefits of MTSI. In an economy with no medical expenses, all households, indexed either by permanent earnings quintile or education status, actually prefer the 'no MTSI' floors to those provided by MTSI. The

Table 9: Aggregate variables in the baseline, the baseline without MTSI and the baseline without SS

	Baseline	No MTSI	No SS
Output	1.00	1.07	1.07
Consumption	0.67	0.73	0.73
Wealth	2.78	4.03	4.21
Tax Revenue Relative to Output	0.20	0.17	0.13
Aggregate Labor input	1.00	1.00	0.98
Older Male Labor-Force Part.	0.71	0.68	0.68
Female Labor-Force Part.	0.50	0.53	0.47
Working Females' Hours	0.33	0.35	0.32

Results are reported for the baseline economy, baseline economy without MTSI (consumption floors at $0.50 per year) and baseline economy with no SS. All flows are annualized. The measure of output is GNP.

intuition for this result was discussed in Section 3, where we illustrated that MTSI transfers are state-contingent, offering large payouts when medical expenses are large. We also demonstrated that the need for insurance is larger when both medical expenses and earnings risk are present because these risks are correlated.

The welfare benefits of MTSI are larger when medical expenses are present, even though the saving and tax distortions described in Section 3 are also most pronounced in this setting. First, when MTSI is present in the baseline, a larger percentage of poorer households choose not to save and to rely on MTSI when they retire. As a result, in the baseline economy 10.9% of individuals start receiving means-tested benefits when they retire at age 65. In the economy with no medical expenses, this fraction falls to about 7%. Second, income taxes are higher in the baseline since MTSI transfers are 1.02% of output in this economy but only 0.41% in the 'no medical expenses' economy.

Column 3 shows that lifetime earnings risk has an even bigger effect on the value of MTSI. If MTSI is removed from the economy without this risk, ex-ante welfare increases by 2.85%. This result may seem surprising given that the MTSI recipiency rate is only 1.0% in the 'no earnings risk' economy. Without earnings risk, all households are reasonably affluent and have significant SS income, which prevents them from qualifying for MTSI via the categorically needy path. Moreover, only households that survive to at least age 75 experience medical expense shocks that are large enough for them to qualify for MTSI via the medically needy path. However, MTSI still provides substantial insurance to older retirees when earnings risk is absent. Recipiency rates for those 90 and older are 24% and removing MTSI from this economy results in a 43% increase in private savings. By comparison, savings only increases by 6% when MTSI is removed from the 'no medical expenses' economy. In the 'no medical expenses' economy MTSI provides insurance against low lifetime earnings

Table 10: Welfare and fiscal effects of changes in MTSI

Consumption Floors	30% up	30% up	no change	30% up	30% down
Income Thresholds	30% up	no change	30% up	30% up	30% down
Tax Adjusted	Payroll	Payroll	Payroll	Income	Income
Welfare					
Ex-ante	0.32	0.16	0.17	-0.77	0.25
By HH education type (female, male):					
high school, high school	0.35	0.18	0.19	-0.61	-0.06
high school, college	0.23	0.11	0.12	-1.17	0.69
college, high school	0.37	0.16	0.21	-0.92	0.50
college, college	0.22	0.10	0.12	-1.40	0.94
Final levels of MTSI					
recipiency rates, %	21.7	15.7	16.5	22.0	6.32
outlays, % of GNP	1.82	1.15	1.44	1.87	0.40

The columns show the welfare and fiscal effects of changing both or one of the MTSI consumption floors and income thresholds by 30% financed by the indicated tax. The bottom two rows show the levels of the recipiency rates and government outlays for MTSI in the economy after MTSI is changed.

and longevity risk but these risks are relatively small because, absent MTSI, those with low lifetime earnings or a long life still receive SS benefits which bound their consumption away from zero. In the 'no earnings risk' economy, in contrast, individuals face the risk of zero consumption late in life when MTSI is absent. They respond to this risk by holding more wealth in old age. This large increase in aggregate savings puts upward pressure on government tax revenue which, in turn, results in a lower average income tax rate. Moreover, holding savings at old ages is not particularly costly because households see death one period in advance and consume all of their wealth in the final period of life.

To summarize, MTSI insures against lifetime earnings risk and medical expense risk and this insurance is welfare-improving when both risks are present. Our results also indicate that there is an overlap between the benefits provided by MTSI and SS. We will discuss these interactions in more detail in Section 6.4.

6.2 Reforming Means-Tested Social Insurance for Retirees

Removing MTSI entirely is an informative counterfactual because it measures the overall value of these programs. Given that the overall value is positive, it is worthwhile to explore whether the current scale of these programs is too big or too small. Table 10 reports welfare changes based on comparing the baseline economy to alternative economies in which MTSI consumption floors and/or income thresholds are either 30% higher or 30% lower.[39] We report ex-ante utility and utility by educational type.

The most interesting result in this table is that the welfare of all newborn households increases if MTSI is expanded either by increasing the consumption floors, the income thresholds or both, as long as it is financed with a payroll tax. This point is illustrated in columns 1–3. Ex-ante welfare is largest when the floors and thresholds are both increased and the effects of increasing each individually roughly add up. Since educational status is the only source of initial heterogeneity, these results imply that all newborn households would prefer to be born into the economy with higher means-tested benefits and higher payroll taxes even after they know their educational type. It follows that if this policy was implemented along a transition, welfare of both newborn households and current retirees would increase.[40] As a result, in our open economy, the only potential compensations during the transition would go to middle-aged workers, and these are likely to be small given that both the young and old like this policy.

Welfare falls, however, if the same expansion of MTSI is financed by higher income taxes instead. Ex-ante welfare of a newborn household declines by 0.77% and all educational types are worse off. The main reasons for this difference are that the payroll tax is proportional and only applies to labor income, while the income tax is progressive and applies to both labor and capital income. As a result, an expansion of MTSI financed by the income tax induces a larger negative wealth effect, which generates a larger reduction in savings, an *increase* in male labor supply and a slightly larger increase in MTSI recipiency rates.

Our finding that households don't want to increase MTSI if it is financed with a higher income tax raises the question of whether they would prefer a smaller MTSI program and lower income taxes. The final column of Table 10 reveals that ex-ante utility is in fact 0.25% higher when MTSI is reduced by 30%. But, there is disagreement among newborn households. Households with two high school educated members are worse off. However, their loss is smaller than the combined gain of the other types.

[39] We do not report results where we vary the asset thresholds or copays because we found that they have significantly smaller effects on welfare for reforms of this scale. We also do not compute the optimal scale of MTSI because the computing costs are prohibitive.

[40] Retirees' welfare would increase because they would enjoy higher benefits and their taxes would not change.

6.3 The Value of Social Security

As we discussed in the introduction, a large previous literature has found that removing SS increases steady-state welfare.[41] Our model is different from those used in the previous literature in that we model medical expenses and MTSI. This raises the question of whether SS is valued in our economy.

Columns 1 and 2 of Table 11 document the welfare effects of removing SS from our baseline economy and from an economy with no MTSI. Removing SS has large positive welfare effects whether MTSI is present or not. When SS is removed from the baseline economy, ex-ante welfare of a newborn household increases by 12.2%.[42] The welfare gains from removing SS are due to several factors. First, SS is a pay-as-you-go system and it is well known that the effective real return on SS contributions is lower than the return on capital in dynamically efficient economies such as ours. Second, SS is a much larger program than MTSI and financing it requires higher distortionary taxes. Third, many of the benefits provided by SS overlap with benefits that are provided by MTSI. When SS is removed from an economy with no MTSI, ex-ante welfare increases by only 2.6%.[43]

6.4 The Interactions of Means-Tested Social Insurance and Social Security

Is MTSI even more valuable when SS is absent? Our previous results suggest that this may be the case. SS benefits overlap with those offered by MTSI. However, these considerations need to be balanced against the negative incentive effects that MTSI has on saving. In Section 3, we found that MTSI severely distorts the saving incentives of poorer households who choose to consume all of their income when young and to rely on MTSI during their retirement. SS is a form of forced savings that mitigates this negative incentive effect. It is thus interesting to see whether the presence of SS increases or decreases the welfare effects

[41]These results raise questions about why the U.S. and many other countries have pay-as-you-go public pension programs. Conesa and Krueger (1999) and Nishiyama and Smetters (2007) find that scaling down or removing SS creates welfare costs during the transition that exceed the long-run welfare benefits of reducing its size. However, Conesa and Garriga (2008) and McGrattan and Prescott (2015) describe welfare-enhancing ways to transition from a pay-as-you-go to a fully-funded pension system. Their schemes include other concurrent fiscal policy reforms. Conesa and Garriga (2008) compensate the initial old by issuing government debt and McGrattan and Prescott (2015) reduce the tax rate on capital income of retirees.

[42]Changes in aggregate variables when SS is removed are standard and can be seen by comparing the first and third columns of Table 9.

[43]The welfare cost of removing SS in the economy with no MTSI, though positive, is small in our model as compared to, e.g., Hong and Ríos-Rull (2007) who consider a similar economy. They report about a 12% welfare gain from removing SS. An important distinction between our analysis and theirs is that we model medical expenses and their associated risks. When medical expenses are absent the welfare gain from removing SS increases to 10.8%.

Table 11: A comparison of the welfare effects of removing SS with the welfare effects of removing MTSI

	Removing SS		Removing MTSI	
Economy	Baseline	No MTSI	Baseline	No SS
Welfare				
Ex-ante	12.2	2.6	-4.3	-13.9
By HH education type (female, male):				
high school, high school	12.5	1.6	-5.4	-16.3
high school, college	11.3	4.7	-2.3	-8.8
college, high school	12.1	4.8	-1.7	-9.0
college, college	11.0	7.2	0	-3.8
Initial (final) levels of MTSI				
recipiency rates, %	13.1 (38.8)	0.00	13.1	38.8
outlays, % of GNP	1.02 (3.49)	0.00	1.02	3.49

The first two columns show the percentage change in welfare when SS is removed from the baseline economy and the economy with no MTSI. The second two columns show the welfare change when MTSI is removed from the baseline and the economy with no SS. The last two rows show the MTSI recipiency rates and outlays for retirees in the initial economies. Numbers in parenthesis are the levels after removal of SS. After removal of MTSI all levels are essentially zero.

of MTSI.

The final two columns of Table 11 report the welfare effects of removing MTSI from two economies. Column 3 removes MTSI from the baseline economy and was previously reported in Table 8. Column 4 removes MTSI in an economy with no SS. Comparing across these two economies shows that the benefits of MTSI are even larger when SS is absent. Reducing MTSI to the 'no MTSI' consumption floor results in an ex-ante welfare loss of 13.9% of consumption absent SS. This is more than double the decline in welfare that occurs when MTSI is removed from the baseline economy.

Given that all agents prefer the economy with MTSI but no SS, it is of interest to consider in more detail how the properties of the model change when SS is removed. Removing SS increases MTSI recipiency rates from 13.1% to 38.8%. This large increase in recipiency rates can be decomposed into two effects. First, there is an incentive effect. Mandatory SS contributions are a form of forced savings for poorer households. They would choose not to save if SS was absent, as we discussed in Section 3. When these households reach retirement, their SS income is too high for them to qualify for MTSI. As a result, these households save more when SS is present and rely on MTSI less. Second, there is an insurance effect. Some of the insurance against survival, lifetime earnings and medical expense risks that was provided by SS is now provided by MTSI.

Both effects can be seen in Figure 6 which displays the increase in MTSI recipiency rates

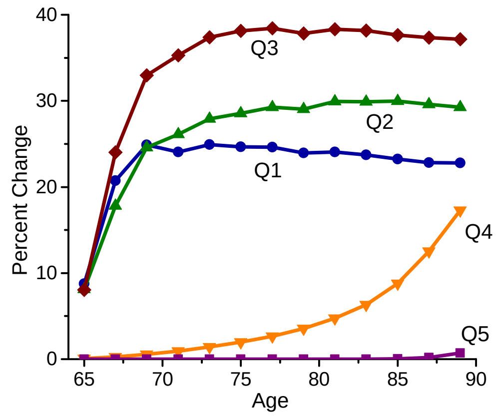

Figure 6: The percentage increase in MTSI recipiency rates of retirees when SS is removed from the baseline economy. The change in the recipiency rates is shown by age and male permanent earnings quintile. The percentage increase is calculated by subtracting the recipiency rates in the baseline economy from those in the economy with MTSI only.

by age for each male permanent earnings quintile when SS is removed. The negative incentive effect can be measured by the change in the fraction of households who choose to roll into MTSI at or shortly after retirement. This percentage increases by about 10% at age 65 for permanent earnings quintiles 1–3 and rises quickly during the first 5 years of retirement as these households exhaust their savings and qualify for MTSI. The insurance effect can be inferred from the change in the pattern of MTSI enrollment by age for quintiles 4 and 5. Recipiency rates don't change for these two quintiles until age 70. Thereafter they start to rise, reaching nearly 20% at age 90 for those in quintile 4.

The increase in MTSI recipiency rates when SS is removed is accompanied by an increase in MTSI outlays but, surprisingly, a decrease in tax revenues as can be seen in Table 9. Wealth in the economy without SS is so much higher that the government can both finance the increase in MTSI outlays and decrease tax rates at the same time.

Our finding that the MTSI recipiency rate for retirees increases by 25.7% when SS is removed is due to the presence of both medical expenses and earnings risk. Essentially, the large increase only occurs if there are both poor retirees and significant shocks after retirement. In particular, if we consider an economy with no medical expenses, recipiency rates only increase by 18.1% when SS is removed. If instead we consider an economy with no earnings risk, recipiency rates increase by 8.7% when SS is removed.[44]

[44] Our result that welfare is much higher in the economy with MTSI only is very robust to other details of the model: anticipated death, open economy, and/or general equilibrium. As long as lifetime earnings risk and medical expenses are present, utility of newborn households is higher when MTSI is the only form of social insurance available to retirees.

6.5 Robustness

Have we overstated the welfare-enhancing effects of U.S. MTSI programs for retirees? We now consider the robustness of our results to the setting of the 'no MTSI' consumption floors and income thresholds, the incidence of the low earnings shock, and the assumption that those experiencing the nursing home shock can only qualify for MTSI via the medically needy path. Results are reported in Section 8 of the Online Appendix. Here we briefly summarize them. Ex-ante households value MTSI even if the 'no MTSI' consumption floors and income thresholds are 1000 times larger or about \$476 year. They also continue to value MTSI if only high-school-educated males are subject to the low earnings shock. If households experiencing a nursing home shock can qualify for MTSI under both the categorically-needy and medically-needy paths, the model understates the persistence of the lowest wealth quintile conditional on a nursing home event, and yet the costs of removing MTSI are virtually the same as in our baseline specification.

There is a reason to believe that our estimates of the value of MTSI may be too conservative. The average Frisch labor supply elasticity for females in our model is 2.4. If we reduce it to about 1, which is more consistent with micro estimates, the welfare loss from removing MTSI increases from 4.3% to 5.3%. Also, we have assumed that medical expenses are not growing. Since 1980 health expenses as a fraction of GDP have doubled.[45] If we were to model this observation, the welfare benefits of MTSI would be even larger.

Our conclusions are premised on a model that abstracts from private insurance markets for the risk of being born into a particular type of household, experiencing low lifetime earnings, high medical expenses after retirement or a long life. For some of these risks, such as lifetime earnings risk, the extent of private insurance markets is very small and the coverage is incomplete.[46] For other risks, such as long-term care and life insurance, private insurance products exist but appear to be imperfect. It is doubtless the case that if these markets were modeled and no social insurance was available, demand for products such as life insurance and long-term care insurance would increase. However, it is our view that the increase in take-up rates in these markets would be small. Brown and Finkelstein (2008) show that Medicaid may crowd out the demand for private long-term care insurance. However, Hendren (2013) finds that rejection rates in nongroup life, disability and long-term care insurance markets are high. He argues that an important reason for this is asymmetric information. Namely, individuals have superior information about their health status as

[45] See OECD Health Data.

[46] The only private market we know of that offers even partial coverage against lifetime earnings risk is private disability insurance. Only 3% of nongovernment workers directly participate in this market and only 30% participate indirectly through their employer (see Hendren (2013)).

compared to issuers, and this information is significant as it can have a very large impact on payouts and thus pricing. Adverse selection limits the functioning of these markets in several ways. Insurers deny coverage to individuals who have observable characteristics that predispose them to these risks. Other individuals who know they have low risk will choose not to purchase insurance. Moreover, some poor individuals will not be able to afford private insurance even if they want it. Absent a government mandate or other types of regulation, it is likely that many individuals will end up old, sick, alone, poor and uninsured.

7 Conclusion

One of the central objectives of public policy is to provide for those who are sick and do not have the financial means to cover their medical and living expenses. For the aged, this risk is significant and can be compounded by a spousal death event, leaving the retiree not only sick and poor but also alone. We have shown that U.S. means-tested social insurance programs are highly valued when these risks are recognized. In fact, the current scale of these programs may be too small. We have found that there would be general agreement among households to increase the scale of current U.S. means-tested social insurance programs by 1/3 if that increase was financed with a higher payroll tax.

8 Appendix

8.1 Additional tables

Table 12: Summary of model notation

$i \in \{m, f\}$	gender {male, female}
j	age
$\mathbf{s} \equiv (s^m, s^f)$	education type {high school, college}
$d \in \{0, 1, 2\}$	marital status {married, widow, widower}
$\bar{\mathbf{e}} \equiv (\bar{e}^m, \bar{e}^f)$	average earnings (male, female)
$\boldsymbol{\varepsilon_e} \equiv (\varepsilon_e^m, \varepsilon_e^f)$	earning shocks (male, female)
$\mathbf{h} \equiv (h^m, h^f)$	health status (male, female)
$\boldsymbol{\varepsilon_M} \equiv (\varepsilon_m^p, \varepsilon_m^t)$	medical expense shocks (persistent, transient)

A summary of the most frequently used model notation.

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Online Appendix

Old, Sick, Alone and Poor: A Welfare Analysis of Old-Age Social Insurance Programs

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This Appendix is not intended for publication but is to be made available to readers on the Journal's webpage.

1 Our HRS Sample and Wealth Transitions

The principal data set used in this paper is the 1995–2010 waves of HRS and AHEAD and includes retired individuals aged 65 and above who are single or married to retired spouses. Our sample is essentially the same as that of Kopecky and Koreshkova (2014) and we refer the interested reader to that paper for more specifics on the construction of the sample. We define healthy individuals to be those who self-report their health status to be excellent, very good or good.

1.1 Wealth Transition Computations

We use the wealth variable ATOTN which is reported at the household level in the HRS. This wealth measure is the sum of the value of owned real estate (excluding primary residence), vehicles, businesses, IRA/Keogh accounts, stocks, bonds, checking/savings accounts, CDs, treasury bills and "other savings and assets," less any debt reported. To carry out an analysis of individuals, wealth is divided by two for married couples (and is left as is for single people). Additionally, irregular patterns in the dataset are fixed to eliminate spurious wealth transitions. For example, if a person has wealth > 0 in period 1, wealth $= 0$ in period 2, and wealth > 0 in period 3, the wealth in period 2 is replaced by the average of the wealth in period 1 and period 3. These patterns are present in less than 1 percent of the total number of observations. Finally, wealth is censored at -\$500 (if -\$500 $<$ wealth < 0) and at \$500 (if $0 \leq$ wealth $<$ \$500) to avoid problems of dividing by 0 or very small numbers when calculating percent changes in wealth from period to period. Wealth is reported in real terms. This is accomplished by deflating reported nominal wealth using the CPI.

For the unconditional wealth transitions, we omit most imputations of wealth performed by RAND. In particular, we only include observations where there is no imputation or wealth lies in a reported range. For the conditional wealth transitions, the resulting samples are too small if we omit the wealth imputations performed by RAND so we include all of their imputed wealth data. Their imputations of wealth only use a households current characteristics. As a result, we are concerned that some of these imputations create spurious wealth transitions. These effects are partially controlled for by the interpolation scheme we described above. To further control for these effects, we trim the top and bottom 1% of wealth transitions in each two year interval. The omitted observations do not appear to be clustered in any systematic way.

Table 1: Percentage of retired women moving from each quintile of the wealth distribution to quintile 1 two years later by marital status

	65–74 Year-olds		75–84 Year-olds		85+ Year-olds	
Quintile	**Married**	**Widowed**	**Married**	**Widowed**	**Married**	**Widowed**
1	72.5	80.0	69.6	75.9	80.2	76.1
2	17.3	22.9	17.2	20.6	28.1	28.0
3	3.4	6.5	4.4	6.9	8.1	11.5
4	1.0	1.6	1.1	2.4	3.7	6.2
5	0.4	1.1	0.3	0.5	2.6	2.8

The percentage of women moving down to quintile 1 from quintiles 2–5 in a 2-year period by marital status in the initial period. The first row is the percentage of women who stay in quintile 1. Source: Authors' computations using our HRS sample.

1.2 Additional Wealth Transitions

Table 1 has three noteworthy properties. Observe first that impoverishment increases with age among both married and widowed women. This point is clearest if one compares women aged 65-74 with those aged 85+. The probability of a transition into wealth quintile 1 is higher for those starting in each of quintiles 2-5 for women who are 85 or older. This regularity is equally apparent among married and widowed women and can also be seen if one compares women aged 75-84 with those aged 85+ instead. A second interesting property of Table 1 is that a higher percentage of widows transit to quintile 1 from each other wealth quintile as compared to married women. This pattern is robust across wealth quintiles and also across age with one exception. For 85+ year old women in the second wealth quintile, the percentage experiencing transitions to quintile 1 is about the same for married women and widows. The third property is that low wealth is more persistent for widows than married women aged 65–74 and 75–84. The percentage of quintile 1 to quintile 1 transitions for married women and widows is respectively 73% and 80% for women aged 65–74 and 70% for married versus 76% for widows in the 75–84 age group.

Table 2 reports wealth mobility transitions to the first wealth quintile for married men and widowers. Observe that the results for older men are similar to those for older women. Men aged 85+ also exhibit higher transitions into quintile 1 than men aged 65-74. However, this only occurs for those starting in wealth quintiles 3-5. Widowers have higher probabilities of impoverishment as compared to married men and the lowest wealth state is more persistent for widowers.

Poor health is also associated with higher flows into the lowest wealth quintile as Table 3 shows. Some of the differences are small, but we find it remarkable that the pattern is

Table 2: Percentage of retired men moving from each quintile of the wealth distribution to quintile 1 two years later by marital status

	65–74 Year-olds		75–84 Year-olds		85+ Year-olds	
Quintile	**Married**	**Widowed**	**Married**	**Widowed**	**Married**	**Widowed**
1	74.5	75.7	73.9	79.0	70.7	73.9
2	18.3	24.1	17.4	18.8	15.0	19.2
3	3.9	12.2	3.5	9.6	4.6	8.1
4	1.3	3.5	2.0	2.0	4.1	4.3
5	0.7	1.7	0.9	1.8	0.0	4.0

The percentage of men moving down to quintile 1 from quintiles 2–5 in a 2-year period by marital status in the initial period. The first row is the percentage of men who stay in quintile 1. Source: Authors' computations using our HRS sample.

Table 3: Percentage of retired individuals moving from each quintile of the wealth distribution to quintile 1 two years later by health status

	65–74 Year-olds		75–84 Year-olds		85+ Year-olds	
Quintile	**Healthy**	**Unhealthy**	**Healthy**	**Unhealthy**	**Healthy**	**Unhealthy**
1	69.7	80.9	70.8	79.3	67.8	73.1
2	15.6	22.6	15.1	22.1	17.7	27.5
3	3.4	5.5	3.8	7.2	7.8	8.2
4	0.9	2.2	1.3	4.1	4.1	4.7
5	0.4	1.5	0.5	1.3	1.4	2.8

The percentage of individuals moving down to quintile 1 from quintiles 2–5 in a 2-year period by health status in the initial period. The first row is the percentage of individuals who stay in quintile 1. Source: Authors' computations using our HRS sample.

consistent across quintiles and all three age groups. A report of poor health is also associated with higher persistence of low wealth. The difference is largest for the 65–74 age group and narrows a bit as individuals age.

Table 4 reports wealth mobility transitions to the first wealth quintile conditional on whether or not individuals experience a nursing home stay and Table 5 reports the transitions conditional on whether or not they experience a hospital stay. Both nursing home and hospital stays are associated with an increased frequency of transitions to quintile 1. Hospital stays have a smaller impact compared to nursing home stays but the impoverishing effect of a hospital stay is clearly discernible in Table 5. Given that acute medical expenses are transient in nature, it is not surprising at all to see a weaker pattern of impoverishment for hospital stays than nursing home stays.

Table 4: Percentage of retired individuals moving from each quintile of the wealth distribution to quintile 1 two years later conditional on having a nursing home (NH) stay

	65–74 Year-olds		75–84 Year-olds		85+ Year-olds	
Quintile	**None**	**NH Stay**	**None**	**NH Stay**	**None**	**NH Stay**
1	74.4	85.2	67.5	80.2	74.3	87.4
2	16.5	37.2	18.5	37.3	17.4	39.4
3	4.1	18.4	6.2	17.6	4.1	25.0
4	1.6	15.8	3.0	11.7	14.4	15.3
5	0.6	2.0	0.9	7.3	0.6	3.9

The percentage of individuals moving down to quintile 1 from quintiles 2–5 in a 2-year period conditional on spending at least 90 days in a nursing home during that period. The first row is the percentage of individuals who stay in quintile 1. Source: Authors' computations using our HRS sample.

Table 5: Percentage of retired individuals moving from each quintile of the wealth distribution to quintile 1 two years later conditional on whether or not they stayed overnight in a hospital

	65–74 Year-olds		75–84 Year-olds		85+ Year-olds	
Quintile	**None**	**Hospital Stay**	**None**	**Hospital Stay**	**None**	**Hospital Stay**
1	75.1	78.3	73.8	77.3	70.7	71.8
2	17.9	18.8	16.4	18.8	19.7	24.3
3	3.4	5.1	4.3	5.5	6.6	9.6
4	1.0	1.3	1.4	3.0	3.1	5.4
5	0.5	0.7	0.5	0.9	2.0	1.7

The percentage of individuals moving down to quintile 1 from quintiles 2–5 in a 2-year period conditional on an overnight hospital stay during the 2-year period. The first row is the percentage of individuals who stay in quintile 1. Source: Authors' computations using our HRS sample.

2 Additional Details on the Two-Period Model

The government budget constraint is

$$(1+r)\left[\theta y_h + (1-\theta)y_l\right]\tau = \gamma\Big\{\phi\left[\theta TR_h^b + (1-\theta)TR_l^b\right] + (1-\phi)\left[\theta TR_h^g + (1-\theta)TR_l^g\right]\Big\},$$

where TR_i^j are transfers to individuals of type $i \in \{h,l\}$ who are in state $j \in \{b,g\}$. We assume that accidental bequests are taxed and consumed by the government. This assumption is made because we want to omit the potentially large redistributional consequences of giving the bequests to survivors. Thus government consumption g is given by

$$g = (1-\gamma)(1+r)(\theta a_h + (1-\theta)a_l),$$

where a_i is the savings of agents of type i where $i \in \{h,l\}$. The aggregate resource constraint is

$$\begin{gathered}\theta c_h^y + (1-\theta)c_l^y + \gamma\left[\phi(\theta c_h^b + (1-\theta)c_l^b) + (1-\phi)\left(\theta c_h^g + (1-\theta)c_l^g\right) + \phi m\right] + g = \\ (1+r\tau)(\theta y_h + (1-\theta)y_l) + r(\theta a_h + (1-\theta)a_l),\end{gathered}$$

where c_i^y is the consumption of individuals of type $i \in \{h,l\}$ when young, and c_i^j, $j \in \{b,g\}$, is their consumption when old in each medical expense state.

3 Additional Features of the Model

3.1 Evolution of the population

Let the fraction of households with health and marital status (h^m, h^f, d) at age j be denoted by $\lambda_j(h^m, h^f, d)$ and be determined as follows. First, for $j = 1, 2, 3, \ldots, R$, let $\lambda_j(g,g,0) = 1$, and set it to 0 for all other combinations of h^m, h^f and d. Then set

$$\lambda_{R+1}(h^m, h^f, d) = \sum_{\mathbf{s}} \int_{\bar{e}^m} \Lambda_d(\bar{e}^m)\Lambda_h^m(s^m)\Lambda_h^f(s^f)\iota_R(\bar{e}^m, \mathbf{s})d\bar{e}^m,$$

where $\Lambda_d(\bar{e}^m)$ is the age-65 marital status distribution,$\Lambda_h^i(s^i)$, $i \in \{m,f\}$ are the initial distributions of health status conditional on education for males and females, and $\iota_R(\bar{e}^m, \mathbf{s})$

is the distribution of households across $(\bar{e}^m, \mathbf{s})$ at age R. Finally, set

$$\lambda_j(g,g,0) =$$
$$\lambda_{j-1}(g,g,0)\pi_j(0|g,g,0)\nu_j^m(g,0)\nu_j^f(g,0) + \lambda_{j-1}(b,g,0)\pi_j(0|b,g,0)\nu_j^m(b,0)\nu_j^f(g,0)$$
$$+\lambda_{j-1}(g,b,0)\pi_j(0|g,b,0)\nu_j^m(g,0)\nu_j^f(b,0) + \lambda_{j-1}(b,b,0)\pi_j(0|b,b,0)\nu_j^m(b,0)\nu_j^f(b,0),$$

$$\lambda_j(b,g,0) =$$
$$\lambda_{j-1}(g,g,0)\pi_j(0|g,g,0)\left(1-\nu_j^m(g,0)\right)\nu_j^f(g,0) + \lambda_{j-1}(b,g,0)\pi_j(0|b,g,0)\left(1-\nu_j^m(b,0)\right)\nu_j^f(g,0)$$
$$+\lambda_{j-1}(g,b,0)\pi_j(0|g,b,0)\left(1-\nu_j^m(g,0)\right)\nu_j^f(b,0) + \lambda_{j-1}(b,b,0)\pi_j(0|b,b,0)\left(1-\nu_j^m(b,0)\right)\nu_j^f(b,0),$$

$$\lambda_j(g,b,0) =$$
$$\lambda_{j-1}(g,g,0)\pi_j(0|g,g,0)\nu_j^m(g,0)\left(1-\nu_j^f(g,0)\right) + \lambda_{j-1}(b,g,0)\pi_j(0|b,g,0)\nu_j^m(b,0)\left(1-\nu_j^f(g,0)\right)$$
$$+\lambda_{j-1}(g,b,0)\pi_j(0|g,b,0)\nu_j^m(g,0)\left(1-\nu_j^f(b,0)\right) + \lambda_{j-1}(b,b,0)\pi_j(0|b,b,0)\nu_j^m(b,0)\left(1-\nu_j^f(b,0)\right),$$

$$\lambda_j(b,b,0) =$$
$$\lambda_{j-1}(g,g,0)\pi_j(0|g,g,0)\left(1-\nu_j^m(g,0)\right)\left(1-\nu_j^f(g,0)\right)$$
$$+\lambda_{j-1}(b,g,0)\pi_j(0|b,g,0)\left(1-\nu_j^m(b,0)\right)\left(1-\nu_j^f(g,0)\right)$$
$$+\lambda_{j-1}(g,b,0)\pi_j(0|g,b,0)\left(1-\nu_j^m(g,0)\right)\left(1-\nu_j^f(b,0)\right)$$
$$+\lambda_{j-1}(b,b,0)\pi_j(0|b,b,0)\left(1-\nu_j^m(b,0)\right)\left(1-\nu_j^f(b,0)\right),$$

$$\lambda_j(h^m,b,1) =$$
$$\lambda_{j-1}(g,g,0)\pi_j(1|g,g,0)\left(1-\nu_j^f(g,0)\right) + \lambda_{j-1}(b,g,0)\pi_j(1|b,g,0)\left(1-\nu_j^f(g,0)\right)$$
$$+\lambda_{j-1}(g,b,0)\pi_j(1|g,b,0)\left(1-\nu_j^f(b,0)\right) + \lambda_{j-1}(b,b,0)\pi_j(1|b,b,0)\left(1-\nu_j^f(b,0)\right)$$
$$+\lambda_{j-1}(h^m,b,1)\pi_j^f(b,0)\left(1-\nu_j^f(b,0)\right) + \lambda_{j-1}(h^m,g,1)\pi_j^f(g,0)\left(1-\nu_j^f(g,0)\right),$$

$$
\begin{gathered}
\lambda_j(h^m, g, 1) = \\
\lambda_{j-1}(g,g,0)\pi_j(1|g,g,0)\nu_j^f(g,0) + \lambda_{j-1}(b,g,0)\pi_j(1|b,g,0)\nu_j^f(g,0) \\
+\lambda_{j-1}(g,b,0)\pi_j(1|g,b,0)\nu_j^f(b,0) + \lambda_{j-1}(b,b,0)\pi_j(1|b,b,0)\nu_j^f(b,0) \\
+\lambda_{j-1}(h^m,b,1)\pi_j^f(b,0)\nu_j^f(b,0) + \lambda_{j-1}(h^m,g,1)\pi_j^f(g,0)\nu_j^f(g,0),
\end{gathered}
$$

$$
\begin{gathered}
\lambda_j(b, h^f, 2) = \\
\lambda_{j-1}(g,g,0)\pi_j(2|g,g,0)\left(1-\nu_j^m(g,0)\right) + \lambda_{j-1}(b,g,0)\pi_j(2|b,g,0)\left(1-\nu_j^m(b,0)\right) \\
+\lambda_{j-1}(g,b,0)\pi_j(2|g,b,0)\left(1-\nu_j^m(g,0)\right) + \lambda_{j-1}(b,b,0)\pi_j(2|b,b,0)\left(1-\nu_j^m(b,0)\right) \\
+\lambda_{j-1}(b,h^f,2)\pi_j^m(b,0)\left(1-\nu_j^m(b,0)\right) + \lambda_{j-1}(g,h^f,2)\pi_j^m(g,0)\left(1-\nu_j^m(g,0)\right),
\end{gathered}
$$

and

$$
\begin{gathered}
\lambda_j(g, h^f, 2) = \\
\lambda_{j-1}(g,g,0)\pi_j(2|g,g,0)\nu_j^m(g,0) + \lambda_{j-1}(b,g,0)\pi_j(2|b,g,0)\nu_j^m(b,0) \\
+\lambda_{j-1}(g,b,0)\pi_j(2|g,b,0)\nu_j^m(g,0) + \lambda_{j-1}(b,b,0)\pi_j(2|b,b,0)\nu_j^m(b,0) \\
+\lambda_{j-1}(b,h^f,2)\pi_j^m(b,0)\nu_j^m(b,0) + \lambda_{j-1}(g,h^f,2)\pi_j^m(g,0)\nu_j^m(g,0).
\end{gathered}
$$

It follows that the fraction of households that are age j is given by

$$
\eta_j = \frac{\eta_{j-1}}{1+n} \sum_{h^m} \sum_{h^f} \sum_{d} \lambda_j(h^m, h^f, d), \text{ for } j = 2, 3, ..., J,
$$

where η_1 is set such that

$$
\sum_{j=1}^{J} \eta_j = 1.
$$

3.2 Distribution of Education

We use x_s^i to denote the fraction of individuals of gender $i \in \{m, f\}$ with either high school or college educational attainment $s \in \{hs, col\}$. The distribution of households across education types $\mathbf{s} \equiv (s^m, s^f)$ is $\Gamma_{\mathbf{s}}$.

3.3 Marital Status Transition Probabilities

During retirement, households face uncertainty about their members' health and survival, and household medical expenses. An individual's health status, h^i, takes on one of two values:

good ($h^i = g$) and bad ($h^i = b$). The probability of having good health next period, $\nu_j^i(h, d)$, depends on age, gender, current health status and marital status. The initial distribution of health status, $\Gamma_h^i(s^i)$, depends on education. We denote a household's health status by $\mathbf{h} \equiv (h^m, h^f)$. The probability of an individual surviving to age $j+1$ conditional on surviving to age j is given by $\pi_j^i(h, d)$ and depends on age, gender, health status and marital status. Household marital status changes as individual household members die. Let $\pi_j(d'|\mathbf{h}, d)$ denote the probability of marital status d' at age $j+1$ for an age-j household with health status $\mathbf{h}$ and marital status d. The probabilities are given by

	$d' = 0$	$d' = 1$	$d' = 2$
$d = 0$	$\pi_j^m(h^m, 0)\pi_j^f(h^f, 0)$	$\left[1 - \pi_j^m(h^m, 0)\right] \pi_j^f(h^f, 0)$	$\pi_j^m(h^m, 0)\left[1 - \pi_j^f(h^f, 0)\right]$
$d = 1$	0	$\pi_j^f(h^f, 1)$	0
$d = 2$	0	0	$\pi_j^m(h^m, 2)$

3.4 Medical Expenses Transition Probabilities

Household-level medical and long-term care expenses evolve stochastically according to the function $\Phi(j, \mathbf{h}, \boldsymbol{\varepsilon_M}, d, d')$ that depends on household age j, household health status $\mathbf{h}$, the vector of medical expense shocks $\boldsymbol{\varepsilon_M} \equiv (\varepsilon_m^p, \varepsilon_m^t)$, marital status d, and death year, captured by the change in the marital status ($d \neq d'$).[1] The first medical expense shock follows an age-invariant Markov process with transition probabilities $\Lambda_{MM'}$ and initial distribution Γ_{M_p}. The largest realization of this persistent medical expense shock is a nursing home event and is denoted by $\bar{\varepsilon}_m^p$. The second shock is a transient, *iid* shock with probability distribution Γ_{M_t}.

3.5 Definition of Equilibrium

For the purposes of defining an equilibrium in a compact way, we suppress the household state into a vector (j, x), where

$$x = \begin{cases} x_W \equiv (a, \bar{\mathbf{e}}, \boldsymbol{\varepsilon_e}, \mathbf{s}), & \text{if } 1 \leq j \leq R, \\ x_R \equiv (a, \bar{\mathbf{e}}, \mathbf{h}, \boldsymbol{\varepsilon_M}, d, d'), & \text{if } R < j \leq J. \end{cases}$$

Accordingly, we redefine value functions, decision rules, income taxes, means-tested transfers and SS benefits to be functions of the household state (j, x): $V^W(j, x)$, $V^R(j, x)$, $c(j, x)$,

[1] The assumption that medical expense shocks are household level is made for reasons of tractability.

$a'(j,x)$, $l_f(j,x_W)$, $l_m(j,x_W)$, $T_y(x)$, $Tr(j,x)$ and $S(x_R)$. Define the household state spaces:

$$X_W \subset [0,\infty) \times [0,\infty) \times [0,\infty) \times \{(hs,hs),(hs,col),(col,hs),(col,col)\},$$
$$X_R \subset [0,\infty) \times [0,\infty) \times \{(g,g),(b,g),(g,b),(b,b)\} \times [0,\infty) \times \{0,1,2\} \times \{0,1,2\}.$$

and denote by $\Xi(X)$ the Borel σ-algebra on $X \in \{X_W, X_R\}$. Let $\Psi_j(X)$ be a probability measure of age-j households with state $x \in X$. Note that these households constitute a fraction $\eta_j \Psi_j(X)$ of the total number of households.

DEFINITION. Given a fiscal policy $\{S(\bar{\mathbf{e}},d), \tau_c, \tau_{mc}(e), \tau_{ss}(e), T_y(x), \underline{a}^d, \underline{c}^d, \underline{y}^d, \kappa\}$ and a real interest rate r, a steady-state competitive equilibrium consists of household policies $\{c(j,x), a'(j,x), l_f(j,x), l_m(j,x)\}_{j=1}^J$ and associated value functions $\{V^W(j,x)\}_{j=1}^R$, $\{V^R(j,x)\}_{j=R+1}^J$, government purchases and prices $\{G, w\}$, per capita capital stocks $\{\bar{K}, K\}$ and an invariant distribution $\{\Psi_j\}_{j=1}^J$ such that

1. At the given prices and taxes, the household policy functions $c(j,x)$, $a'(j,x)$, $l_f(j,x)$ and $l_m(j,x)$ achieve the value functions.

2. At the given prices, firms are on their input demand schedules: $w = F_L(K,L)$ and $r = F_K(K,L) - \delta$.

3. Aggregate domestic savings are given by $\sum_j \eta_j \int_X a'(j,x) d\Psi_j = (1+n)\bar{K}$.

4. Markets clear:

   (a) Goods $\sum_j \eta_j \int_X c(j,x) d\Psi_j + (1+n)\bar{K} + \tilde{M} + G = F(K,L) + (1-\delta)\bar{K} + (r+\delta)(\bar{K} - K)$, where $\tilde{M} = \sum_{j=R}^J \eta_j \int_{X_R} \Phi(j, \mathbf{h}, \boldsymbol{\varepsilon_M}, d, d') d\Psi_j$.

   (b) Labor: $\sum_j \eta_j \int_X \{(1 - l_f(j,x))\Omega^f(j, \boldsymbol{\varepsilon_e}, s^f) +$
   $(1 - l_m(j,x)\mathbf{I}_{j \geq \bar{j}} - \bar{l}\mathbf{I}_{j<\bar{j}})\Omega^m(j, \boldsymbol{\varepsilon_e}, s^m)\} d\Psi_j = L.$

5. Distributions of households are consistent with household behavior:

$$\Psi_{j+1}(X_0) = \int_{X_0} \left\{ \int_X Q_j(x,x') \mathbf{I}_{j'=j+1} d\Psi_j \right\} dx',$$

   for all $X_0 \in \Xi$, where $\mathbf{I}$ is an indicator function and $Q_j(x,x')$ is the probability that a household of age j and current state x transits to state x' in the following period.

6. The government's budget is balanced:

$$IncomeTaxes + CorporateTaxes + MedicareTaxes + PayrollTaxes =$$
$$SSbenefits + Transfers + G$$

where income tax revenue is given by

$$IncomeTaxes = \sum_{j=1}^{J} \eta_j \int_X T_y(x) d\Psi_j,$$

corporate profits tax revenue is

$$CorporateTaxes = \sum_{j=1}^{R} \eta_j \int_{X_W} \tau_c ra(j,x) d\Psi_j,$$

Medicare tax revenue is

$$MedicareTaxes = \sum_{j=1}^{R} \eta_j \int_{X_W} \left\{ \tau_{mc}\left(e^m(j,x)\right) e^m(j,x) + \tau_{mc}\left(e^f(j,x)\right) e^f(j,x) \right\} d\Psi_j,$$

payroll tax revenue is

$$PayrollTaxes = \sum_{j=1}^{R} \eta_j \int_{X_W} \left\{ \tau_{ss}\left(e^m(j,x)\right) e^m(j,x) + \tau_{ss}\left(e^f(j,x)\right) e^f(j,x) \right\} d\Psi_j$$

SS benefits are

$$SSbenefits = \sum_{j=R+1}^{J} \eta_j \int_{X_R} S(x) d\Psi_j$$

and means-tested transfer payments are

$$Transfers = \sum_{j=1}^{J} \eta_j \int_X Tr(j,x) d\Psi_j.$$

3.6 Computational Algorithm

The steps in computing the equilibrium of the baseline economy are as follows. First, a guess of average earnings is made. From this guess, a guess on average household income is derived. Second, individual maximization problems are solved. Agents' problems in the last period of their lives are solved first, followed by the previous period, up to the first period. To this end, the state space is discretized and optimal assets and labor supply are found via grid search. Value functions are constructed using piecewise linear interpolation. The grids for assets and average lifetime earnings consist of 100 and 10 nonlinearly-spaced points, respectively. Increases in these grid sizes does not significantly change the solution. Female labor supply is chosen from an evenly-spaced grid of 10 points. Third, the distribution of the population over the discrete state is computed using forward iteration. Finally, average earnings and average household income are updated. This procedure is iterated on until both average earnings and average household income converge. The government budget constraint is cleared by setting government spending to the residual.

The algorithm to compute counterfactual economies is similar. The main difference is that, in addition to average earnings and average household income, the tax rate used to clear the government budget constraint is also iterated on while government spending as a fraction of output is held fixed at the baseline economy level.

4 Calibration Details

4.1 Stochastic Structure of Medical expenses

When calibrating the five state Markov process of medical expense shocks, we allow one of the states to be associated with nursing home stays. We set the fifth state to reproduce the average annual cost of a nursing home stay for a Medicaid recipient. This cost is $33,500 in year 2000 dollars and includes both the cost of care and the cost of room and board.[2] We focus on Medicaid recipients because it allows us to decompose this expense into a consumption and medical expense component. In particular, for these individuals, the consumption component is given by $\underline{c}$. One way to assess this calibration is to consider the situation of a private payer. Under the assumption that 1/2 of total consumption is room and board for nursing home care, total average nursing home expenses for a private payer in the model are about $70,000 per year in year 2000 dollars. For purposes of comparison the average annual cost of a semi-private room was $60,000 in 2005 and the cost of a private room was $75,000 in 2005 according to the Metlife Market Survery of Nursing Home and Assisted Living Costs.

The probabilities of a nursing home stay are assumed to vary with age. We estimate the transition probabilities in and out of this state using the following targets. The probabilities of entry into the nursing home state are chosen to match the distribution of age of first nursing

[2]This number is based on Medicaid per diem rates in Meyer (2001).

home entry for individuals aged 65 and above. This distribution is taken from Murtaugh, Kemper, Spillman and Carlson (1997). They find that 21% of nursing home stayers have their first entry between ages 65–74, 46% between ages 75–84, and 33% after age 85. The probabilities of exiting the nursing home state are chosen to match the average years of nursing home stay over their lifetime organized by age of first entry. We limit attention to stays of at least 90 days because we want to focus on true long-term care expenses. Murtaugh et al. (1997) do not report the figures we need. However, we are able to impute these durations by combining data they provide with data from Liu, McBride and Coughlin (1994). The specific targets are as follows. For those who had a first entry between 65-74, the average duration of all nursing home stays is 3.9 years. For those whose first entry is between the ages of 75-84 the average duration is 3.2 years and for those with first entry after age 85 the average duration is 2.9 years.

The above targets are all conditional on a nursing home entry. In order to estimate the unconditional probability of a nursing home entry, we target the probability that a 65 year old will enter a nursing home before death for a long term stay. That probability is 0.295 and is imputed using data from the two sources above.

In order to hit these targets, as well as the French and Jones (2004) AR(1) targets, we use a simulated method of moments procedure that does a bias correction for the well known downward bias in estimated AR(1) coefficients.

4.2 Preferences

We set $\beta = 0.944$ to obtain a wealth to earnings ratio in the model of 3.2. This is the wealth to earnings ratio for the bottom 95 percent of the wealth distribution in the US and the same target used by Hong and Ríos-Rull (2007). Following the macro literature, we set σ equal to 2.0.[3] The degree of joint consumption is governed by χ. We set χ to 0.67 following Attanasio, Low and Sanchez-Marcos (2008).

We set γ, the leisure exponent for females to 2. This is the baseline value used by Erosa, Fuster and Kambourov (2014). This choice in conjunction with steady-state hours worked implies a theoretical Frisch-elasticity of 2.43. This choice implies that the correlation between the year-on-year growth rate of the husbands wages and the corresponding growth rate of the wive's hours worked is -0.34 in our model. For purposes of comparison, the model of Heathcote et al. (2010) produces a correlation of -0.11 for the same statistic.

We allow $\psi(\mathbf{s})$ to vary with the education level of each household member. The targets, taken from McGrattan and Rogerson (2007), are average female hours by educational attain-

[3] See for example Castañeda, Díaz-Giménez and Ríos-Rull (2003), Heathcote, Storesletten and Violante (2010) and Storesletten, Telmer and Yaron (2004).

ment of both household members. Expressed as a fraction of a total time endowment of 100 hours per week, they are 0.16 for high-school-educated households, 0.17 for households where the female has a high-school degree and her spouse has a college degree, 0.24 for households where the female has a college degree and her husband has a high-school degree, and 0.21 for college-educated households. The corresponding parameter values are 3.5, 1.7, 2.25, and 1.7.

Our general strategy for calibrating the preferences for leisure is to choose them to reproduce differences in hours and employment for different types of married individuals over the lifecycle. We do not use any business cycle observations as targets because our model period is 2 years and thus too long to analyze business cycle moments. The parameters that govern the extent of disutility the household experiences if the female or older male is participating in the labor market, $\phi_f(\mathbf{s})$ and $\phi_m(\mathbf{s})$, also vary with education. The targets for $\phi_f(\mathbf{s})$, taken from Kaygusuz (2010), are female participation rates by educational attainment of each household member. The participation rates are for married females aged 50 to 59. For high-school-educated households the rate is 0.48. For households with high-school-educated females and college-educated males the rate is 0.45. For households with college-educated females and high-school-educated males the rate is 0.68 and for college-educated households the rate is 0.58. The corresponding parameter values are 0.21, 0.16, 0.11, and 0.11. The targets for $\phi_m(\mathbf{s})$ are the participation rates by educational attainment of each household member for married males aged 55 to 64. For high-school-educated households the rate is 0.68. For households with high-school-educated females and college-educated males the rate is 0.77. For households with college-educated females and high-school-educated males the rate is 0.72 and for college-educated households the rate is 0.82. The corresponding parameter values are 1.33, 0.94, 0.71, and 0.59. The targets for all these parameters are based on IPUMS data from the 1980 and 1990 U.S census.

4.3 Technology

Consumption goods are produced according to a production function,

$$F(K, L) = AK^{\alpha}L^{1-\alpha},$$

where capital depreciates at rate δ. The parameters α and δ are set using their direct counterparts in the U.S data: a capital income share of 0.3 and an annual depreciation rate of 7% (Gomme and Rupert, 2007). The parameter A is set such that the wage per efficiency unit of labor is normalized to one under the baseline calibration.

4.4 Earnings Process

The basic strategy for calibrating the labor productivity process follows Heathcote et al. (2010) who also consider earnings for married households. We assume that college graduates begin their working career four years later than high school graduates. The specific form of the labor productivity process is:

$$\log \Omega^i(j, \epsilon_e, s^i) = \alpha_1 \mathbf{I}(s^i = col) + \alpha_2 \mathbf{I}(i = f) + \beta_1 j + \beta_2 j^2 + \beta_3 j^3 + \epsilon_e^i,$$

where α_1 and α_2 are intercepts that capture the college premium and the gender gap. The β's determine the experience premium. The specific values of these parameters are $\alpha = 4.96 \times 10^{-1}$, $\alpha_2 = -4.78 \times 10^{-1}$, $\beta_1 = 4.80 \times 10^{-2}$, $\beta_2 = -8.06 \times 10^{-4}$ and $\beta_3 = -6.46 \times 10^{-7}$. All these values are taken from Heathcote et al. (2010).

Following Heathcote et al. (2010), we assume that females and males face a persistent productivity shock process. In particular, ϵ_e^i is assumed to follow an AR(1) process with a serial correlation coefficient of $\epsilon_e^i = 0.973$ and a standard deviation of 0.01. We allow the innovation to earning productivity to be correlated with the spouse's innovation. Heathcote et al. (2010) choose this correlation to reproduce a targeted correlation of male wage growth and female wage growth of 0.15. We set the correlation of the earnings innovations to match this same target. The resulting correlation between the two earnings innovations is 0.05.

Heathcote et al. (2010) also allow for a transient shock to labor productivity. We abstract from this second shock. This reduces the size of the state space for working households and allows us to model the problem of retirees in more detail.

The distribution of initial productivity levels Γ_e is assumed to be bivariate normal with a standard deviation of 0.352, a correlation of 0.517 and a gender productivity gap of 0.62 in 1970. All of these targets are taken from Heathcote et al. (2010) and apply to males and females.[4]

One difference between us and Heathcote et al. (2010) is that we allow for an earnings state that has a much lower level of earnings as compared to what Gaussian quadrature methods would imply. See Section 5.2 of the paper for more details.

[4] Specifications similar to this have been used by Attanasio et al. (2008) and Heathcote, Storesletten and Violante (2008) to model the joint earnings of married couples.

4.5 Progressive Income Tax Formula

The effective progressive income tax formula is given by:

$$\tau^y(y^{disp}, d) = \left[\eta_1^d + \eta_2^d \log\left(\frac{y^{disp}}{\bar{y}}\right)\right] y^{disp} \tag{1}$$

where y^{disp} is disposable household income, $\bar{y}$ is mean income in the economy. Guner, Kaygusuz and Ventura (2012) estimate $\eta_1^0 = 0.113$ and $\eta_2^0 = 0.073$ for married households and $\eta_1^{d\in\{1,2\}} = 0.153$ and $\eta_2^{d\in\{1,2\}} = 0.057$ for single households. We shift the income tax formula down by 0.07 to match income tax revenue as a fraction of GDP in the model and the data.

The U.S. Federal tax code allows tax-filers a deduction for medical expenses that exceed 7.5% of income. Our income tax schedules indirectly account for deductions when estimating effective tax functions. However, their effective tax functions are averages across many households and do not capture the full benefit of this deduction to those who experience large medical expense shocks such as long-term care. We allow for a deduction for medical expenses that exceed 7.5% of income.

U.S. Federal tax code provides for an exemption of SS benefits. This exemption is phased out in two stages as income rises. Table 6 reports exemption thresholds and minimum income levels by marital status. The left column of Table 6 reports the actual dollar amounts in the year 2000. The right column expresses these figures as a fraction of average earnings of full-time, prime-age male workers. According to our source, the thresholds and minimum income are not indexed to inflation or wage growth.

We use these thresholds to compute the exemptions formulas in the following way. We start by calculating provisional income, Y, which is defined as asset income,Y^a, plus half of the household's SS income, Y^{ss}. If $Y < T_i^1, i \in \{s, m\}$, there is a full exemption for SS benefits and taxable income for that household is equal to Y^a net of the medical expense tax deduction. If $T_i^1 < Y < T_i^2, i \in \{s, m\}$, taxable income is given by

$$Y^a + 0.5 \min(Y^{ss}, Y - T_i^1),$$

net of the medical expense tax deduction if eligible. If $Y > T_i^2, i \in \{s, m\}$, then taxable income is given by

$$Y^a + \min\Big\{0.85 Y^{ss}, 0.85\big[Y - T_i^2 + \min(\underline{Y}_i, 0.5 Y_i^{ss})\big]\Big\},$$

net of medical expense tax deduction if eligible.

Table 6: Exemption thresholds and minimum income levels for taxation of social security benefit income

Description	Levels ($)	% of ave. earnings
Threshold 1		
Single (T_s^1)	25,000	53
Married (T_m^1)	32,000	67
Threshold 2		
Single (T_s^2)	34,000	72
Married (T_m^2)	44,000	93
Minimum income		
single ($\underline{Y}_s$)	4,500	9
married ($\underline{Y}_m$)	6,000	13

Source: Scott, C. and J. Mulvey (2010). "Social Security: Calculation and History of Taxing Benefits", *Congressional Research Service.*

Table 7: Average Tax Rates in the Baseline Economy

Overall	0.108		
By male permanent earnings quintile:		*By household education type (female, male):*	
1	0.032	high school, high school	0.087
2	0.053	high school, college	0.140
3	0.075	college, high school	0.109
4	0.111	college, college	0.150
5	0.166		

The average income tax rate and average tax rates by household education type and male permanent earnings quintile in the model under the baseline calibration.

The average income tax rate under our baseline calibration is shown in Table 7. The table also shows how the average income tax rate varies by male permanent earnings quintile and household education type. Average tax rates are higher for higher income households.

4.6 Social Security Benefits

The U.S. Social Security system links a worker's benefits to an index of the worker's average earnings, $\underline{e}$. Benefits are adjusted to reflect the annual cap on contributions and there is also some progressivity built into the U.S. Social Security system. We use the following formula

Table 8: Bi-annual Flows into Medicaid by Age and Marital Status

Age	65–74	75–84	85+
Married			
data	0.028	0.029	0.043
model	0.017	0.031	0.037
Widows			
data	0.065	0.055	0.088
model	0.079	0.061	0.058
Widowers			
data	0.077	0.066	0.090
model	0.057	0.049	0.056

The flows are the fraction of retirees with given initial marital status not receiving Medicaid but who become recipients over the next two years. Data source: Authors' computations using our HRS sample.

to link contributions to benefits for an individual

$$\hat{S}(\bar{e}) = \begin{cases} s_1\bar{e}, & \text{for } \bar{e} \leq \tau_1, \\ s_1\tau_1 + s_2(\bar{e} - \tau_1), & \text{for } \tau_1 \leq \bar{e} \leq \tau_2, \\ s_1\tau_1 + s_2(\tau_2 - \tau_1) + s_3(\bar{e} - \tau_2), & \text{for } \tau_2 \leq \bar{e} \leq \tau_3, \\ s_1\tau_1 + s_2(\tau_2 - \tau_1) + s_3(\tau_3 - \tau_2), & \text{for } \bar{e} \geq \tau_3. \end{cases}$$

Following the Social Security administration, we set the marginal replacement rates, s_1, s_2, and s_3 to 0.90, 0.33, and 0.15, respectively. The threshold levels, τ_1, τ_2, and τ_3, are set to 20%, 125% and 246% of average earnings for all workers. The U.S. Social Security system also provides spousal and survivor benefits. We model these benefits. Household benefits are determined using the following formula

$$S(\bar{\mathbf{e}}, d) = \begin{cases} \hat{S}\left(\max_{i\in\{m,f\}}\{\bar{e}^i\}\right) + \max\left\{0.5\hat{S}\left(\max_{i\in\{m,f\}}\{\bar{e}^i\}\right), \hat{S}\left(\min_{i\in\{m,f\}}\{\bar{e}^i\}\right)\right\}, & \text{if } d = 0, \\ \max\left\{\hat{S}\left(\bar{e}^m\right), \hat{S}\left(\bar{e}^f\right)\right\}. & \text{if } d \in \{1, 2\}. \end{cases}$$

5 Other Model Assessment Results

5.1 Medicaid Flows

Another implication of the model that was not targeted is flows into Medicaid. Table 8 reports flows into Medicaid by age and marital status. Observe that in the data, the flows into Medicaid are much lower for married than singles. Moreover, the flows increase monotonically

Table 9: Additional conditional transitions into and persistence of low wealth statistics

	Model			Data		
Cohort	65–74	75–84	85+	65–74	75–84	85+
Marital Status (Men)						
married	1.10	3.24	5.83	6.08	5.93	5.90
widower	4.05	5.14	32.96	10.36	8.05	8.89
Hospital						
no hospital stay	3.71	5.60	6.28	5.71	5.67	7.87
hospital stay	7.86	14.21	18.69	6.47	7.04	10.25
Marital Status (Men)						
married	87.2	74.6	26.4	74.5	73.9	70.7
widower	97.5	89.9	100	75.7	79.0	73.9
Hospital						
no hospital stay	78.1	66.5	67.7	75.1	73.1	70.7
hospital stay	96.3	90.6	67.1	78.3	77.3	71.8

The upper-panel numbers are the percentage of individuals in wealth quintiles 2–5 who move to quintile 1 two years later conditional on their initial status. The lower-panel numbers are the percentage of individuals in wealth quintile 1 who are still in quintile 1 two years later conditional on their initial status. Wealth quintiles are determined from an individual wealth distribution specific to each age group. Married individuals are assigned half of the household wealth.

with age for married but follow a U-shaped pattern for singles. Model flows into Medicaid reproduce almost all of these features of the data.

5.2 Other Wealth Transitions

Table 9 indicates that the model is in reasonably good accord with the data with respect to both wealth transitions conditional on widowhood for men and medical expenses. First, observe that widowers of all ages face a higher probability and a higher persistence of low wealth compared to married men. One way to compare the effects of medical expenses is to interpret the second highest draw of the medical expense shock in the model as a hospital stay. Notice that, with this interpretation, hospital stays increase the likelihood and persistence of low wealth in the model as in the data. We do not read much into these statistics from the model for the 85+ widowers because the sample size for this group in our model simulated data is extremely small.

6 Additional Tables

Table 10 shows how aggregate variables change when MTSI is removed from the 'No Medical Expenses' baseline and the 'No Earnings Risk' baseline.

Table 10: Aggregate variables in 'No Medical Expenses' economies and 'No Earnings Risk' economies with and without MTSI

	No Medical Expenses		No Earnings Risk	
	Baseline	No MTSI	Baseline	No MTSI
Output	1.00	1.01	1.00	1.05
Consumption	0.68	0.69	0.71	0.75
Wealth	2.55	2.69	1.97	2.82
Tax Revenue Relative to Output	0.20	0.14	0.17	0.13
Aggregate Labor input	1.00	1.00	1.00	1.01
Older Male Labor-Force Part.	0.70	0.69	1.00	1.00
Female Labor-Force Part.	0.50	0.50	0.47	0.54
Working Females' Hours	0.33	0.33	0.20	0.19

Results are reported for the baseline economy with no medical expenses, the baseline economy with no medical expenses when MTSI is at the 'no MTSI' level, the baseline economy with no earnings risk, and the baseline economy with no earnings risk when MTSI is at the 'no MTSI' level. The numbers in the first four rows for each pair of economies are normalized by output in the respective baseline. The numbers in the fifth row are normalized by aggregate labor input in each respective baseline. All flows are annualized. The measure of output is GNP.

7 Additional Figures

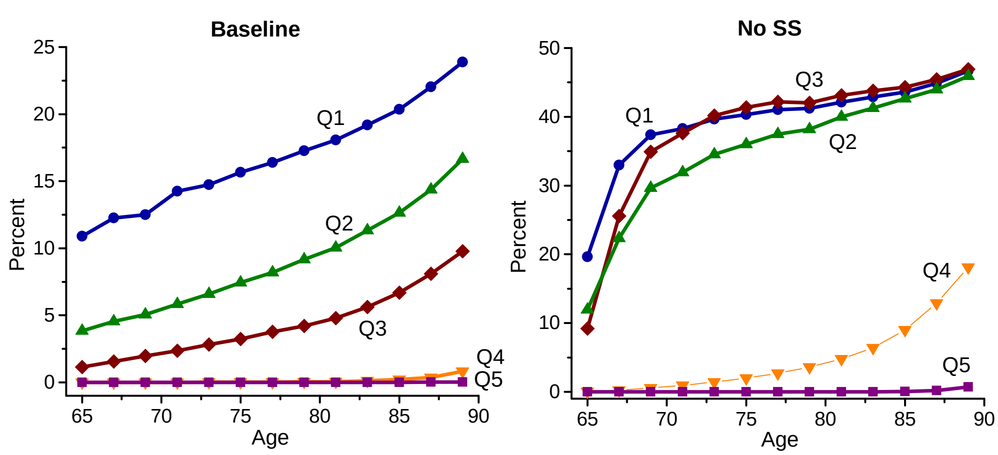

Figure 1: MTSI recipiency rates of retirees in the baseline economy and the baseline economy without SS.

Table 11: Welfare effects of removing MTSI under different assumptions about the alternative consumption floor

Economy	Baseline $\underline{c} = 1.1\text{e-}5$	$\underline{c} = 1.1\text{e-}4$	$\underline{c} = 0.0011$	$\underline{c} = 0.011$
Welfare				
Ex-ante	-4.3	-2.8	-1.7	-0.67
By male permanent earnings:				
quintile 1	-7.0	-4.9	-3.2	-1.8
quintile 2	-4.9	-3.3	-2.1	-0.99
quintile 3	-3.9	-2.5	-1.5	-0.54
quintile 4	-3.0	-1.8	-0.9	-0.12
quintile 5	-1.2	-0.41	0.20	0.70
By household education type (female, male):				
high school, high school	-5.4	-3.7	-2.3	-1.2
high school, college	-2.3	-1.1	-0.21	0.49
college, high school	-1.7	-0.96	-0.34	0.17
college, college	0.0	0.52	0.90	1.2
No MTSI				
percent of retirees at floor	0.07	0.34	2.5	2.6

The welfare effects of replacing MTSI in the baseline economy with the 'no MTSI' consumption floor (first column) and consumption floors that are 10 (second column), 100 (third column) and 1000 (fourth column) times larger than the 'no MTSI' floor. The last row of the table shows the percent of retirees at the floors when MTSI is not available. The consumption floor values are expressed here as a fraction of average male earnings.

The left panel of Figure 1 shows the MTSI recipiency rates in the baseline economy. The right panel shows the same rates in the economy without SS. These rates were used to construct the changes in recipiency rates shown in Figure 6 in the paper.

8 Additional Robustness Experiments

Table 11 shows that our result that MTSI is welfare-enhancing is robust to the setting of the 'no MTSI' consumption floor and income thresholds. The table reports the welfare effects of removing MTSI under alternative assumptions about the level of this floor. In each scenario, the income thresholds are adjusted down proportionately. Ex-ante welfare of a newborn household falls even when the floor guaranteed when formal MTSI is absent is increased by a factor of 1000 relative to the baseline value. In addition, most types of households continue to experience a welfare loss.

We have posited a non-Gaussian process for earnings. In particular, we have included a low earnings state that helps us reproduce the left tail of the earnings distribution. In

Table 12: Welfare effects of removing MTSI under different model assumptions

Economy	Baseline	HS only shock	NH not med. needy
Ex-ante	-4.3	-4.2	-4.3
By household education type (female, male):			
high school, high school	-5.4	-5.6	-5.4
high school, college	-2.3	0.69	-2.2
college, high school	-1.7	-1.9	-1.7
college, college	0.0	1.8	0.08

The welfare effects of replacing MTSI with the 'no MTSI' consumption floor in the baseline economy (first column), an economy where only high-school-educated males can get the low-earnings shock (second column) and an economy where households that get the nursing home shock are not only eligible for MTSI through the medically-needy pathway (third column).

the baseline model this shock hits all households with equal probability. For retirees in the HRS this was a reasonable assumption. However, in more recent cohorts the poverty rate of high-school educated individuals relative to college-educated individuals has doubled.[5] The second column of Table 12 illustrates how the welfare effects of removing MTSI change when the low earnings shock is assumed to hit households with high-school-educated males only. The ex-ante welfare benefits of MTSI are smaller and there is now disagreement among households. Households with college-educated males now prefer the economy with the 'no MTSI' consumption floor to the one with MTSI.[6]

In the baseline economy we assume that residents can only qualify for MTSI via the medically needy path. The final column of the same table shows how the welfare results change when we assume that can qualify for MTSI via either path. Notice that the welfare results are essential identical to those of the baseline. This economy is of interest because nursing home stays are less persistent in this economy as compared to the baseline as Table 13 shows.

[5] Pew Research Center (2014) "The Rising Cost of Not Going to College"

[6] Notice that the welfare rankings also change. In the baseline economy, the households with high-school-educated females value MTSI the most as it is more costly for these households to self-insure by increasing female labor supply when MTSI is removed. However, once college males no longer face the risk of incurring the low-income shock, households with high-school-educated females and college-educated males value MTSI much less.

Table 13: Conditional transitions into and persistence of low wealth

	Baseline			NH not med. needy			Data		
Cohort	65–74	75–84	85+	65–74	75–84	85+	65–74	75–84	85+
Transitions to Quintile 1									
no NH stay	4.35	6.21	6.12	5.23	7.86	9.43	5.79	5.67	7.16
NH stay	7.57	17.22	27.86	7.79	9.92	12.7	23.19	18.64	18.49
Persistence of Quintile 1									
no NH stay	82.2	71.9	58.9	78.9	67.9	59.9	75.8	74.4	67.5
NH stay	97.6	99.9	99.2	80.7	73.9	66.4	90.7	85.2	80.2

The upper (lower) panel numbers are the percentage of individuals in wealth quintiles 2–5 who move to (stay in) quintile 1 two years later conditional on nursing home status. Wealth quintiles are determined from an individual wealth distribution specific to each age group. Married individuals are assigned half of the household wealth.

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