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

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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 programme? A large literature has analysed the costs and benefits of pay-as-you-go public pensions and found that the costs exceed the benefits. This article, instead, considers means-tested social insurance (MTSI) programmes for retirees such as Medicaid and Supplemental Security Income. We find that the welfare gains from these programmes are large. Moreover, the current scale of MTSI in the U.S. is too small in the following sense. If we condition on the current Social Security programme, increasing the scale of MTSI by 1/3 benefits both the poor and the affluent when a payroll tax is used to fund the increase.

Key words: Means-tested social insurance, Medicaid, Welfare, Elderly, Medical expenses

JEL Codes: E62, H31, H52, H55

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 poverty are lifetime earnings risk, longevity, sickness/disability, and marital status risk. Some individuals enter retirement with low assets due to bad luck in the labour 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.

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 that 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.

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 labour force. Is there a role for social insurance for the aged and, if so, what is a good programme?

The largest U.S. social insurance programme 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 analysed the U.S. SS programme and found that it reduces steady-state welfare in dynamically efficient economies. Starting with Auerbach and Kotlikoff (1987), the literature has consistently found that SS reduces incentives to save and work and that these distortions outweigh its insurance benefits. This finding has been found to be robust to the presence of a variety of different risks and insurance arrangements. Conesa and Krueger (1999) and İmrohoroğlu *et al*. (1999) find that it holds when agents face mortality and lifetime earnings risk. İmrohoroğlu *et al*. (1995) show it holds when individuals face the risk of catastrophic health expenses. Hong and Ríos-Rull (2007) show that the result holds even if agents have access to annuities and life insurance. Fuster *et al*. (2007) reach the same conclusion in a dynastic framework where individuals have intrafamily insurance.[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 (MTSI) programmes for the aged and find that these programmes are highly valued. MTSI programmes that benefit the aged include Medicaid, Supplemental Security Income (SSI), food stamps and housing, and energy assistance programmes. 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 labour 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 of whether there is an opportunity to increase the scale of current MTSI programmes. Indeed, we document broad-based welfare gains if the scale of these programmes 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 programmes that are much smaller than SS. Medicaid, which subsidizes medical costs, is the largest MTSI programme for retirees. Yet, Medicaid expenditures for individuals 65 and over (65+) only constitute 0.6% of GDP. About 5% of those aged 65+ receive assistance from SSI, the second largest programme, and expenditures on this programme 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 *et al*. (1995) find that means-testing results in a 100%

2. In the U.S., this programme 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 article. Results in the literature pertaining to transitions are mentioned in footnote 43.

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).

tax on wealth in some states of nature. Feldstein (1987) shows that old-age MTSI programmes 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 (2000) suggest that these effects are quantitatively significant. Funding MTSI programmes 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 effects.[6]

Our principal objective is to assess U.S. MTSI programmes 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 *et al*. (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. Labour productivity evolves stochastically over the life cycle and a borrowing constraint limits their ability to self-insure. Prime-age male labour 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 programme that includes spousal and survivor benefits, and a MTSI programme that includes both categorically and medically needy paths to Medicaid. Medicare is modelled 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 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

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 programmes for workers have been shown, for example, to have much larger effects on labour supply (Krueger and Meyer, 2002).

7. See for example, Heathcote *et al*. (2008), Guvenen (2009), Heathcote *et al*. (2010), and Huggett *et al*. (2011).

in the model are in line with impoverishment statistics 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 programmes. From the perspective of poorer households SS is a form of forced savings that makes it more difficult for them to qualify for MTSI at retirement.

To our knowledge, our article is the first to demonstrate that MTSI programmes for U.S. retirees are welfare-enhancing. De Nardi *et al*. (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 labour supply of workers nor the tax burden born by workers in financing these programmes are present.

Other recent research analyzes means tests in the context of public pension reform in overlapping generations (OLG) models where lifetime earnings risk and longevity are the only risks faced by retirees. Tran and Woodland (2014) 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 *et al*. (2008) find that the Pension Credit programme that was instituted in the UK in 2003 and that relaxed the public pension means test is preferred to both the previous programme and a universal SS system.

In addition to transfers from MTSI programmes, which are the subject of our analysis, U.S. retirees also receive entitlement transfers to cover acute medical expenses from the Medicare programme. We model the Medicare programme but do not alter its scale. Attanasio *et al*. (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 article 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 analysed 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

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	69.9	79.4	74.3	87.4
2	18.7	22.7	15.7	23.0	17.4	39.4
3	4.4	7.4	4.0	6.5	4.1	25.0
4	1.4	2.5	1.4	3.2	1.4	15.3
5	0.7	1.1	0.5	1.6	0.6	3.9

Notes: 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.

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.

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 1 year stay in a nursing home can easily exceed \$60,000 and, while the average duration is only approximately 2 years, Brown and Finkelstein (2008) estimate that approximately 9% of entrants will spend more than 5 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]

8. More information on this sample is available in Section 1 of the Online Appendix.
9. See Table 5 of the Online Appendix.
10. See Tables 1–4 of the Online Appendix.

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, longevity, and permanent earnings risks and that it is particularly valuable when multiple risks are present. This is accomplished by analysing 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 consistent with our quantitative model. Our reasons for this modelling 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

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

subject to

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

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.

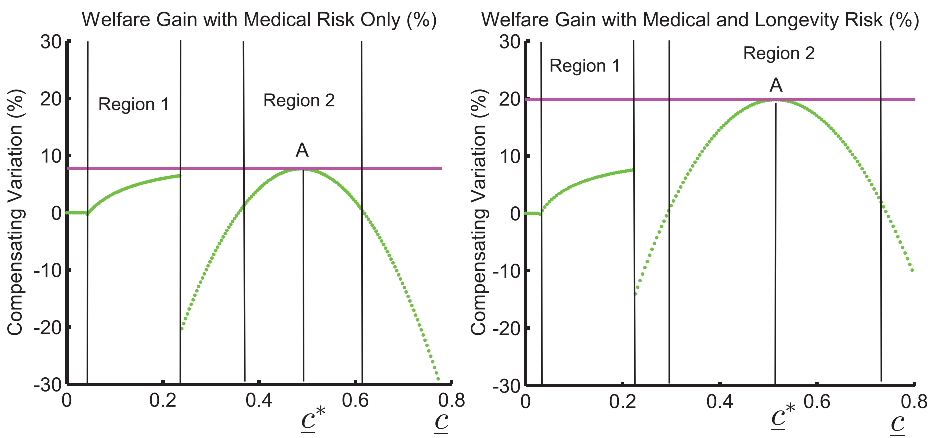

FIGURE 1

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

3.2. *The welfare-improving effects of MTSI*

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 transfers are state-contingent. 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.

3.2.1. 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 programme may be welfare improving if medical risks are sufficiently large. The left panel of Figure 1, which plots compensating variations of MTSI as compared to LF, illustrates this point.[11] The horizontal axis of this graph denotes the scale of the MTSI programme, as measured by the consumption floor $\underline{c}$. Welfare is not monotonically increasing in the scale of the MTSI programme because of its effects on the individual's 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 zero. Underlying the result that MTSI is welfare improving in the two regions is a positive insurance effect provided by the

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 $r = 1/\beta - 1 = 0$.

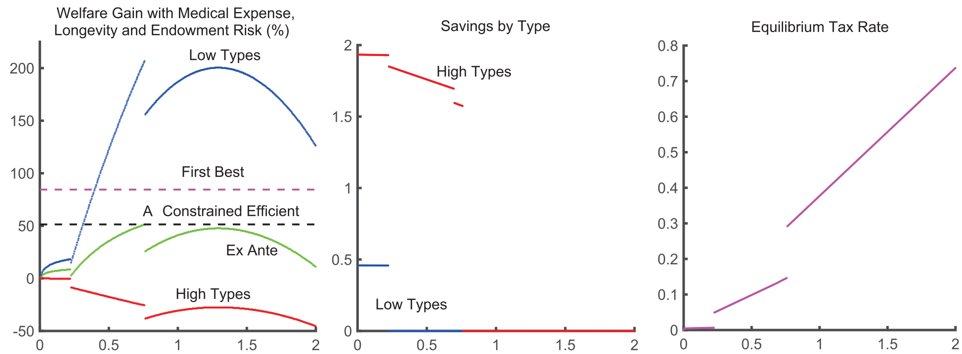

FIGURE 2

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

state-contingent nature of the programme 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 programme 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.

3.2.2. Medical expense and longevity risk. The right panel of Figure 1 reports compensating variations, as a function of the consumption floor $\underline{c}$, 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 implement the Pareto optimal (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 1. Thus, a higher value is placed on insurance that reduces the need for savings.

3.2.3. 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) lies below the first best line and thus is not Pareto Optimal. This illustrates the claim of Feldstein (1987) that MTSI distorts savings incentives of the poor. 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 programmes.

4. THE MODEL

Our quantitative model is a rich overlapping generations model of the U.S. economy. Individuals differ by gender and educational attainment, and are matched with a spouse. Differences in educational attainment, in conjunction with stochastic shocks to labour 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 programme 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 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 labour 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 variation in labour supply of married households is due to changes in the employment and work hours of females or in the employment of older males (see *e.g.* Keane and Rogerson, 2012 for a survey). Thus, we assume that females make employment and hours decisions each period. However, males have

12. Table A1 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.

no hours choice and only males older than age $\bar{j}$ have an employment 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

$$U(c,\mathbf{l};d,\mathbf{s},j)=$$
$$N(d)\frac{c^{1-\sigma}}{1-\sigma}+\psi(\mathbf{s},j)\frac{l_f^{1-\gamma}}{1-\gamma}-\phi_f(\mathbf{s},j)\mathbf{I}(l_f<1)-\phi_m(\mathbf{s},j)\mathbf{I}(j\geq\bar{j})\mathbf{I}(l_m<1), \tag{4.1}$$

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 labour. 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. 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 health status of new retirees is drawn from education and gender-specific distributions. 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 $\pi_j^i(h^i,d)$ and depends on age, gender, health status, and marital status. Household marital

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.

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 $\pi_j^i(h^i,d)$ 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 $\boldsymbol{\varepsilon_M} \equiv (\varepsilon_m^p, \varepsilon_m^t)$, 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 $\bar{\varepsilon}_m^p$. 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 programmes*

The government runs two social insurance programmes: 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. SS 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 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 programmes for the elderly.

By far, the largest MTSI programme for the elderly in the U.S. is the health insurance programme Medicaid. The second largest programme 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 programmes and determine the scope of coverage. States also run other welfare programmes 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 programmes. Therefore, for the sake of simplicity, we refer to the entire system of these programmes as MTSI.

De Nardi *et al*. (2012) provide an excellent description of eligibility rules for SSI and Medicaid programmes for the elderly and argue that a good way to model U.S. Medicaid, SSI and other MTSI programmes 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

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

can qualify via the medically needy path if they have high medical expenses. Household MTSI transfers corresponding to each path are modelled as follows:

$$Tr^R \equiv \begin{cases} \max\left\{\underline{y}^d + \varphi M - S(\bar{\mathbf{e}}, d), \underline{c}^d + M - S(\bar{\mathbf{e}}, d)\right\}, & \text{if } S(\bar{\mathbf{e}}, d) < \underline{y}^d,\ a < \underline{a}^d \\ & \text{and } \varepsilon_m^p \neq \bar{\varepsilon}_m^p, \\ \max\{0, \underline{c}^d + M - I^R\}, & \text{otherwise,} \end{cases} \tag{4.2}$$

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 categorically 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 (4.2).[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 expenditure on consumption 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 (4.2) ensures 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 programmes 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 labour 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 programmes 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

$$e^i = w\Omega^i(j, \boldsymbol{\varepsilon_e}, s^i)\Big(1 - l_f \mathbf{I}_{i=f} - \big[\bar{l}\mathbf{I}_{j<\bar{j}} + l_m \mathbf{I}_{j\geq\bar{j}}\big]\mathbf{I}_{i=m}\Big), \tag{4.3}$$

and household income,

$$y^W \equiv e^m + e^f + (1-\tau_c)ra, \tag{4.4}$$

consists of labour income and capital income net of a corporate tax τ_c. Household income is subject to a non-linear income tax $\tau_y(\cdot)$ and a non-linear payroll tax $\tau_e(\cdot)$

$$T_y^W \equiv \tau_y\big(y^W - \tau_e(e^m)e^m - \tau_e(e^f)e^f\big) + \tau_e(e^m)e^m + \tau_e(e^f)e^f. \tag{4.5}$$

It follows that the household budget constraint is

$$c(1+\chi) + a' = a + y^W - T_y^W, \tag{4.6}$$

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

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

subject to equations (4.4–4.6), the law of motion for $\boldsymbol{\varepsilon_e}$, and

$$c \geq 0, \quad 0 \leq l_f \leq 1, \quad a' \geq 0, \quad l_m \in \{\bar{l}, 1\}, \tag{4.7}$$

$$\bar{e}^{i\prime} = (e^i + j\bar{e}^i)/(j+1), \quad i \in \{m,f\}, \tag{4.8}$$

where equation (4.7) describes regularity conditions on consumption and leisure and imposes a borrowing constraint which rules out uncollateralized lending. Equation (4.8) 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,

$$y^R \equiv (1-\tau_c)ra + S(\bar{\mathbf{e}}, d), \tag{4.9}$$

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

$$T_y^R \equiv \tau_y^R\big((1-\tau_c)ar, S(\bar{\mathbf{e}}, d), d, M\big). \tag{4.10}$$

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 (4.2), where cash-on-hand is given by

$$I^R \equiv a + y^R - T_y^R. \tag{4.11}$$

Finally, the household's budget constraint is

$$c(1+\chi \mathbf{I}_{d=0}) + M + a' = a + y^R - T_y^R + Tr^R, \tag{4.12}$$

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

$$V^R(j, a, \bar{\mathbf{e}}, \mathbf{h}, \boldsymbol{\varepsilon_M}, d, d') =$$

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

subject to equations (4.9–4.12) and the laws of motion for $\mathbf{h}$ and $\boldsymbol{\varepsilon_M}$. The expectations operator $\mathbf{E}$ is taken over $\boldsymbol{\varepsilon}'_{\boldsymbol{M}}$ 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 *et al.* (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, 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 *et al.* (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 to 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,

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%

Notes: The parameter r is the annual pre-tax interest rate. The average post-tax rate is 4.1%.

female labour supply, and male labour 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 labour L and combine them to produce a single 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, international 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 programmes 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.

19. For simplicity, we do not explicitly model the SS trust fund but instead assume that the SS programme is part of the total government budget.

20. Solving the quantitative model takes over 45 minutes on a computer with sixteen 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.

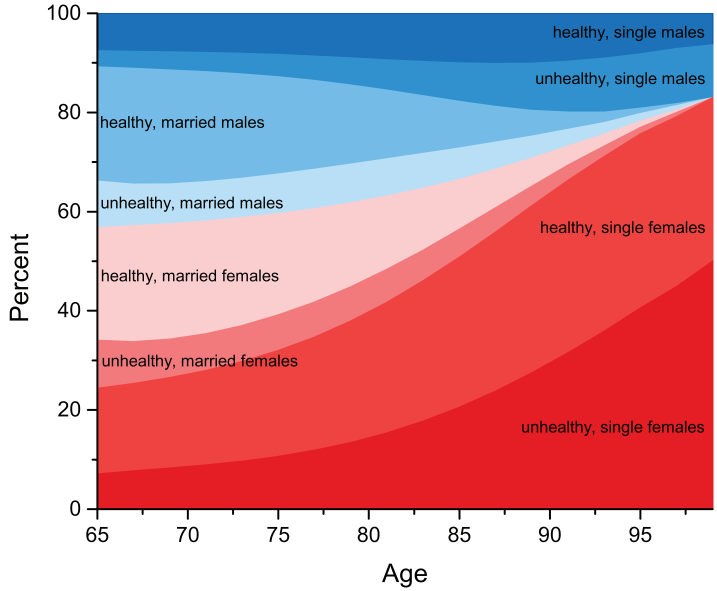

FIGURE 3

The population distribution of retirees by age. Individuals are classified by gender, health, and marital status

Source: 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 2 years because the data on OOP medical expenses is only available biannually. Thus, the maximum lifespan 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 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- to 66-year-old households; only the male has a college degree in 14% of households; only 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- to 66-year-old heads by SS 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

Notes: 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.

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- to 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 deaths helps the model replicate the left tail of the SS income distribution for singles and hence Medicaid recipiency rates in the data, as we explain below in Section 5.4.2.

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- to 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 5 years for both genders. Finally, females live on average 2.9 years longer than males.

5.2. *Earnings process*

Our strategy for calibrating the labour productivity process follows Heathcote *et al*. (2010), 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.

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. 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.

TABLE 5
SS income distribution in the data and the model

	Quintiles					Top percentiles			
	Q1	Q2	Q3	Q4	Q5	10	5	1	Gini
	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.

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 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.

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]

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

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.

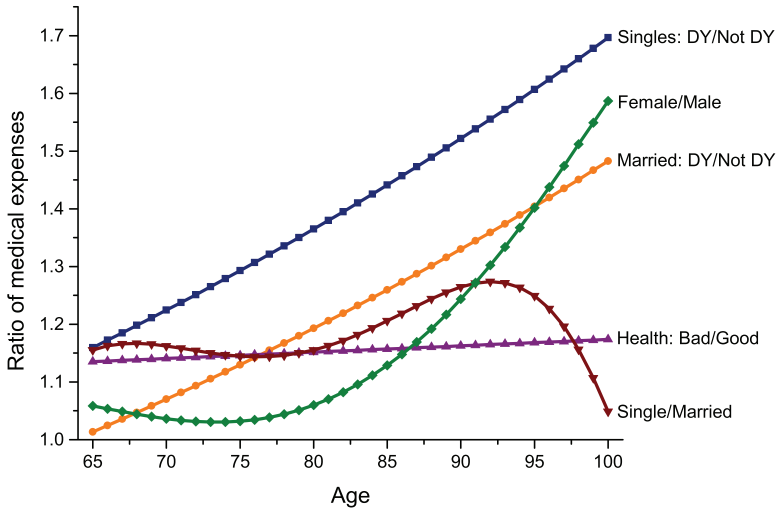

FIGURE 4

Estimated effects of marital status, health and death year (DY) 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.

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 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

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.

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.

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 1999–2005.[28]

5.4. *Government*

The government has three sources of funds: a proportionate corporate profits tax, a non-linear income tax, and a non-linear payroll tax. 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 and 2008, and revenue from the income tax averaged 8% of GDP.[29] We choose the corporate 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 *et al*. (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%.

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 life cycle.

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

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

5.4.2. Uses of government revenue. Benefits under the U.S. SS system are non-linear 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 programmes in the U.S., but Medicaid has less stringent eligibility rules. Eligibility rules for other means-tested programmes, 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 (4.2) and represent all of these programmes. Since Medicaid is the least stringent, we set model asset and income thresholds using its programme rules. 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%.

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 are high enough to 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 Section 4.7 of the Online Appendix for more details.

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

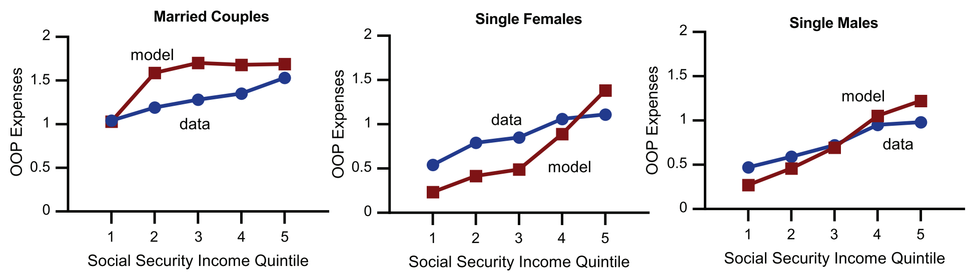

FIGURE 5

OOP 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 (squares) and the data (circles)

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 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 modelled 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

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.

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

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

Notes: 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.

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 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 2 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]

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

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.

36. In Section 8 of the Online Appendix, we show that if nursing home residents can qualify for MTSI under both the categorically needy and medically needy paths, the model understates the magnitudes by nursing home status. However, our welfare results are essentially unchanged.

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 MTSI 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. The "no earnings risk" economy has no idiosyncratic shocks to earnings in that each individual faces the average productivity profile conditional on his/her education type.[37] 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. The 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.[38] 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.[39] 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 is indexed by permanent earnings quintile. This result may be surprising given that the high permanent earnings types

37. Note that variation in earnings due to variation in education still remains as do changes in spousal earnings at age 65 due to the age-65 spousal death shock.

38. We use permanent earnings of males aged 21–55 because they are exogenous. This makes it possible to compare the same households across economies with different levels of social insurance.

39. We could also set the "no MTSI" consumption floor to zero and the welfare results for the baseline economy would not change. SS is still present and it forces individuals to save for retirement which prevents bankruptcy in old age. However, setting the floor to zero does create problems with bankruptcy in old age when both MTSI and SS are absent. To avoid the resulting computational problems, we set the "no MTSI" floor to a small positive number. The specific value we use makes households with two college-educated members indifferent between the baseline and the "no MTSI" economy.

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	1.11
By HH education type (female, male):			
High school, high school	−5.36	0.26	0.83
High school, college	−2.27	0.72	1.67
College, high school	−1.74	0.62	2.13
College, college	0	0.93	2.19
By male permanent earnings:			
Quintile 1	−7.02	0.04	0.83
Quintile 2	−4.93	0.30	0.83
Quintile 3	−3.89	0.45	0.83
Quintile 4	−2.95	0.58	1.42
Quintile 5	−1.21	0.83	2.01
Initial levels of MTSI			
Recipiency rates (%)	13.1	8.1	1.0
Outlays, percentage of GNP	1.02	0.41	0.12

Notes: 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 individual faces the average productivity profile conditional on his/her 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.

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 labour 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 labour input also goes up, albeit slightly, from 1.00 to 1.002.

The small response of labour supply to the removal of MTSI occurs because of two offsetting effects. The loss of insurance when MTSI is removed acts to increase labour supply, while a positive wealth effect due to the large increase in savings acts to reduce it. The former effect is known to be particularly pronounced for social insurance programmes that benefit workers. Literature surveyed by Krueger and Meyer (2002) finds that unemployment insurance and workers' compensation, have significant negative incentive effects on labour supply. However, consistent with our finding, other research cited in their survey finds that social insurance *for retirees* has much smaller effects on labour supply of working-age individuals.

The impact of these two effects on labour supply varies by gender in our model. Female labour input increases when MTSI is removed but male labour input declines. The decline in male labour is due to the positive wealth effect. 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, females working more helps to insure

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 labour input	1.00	1.00	0.98
Older male labour-force part.	0.71	0.68	0.68
Female labour-force part.	0.50	0.53	0.47
Working females' hours	0.33	0.35	0.32

Notes: 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.

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. In contrat, females in more affluent households where wealth effects are larger, choose not to change or even slightly decrease their labour supply.

Comparing columns 2 and 3 of Table 8 to column 1 illustrates that the welfare effects of removing MTSI switch from negative to positive if either medical expenses or earnings risk are absent. The intuition for these results was discussed in Section 3, where we 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 with medical expenses and earnings risk, even though the saving and tax distortions described in Section 3 are also more pronounced in this setting. First, a larger percentage of poorer households choose to rely on MTSI instead of saving in the baseline economy as compared to the "no medical expenses" or "no earnings risk" economies. As a result, in this economy, 13.1% of retirees are on MTSI as compared to 8.1% in the "no medical expenses" economy and 1.0% in the "no earnings risk" economy. 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 and 0.12% in the "no earnings risk" economy.

Column 3 shows that lifetime earnings risk has the biggest effect on the value of MTSI. If MTSI is removed from the economy without this risk, welfare rises for all types indexed either by education status or permanent earnings quintile and *ex ante* welfare increases by 1.11%. It may be surprising that the welfare change is large and positive since the MTSI reicipiency rate is only 1.0% in the "no earnings risk" economy. Why does removing this small programme generate such a large positive welfare change? Without earnings risk, all households are reasonably affluent and have significant SS income that 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. Recipiency rates for those 90 and older are 24%. Essentially, MTSI protects individuals from the tail-risk of zero consumption late in life due to a large medical expense shock. When MTSI is removed, they self-insure against this risk by carrying more wealth into old age and aggregate savings increases by 39% (see Table 10 of the Online Appendix). The increase in savings is not particularly costly because households see death one period in advance and consume all of their wealth in the final period of life. Moreover, the increase in savings puts upward pressure on tax revenue

TABLE 10
Welfare and fiscal effects of changes in MTSI

Consumption floors Income thresholds Tax adjusted	30% up 30% up Payroll	30% up no change Payroll	no change 30% up Payroll	30% up 30% up Income	30% down 30% down 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, percentage of GNP	1.82	1.15	1.44	1.87	0.40

Notes: 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.

which, in turn, results in a lower average income tax rate.[40] The decrease in the tax rate is responsible for the large welfare benefit of removing MTSI from this economy. If taxes are held fixed at their baseline level instead, removing MTSI results in a 0.37% decline in *ex ante* welfare.

Column 2 shows that removing MTSI also increases welfare for all education and permanent earnings groups in the "no medical expense" economy. However, the welfare gains are much smaller in column 2 as compared to column 3. The *ex ante* welfare benefit for instance is only 0.4% in the "no medical expense economy". This difference in welfare can be attributed to savings which only increase by 6% when MTSI is removed in the "no medical expense" economy. When medical expenses are absent, MTSI continues to provide insurance against low lifetime earnings 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 well away from zero. This result suggests that there is an overlap between the benefits provided by MTSI and SS. We discuss these interactions in more detail in Section 6.4.

To summarize, MTSI insures against lifetime earnings risk and medical expense risk and this insurance is welfare-improving when both risks are present. Earnings risk opens the prospect of arriving at retirement with low resources and risky medical expenses introduce the possibility of large expenditures at the end of life.

6.2. *Reforming MTSI for Retirees*

Removing MTSI entirely is an informative counterfactual because it measures the overall value of these programmes. Given that the overall value is positive, it is worthwhile to explore whether the current scale of these programmes is too big or too small. Table 10 reports welfare changes based on comparing the baseline economy to alternative economies in which MTSI consumption

40. The general equilibrium effects of a reduction in the consumption floor on savings and taxes also arises in the two-period model as shown in Figure 2. Note that savings are higher and lump sum taxes are lower at smaller levels of the consumption floor. These effects are more pronounced here because savings are subject to taxation.

floors and/or income thresholds are either 30% higher or 30% lower.[41] 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. These results show that all education types benefit from the reform. It follows that if this policy was implemented along a transition, welfare of both newborn households and current retirees would increase.[42] 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 labour income, while the income tax is progressive and applies to both labour 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 labour supply and a slightly larger increase in MTSI recipiency rates.

Our finding that households do not want to increase MTSI if it is financed with a higher income tax raises the question of whether they would prefer a smaller MTSI programme 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.

6.3. *The Value of SS*

As we discussed in the introduction, a large previous literature has found that removing SS increases steady-state welfare.[43] 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%.[44] 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

41. 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.

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

43. These results raise questions about why the U.S. and many other countries have pay-as-you-go public pension programmes. 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.

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

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, percentage of GNP	1.02 (3.49)	0.00	1.02	3.49

Notes: 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.

return on SS contributions is lower than the return on capital in dynamically efficient economies such as ours. Second, SS is a much larger programme 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%.[45]

6.4. *The Interactions of MTSI and SS*

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 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. Interestingly, removing SS increases both aggregate wealth and the MTSI recipiency rate. Aggregate wealth increases by

45. 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%.

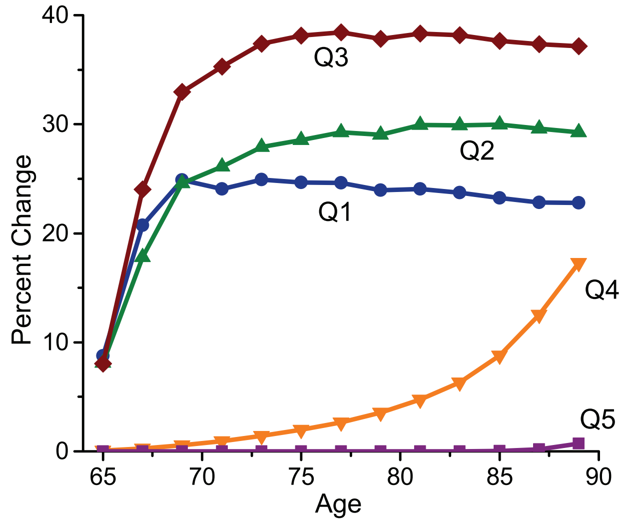

FIGURE 6

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

51.4% and the MTSI recipiency rate rises from 13.1% to 38.8%. The increase in the recipiency rate can be decomposed into two effects. First, 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. Second, there is an incentive effect. Mandatory SS contributions in the baseline economy are a form of forced savings for poorer households that prevent them from qualifying for MTSI upon retirement. When SS is absent, poorer households prefer to save less for their retirement as was illustrated in the model in Section 3. Following this strategy allows them to consume more and work less while young and then to qualify for MTSI benefits when they retire. Consistent with this behaviour, we find that, despite the large increase in aggregate wealth, wealth of retirees in quintiles 1–3 declines when SS is removed.

Both effects can be seen in Figure 6 which displays the increase in MTSI recipiency rates 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 do not 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.[46]

6.5. *Robustness*

Have we overstated the welfare-enhancing effects of U.S. MTSI programmes 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 labour 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.[47] 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.[48] 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 modelled 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 non-group 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 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.

46. Our result that welfare is much higher in the economy with MTSI only is 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.

47. See OECD Health Data.

48. The only private market we know of that offers even partial coverage against lifetime earnings risk is private disability insurance. Only 3% of non-government workers directly participate in this market and only 30% participate indirectly through their employer (Hendren, 2013).

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. MTSI programmes are highly valued when these risks are recognized. In fact, the current scale of these programmes may be too small. We have found that there would be general agreement among households to increase the scale of current U.S. MTSI programmes by 1/3 if that increase was financed with a higher payroll tax.

Appendix

TABLE A1
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)

Notes: A summary of the most frequently used model notation.

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Supplementary Data

Supplementary data are available at *Review of Economic Studies* online.

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