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The Effects of Collecting Income Taxes on Social Security Benefits

John Bailey Jones[‡] and Yue Li[§]

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September 2017

Abstract

Since 1983, Social Security benefits have been subject to income taxation, a provision that can significantly increase the marginal income tax rate for older individuals. To assess the impact of this tax, we construct and calibrate a detailed life-cycle model of labor supply, saving, and Social Security claiming. We find that in a long-run stationary environment, replacing the taxation of Social Security benefits with a revenue-equivalent change in the payroll tax would increase labor supply, consumption, and welfare. From an ex-ante perspective an equally desirable reform would be to make the portion of benefits subject to income taxes completely independent of other income.

JEL Classifications: E21, H24, H55, I38.

Keywords: Social Security, Labor Supply, Taxation.

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1 Introduction

The sustainability of the Social Security system has been a pressing concern for several decades. Even after a number of reforms, the system's trust fund is expected to be depleted in 2035 (Social Security Administration, 2016a). Many observers also fear that Social Security unduly discourages labor supply and private saving. The extensive literature on potential Social Security reforms thus continues to grow. There are nonetheless provisions of Social Security that remain relatively unexamined. In this paper, we focus on one such provision, the income taxation of Social Security benefits.

According to the Congressional Budget Office (Congressional Budget Office, 2015), in 2014 about half of Social Security recipients owed income taxes on their Social Security benefits. An important feature of these taxes is that the amount of Social Security benefits subject to taxation is an increasing function of the beneficiaries' "combined" income, which includes earnings.[1] At certain income levels, each additional dollar of earnings, in addition to being taxable itself, adds 50-85 cents of Social Security benefits to taxable income, increasing the effective marginal income tax rate on these earnings by 50% to 85%. The effects of this provision are thus potentially quite large.

The income taxation of Social Security benefits is a mechanism distinct from the Social Security Earnings Test, where earnings above a certain threshold result in a reduction in current Social Security benefits and an increase in future benefits. The effects of the Earnings Test, and in particular its partial elimination through the Senior Citizens Freedom to Work Act of 2000, have been studied extensively: see the review in Engelhardt and Kumar (2014). In contrast, only a few studies have analyzed the effects of taxing Social Security benefits, and none of them have developed models that formalize the dynamic aspects of the taxes. To fill this gap in the literature, we develop a heterogeneous-agent, life-cycle model, and use it to assess the effects of taxing Social Security benefits

[1]Combined income is the total of adjusted gross income, interest on tax-exempt bonds, and 50% of Social Security benefits and Tier I Railroad Retirement Benefits.

on asset accumulation, employment, Social Security claiming, and welfare.

Using a dynamic model allows individuals to respond to benefit taxation along multiple dimensions. For example, if a beneficiary's unearned income is sufficiently high, she will pay the maximum possible taxes on her Social Security benefits even if she does not work at all. In a static framework, this results in a pure income effect that encourages work (Page and Conway, 2015). In a dynamic framework, people can also adjust their asset accumulation and the age at which they first claim Social Security benefits. Such responses may attenuate the income effect. Using a dynamic framework allows for the intertemporal substitution of labor as well. Individuals may respond to higher tax rates in retirement by shifting their labor supply to earlier ages, or they may view the taxation of retirement benefits, which depend on their lifetime earnings, as a reduction in their total labor compensation at every age.

Because the revenues raised by taxing Social Security benefits are dedicated to the Social Security and Medicare trust funds, the most likely alternative to this tax is the payroll tax, the principal revenue source for the two trust funds. In all of our experiments, changes in the income taxation of Social Security benefits will be accompanied by surplus-balancing changes in the Social Security payroll tax rate. The two tax mechanisms differ in three important ways. First, the burden of payroll taxes falls heavily on young and middle-aged people, who arguably have a smaller labor supply elasticity than the elderly people who receive Social Security benefits (French and Jones 2012; Karabarbounis 2016). Second, payroll taxes impose fewer distortions on asset accumulation and Social Security claiming decisions. Third, income taxes are progressive. In contrast, the payroll tax for Social Security is regressive, as earnings above an upper bound are not taxed at all, and earnings below are taxed at a flat rate.

We conduct these experiments using an extension of the Bewley-Aiyagari-Huggett framework that includes a detailed model of Social Security and the income taxation of benefits. In the model, individuals face uncertain wages, health, health spending, and survival. They choose how much to work and save and when to claim Social Security benefits. Consistent with the empirical evidence (Aaronson and French, 2004), as older workers transit into part-time jobs, their wages fall. The government collects income, payroll and consumption taxes, and provides Social Security, Medicare, and means-tested social insurance. The timing of Social Security claims affects the amount of benefits, the treatment of the Earnings Test, and the level of income taxes. We calibrate the model to match the 2006 US economy and use it to examine the effect of replacing the income taxes on Social Security benefits with payroll taxes.

In the structural analysis of Social Security reforms, little attention has been paid to the taxation of Social Security benefits (e.g., Feldstein and Liebman 2002). Our analytical framework is similar to that of Imrohoroğlu and Kitao (2012), expanded to include benefit taxation and labor supply decisions after age 70.[2] The paper also adds to the large body of work on life-cycle labor supply decisions (see, e.g., the review in Blundell et al. 2016). Our contribution to this literature is to carefully model the tax incentives of elderly workers and discuss their implications for labor supply.

Although there are, to our knowledge, no existing structural analyses of the Social Security benefits tax, there are a few nonstructural empirical studies.[3] Here, two papers are of note. Burman et al. (2014) exploit the fact that Social Security benefits are taxable only when combined income exceeds a statutory threshold. Finding that the income of older workers is not bunched around this threshold, they argue that the benefit tax has little impact, perhaps because of its complicated structure. But if workers cannot modulate their labor supply very precisely, for reasons such as fixed costs, pronounced bunching may not appear (Chetty 2012; Engelhardt and Kumar 2014). Moreover, analyses of bunching do not identify responses along the extensive margin.[4] Our model allows us

[2]In our data the employment rate for people aged 71-84 is nearly 19%.

[3]While Kopecky and Koreshkova (2014) and Braun et al. (2016) explicitly model benefit taxation, in their framework the retirement age is fixed and Social Security beneficiaries are unable to work.

[4]The techniques developed by Gelber et al. (2017), who estimate extensive margin responses from budget kinks, were not available in earlier studies.

to examine participation decisions. Page and Conway (2015) find that the introduction of benefit taxation in 1983 increased the labor force participation of the highest-income people, for whom the tax generated (in a static framework) an income loss but no change in marginal tax rates. Our framework allows us to consider effects across the entire income distribution and life cycle. Perhaps more important, Page and Conway's approach exploits a one-time change in the taxation rules introduced in 1983. Our model, which is identified by life-cycle variation, can be applied to the current taxation regime, which has been stable in nominal terms since 1993.

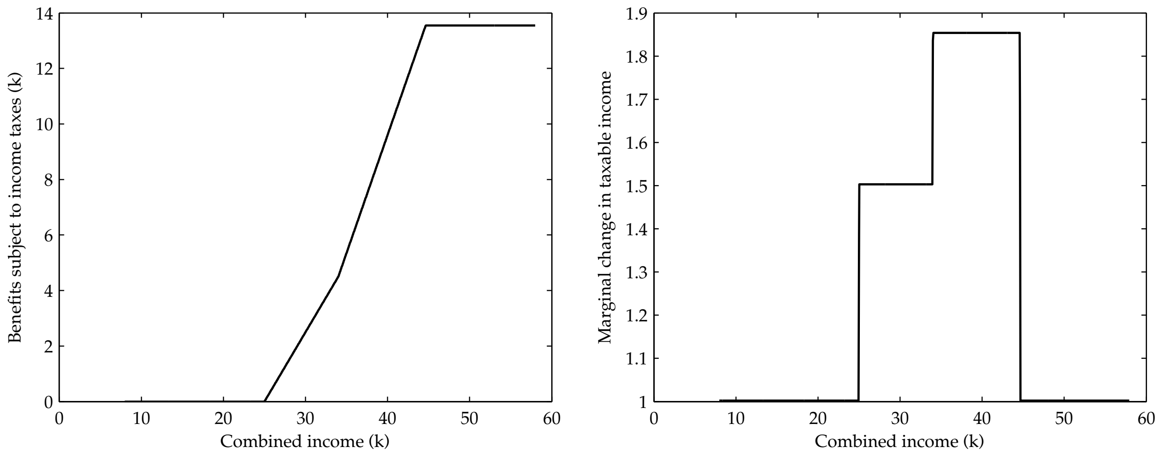
We find that the model fits well the life-cycle patterns of employment, wealth, and Social Security claiming with a fairly modest number of internally calibrated parameters. This gives us confidence in the model's ability to make counterfactual policy predictions. We have four principal findings. The first finding is that replacing the taxation of Social Security benefits with a revenue-equivalent change in the payroll tax would increase aggregate labor supply, consumption, and welfare. Given that the provision applies only to older workers, its effects are relatively large. This is because the work disincentives of the benefit tax are most potent at older ages, when labor supply is very elastic. Replacing it with the payroll tax, which affects all ages evenly, is beneficial. The second finding is that benefit taxation affects the aggregate labor supply primarily through the extensive margin. To reproduce the observed distribution of hours, and following a number of earlier studies, our model includes a fixed cost of work. The fixed cost leads most individuals to work either full time or not at all. In practice, most Social Security beneficiaries do not need to know the exact benefit taxation formula: when deciding whether to work, they need only to know that working will lead to significantly higher income taxes. Our third finding is that the effects of eliminating benefit taxation are larger than the effects of eliminating the remainder of the Earnings Test. This finding is in part driven by our assumption that workers understand that benefits withheld through the Earnings Test are credited to future benefits, but it is also in part driven by interactions between the income taxation of benefits and the Earnings Test. Because the effects of benefit taxation are bounded by the total amount of benefits, the reduction of benefits through the Earnings Test attenuates the (immediate) effect of the benefits tax. Removing the Earnings Test exposes more benefits to taxation.

Our final finding is that from an ex-ante perspective a desirable reform would be to continue taxing Social Security benefits but make the portion of benefits taxable independent of other income such as earnings and asset income. Although the largest welfare gains come from eliminating the Earnings Test and benefit taxation together, the gains from unconditional benefit taxation are nearly as large. Like most tax provisions, the taxation of benefits generates both income and substitution effects. The largest substitution effect comes from the way in which higher earnings can lead to higher benefit taxes. Making the taxation of Social Security benefits unconditional severs this link, encouraging work. This reform has the additional benefit of increasing benefit-based income tax revenues, which in turn allows the government to lower the payroll tax rate. Replacing the regressive payroll taxes with progressive income taxes increases aggregate welfare. One drawback of this reform is that its welfare effects vary greatly by age. While the young benefit, the increase in benefit-related income taxes harms older individuals.

The remainder of the paper is organized as follows: Section 2 details the current rules for taxing Social Security benefits; Section 3 presents the model; Section 4 describes the calibration and the benchmark economy; Section 5 conducts counterfactual experiments; Section 6 contains a number of alternative specifications and robustness tests; and Section 7 concludes.

2 Institutional Background

Aiming to increase Social Security revenues and to make the treatment of Social Security benefits more like that of private pensions, the 1983 Social Security Amendment introduced income taxes on Social Security benefits.[5] Under the amendment, if a taxpayer's combined income – the sum of adjusted gross income (AGI), interest on tax-exempt bonds, and 50% of Social Security benefits – exceeded a threshold ($25,000 for an individual), the amount of benefits subject to income taxation were the lesser of 50% of the benefits or 50% of the combined income in excess of the threshold. Ten years later, the Omnibus Budget Reconciliation Act of 1993 introduced a second, higher threshold ($34,000 for an individual). For taxpayers with income in excess of the second threshold, the amount of benefits subject to income taxation were increased to the sum of: 50% of the difference between the second and first thresholds; and 85% of any combined income in excess of the second threshold, up to 85% of total benefits. Because neither threshold is indexed for inflation, the number of beneficiaries affected by these provisions has been rising over time.



(a) Benefits Subject to Taxes (b) Change in Taxable Income

Figure 1: Taxation of Social Security Benefits

Note: Calculations for a person receiving an annual Social Security benefit of $15,942.

Figure 1 illustrates the benefit taxation rules for an individual who receives an an-

[5] Historical detail can be found in Meyerson (2014) and Goodman and Liebman (2008).

nual Social Security benefit of \$15,942.[6] Figure 1(a) plots taxable Social Security benefits against combined income, holding total Social Security benefits fixed but allowing other sources of income (such as earnings) to vary. Once combined income reaches the initial threshold of \$25,000, each additional dollar of income adds 50 cents of Social Security benefits to taxable income. Once the second threshold of \$34,000 is reached, each additional dollar of income adds 85 cents of Social Security benefits to taxable income until 85% of Social Security benefits are taxed; in the current example the taxable limit of \$13,551 (= \$15,942×0.85) is reached at a combined income of \$44,648.[7] Figure 1(b) shows the increase in taxable income associated with a \$1 increase in earnings. Between the first and second thresholds, each additional dollar of earnings adds 1.5 dollars to taxable income; after the second threshold, the ratio increases to 1.85, until the maximum is reached.

In a static model, this way of taxing Social Security benefits has no effect on people whose combined income, if they work full time, falls below the first threshold. It has a pure income effect for people with combined nonearnings income above the maximum, and it has a combination of income and substitution effects on people with income between these extremes. The range of tax distortions is increasing in the Social Security benefit and thus depends on the beneficiary's claiming decisions and lifetime earnings.

3 Model

3.1 Demographics

The population consists of overlapping generations of single-person households. Let $j \in \{1, 2, \ldots, J\}$ denote age, with J the maximum possible life span. Let $s_j(h_j)$ denote the survival rate between periods, which depends on each individual's age and idiosyncratic health status, $h_j \in \{\text{good}, \text{bad}\}$. The population grows at the constant rate χ.

[6] This is the annual benefit for an average retired worker (2015 Social Security statistical supplement).
[7] As $[\$44,648 - \$34,000] \times 0.85 + [\$34,000 - \$25,000] \times 0.5 = \$13,551$.

3.2 Preferences

Each period, surviving individuals receive utility from consumption (c) and leisure (l) according to the function $u(c, l)$. Leisure in turn depends on hours of work, n_j, health, and labor market participation in the previous period (n_{j-1}):

$$l_j = 1 - \phi_h I_{\{h_j=\text{bad}\}} - \phi_n I_{\{n_j>0\}} - \phi_{re} I_{\{n_{j-1}=0 \text{ and } n_j>0\}} - n_j, \tag{1}$$

where $I_{\mathcal{A}}$ is the 0-1 indicator function that takes the value of 1 when event $\mathcal{A}$ occurs. The term $\phi_h I_{\{h=\text{bad}\}}$ reflects the time cost of bad health, aiming to reproduce the empirical observation that unhealthy people work less. The term $\phi_n I_{\{n>0\}}$ captures the fixed time costs of work, aiming to reproduce the observation that most people work full time or not at all (see, e.g., Cogan 1981 and French and Jones 2012). The term $\phi_{re} I_{\{n_{j-1}=0 \text{ and } n_j>0\}}$ captures the time cost of reentering the labor market, aiming to reproduce the observation that most people do not repeatedly enter and exit the labor market in response to transitory changes in wages. Similar specifications for leisure have been used in, among other studies, French (2005) and French and Jones (2011).

When they die, individuals receive warm-glow utility from bequests according to the function $v(a)$, where a denotes the amount of assets bequeathed. Future utility is discounted using the factor β.

3.3 Earnings

Individuals who work at age j receive the wage w_j,

$$w_j = w \varepsilon_j \eta_j \cdot \min \left\{ 1, \left(\frac{n_j}{\bar{n}} \right)^{\zeta} \right\}. \tag{2}$$

where w is the unit wage, ε_j is an age-specific life-cycle productivity level, and η_j is an idiosyncratic productivity shock following a Markov process with transitions $\Pi^{\eta}(\eta_j, \eta_{j+1})$.

The final term, $\min\left\{1, [n_j/\overline{n}]^{\zeta}\right\}$, imposes a penalty for working less than the full-time work load of $\bar{n}$. Aaronson and French (2004) show that part-time workers earn lower wages; potential explanations include fixed costs on the employer's side and the loss of human capital as older workers transit from career to bridge jobs (Ruhm 1990; Giandrea et al. 2009). Following Aaronson and French (2004), we set ζ to 0.415, implying that half-time workers are paid 25% less than full-time workers. This feature combines with the fixed time cost of work to encourage full-time work.

3.4 Medical Expenditure and Health Insurance

Each individual's health status (h_j) changes stochastically over the life cycle, following a Markov process with the age-dependent transitions $\Pi_j^h(h_j, h_{j+1})$. Health status affects individuals through three channels: survival probabilities, the time endowment, and medical expenditures. Total medical expenditures, denoted by $m_j = m_j(h_j, \epsilon_j)$, depend on age, health, and the idiosyncratic white noise shock ϵ_j, which follows the stationary distribution $\Pi(\epsilon)$. Health insurance coverage is universal: Medicare covers all individuals 65 and older ($j \geq J^M$), and private health insurance covers the rest of the population.[8] The medical expenses paid by the individuals themselves can be split into two parts: insurance premiums, p_j, which are paid at the beginning of each period before the medical spending shocks for that period are revealed; and copayments, $Q_j\big(m_j(h_j, \epsilon_j)\big)$, which are paid at the end of each period after the shocks are revealed. Premiums and co-payments follow

$$p_j = \begin{cases} p^{\text{priv}} & \text{if } j < J^M \\ p^{\text{mcr}} & \text{otherwise,} \end{cases}$$

[8]The model abstracts from heterogeneity in private insurance access. Dynamic models with different insurance eligibility and insurance take-up include Jeske and Kitao (2009) and Pashchenko and Porapakkarm (2013).

$$Q_j\big(m_j(h_j,\epsilon_j)\big) = \begin{cases} \kappa^{\text{priv}} m_j(h_j,\epsilon_j) & \text{if } j < J^M \\ \kappa^{\text{mcr}} m_j(h_j,\epsilon_j) & \text{otherwise,} \end{cases}$$

where the superscripts "priv" and "mcr" denote, respectively, private insurance and Medicare, and $\kappa^i, i \in \{\text{priv}, \text{mcr}\}$, is the coinsurance rate.

3.5 Government

The government collects taxes and provides social insurance. The difference between the government's revenues and its transfer spending is absorbed by direct spending (G). The government also appropriates all bequests, which it then distributes equally among all living individuals, each of whom receives the transfer B.

Social Security. Let J^E denote the Early Retirement Age (ERA), J^N denote the Normal Retirement age (NRA), and J^L denote the Late Retirement Age (LRA). Individuals can choose any age from the ERA of 62 to the LRA of 70 to claim their Social Security benefits. Social Security recipients receive benefits according to $A_k ss(e_j)$. The variable e_j is an index of the individual's earnings over her 35 highest earnings years. The piecewise linear function $ss(\cdot)$ determines the benefits received if Social Security is first claimed at the normal retirement age J^N. The final term, A_k, is an adjustment factor based on the benefit claiming age k, reflecting early retirement penalties and delayed retirement credits, with $A_{J^N} \equiv 1$. As described in Appendix A, we capture the effect of A_k through adjustments to e_j; this allows us to find the consumer's decision rules without having to keep track of k.

Until benefits are claimed, e_j is updated any time that current earnings qualify as one of the 35 highest annual totals. Once Social Security benefits have been claimed,

e_j is updated to only reflect the benefits that are withheld due to the Earnings Test.[9] Beneficiaries who are below the NRA and have labor income in excess of the earning limit y_j^{et} have their benefits withheld at a rate of τ_j^{et}: for each additional dollar earned, Social Security benefits are reduced by τ_j^{et}, until all benefits are withheld. Let $W_j = w_j n_j$ denote total earnings, T_j^{et} denote benefits lost through the Earnings Test, and ss_j^* denote the remaining benefits. We have

$$T_j^{\text{et}}(ss_j, W_j) = \min\left\{ss_j,\ \ \tau_j^{\text{et}} \max\{0,\ W_j - y_j^{\text{et}}\}\right\}, \tag{3}$$

$$ss_j^*(ss_j, W_j) = ss_j - T_j^{\text{et}}(ss_j, W_j). \tag{4}$$

Any such reductions in current benefits, however, are offset by permanent increases in future benefits, implemented in our framework through increases in e_{j+1}.[10] The net incentive generated by the Earnings Test depends on whether the increases in future benefits are actuarially fair; because the current crediting formula is considered actuarially fair for the average person, for most workers the net tax rate associated with the Earnings Test is small.

Taxes. The government collects income taxes, consumption taxes, payroll taxes, and Medicare premiums. Income taxes are progressive and are based on taxable income y_j according to the tax function $T(y_j)$. Taxable income itself is the sum of asset income (ra_j), earnings and the taxable portion of Social Security benefits, $SS(ss_j^*, ra_j, W_j)$. Consumption taxes are imposed on all consumption goods at the flat rate τ^c. Payroll taxes consist of two parts: a Medicare tax imposed on all earned income at the flat rate τ^{mcr}, and a Social Security tax imposed on earned income up to the taxable threshold y^{ss} at the flat rate τ^{ss}. We set τ^{mcr} and τ^{ss} to equal the tax rates faced by employees; identical

[9] In actual practice, e_j continues to be updated for high current earnings even after benefit claiming. This is a relatively rare event, however, and to simplify the model we rule it out.

[10] This is a simplification, as in actual practice benefits are adjusted only when a person reaches the NRA.

taxes are collected from employers.

Means-Tested Social Insurance. Means-tested social insurance can be thought of as a combination of TANF, SNAP, SSI, uncompensated medical care and Medicaid. Following the practice established by Hubbard et al. (1995), we assume that this program provides a consumption floor of $\underline{c}_j$. At the beginning of each period means-tested transfers are given by

$$tr_j = \max\{0, (1+\tau^c)\underline{c}_j - y_j^d\}, \tag{5}$$

where y_j^d denotes total financial resources – the sum of assets, after-tax income and distributed bequests, less insurance premiums – prior to receiving means-tested transfers:

$$\begin{aligned} y_j^d = {} & (1+r)a_j + W_j + ss_j^*(ss_j, W_j) - T\big(ra_j + W_j + SS(ss_j^*, ra_j, W_j)\big) \\ & - \tau^{\text{mcr}} W_j - \tau^{\text{ss}} \min\{W_j, y^{\text{ss}}\} + B - p_j. \end{aligned} \tag{6}$$

3.6 The Individual's Problem

Individuals can be characterized by their age j and the six-element state vector $\mathbf{x}_j = \{a_j, \eta_j, h_j, e_j, b_{j-1}, n_{j-1}\}$, where a_j records assets carried over from period $j-1$, η_j is the idiosyncratic productivity shock, h_j is health, e_j is the earnings index, b_{j-1} is an indicator function for having received Social Security in the previous period, and n_{j-1} records labor force participation in the previous period.

At the beginning of each period, individuals choose labor hours and whether to file a Social Security claim (if they are age eligible and have not already claimed). Claiming allows them to receive Social Security benefits from the current period forward and is not reversible. At this point, individuals' financial resources consist of their labor income, assets and asset income, Social Security benefits, and lump-sum bequest transfers, net of taxes and health insurance premiums. If this amount is below the consumption floor, government transfers via means-tested insurance bridge the gap. Individuals then choose how much to consume out of their (post-transfer) financial resources. They can save, but borrowing constraints prevent them from consuming more than their current resources.

At the end of each period, medical expenditure shocks are realized. If out-of-pocket medical expenditures exceed available (post-consumption) resources, assets in the next period, a_{j+1}, are negative. The survival shock is realized. Individuals who die receive warm-glow utility from bequests, while surviving individuals realize their new productivity shocks (η_{j+1}) and health shocks (h_{j+1}), and enter the next period with state vector $\mathbf{x}_{j+1} = \{a_{j+1}, \eta_{j+1}, h_{j+1}, e_{j+1}, b_j, n_j\}$.

In recursive form, the individual's problem is

$$V_j(\mathbf{x}_j) = \max_{c_j, n_j, b_j} \Big\{ u(c_j, l_j) + \beta E_j \big[s_j(h_j) V_{j+1}(\mathbf{x}_{j+1}) + (1 - s_j(h_j)) v(a_{j+1}) \big] \Big\}$$

subject to equations (1)-(6) and:

$$\begin{aligned} (1+\tau^c)c_j &\leq y_j^d + tr_j, & (7)\\ a_{j+1} &= y_j^d + tr_j - (1+\tau^c)c_j - Q_j\big(m_j(h_j, \epsilon_j)\big), & (8)\\ e_{j+1} &= f_j(e_j, W_j, b_{j-1}, b_j). & (9) \end{aligned}$$

Equation (7) prohibits borrowing to fund current goods consumption. Equation (8) describes the law of motion for assets. Note that individuals are allowed to take on medical expense debt. Equation (9) describes the law of motion of the earnings index e_j, which depends on age, the index's current value, current earnings, and Social Security recipiency status.

3.7 Stationary Equilibrium

Our approach will be to take pre-tax wages and the interest rate from the data and to find the private insurance premium and government policies that produce budget balance for a stationary distribution of individuals. Such an approach is consistent with a small open economy, where the capital-labor ratio and pre-tax wages depend only on the (constant) international interest rate. Our equilibrium concept is identical to the one used in Kitao (2014).

Definition 1. *A stationary equilibrium is a collection of government policies, a lump-sum transfer, a private health insurance premium, decision functions, and a distribution* $\mu(\tilde{\mathbf{x}})$, $\tilde{\mathbf{x}} = [\mathbf{x_j}', \epsilon_j, j]'$, *of individuals, such that the following conditions hold.*

1. *Given government policies, the lump-sum transfer, the private health insurance premium, and the decision functions are the solutions to the individual problem described in subsection 3.6.*

2. *The government budget is balanced:*

$$\begin{aligned}&\int \Big[\tau^c c + T\big(ra + W + SS(ss^*, ra, W)\big) + 2\tau^{mcr} W + 2\tau^{ss} \min\{W, y^{ss}\} \\ &\qquad + T_j^{et}(ss, W) + p^{mcr} I_{j \geq J^M}\Big] \ \mu(\tilde{\mathbf{x}}) \ d\tilde{\mathbf{x}} \\ &= \ G + \int \left[ss + tr + (m - Q) I_{j \geq J^M}\right] \ \mu(\tilde{\mathbf{x}}) \ d\tilde{\mathbf{x}};\end{aligned}$$

3. *Health insurers earn zero profits:*

$$p^{priv} \int I_{j<J^M} \ \mu(\tilde{\mathbf{x}}) \ d\tilde{\mathbf{x}} = \int (m - Q) I_{j<J^M} \ \mu(\tilde{\mathbf{x}}) \ d\tilde{\mathbf{x}};$$

4. *Total lump-sum transfers equal the assets of deceased individuals:*

$$(1 + r) \int (1 - s(\tilde{\mathbf{x}}))a'(\tilde{\mathbf{x}}) \ \mu(\tilde{\mathbf{x}}) \ d\tilde{\mathbf{x}} = (1 + \chi)B;$$

5. *The distribution of individuals is stationary.*

4 Calibration and Benchmark Economy

4.1 Data

Our principal data source is the Medical Expenditure Panel Survey (MEPS). The MEPS is a rotating panel, with each individual interviewed multiple times over a two-year period. We use panels 10 and 11, which were collected around 2006, just prior to the Great Recession, for data on employment, health insurance, health status, and medical expenditures. Because our model is one of singles, and thus does not account for child-rearing and secondary earners, our data for employment and Social Security claiming are only for men.[11] For all other uses, we include both genders.

To estimate median asset holdings by age, we use the 2004 Survey of Consumer Finances (SCF).[12] Because the benchmark model is calibrated to match the 2006 US economy, all values are denominated in 2006 dollars unless otherwise stated.

4.2 Demographics and Health

Each generation enters the economy at age 20 and lives up to 100. Survival rates, $s_j(h_j)$, are set to match those in Imrohoroğlu and Kitao (2012). The process for the health measure h_j is estimated from MEPS data on perceived health status. We allow the medical spending shock ϵ to take on three values. As in Kitao (2014), we capture the long tail in the distribution of medical expenses by using: a small shock with a 60% probability, a medium shock with a 35% probability, and a large shock with a 5% probability. These values are estimated from MEPS data as well. Appendix A describes the calibration of these and other health-related parameters in more detail.

[11] An individual is coded as participating in the labor force if he was employed at the point of any interview date in the year of 2006.

[12] Assets for married couples are split evenly.

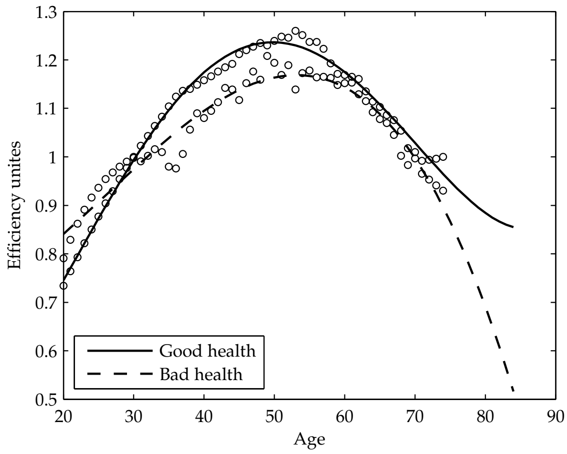


Figure 2: Age Efficiency Profiles

4.3 Endowments and Preferences

The life-cycle productivity profiles are based on the profiles for workers with "tied" wages found in French (2005).[13] The profiles are normalized so that the age-30 productivity level for a healthy worker equals 1. Figure 2 shows both the raw profiles (the circles) and the polynomial approximations we use in the model. We model the log of the idiosyncratic productivity shock η using a five-state Markov chain, which we set to approximate a first-order auto-regressive process with a persistence parameter of 0.97 and an unconditional variance of 0.305, as in Heathcote et al. (2010).

A number of preference parameters are calibrated by fitting the model to a set of empirical targets. Table 1 lists the parameters and associated targets and reports the model's fit.

The flow utility function is specialized as:

$$u(c, l) = \frac{1}{1-\sigma}\left(c^{\gamma} l^{1-\gamma}\right)^{1-\sigma},$$

[13]French's (2005) profiles are based on data for male household heads. The profiles are the combination of a base profile and an adjustment for selection bias. Because the model in French (2005) underpredicts employment at older ages, from age 60 forward we use the wage bias adjustments from French and Jones (2011), splicing the series together. We are grateful to Eric French for sharing these data.

where l denotes leisure as defined in equation (1). γ determines the weight on consumption relative to leisure and is calibrated so that an average worker spends 33% of her disposable time on her job.[14] The parameter ϕ_n determines the fixed cost of working and is calibrated to match the average employment rate of people aged 62-69, the group deciding when to claim Social Security benefits. The parameter ϕ_h determines the time cost of being in bad health and is set to match the difference in employment between good-health and bad-health individuals in the 62-69 age group. The parameter ϕ_{re} determines the cost of reentering the labor market and is calibrated to match the reentry rate of individuals aged 62-69. We set σ to 7.5, the (approximate) value estimated by French (2005) and French and Jones (2011), who use utility functions and wage processes very similar to ours. Setting σ to 7.5 implies a coefficient of relative risk aversion $(1 - \gamma(1 - \sigma))$ of 3.19, which is in line with the results in French (2005), French and Jones (2011), and De Nardi et al. (2010).

Deceased individuals derive utility from bequests according to

$$v(a) = \psi_1 \frac{(\psi_2 + \max\{a, 0\})^{\gamma(1-\sigma)}}{1-\sigma}, \tag{10}$$

where ψ_2 is set to \$500,000, as in De Nardi (2004) and French (2005). ψ_1 is calibrated to match the median assets of individuals aged 75-84, a relatively older age group. The maximum operator is added to ensure that any debt due to medical expenditure shocks is waived upon death.

The discount factor β is set to match the median assets of individuals aged 45-54, an age group accumulating wealth for retirement. The pre-tax interest rate is set to 0.05 per year, the value suggested in Cooley (1995). The unit wage rate w is set to generate average earnings of \$37,078, the earnings level for 2006 used by the Social Security Administration

[14] If an individual has 16 waking hours each day, a workload of 2,000 hours absorbs 34.25% of her annual time endowment.

in its indexing calculations (Social Security Administration, 2015).

Table 1: Calibrated Parameters

Param.	Interpretation	Value	Target	Model	Data
β	discount factor	0.981	median assets, 45-54 (\$000s)	118.0	117.1
γ	consumption weight	0.337	average hours of workers	0.334	0.333
ϕ_n	participation cost	0.061	employment rate, 62-69	0.499	0.509
ϕ_h	bad health cost	0.131	emp. rate good health, 62-69 / emp. rate bad health, 62-69	2.263	2.275
ϕ_{re}	reentry cost	0.059	re-entry rate, 62-69	0.053	0.053
ψ_1 (000s)	bequest intensity	48.18	median assets, 75-84 (\$000s)	153.2	155.2
w (000s)	unit wage	98.13	avg. earnings of workers (\$000s)	37.83	37.08

Note: Employment targets based on data from the MEPS. Asset targets based on data from the SCF. See Section 4.1 for more detail. Targets for hours and earnings are described in Section 4.3.

4.4 Government

We calibrate government policy parameters to those in effect in 2006. Appendix A describes our calibration procedure in some detail; here we provide an overview.

Social Security. Social Security benefits are given by $A_k ss(e_j)$, where the index e_j equals the beneficiary's average earnings over her 35 highest earnings years prior to claiming. Because keeping track of 35 years of earnings is infeasible, we use an approximation for e_j similar to that used by Imrohoroğlu and Kitao (2012). A_k is an adjustment factor based on the benefit claiming age k, reflecting early retirement penalties and delayed retirement credits. Both $ss(\cdot)$ and $\{A_k\}_k$ are set to match the rules for the 1940 birth cohort, which reaches its NRA in 2006.

Taxes. The baseline income tax function $T(y_j)$ is a simplified application of the 2006 Federal Income Tax code, using the personal exemption and standard deduction, and not accounting for credits or itemized deductions or other complications. Total taxable income y_j is in turn the sum of earnings, asset income, and taxable Social Security benefits, the latter modeled as described in Section 2.

In our benchmark specification τ^{ss} and τ^{mcr} equal the employee share (one-half) of payroll taxes, as the earnings data to which we calibrate our model do not include the payroll taxes paid by employers. We recognize the employer share in the government budget constraint, however, and when we adjust payroll taxes in our numerical experiments we assume that the entire change is borne by the worker, consistent with our equilibrium assumption that the pre-tax wage is fixed.[15]

The consumption tax rate τ^c is set so that in a balanced budget equilibrium direct government spending (G) equals about 23% of total earned income.

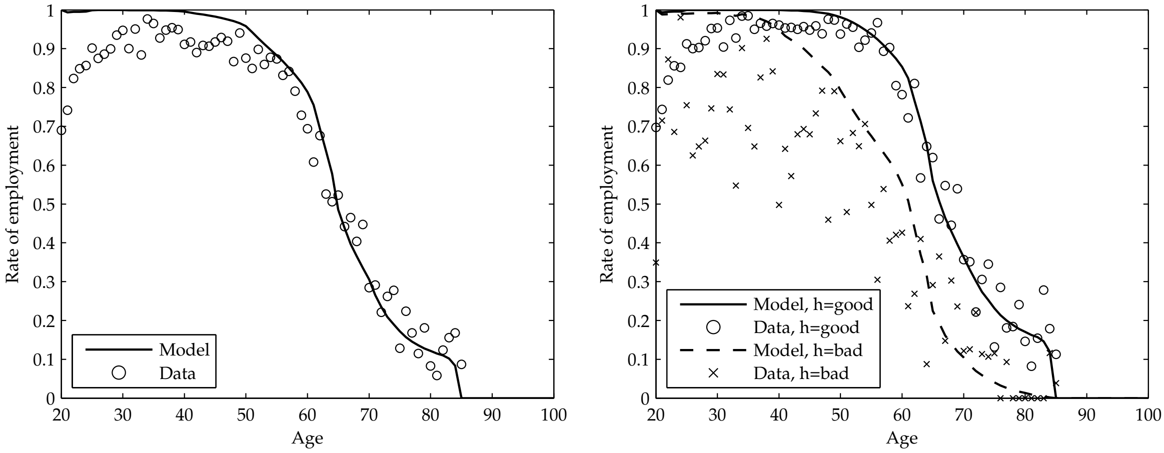
Means-Tested Insurance. In the model means-tested social insurance provides a consumption floor ($\underline{c}_j$) of \$3,000 for individuals under age 65 and of \$6,377 for individuals aged 65 and above.

4.5 Model Fit

We turn to assessing the model's fit of the data. While the model is calibrated to a number of important data features – see Table 1 – it in general matches employment and wealth over the life cycle. This gives us confidence in using the model for counterfactual experiments.

Employment. Figure 3 shows that the model fits well both the aggregate life-cycle employment profile and the disaggregated profiles for good and bad health. In particular, the model captures the sharp drop in employment after the ERA of 62. As discussed below, part of the drop is explained by the income tax treatment of Social Security benefits. In line with the data, the model also produces a substantial number of older people who continue to work after age 70. The model does less well at the youngest ages, where it overstates employment. This may reflect the absence of higher education in the model. Overstating employment at younger ages will affect our findings to the extent

[15] Recall that our definition of equilibrium is that of a small open economy, where the capital-labor ratio is determined by the international rate of interest.



(a) Average

(b) By Health

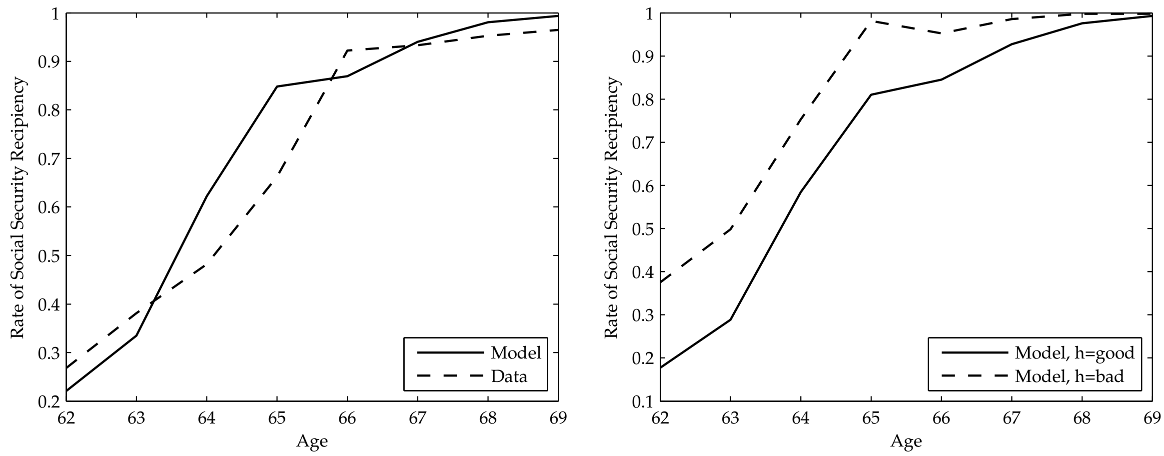
Figure 3: Rate of Employment by Age

Source: Employment data for male respondents from MEPS panels 10 and 11.

that it affects assets and Social Security entitlements around the time of retirement. But as shown below, the model if anything understates asset holdings around age 60, and it matches Social Security claiming patterns.

Social Security Claims. Figure 4(a) compares the model-generated claiming profile to the observed claiming profile. Although the model does not target these data, it matches the general pattern of Social Security claims. In particular, the model correctly predicts that most individuals do not claim benefits at the ERA of 62, even though early filing maximizes expected discounted benefits (at an assumed after-tax interest rate of 4.25%). Within our model, there are at least two reasons why individuals defer claiming their benefits. First, risk-averse individuals will defer claiming in order to have higher benefits should they live to unexpectedly old ages (Imrohoroğlu and Kitao, 2012). Second, claiming decisions are distorted by the combination of the Earnings Test and the income tax on Social Security benefits.

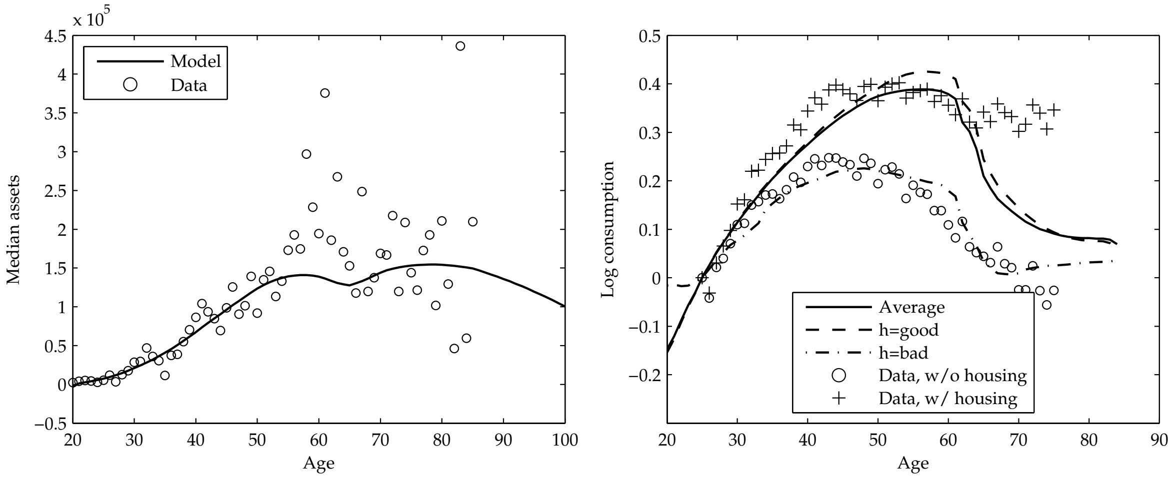
Assets and Consumption. As shown in Figure 5(a), individuals hold significant amounts of assets at very old ages. This reflects the bequest motive, precautionary saving



(a) Average (b) By Health

Figure 4: Rate of Social Security Recipiency by Age

Notes: The claiming rate for the data is computed as the age-by-age ratio of male retired worker beneficiaries from the 2007 Statistical Supplement (Social Security Administration 2008, Table 5.A1.1) to the intercensal population estimates for men in 2006 (United States Census Bureau, 2016).



(a) Median assets (b) Log Consumption

Figure 5: Median Assets and Average Log Consumption by Age

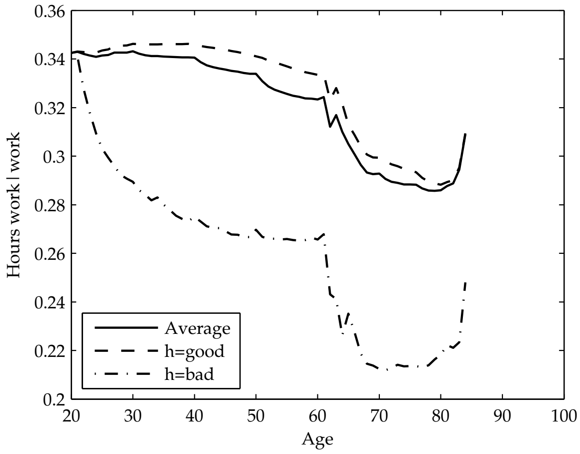
Notes: Observed asset values are from the 2004 SCF. Consumption data are from Aguiar and Hurst (2013).

for health spending, and mortality bias – people with bad health are more likely to both have small asset holdings and die young (De Nardi et al., 2016). The asset profile generated by the model is roughly consistent with this pattern. Median assets drop before 65, when some individuals retire early, live on their assets, and wait to claim their Social Security benefits. Assets increase between ages 65 and 80 and fall after age 80.

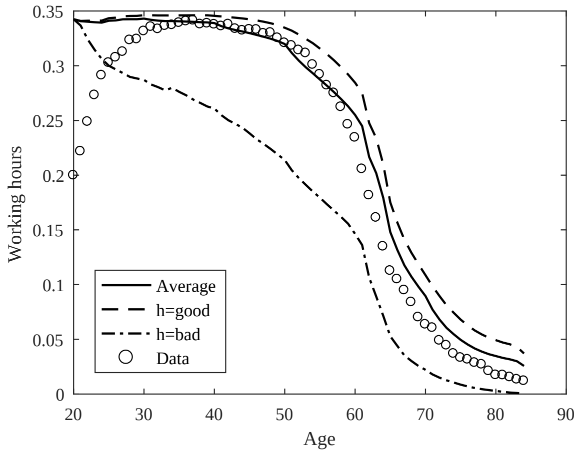
Figure 5(b) displays life-cycle consumption profiles. The shape of the consumption profiles resembles the shape of the efficiency profile, for two reasons. First, because low-earning younger workers cannot borrow against higher future earnings, their consumption tracks their income and thus rises with age (Gourinchas and Parker, 2002). Second, with $\sigma > 1$ consumption and leisure are substitutes (Low, 2005). As workers retire, they substitute leisure for consumption, leading to sharp drops in consumption around ages 60 and 85. The fall in consumption found in the data is smaller than that predicted by the model, mostly because of the consumption of housing; the data profile for nonhousing consumption shows a more pronounced decline. Because older households are slow to downsize their homes, the empirical life-cycle profile of housing consumption is flat at older ages (Yang, 2009). Lacking housing, our model cannot match this dynamic.

Hours and Earnings. Turning to the intensive margin, Figure 6(a) shows that the model predicts that hours worked by workers decline over almost the entire life cycle. At younger ages, borrowing-constrained younger workers work extended hours to build up their wealth (Low, 2005). As wealth accumulates, hours begin to fall. Hours decline sharply after age 60, as many workers transit to part-time jobs. The switch to part-time work reflects the decline in the age-efficiency profile, the increase in asset wealth, and the disincentives generated by the Earnings Test and benefit taxation.[16] Unhealthy individuals work fewer hours at every age, consistent with their reduced time endowment (captured by ϕ_h). The hours profiles documented in French (2005, Figures 2 and 3) show similar patterns.

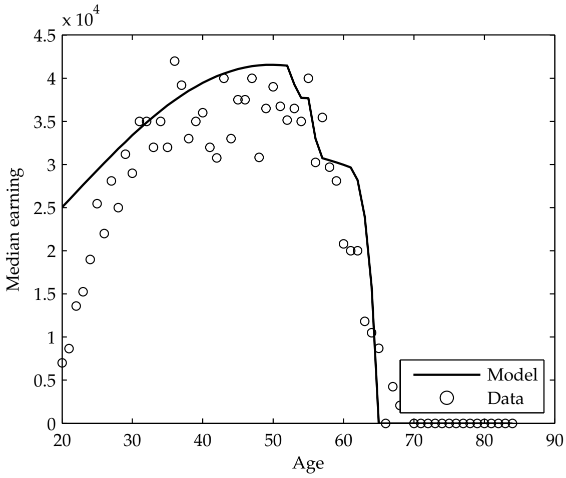
[16] The downward trend in hours reverses after age 80. One reason that hours spike upward is that some individuals at slightly younger ages work to avoid paying reentry costs at later ages. These individuals, who tend to work fewer hours, are less likely to be working as they approach the mandatory retirement age of 85. When we remove the reentry cost, the spike becomes much less pronounced.



(a) Average Hours of Workers



(b) Average Hours



(c) Median earnings

Figure 6: Average Hours and Median Earnings by Age

Notes: Hours data are calculated from the ACS. Earnings data are calculated from the MEPS.

Because the MEPS does not record the number of weeks its respondents work, we compare the model's predictions for annual hours to data from the American Community Survey (ACS). Figure 6(b) uses the ACS variable most easily comparable to model output, namely total hours for everyone, including the nonemployed. The model predictions are fairly similar to those of the data except at very young ages, when the model's tendency to overpredict employment leads it to overpredict total hours of work as well. The model also overpredicts hours at the oldest ages. Because the model matches employment at older ages (see Figure 3), this discrepancy implies that hours of work by workers are higher in the model than in the data.

Figure 6(c) compares the median earnings profile (W_j) generated by the model to that of the data. The model overstates earnings between ages 20 and 30, but otherwise matches the data fairly well. The model predicts that for ages 40-49, the ratio of median assets to median earnings is 2.28; the corresponding ratio from the data is 2.75. Because the model matches asset holdings at these ages quite well (see Figure 5(a)), the mismatch in the ratio is due to overpredicted earnings.

Income Taxes on Social Security Benefits. In the model, about 30% of Social Security recipients pay income taxes on Social Security benefits, about three-quarters of the 2005 value of 39% (Congressional Budget Office, 2015). Among those who pay positive income taxes on their Social Security benefits, average taxable benefits are $5,070 and average taxes are $1,079. In the model, income taxes on Social Security benefits equal about 2.1% of total Social Security benefits. This is less than half of the value for 2006, 5.7%.[17] One likely reason why the model generates a smaller ratio is that it abstracts from household structure, treating everyone as single. While the taxation of benefits for married couples depends on their joint income, the benefit taxation thresholds for couples are only about 30% higher than those for singles.[18] Another potential reason is that the model assumes that individuals are fully aware that their Social Security benefits may be taxed when they make their claiming and work decisions. If individuals are unaware of

[17]Income taxes on Social Security benefits are divided between the Social Security and Medicare Trust Funds. (There are also income taxes on Disability Insurance benefits that are directed to the Disability Insurance Trust Fund, which we ignore in our model.) In 2006, $15.6 billion of such taxes were directed to the Social Security fund (Social Security Administration 2007, Table IV.A1) and $10.3 billion to the Medicare fund (Centers for Medicare and Medicaid Services 2007, Table II.B1). Total Social Security benefits were $454.5 (Social Security Administration 2007, Table IV.A1) for a ratio of (15.6+10.3)/454.5 = 5.7%.

[18]The two thresholds for married couples are $32,000 and $44,000, which are, respectively, 28% and 29% greater than those of singles.

the tax, they may be more likely to incur it. A third possibility is that people who work after claiming benefits are doing so for nonpecuniary reasons not captured in the model.

Labor Supply Elasticities.

The first panel of Table 2 shows the wage elasticity of total hours of work at different ages and in response to different wage changes. Columns (1)-(3) show the elasticities associated with temporary (one-period) wage changes, while columns (4)-(6) show elasticities for changes that are permanent from the listed age forward. All of these wage changes are fully anticipated; Appendix B shows elasticities for unexpected changes.

The elasticities shown in Table 2 are similar to those found in French (2005), French and Jones (2012), and Fan et al. (2015), which are derived from fairly similar models. The contemporaneous elasticities are highest at older ages, where workers are most likely to be indifferent between work and leisure. By way of example, the contemporaneous elasticity for a temporary wage change is 0.15 at age 30 and 2.02 at age 70. This is also a major reason why the wage elasticities for a permanent wage change are higher in the years following the change than during the year of the change itself.[19]

Table 2 shows that the contemporaneous elasticity is often higher when the wage change is permanent. The elasticity of a permanent wage change at age 70 is 2.54, while the elasticity for a temporary change is 2.02. This result, which seems at odds with the intuition that permanent wage changes have bigger wealth effects, is due to the labor market reentry cost; workers are more willing to pay this cost when wages increase for an extended period. At older ages, when more workers are out of the market, the dynamics of the reentry cost dominate the wealth effects. At younger ages, wealth effects dominate, and temporary wage changes have higher contemporaneous elasticities than permanent changes. The reentry cost also reduces the elasticities in general. For example, without

[19]A second reason is more mechanical. Because fewer people work at very old ages, at these ages any given change in labor supply will be larger in relative terms. A third reason is the reentry cost, which we discuss immediately below. Workers who reenter the labor market will be more inclined to stay in afterward.

the reentry cost the contemporaneous elasticity for a permanent (temporary) change in wages at age 70 jumps from 2.54 (2.02) to 3.87 (4.02).

Panels B and C of Table 2 divide the elasticities for total hours of work between the extensive and intensive margins. Consistent with the presence of fixed costs, in our model the employment elasticities are significantly larger than the elasticities for hours worked by workers. It bears noting that the intensive margin elasticities are sometimes driven by composition effects; as discussed below, new workers, who are nearly indifferent about working at all, often work fewer hours than incumbents, especially at older ages.

Table 2: Decomposition of Total Hours Elasticity for Anticipated Wage Changes

	Temporary change			Permanent change		
Age	30	60	70	30	60	70
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Total hours						
In the year of the change	0.15	0.72	2.02	0.09	0.84	2.54
Over the entire life	-0.01	0.01	0.01	0.09	0.23	0.11
In years prior to the change	0.00	0.00	0.00	-0.03	-0.01	-0.01
In years after the change	-0.02	-0.04	0.01	0.13	1.97	3.81
Panel B: Employment						
In the year of the change	0.00	0.44	1.50	0.00	0.68	2.26
Over the entire life	-0.01	0.01	0.02	0.07	0.25	0.13
In years prior to the change	0.00	0.01	0.01	0.00	0.00	0.00
In years after the change	-0.02	-0.03	0.01	0.09	1.85	3.55
Panel C: Hours of work for workers						
In the year of the change	0.14	0.28	0.52	0.09	0.16	0.28
Over the entire life	0.00	0.00	0.00	0.02	-0.02	-0.02
In years prior to the change	0.00	-0.01	0.00	-0.03	-0.02	-0.01
In years after the change	0.00	0.00	0.00	0.03	0.12	0.26

Aggregating over several micro-level studies, Chetty et al. (2013, Table 2) conclude that the steady-state (Hicksian) wage elasticity is 0.33 on the intensive margin and 0.25 on the extensive margin. The corresponding Frisch elasticities are 0.54 and 0.32. Engelhardt and Kumar (2014) review several recent analyses of the Social Security Earnings Test. If beneficiaries view the Earnings Test as a pure tax, the estimated intensive margin elasticities are small, ranging from 0.05 to 0.12; if beneficiaries understand the crediting rule, the implied elasticity will be much higher. Because most of these studies rely on bunching analyses, they do not measure extensive margin elasticities (Engelhardt and Kumar, 2014). However, in a recent study Gelber et al. (2017) apply a new methodology to the same budget kinks and find an extensive margin elasticity of least 0.49. Examing the effects of income taxes, Alpert and Powell (2016) estimate participation elasticities for older women and men of 1.2 and 0.7, respectively.

Table 3: Elasticity of Total Hours with respect to an Unanticipated Increase in PIA

Age	In the year of the change	Over the entire life	In years before the change	In years after the change
60	-0.36	-0.02	0.00	-0.14
70	-1.07	-0.02	0.00	-0.36

Table 3 shows the elasticities associated with a change in pension wealth, namely an unexpected increase in the Social Security Primary Insurance Amount (PIA). A 1% increase in PIA at age 60 is associated with a 0.36% decrease in total labor hours at age 60 and a 0.14% decrease in hours in later years. The most comparable estimates may be those of Gelber et al. (2016), who study the 1977 Social Security Act Amendments, which sharply reduced the benefits of people born on or after 1917. Gelber et al. (2016) find the elasticity of employment with respect to discounted lifetime benefits to be 0.7.[20]

More generally, there is a large body of work (see the reviews in French and Jones 2012, 2017) showing that retirement decisions are sensitive to financial incentives. For example, basic cross-country regressions by Duval (2003, Table 8) show that a 10 percentage point (pp.) increase in the implicit tax rate on older workers leads to a 3.5-5.6 pp. decrease in male participation between ages 55-59 and 60-64. Because employment declines rapidly between ages 60 and 70, even for those in good health, our model can fit the data only

[20]The 1977 amendments also reduced the extent to which working after age 60 increased Social Security benefits. Gelber et al. (2016) find this substitution effect to be negligible and suggest that workers might not have recognized the complicated changes in incentives.

if labor supply is elastic at older ages. The empirical literature thus suggests that the elasticities generated by our model, while high, are by no means implausible.

5 Policy Experiments

We assess the impact of benefit taxation through six policy experiments. These are, in order:

1. Eliminating the income taxation of Social Security benefits
2. Eliminating the Social Security Earnings Test
3. Eliminating both benefit taxation and the Earnings Test
4. Making 85% of Social Security benefits subject to income taxation at any income level
5. Eliminating the second taxation threshold ($34,000) and conversion rate (85%) introduced by the 1993 legislation
6. Adjusting the two taxation thresholds to reflect inflation between 1993 and 2006.

In all experiments, the Social Security payroll tax (τ^{ss}) is adjusted to preserve the balance of the combined Social Security and Medicare budgets:

$$\begin{aligned}&\int \Big[T\big(ra + W + SS(ss^*, ra, W)\big) - T\big(ra + W\big) + 2\tau^{\text{mcr}}W + 2\tau^{\text{ss}}\min\{W, y^{\text{ss}}\}\\ &\qquad + T_j^{\text{et}}(ss, W) + p^{\text{mcr}} I_{j\geq J^M}\Big]\ \mu(\tilde{\mathbf{x}})\ d\tilde{\mathbf{x}}\\ &= \ G_{OAIHI} + \int \big[ss + (m - Q) I_{j\geq J^M}\big]\ \mu(\tilde{\mathbf{x}})\ d\tilde{\mathbf{x}};\end{aligned}$$

where G_{OAIHI} denotes the surplus of the Social Security and Medicare systems in the benchmark economy and is fixed across different experiments. Although the payroll tax is nominally split between workers and employers, we will assume that any changes in Social Security taxes ($2 \cdot \Delta\tau^{\text{ss}}$) are borne solely by the workers and will report them accordingly.

Table 4: Comparisons across Stationary Economies

	Benchmark (0)	SSB not taxable (1)	No Earnings Test (2)	Neither (3)	SSB always taxable (4)	Single threshold (5)	Thresholds indexed (6)
Panel A: Aggregate Statistics							
Participation	80.37%	81.17%	80.44%	81.21%	80.24%	80.60%	80.91%
Hours of workers	0.3349	0.3350	0.3348	0.3351	0.3366	0.3352	0.3343
Efficiency units		+1.17%	+0.04%	+1.26%	+0.76%	+0.45%	+0.37%
Mean assets ($000s)	100.59	101.43	100.44	102.06	101.99	101.03	100.85
Mean consumption ($000s)	25.70	26.04	25.71	26.07	25.91	25.82	25.82
Panel B: Government Budget (Dollars per capita)							
OASDI+HI							
Revenue	5,133	5,144	5,065	5,032	5,152	5,148	5,127
Expenditure	4,228	4,240	4,159	4,123	4,235	4,233	4,227
Surplus	905	904	906	909	917	915	900
General Budget							
Revenue	6,113	6,192	6,113	6,203	6,200	6,145	6,124
Expenditure	7,018	7,018	7,019	7,018	7,019	7,018	7,018
Surplus	-905	-826	-905	-815	-819	-873	-894
Panel C: General Equilibrium Variables							
OASDI tax	6.20%	6.19%	6.20%	6.14%	5.34%	6.16%	6.21%
Bequests	1,990	2,079	1,990	2,090	1,931	2,014	2,021
Panel D: Welfare							
CEV		0.52%	0.01%	0.66%	0.60%	0.18%	0.18%
Panel E: Partial Equilibrium Results							
Efficiency units		+1.33%	+0.04%	+1.43%	+0.57%	+0.49%	+0.43%
Mean consumption ($000s)	25.70	25.99	25.71	26.00	25.67	25.80	25.81
OASDI+HI Budget Surplus	905	912	906	934	1,168	928	898
General Budget Surplus	-905	-822	-905	-813	-862	-874	-892
CEV		0.08%	0.01%	0.09%	-0.16%	0.02%	0.04%

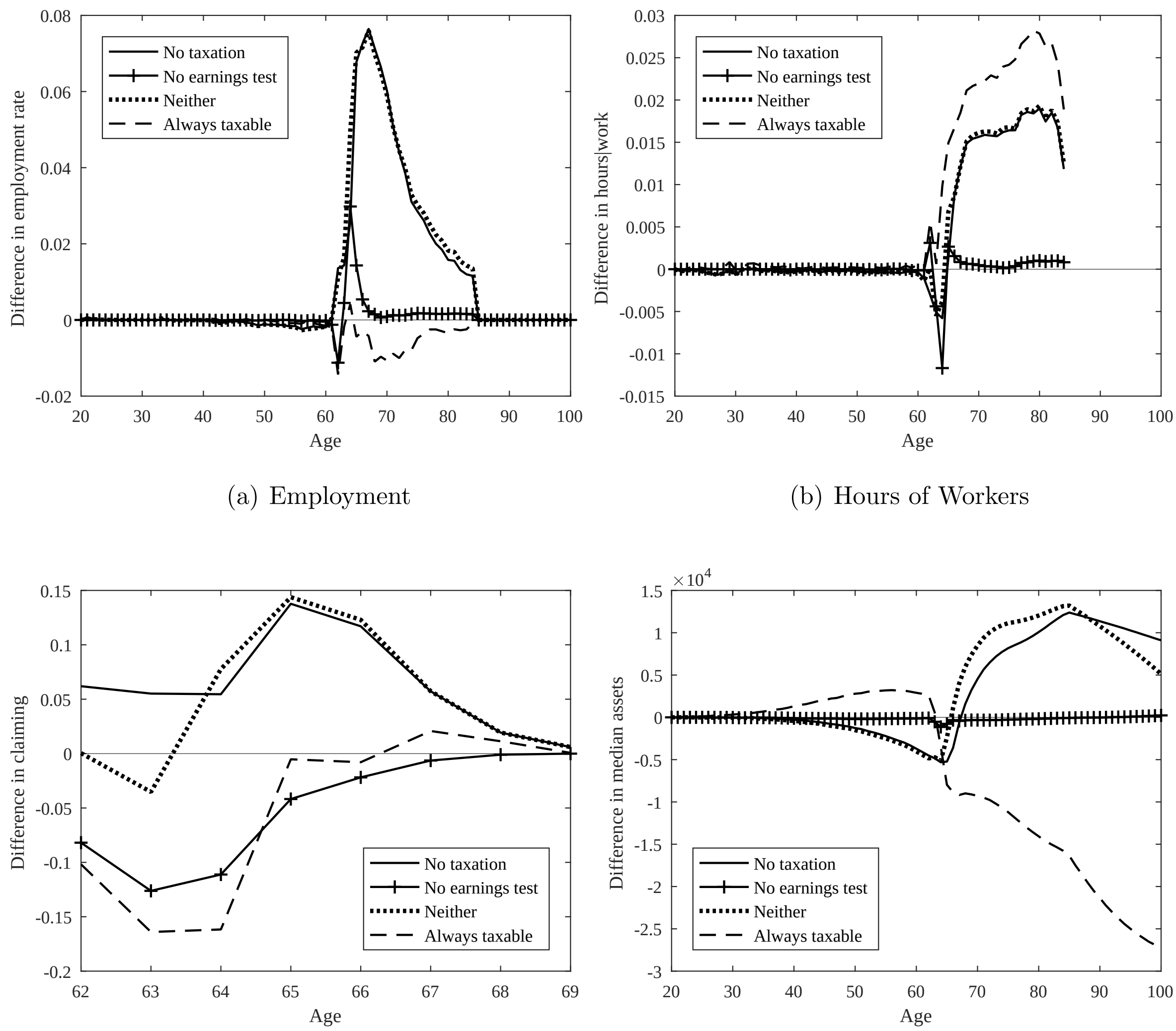
5.1 No Income Taxes on Social Security Benefits

The first policy reform we consider is the complete elimination of Social Security benefit taxation. The effects of this reform can be seen by comparing column (0) of Table 4, which shows results for the baseline model, to column (1). Eliminating benefit taxation raises the aggregate employment rate by 0.8 pp., from 80.4% to 81.2%. The solid line in Figure 7(a) shows how employment changes over the life cycle. The largest effects are after age 65, reflecting that workers near retirement are sensitive to changes in the after-tax wage (French and Jones 2012; Karabarbounis 2016). This can also be seen in Appendix Table A4, which shows labor market results for ages 57-61, 62-65, 66-70, and 71-84.

In contrast to employment, average hours of work for workers rise only slightly when benefit taxes are eliminated. Figure 7(b) reveals that just prior to age 65, hours of work fall, as new workers work fewer hours than existing ones. While average hours of work rise after age 70, their effect is largely offset by increases in employment at the same ages: because older workers generally work fewer hours than younger workers, increases in employment at older ages pull down the aggregate average.

To measure the overall change in labor supply, we track labor efficiency units. This measure incorporates not only participation and hours of work, but also skill heterogeneity and the efficiency loss associated with part-time work. Eliminating benefit taxation causes efficiency units to increase by 1.17%. Total labor supply thus moves in the same direction as participation and with a similar magnitude. The taxation of Social Security benefits alters the aggregate labor supply primarily through the extensive margin.

The top panel of Table 4 also shows that removing the income tax on Social Security benefits increases consumption and assets, especially for the elderly population (see Figure 7(d)). Panel B shows how the policy reforms affect the government budget. To balance the combined Social Security and Medicare budget, when benefit taxes are removed



(a) Employment

(b) Hours of Workers

(c) Social Security Recipients

(d) Median Assets

Figure 7: Life-cycle Effects of Policy Reforms: Experiments (1)-(4)

the payroll tax rate falls slightly, from 6.20% to 6.19% (see panel C). Aggregate Social Security expenditures increase, even though eliminating benefit taxation leads individuals to claim Social Security benefits at earlier ages (Figure 7(c)), and in the cross-sectional aggregate earlier claiming reduces total Social Security spending.[21] This is explained by

[21]From the perspective of the individual, who discounts future benefits at her after-tax interest rate, early claiming maximizes the present discounted value of benefits. In a cross-sectional aggregate, however, payments made to older individuals are given the same weight as payments made to younger individuals (with minor adjustments for population growth). In this case, earlier claiming reduces the sum.

increased use of the Earnings Test, which withholds some early claimers' current benefits but credits their future benefits, causing an increase in cross-sectional aggregate spending. This reform to Social Security has spillover effects on other government programs: the increase in the aggregate labor supply increases general government revenues by 1.3%, and the increase in assets reduces government spending on means-tested transfers,[22] leading to a very small decrease in general government spending (not visible in the table). The general government deficit falls by $79.

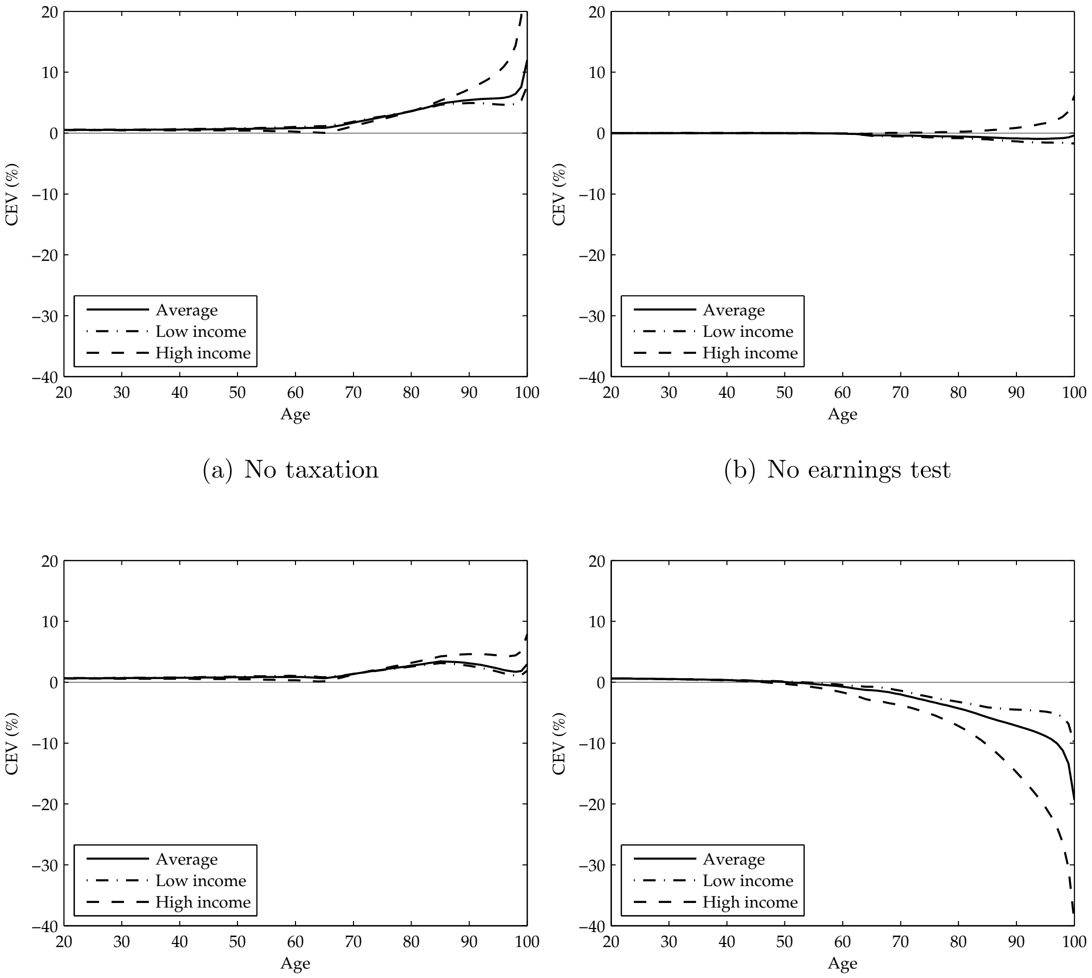
To measure the welfare implications of the reform, we calculate the ex-ante consumption equivalent variation (CEV), the proportional increase in lifetime consumption needed to make a newborn individual in the benchmark economy as well off as a newborn in the counterfactual economy.[23] As reported in Panel D, the ex ante CEV is 0.52%, indicating that eliminating the tax increases welfare. This finding might seem at odds with those of Goodman and Liebman (2008), who point out that balancing the Social Security budget through the income tax system, which accounts for all sources of income, is more progressive than achieving balance within the Social Security system itself. As we show below, increasing the regressive payroll tax does reduce welfare. However, the work disincentives of the benefit tax are most potent at older ages, when labor supply is extremely elastic. Eliminating the tax raises labor supply and the associated income tax revenues so much that the payroll tax rate does not need to be raised.

We also calculate the CEV separately for different ages and for two permanent income groups: high-income individuals who have an earnings index e_j above the median level of their age group, and low-income individuals who have an earnings index below the median.[24] As shown in Figure 8(a), the reform benefits individuals of all ages in both

[22]Direct government spending is held fixed throughout the experiments.

[23]We calculate this as $\left(\frac{\text{lifetime utility}_{\text{reform}} - \text{utility from bequests}_{\text{benchmark}}}{\text{lifetime utility}_{\text{benchmark}} - \text{utility from bequests}_{\text{benchmark}}}\right)^{1/[\gamma(1-\sigma)]} - 1$, with all utility measured ex-ante.

[24]While individuals aged 60 and below are sorted according to their current earnings index e_j, individuals older than 60 are sorted according to their age-60 earnings index e_{60}, to remove the effects of retirement and claiming choices on the earnings index.



(a) No taxation

(b) No earnings test

(c) Neither

(d) All taxable

Figure 8: CEV for Each Policy Reform, by Age and by Earnings Group

income groups. The smallest gains are realized by high-income individuals around age 60. Because individuals respond to the change in tax distortions by shifting their labor supply to older ages, some individuals around age 60 receive almost no benefit from the reform.

The comparisons plotted in Figure 8 are between two permanent tax regimes, where individuals face the same tax incentives over their entire lives. Figure 8(a) thus does not give the change in welfare for a, say, 60-year-old in the baseline model who is suddenly switched to the no-benefit-taxation regime and is thus not a direct guide to how people in the baseline economy would vote if given the opportunity to end the income taxation of Social Security benefits. Nonetheless, Figure 8(a) suggests that proposals to eliminate benefit taxation should receive broad political support.

Because our equilibrium concept is that of a small open economy with no capital adjustment costs, the capital-labor ratio and pre-tax wage remain fixed throughout our experiments. However, two equilibrium variables do adjust, namely the payroll tax rate τ^{ss} and the annual bequest transfer B. The bottom panel of Table 4 shows how several outcomes change when these variables are held fixed. This allows us to isolate the effects of the benefit tax. Column (1) shows that eliminating benefit taxation in partial equilibrium leads to a 1.33% increase in efficiency units, modestly higher than the general equilibrium increase of 1.17%. In contrast, the CEV falls from 0.52% to 0.08%. This is because ending benefit taxation causes a negligible change in the payroll tax but a 4.5% increase in bequests. A higher value of B allows younger workers to consume more, raising ex-ante CEV, while generating an income effect that discourages work.

Table 5 also uses partial equilibrium results, to show how eliminating benefit taxation affects employment and hours across the wealth and productivity distributions. To construct Table 5, we partition individuals by their age-60 assets (a_{60}) and productivity (η_{60}) and then find the differences in average employment and hours of work for each group. Using the distribution of the state variables generated by the benchmark model at every age, we evaluate both the benchmark decision rules and the no-tax decision rules at every point in the state space and take averages. Because we are holding fixed the distribution of state variables, the differences shown in Table 5 are essentially static – they are the immediate responses to an unexpected policy change. This makes them easier to interpret but different from the results in Table 4 and Figure 7.

The productivity groups are: low, who have the lowest possible productivity value at age 60; medium, who have one of the three intermediate values; and high, those with the highest productivity value. All else equal, individuals with higher productivity should be

Table 5: Effects of Eliminating Benefit Taxation by Assets, Labor Productivity, and Age

Assets	Productivity	Change in Employment Rate 60-69 (1)	Change in Employment Rate 70-84 (2)	Change in Hours of Continuing Workers 60-69 (3)	Change in Hours of Continuing Workers 70-84 (4)	Change in Hours of All Workers 60-69 (5)	Change in Hours of All Workers 70-84 (6)
		Panel A: Changes in Levels					
Low	Low	0.000	0.008	0.006	0.022	0.006	0.021
	Medium	0.002	0.023	0.008	0.026	0.008	0.023
	High	0.013	0.057	0.004	0.023	0.003	0.014
Medium	Low	0.003	0.019	0.013	0.031	0.012	0.025
	Medium	0.026	0.036	0.004	0.023	0.001	0.011
	High	0.051	0.043	-0.003	0.011	-0.007	-0.014
High	Low	0.004	0.010	-0.007	0.003	-0.036	-0.037
	Medium	0.035	0.013	-0.008	0.001	-0.017	-0.050
	High	0.050	0.006	-0.005	0.000	-0.013	-0.059
Top 1%	All	0.003	0.000	0.005	0.000	0.004	-0.114
		Panel B: Proportional Changes					
Low	Low	-0.01%	1.58%	1.97%	7.55%	1.96%	7.21%
	Medium	0.24%	5.69%	2.62%	8.93%	2.55%	7.87%
	High	1.41%	22.36%	1.21%	8.00%	0.82%	4.66%
Medium	Low	1.13%	10.47%	4.64%	10.87%	4.28%	9.02%
	Medium	4.75%	26.89%	1.14%	7.88%	0.31%	3.89%
	High	7.17%	62.68%	-0.90%	3.70%	-2.17%	-4.58%
High	Low	90.11%	118.51%	-2.20%	0.94%	-11.82%	-11.69%
	Medium	17.40%	154.05%	-2.69%	0.35%	-5.37%	-15.53%
	High	12.32%	188.47%	-1.66%	0.12%	-3.97%	-18.03%
Top 1%	All	1.87%	NA†	1.52%	-0.03%	1.25%	-35.09%

Notes: Comparison uses distribution of state variables found in benchmark economy. Assets and productivity are as of age 60. The asset categories are: low, who fall in the bottom 25% of the asset distribution; medium, who fall between the 25th and 75th percentiles; high, who fall between the 75th and 99th percentiles; and those in the top 1%. The productivity categories are: low, who have the lowest productivity value at age 60; medium, who have one of the three intermediate values; and high, those with the highest value.

†Although the employment rate increases by a factor of 275, the baseline employment rate for this group is so small that proportional changes have little meaning.

more sensitive to benefit taxation, as those with higher earnings will be more exposed to the tax. The asset groups are: low, who fall in the bottom 25% of the asset distribution; medium, who fall between the 25th and 75th percentiles; high, who fall between the 75th and 99th percentiles; and those in the top 1%. In most cases having more wealth raises the fraction of earnings that will be "double-taxed." Individuals with sufficiently high unearned income, however, will have their benefits taxed fully even if they don't work at all. For these people, removing benefit taxation results in a pure income effect that discourages labor supply. Page and Conway (2015) find that the introduction of the benefit tax in 1983 caused these individuals to increase their participation. Given our assumption of a 5% rate of return, full benefit taxation under the 1983 rules requires assets of at least \$500,000 + $10{\cdot}ss^*$.[25] We thus search for Page and Conway's (2015) effect among the top 1% of the asset distribution.

Column (1) of Table 5 shows that between ages 60 and 69, removing benefit taxation generates the most employment growth among the wealthy in both absolute (panel A) and relative (panel B) terms. A notable exception is among the top 1%, where employment increases by less than 2% (0.3 pp.), suggesting that the income effects emphasized by Page and Conway (2015) are important. Employment growth is also increasing in productivity, at least when measured in levels. Column (2) shows that between ages 70 and 84, eliminating the benefit tax generally causes the most employment growth among the most productive. However, the growth is highest in level terms along the middle and bottom of the wealth distribution. This reflects in part the lower resources of these groups, which leave their members more willing to work at very old ages. In addition, from age 70 forward everyone is receiving Social Security, increasing their potential exposure to the benefit tax.

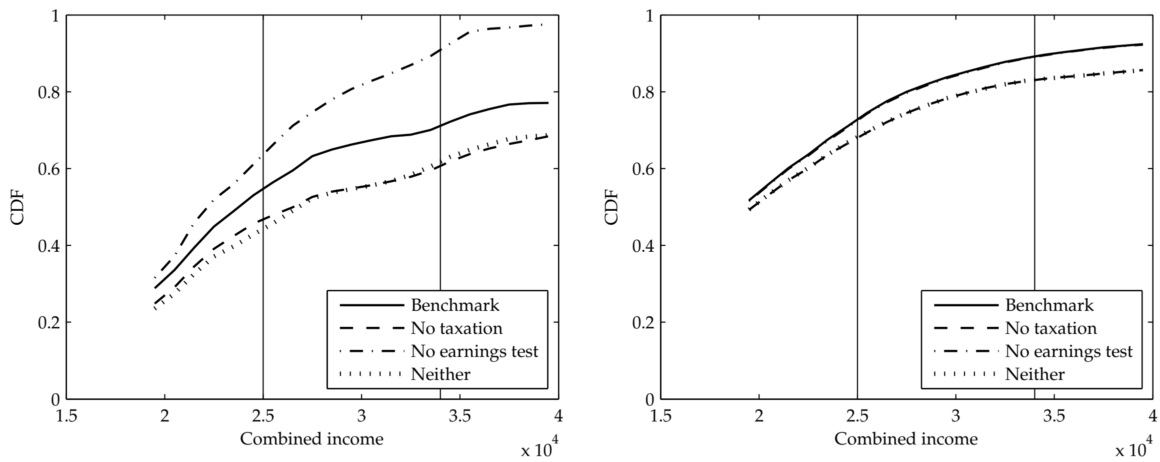
The next two columns of Table 5 consider changes in the hours of work of those

[25] In the absence of earnings, combined income is $Y^{\mathrm{CI}} = 0.05a + 0.5ss^*$. Under 1983 rules, the maximum amount of taxable benefits is achieved when $0.5(Y^{\mathrm{CI}} - 25000) = 0.5ss^*$. Combining and solving for a yields the expression in the main text.

who work both before and after the tax reform. For these individuals there are offsetting income and substitution effects from higher after-tax wages. The income effects are strongest at the top of the productivity and wealth distributions, where a greater fraction of the benefits are taxed. As a result, high-wealth and high-productivity earners are less likely to increase their hours when benefit taxation is eliminated.

Columns (5) and (6) report changes in hours worked by all workers. Two mechanisms are at play. The first is the change in hours among continuing workers shown in columns (3) and (4). Second, eliminating the tax leads new workers to enter the market. These entrants tend to work fewer hours, reducing the overall average. At the bottom of the wealth distribution, the first mechanism dominates and hours increase as in columns (3) and (4). Everywhere else, the composition effect dominates (except at times for the top 1%) and hours decrease.

Comparing the percentage changes in columns (5) and (6) to those in columns (1) and (2) shows that except for the lowest wealth group, the extensive margin of adjustment is far more important than the intensive margin.



(a) Individuals Aged 62-64

(b) Individuals Aged 70-84

Figure 9: Cumulative Distribution Functions of Combined Income among Social Security Recipients: Experiments (1)-(3)

Using tax data, Burman et al. (2014) examine the distribution of combined income among Social Security recipients to see if income is bunched at either of the benefit taxation thresholds. Finding no evidence of bunching except among some of the self-employed, they conclude that benefit taxation has little effect, probably because its mechanisms are too complicated for retirees to understand. It is possible that our findings disagree with those of Burman et al. (2014) because of differences in data or approach: they examine the distribution of combined income in detailed tax data, while we utilize a calibrated life-cycle model. It is nonetheless useful to check our model's implications for bunching. Figure 9 shows the distribution of combined income generated by the model under different policy regimes. Panel (a) shows income distributions for Social Security recipients aged 62-64; panel (b) shows distributions for people aged 70-84, all of whom have claimed Social Security benefits. In the benchmark specification of the model, there are no jumps in the distribution function around the income threshold. Moreover, while eliminating benefit taxation shifts the distribution of combined income to the right, the shape of the distribution function is very similar to the shape of the distribution function in the benchmark specification. This is consistent with the general finding that in our model the aggregate effects of benefit taxation occur mainly along the extensive margin. In practice, Social Security beneficiaries deciding whether to work at all do not need to know the exact taxation formula; they need only to know that working will lead to significantly higher income taxes. Standard bunching analyses cannot identify these effects.

5.2 No Earnings Test

Column (2) of Table 4 shows the outcomes that result when the Earnings Test is eliminated. Eliminating the Earnings Test has very small effects on participation and total efficiency units, while hours of work are almost unchanged. Recall that the Earnings Test reduces current benefits but increases future benefits. Because the crediting rates are close to actuarially fair, the net tax generated by the Earnings Test is close to zero. There is also a key interaction between the Earnings Test and benefit taxation. Because the effect of benefit taxation is capped by the size of the benefit itself, the Earnings Test reduces the impact of benefit taxation on current work, by reducing current benefits, and it increases its effect on future work, by increasing future benefits. Since most people work more at younger ages, eliminating the Earnings Test likely increases the impact of the benefit tax.

Eliminating the Earnings Test has a larger effect on Social Security claiming. Figure 7(c) shows that removing the Earnings Test reduces the number of Social Security recipients at ages 62-67. There are several competing forces. For people who wish to receive benefits early and continue working, removing the Earnings Test eliminates a disincentive to early claiming. For people who prefer to gradually shift from labor income to Social Security benefits over several years and use the Earnings Test as a way to regulate their benefits, removing the Earnings Test may discourage early claiming. Moreover, removing the Earnings Test leaves more current benefits vulnerable to income taxation, which also discourages early claiming. The latter two forces dominate the first, resulting in claiming delays.

A number of studies have shown that the distribution of earnings among Social Security recipients is bunched just below the Earnings Tax thresholds: see the review in Engelhardt and Kumar (2014). The standard interpretation is that many of the beneficiaries are unaware of the crediting dimension of the Earnings Test and view it as a pure tax (Engelhardt and Kumar, 2014). The smooth distribution functions shown in Figure 9(a) suggest that the Earnings Test generates no earnings bunching within our model.[26] This in large part reflects the fixed cost of work, which leads the labor supply decision to be one mostly of participation rather than hours.[27]

[26]Plotting the distribution of earnings, rather than combined income, does not change the conclusion.

[27]Engelhardt and Kumar (2014) conclude that "there is little consensus on the extensive margin (participation) response" to the Earnings Test (page 456).

It bears noting that much of the empirical work on the Earnings Test has focused on its application to earnings received during or after the Normal Retirement Age, which was eliminated in 2000. The crediting rates for this portion of the Test provided a significantly lower actuarial return than the crediting rates for the current Earnings Test. It should not be surprising that our analysis suggests smaller labor market responses than previous work. The differences in the crediting formula may also explain why Song and Manchester (2007) found that the elimination of the Earnings Test above the NRA resulted in earlier Social Security benefit claiming, in contrast to our finding.

Turning to welfare implications, the elimination of the Earnings Test produces an ex-ante gain equivalent to 0.01% of the lifetime consumption. However, as shown in Figure 8(b), the experiment makes the low-income group worse off at older ages.

5.3 No Earnings Test or Benefit Taxation

Column (3) of Table 4 shows the outcomes that result when we combine the previous two experiments and eliminate both the Earnings Test and the income taxation of Social Security benefits. This exercise is particularly useful in illustrating the interactions between benefit taxation and the Earnings Test that were discussed in the previous section. When benefits are not taxed, removing the Earnings Test increases efficiency units by 0.09% (1.26% − 1.17%), more than twice the increase of 0.04% shown in column (2), where benefits are taxed; moreover, removing the earnings test increases welfare by 0.14% (0.66% − 0.52%), many times the increase of 0.01% shown in column (2). Nonetheless, the effects of removing the Earnings Test on labor supply and ex-ante welfare are always smaller than those of removing benefit taxation.

5.4 Unconditional Benefit Taxation

Our next experiment is to assume that 85% of Social Security benefits are subject to income taxation in all circumstances. The effects of this reform run through multiple channels and in multiple directions. The "double taxation" of earnings, where higher earnings increase the portion of benefits subject to taxation, no longer occurs. With all benefits taxed, the income effect of benefit taxation is much larger than in the benchmark economy. Moreover, as column (4) of Table 4 shows, the increase in income-related benefit taxes allows the government to *lower* the payroll tax, from 6.20% to 5.34%. On the other hand, by increasing taxable income the reform may push people, especially poorer ones, into higher income tax brackets and expose them to higher marginal rates.[28] In addition, greater benefit taxation reduces the after-tax value of Social Security benefits and thus reduces the lifetime returns to working.

The net effect of the reform is to lower the employment of low-productivity workers and to raise the employment of high-productivity workers.[29] The latter is consistent with Page and Conway (2015), who find that among those with very high income, the introduction of the benefit tax in 1983 led to higher employment. Aggregate employment drops slightly, to 80.24%. In contrast, hours rise for almost all worker groups and by 0.51% in the aggregate; this is the only reform in Table 4 that produces so large an increase in hours. Total hours of work rise by 0.35%. Efficiency units rise even more, by 0.76%, in large part because the increase in labor supply is concentrated among the most productive. Assets rise by 1.39%.

Figure 7(b) shows that much of the increase in hours occurs at or after age 65, when most individuals have claimed Social Security benefits (see Figures 4 and 7(c)). Figure 7(c) shows that making benefits unconditionally taxable also leads to a significant reduction in

[28] A similar mechanism appears in French's (2005) model, where the onset of private pension benefits at age 62, pushing many people into higher tax brackets, accounts for about half of the job exit observed at that age.

[29] Disaggregated results are available upon request.

Social Security claiming before age 65. Individuals wishing to work at older ages avoid the higher taxation of benefits in part by claiming at older ages. Moreover, with progressive income taxes, tax rates on benefits likely fall with age. Working individuals may be willing to trade current benefits for higher future benefits if the latter are taxed at lower rates. Table 4 shows that aggregate Social Security benefits do rise, albeit modestly.

From an individual's perspective, however, later claiming reduces the present discounted value of benefits. With later claiming and more income taxes on benefits, older individuals receive fewer after-tax benefits over their retirement and rely more heavily on their savings. Figure 7(d) shows when benefits are taxed unconditionally, individuals bring more wealth into retirement but consume it at a faster rate. By age 65, assets are below their benchmark levels.

Overall, making benefits unconditionally taxable leads to higher consumption and a shift from regressive payroll taxes to progressive income taxes. The ex-ante CEV for this reform is 0.60%, almost as high as the gain from eliminating both benefit taxation and the Earnings Test. Figure 8(d) shows, however, that older individuals, especially those with high lifetime earnings, lose from the reform. This suggests that proposals to make Social Security benefits fully and unconditionally taxable would face significant political opposition from the elderly. Panel E of Table 4 shows that the gains from this reform are due almost entirely to the reduced payroll tax. In partial equilibrium, with the payroll tax fixed at its higher benchmark value, the reform reduces welfare by 0.16%, even though bequest flows are kept at their higher baseline value (1,990 vs. 1,931).

5.5 A Single Threshold for the Income Taxation of Benefits

For our fifth experiment, we remove the benefit taxation provisions introduced in 1993. In particular, we remove the second combined income threshold of $34,000 and the associated rate at which benefits are converted to taxable income, 85%, but keep the original income threshold of $25,000 and the original conversion rate of 50%. Column (5) of Table 4 shows the outcomes. Because this reform is essentially a partial elimination of benefit taxation, its effects are reduced versions of the effects shown in column (1), where benefit taxation was eliminated completely.

5.6 Indexing the Thresholds in the Benefit Taxation Formula

The final reform we consider is to raise the combined income thresholds for benefit taxation, which are not indexed, to reflect inflation between 1993 and 2006. Column (6) of Table 4 displays the results. Raising the taxation thresholds reduces the income effect and shifts the substitution effect from individuals who have lower combined income to individuals who have greater combined income. Table 4 shows that while raising the thresholds increases participation, hours of work fall. This is consistent with substitution effects operating along the intensive margin for individuals who would work more hours if the thresholds were not indexed to inflation. (As before, there are composition effects as well.)

6 Robustness Checks

We turn to assessing the sensitivity of our results to a number of parameter values and modeling choices. In addition to testing the robustness of our findings, these exercises illuminate the model's mechanisms. This section contains a summary of the robustness exercises; detailed discussion can be found in Appendix D. Overall, our main findings appear robust.

Table 6 shows results for the first five alternative specifications. For each of these alternatives, we recalibrate the model. The exercises and results are:

1. **Persistent Wage Shocks.** In this exercise, we increase the autocorrelation pa-

rameter for the log of the wage shock η from its benchmark value of 0.97 to 0.999. Relative to the baseline specification, the wages of older workers are more closely correlated with their lifetime earnings, and older workers with high wages are more likely to have high Social Security benefits. As shown in column (1) of Table 6, this raises the number of people paying taxes on their benefits and almost doubles the amount of taxes collected. Nonetheless, the effects of the policy reforms are similar to those under the baseline specification, if somewhat larger.

2. **Lower Coefficient of Relative Risk Aversion.** Next, we consider the effect of cutting σ, the curvature parameter for the consumption-leisure composite, in half. The most notable difference is that the CEV of unconditional benefit taxation falls from 0.60% to 0.41%. This suggests that the redistribution induced by unconditional benefit taxation – through lower payroll taxes – is less beneficial when σ is reduced.

3. **No Fixed Time Cost of Work.** In our third experiment, we set the fixed cost of participation ϕ_n to zero. Eliminating ϕ_n results in significant changes in the other calibrated parameters. The time cost of bad health ϕ_h triples, while the discount factor β falls from 0.98 to 0.87. Workers claim Social Security at much younger ages: the fraction claiming Social Security at the Early Retirement age of 62 rises from 22.1% to 67.1%. With more workers exposed to benefit taxation and the Earnings Test, the gains from eliminating these provisions both rise significantly relative to the baseline specification.

4. **No Wage Penalty for Part-time Work.** Removing the part-time wage penalty makes it less expensive for workers to adjust their labor supply along the intensive margin. It is perhaps not surprising that both the incidence of the benefit tax and the effects of the policy reforms, in terms of efficiency units and CEV, are smaller than under the baseline specification. On the other hand, the pattern of these effects is similar to that of the baseline.

5. **Alternative Income Tax Function.** The baseline income tax function is a simplified application of the 2006 Federal Income Tax code. In column (5) of Table 6, we use instead the tax function developed by Gouveia and Strauss (1994); we compare the two functions in Appendix D. Changing the tax function has little effect on model fit but changes the pattern of welfare gains: unconditional benefit taxation is now the most beneficial reform.

A second set of robustness checks involves workers' beliefs. Our baseline assumption is that individuals understand perfectly how their Social Security benefits will be taxed. This may be strong: Greenwald et al. (2010, Figure 8) report that only 57% of those aged 25-65 are aware that they may have to pay income taxes on their Social Security benefits. In practice, many individuals may not understand the tax treatment of Social Security benefits until they begin receiving benefits themselves. At that point, individuals owing income taxes on their benefits will have to either include them in their quarterly estimated tax payments or have them withheld from their benefits (Social Security Administration, 2016b), making them much better informed.

To assess the importance of the full-information assumption, we simulate a limited-information version of the model where individuals first learn about Social Security benefit taxation the year after they claim benefits.[30] The results are present in Appendix Table A7. When workers are unaware of benefit taxation they claim Social Security at earlier ages, increasing their exposure to the tax. They also accumulate fewer assets. This leaves them less prepared for the tax, which serves as a negative wealth shock. In the end, labor supply is higher than under the baseline specification. This increase is much smaller, however, than that induced by eliminating the tax entirely.

Another potentially confusing aspect of the Social Security system is the way in which benefits withheld via the Earnings Test are credited to future benefits. We thus consider

[30] There are of course many ways to misinterpret the rules: Goodman and Liebman (2008) discuss some other possibilities.

Table 6: Benchmark Economy and Policy Experiments under Alternative Model Assumptions

	Baseline (0)	Persistent Wage Shocks (1)	Lower Coeff. of RRA (2)	No Fixed Cost of Work (3)	No Part-time Wage Penalty (4)	G&S Tax Function (5)
Panel A: Benchmark Economy						
Employment	80.37%	81.54%	79.68%	85.97%	80.94%	80.22%
Hours of workers	0.3349	0.3321	0.3406	0.3135	0.3450	0.3399
Beneficiaries paying taxes on benefits	30.24%	39.22%	29.96%	38.62%	26.42%	33.45%
Taxes/SS Benefits	2.13%	4.12%	1.97%	4.38%	1.18%	2.20%
Receiving SS at 62	22.09%	18.81%	20.25%	67.10%	50.22%	24.67%
Receiving SS at 66	86.92%	87.86%	85.14%	99.97%	99.23%	92.11%
Panel B: Policy Reforms – Proportional Changes from the Benchmark Economy						
SS benefits not taxable						
Efficiency units	1.17%	1.22%	1.09%	0.94%	0.46%	0.95%
OASDI tax	-0.18%	2.11%	-0.31%	3.98%	0.24%	0.62%
Bequests	4.43%	5.73%	5.33%	8.29%	2.73%	3.38%
CEV	0.52%	0.87%	0.59%	0.97%	0.31%	0.37%
SSB not taxable + No Earnings Test						
Efficiency units	1.26%	1.32%	1.13%	1.62%	0.53%	1.05%
OASDI tax	-1.03%	1.03%	-0.95%	-1.23%	-1.50%	-0.38%
Bequests	5.01%	6.18%	6.02%	8.44%	3.26%	4.04%
CEV	0.66%	1.02%	0.70%	1.38%	0.51%	0.53%
SS Benefits always taxable						
Efficiency units	0.76%	0.80%	0.73%	0.87%	0.47%	0.84%
OASDI tax	-13.86%	-13.09%	-13.83%	-12.44%	-12.95%	-14.51%
Bequests	-2.97%	1.38%	-4.63%	-2.71%	-3.95%	-0.95%
CEV	0.60%	0.99%	0.41%	0.49%	0.45%	0.84%

Note: Table reports the statistics about the benchmark economy and five counterfactual economies for the following specifications: column (0) is the baseline specification; in column (1) the persistence parameter of the idiosyncratic productivity process is increased to 0.999; in column (2) the parameter σ is reduced by 50 percent; in column (3) the fixed cost of participation ϕ_n is set to zero; in column (4) there is no wage penalty for part-time work; and in column (5) the income tax function is that of Gouveia and Strauss (1994).

a specification where beneficiaries are unaware of the credits and treat the Earnings Test as a pure tax. This change leads to only a minor reduction in labor supply, in large part because workers avoid the strengthened Earnings Test by delaying their benefit claims.

7 Concluding Remarks

In 2000, President Clinton signed the Senior Citizens Freedom to Work Act, which eliminated the Earnings Test for Social Security beneficiaries at or beyond the NRA. The effects of this act, and the Earnings Test in general, have been studied in some detail. In contrast, relatively little attention has been given to another tax provision that may discourage work at older ages, namely the income taxation of Social Security benefits. This is an unfortunate oversight. Because the portion of benefits subject to taxation is increasing in combined income, benefit taxation can at times significantly reduce the after-tax returns to work.

In this paper, we assess the taxation of Social Security benefits using a detailed dynamic life-cycle model of labor supply, saving, and Social Security claiming. Our principal finding is that the way in which the taxes are calculated significantly lowers the returns to work at older ages, when labor supply is especially elastic. Severing this link, by either eliminating benefit taxation or making the portion of benefits that are taxed independent of other income, would be quite beneficial.

We also find that among many dimensions the effects of reforming or eliminating the benefit tax are much larger than the effects of eliminating the Earnings Test. It may be the case that misunderstandings of the tax code lead older workers to overreact to the Earnings Test and underreact to the taxation of benefits. The magnitudes of our results suggest, however, that reforms to the benefit taxation provisions deserve serious consideration.

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Appendices

Appendix A: Calibration Details

A1 Demographics and Health

Each generation enters the economy at age 20 and lives up to 100. The growth rate of new entrants (χ) is set to 1.1%, the long-run average population growth rate in the US. Survival rates by health status, $s_j(h_j)$, are set to match those in Imrohoroğlu and Kitao (2012); they are displayed in Figure A1. The health measure is derived from the MEPS's question about perceived health status, which is answered on a scale of one (excellent) to five (poor). Following Imrohoroğlu and Kitao (2012), bad health is defined as having an average score (over a year span) that is greater than three, and good health is defined as the complement. Table A1 shows the transition probabilities for this measure.

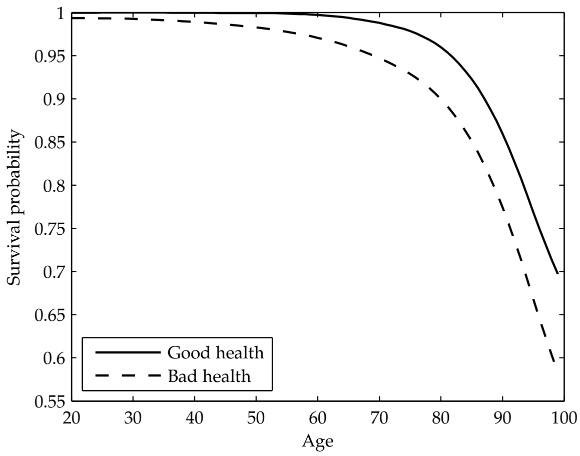


Figure A1: Survival Rates by Health Status and Age

We allow the medical spending shock ϵ to take on three values. As in Kitao (2014), we capture the long tail in the distribution of medical expenses by using: a small shock with a 60% probability, a medium shock with a 35% probability, and a large shock with a 5% probability. Table A2 reports the distribution of medical expenses by age and health

Table A1: Annual Transition Matrices for Health Status by Age Group

Age	Health	Good	Bad	Age	Health	Good	Bad
20-29	good	0.97	0.03	50-59	good	0.91	0.09
	bad	0.61	0.39		bad	0.30	0.70
30-39	good	0.96	0.04	60-69	good	0.92	0.08
	bad	0.48	0.52		bad	0.28	0.72
40-49	good	0.94	0.06	70+	good	0.86	0.14
	bad	0.39	0.61		bad	0.29	0.71

Source: MEPS Panels 10 and 11.

status. The coinsurance rate for Medicare, κ^{mcr}, is set to 38% percent to target the ratio of average Medicare payments to average medical expenses found among people aged 65 and above in the MEPS. The Medicare premium is set to $1,700, which is the sum of Part B and Part D premiums in 2006 (Centers for Medicare & Medicaid Services). The coinsurance rate for private insurance, κ^{priv}, is set to 27% to match the MEPS payment data for those who are covered by private insurance and are under the age of 65. The private health insurance premium p^{priv} is set to solve the insurance firm's zero profit condition and takes an annual value of $2,218 in the benchmark economy.

Table A2: Annual Medical Expenditures by Age Group and Health Status

Age	Health	0-60%	61-95%	96-100%	Age	Health	0-60%	61-95%	96-100%
20-29	good	128	2,165	14,172	50-59	good	677	4,948	28,936
	bad	426	5,917	24,472		bad	2,492	16,442	76,699
30-39	good	210	2,796	18,486	60-69	good	1,226	6,615	32,962
	bad	806	7,361	38,643		bad	3,180	18,070	81,104
40-49	good	292	2,819	15,979	70+	good	1,948	9,512	43,941
	bad	1,222	11,491	62,916		bad	4,254	21,033	70,241

Source: MEPS Panels 10 and 11.

A2 Government

We calibrate government policy parameters to those in effect in 2006.

Social Security. Social Security benefits are given by $A_k ss(e_j)$, where e_j is an index of the individual's earnings over her working life and $ss(\cdot)$ is a piecewise linear function determining the Primary Insurance Amount (PIA), the benefit received when Social Security is first claimed at the NRA (J^N). A_k is an adjustment factor based on the benefit claiming age k, reflecting early retirement penalties and delayed retirement credits, with $A_{J^N} \equiv 1$. The NRA and the adjustment factors are set to match the rules for the 1940 birth cohort, which reaches its NRA in 2006.

Under the 2006 rules, the PIA formula is

$$ss(e_j) = \begin{cases} 0.9e_j & \text{if } e_j \leq 7872 \\ 7084.8 + 0.32(e_j - 7872) & \text{if } 7872 < e_j \leq 47460 \\ 19753.0 + 0.15(e_j - 47460) & \text{if } 47460 < e_j \leq 94200 \\ 26764.0 & \text{otherwise.} \end{cases} \tag{A1}$$

Rather than tracking the individual's claiming age – and adding a variable to the state vector $\mathbf{x}_j$ – when an individual first claims Social Security we replace e_{j+1} with $\tilde{e}_{j+1}$, where $ss(\tilde{e}_{j+1}) = A_k ss(e_{j+1})$, and use $(\tilde{e}_{j+1})$ and $\tilde{A}_k = 1$ in all ensuing calculations.[31]

An additional complication is that individuals who claim Social Security benefits before the NRA may have their benefits reduced through the Earnings Test: for those aged 64 and below, the tax rate τ_j^{et} is 0.5 and the earning threshold y_j^{et} is \$12,480; for those aged 65, the tax rate is 0.33 and the earnings threshold is \$33,240. These mechanisms are captured in $T_j^{\text{et}}(ss_j, W_j)$, as defined in equation (3). Moreover, benefits clawed back through the Earnings Test are credited to future benefits, using the adjustment factors just described, with the credit to e_{j+1} proportional to T_j^{et}.[32]

The index e_j equals the beneficiary's average earnings over her 35 highest earnings years prior to claiming. Because keeping track of 35 years of earnings is infeasible, we

[31] By way of example, suppose a person aged 62 has an earnings index e_{62} of \$10,000 per year. Under the 2006 rules shown in equation (A1), her PIA is $ss(e_{62})$ = \$7,765.8. If she made an early claim at age 62, her monthly benefit would be reduced by 22.5%, to \$6,018.5. Instead of tracking the monthly benefit, we reduce the earnings index to $\tilde{e}_{63}$ = \$6,687.2, as $ss(\tilde{e}_{63})$ = \$6,018.5.

[32] In particular, each dollar withheld through the Earnings Test at age j increases future benefits by $\left(\frac{A_{j+1}}{A_j} - 1\right)$ dollars, i.e., at the same rate as benefits grow when claiming is delayed from age j to age $j+1$.

use an approximation similar to that used by Imrohoroğlu and Kitao (2012). For those who have not claimed Social Security benefits or reached the ERA (J^E), e_j is updated each period using its previous value and current earnings. Once an individual reaches the ERA, but before she claims Social Security benefits, e_j is updated whenever her current earnings exceed the existing index. Once Social Security benefits have been claimed, e_j is updated to only reflect the benefits that are withheld due to the Earnings Test. The resulting formula is

$$e_{j+1} = \begin{cases} \big[(j-1)e_j + W_j\big]/j & \text{if } j < J^E \\ \max\big\{e_j, \big[(j-1)e_j + W_j\big]/j\big\} & \text{if } j \geq J^E, b_{j-1} = 0, b_j = 0 \\ ss^{-1}\Big(A_j ss(e_j) + T_j^{\text{et}}(A_j ss(e_j), W_j)\big(\frac{A_{j+1}}{A_j} - 1\big)\Big) & \text{if } J^N > j \geq J^E, b_{j-1} = 0, b_j = 1 \\ ss^{-1}\Big(ss(e_j) + T_j^{\text{et}}(ss(e_j), W_j)\big(\frac{A_{j+1}}{A_j} - 1\big)\Big) & \text{if } J^N > j \geq J^E, b_{j-1} = 1, b_j = 1 \\ ss^{-1}\big(A_j \times ss(e_j)\big) & \text{if } j \geq J^N, b_{j-1} = 0, b_j = 1 \\ e_j & \text{otherwise} \end{cases}$$

where $ss^{-1}(\cdot)$, converting benefits into values of the earnings index, is the inverse of the function in equation (A1).

Taxes. The Social Security payroll tax rate τ^{ss} is 6.2 percent, and the taxable earnings limit y^{ss} is \$94,200. The Medicare payroll tax rate τ^{mcr} is 1.45 percent. (Recall that τ^{ss} and τ^{mcr} are calibrated to only the employee share (one-half) of payroll taxes.)

The consumption tax rate τ^c is calibrated so that in a balanced budget equilibrium direct government spending (G) equals about 23% of total earned income. We set the target of 23% by noting that direct spending is about 15% of GDP (The World Bank, 2016), and labor income comprises about two-thirds of GDP. τ^c equals 6.3 percent in the benchmark economy, close to the estimates in Mendoza et al. (1994).

We model income taxes using the tax rules for 2006:

$$T(y_j) = \begin{cases} 0 & \text{if } y_j < 8450 \\ 0.1(y_j - 8450) & \text{if } y_j \geq 8450 \text{ and } y_j < 16000 \\ 0.15(y_j - 16000) + 755 & \text{if } y_j \geq 16000 \text{ and } y_j < 39100 \\ 0.25(y_j - 39100) + 4220 & \text{if } y_j \geq 39100 \text{ and } y_j < 82650 \\ 0.28(y_j - 82650) + 15107.5 & \text{if } y_j \geq 82650 \text{ and } y_j < 163250 \\ 0.33(y_j - 163250) + 37675.5 & \text{if } y_j \geq 163250 \text{ and } y_j < 345000 \\ 0.35(y_j - 345000) + 97653 & \text{if } y_j \geq 345000, \end{cases}$$

where \$8,450 is the sum of the personal exemption (\$3,300) and the standard deduction (\$5,150). Total taxable income y_j is in turn the sum of earnings, asset income, and taxable Social Security benefits:

$$y_j = ra_j + W_j + SS(ss_j^*, ra_j, W_j).$$

As described in Section 2, the portion of Social Security benefits subject to income taxes depends on the net benefits themselves, $ss_j^*(ss_j, W_j)$, and "combined income", $Y_j^{\text{CI}} = ra_j + W_j + 0.5ss_j^*$. The exact formula is

$$SS(ss_j^*, ra_j, W_j) = \begin{cases} 0 & \text{if } Y_j^{\text{CI}} < 25000 \\ \min\{0.5ss_j^*, 0.5(Y_j^{\text{CI}} - 25000)\} & \text{if } 25000 \leq Y_j^{\text{CI}} < 34000 \\ \min\{0.85ss_j^*,\ 4500 + 0.85(Y_j^{\text{CI}} - 34000)\} & \text{otherwise.} \end{cases}$$

Means-Tested Insurance. The consumption floor for individuals under age 65, \$3,000, is close to the values used by Kitao (2014) (\$3,760 in 2006 dollars) and De Nardi et al. (2010) (\$3,280). The consumption floor for those 65 and older, \$6,377, is set to be 17% of average earnings as in Kopecky and Koreshkova (2014), reflecting that the government provides more means-tested transfers via Medicaid and SSI to the elderly population.

Appendix B: Expectations and Wage Elasticities

Table A3: Elasticity of Total Hours with respect to Selected Wage Increases

	Temporary change			Permanent change		
Age	30	60	70	30	60	70
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Anticipated changes						
In the year of the change	0.15	0.72	2.02	0.09	0.84	2.54
Over the entire life	-0.01	0.01	0.01	0.09	0.23	0.11
In years prior to the change	0.00	0.00	0.00	-0.03	-0.01	-0.01
In years after the change	-0.02	-0.04	0.01	0.13	1.97	3.81
Panel B: Unanticipated changes						
In the year of the change	0.14	0.57	1.49	0.05	0.50	1.66
Over the entire life	0.00	0.01	0.01	0.16	0.20	0.09
In years prior to the change	0.00	0.00	0.00	0.00	0.00	0.00
In years after the change	0.00	-0.02	-0.01	0.21	1.62	2.99

Table A3 compares elasticities for wage changes that are fully anticipated (Panel A) to those for unexpected changes (Panel B). Comparing the two panels shows that when wage changes are anticipated, workers will shift their labor supply to the periods where wages have increased. For example, when workers anticipate a permanent increase in wages at age 60, they reduce labor supply in earlier years and increase it at or after age 60. The wage elasticity at age 60 (0.84) is thus higher than when the wage increase is unanticipated (0.50).

Appendix C: Disaggregated Results

As a supplement to Table 4, Table A4 shows the effects of the policy reforms for separate age groups.

Table A4: Comparisons across Stationary Economies by Age Group

	Benchmark (0)	SSB not taxable (1)	No earnings test (2)	Neither (3)	SSB always taxable (4)	Single threshold (5)	Thresholds Indexed (6)
Panel A: Share of OAI beneficiaries at different ages							
At 62	22.09%	28.28%	13.90%	22.13%	11.91%	24.73%	27.33%
At 66	86.92%	98.62%	84.73%	99.22%	86.13%	94.50%	90.46%
Panel B: Statistics for ages 57-61							
Participation	80.87%	80.72%	80.83%	80.70%	80.75%	80.82%	80.89%
Hours of workers	0.3239	0.3234	0.3238	0.3233	0.3242	0.3237	0.3236
Efficiency units		-0.36%	-0.09%	-0.40%	+0.02%	-0.15%	-0.04%
Mean assets ($000s)	161.40	158.93	161.15	158.54	167.28	160.68	160.15
Mean consumption ($000s)	31.26	31.41	31.25	31.46	31.39	31.31	31.32
Panel C: Statistics for ages 62-65							
Participation	60.05%	63.03%	60.95%	63.67%	59.63%	60.82%	62.00%
Hours of workers	0.3111	0.3079	0.3085	0.3104	0.3187	0.3100	0.3077
Efficiency units		+2.93%	+0.29%	+4.97%	+2.84%	+0.64%	+1.15%
Mean assets ($000s)	150.98	147.78	150.41	148.89	156.27	150.04	149.76
Mean consumption ($000s)	28.33	28.99	28.38	29.26	28.70	28.51	28.61
Panel D: Statistics for ages 66-70							
Participation	37.02%	43.98%	37.24%	43.87%	36.26%	39.14%	41.16%
Hours of workers	0.2953	0.3085	0.2961	0.3087	0.3152	0.3033	0.2930
Efficiency units		+27.49%	+0.92%	+27.15%	+12.22%	+10.63%	+8.08%
Mean assets ($000s)	158.26	161.13	157.66	166.58	160.51	160.20	159.53
Mean consumption ($000s)	24.80	26.80	24.84	26.77	25.47	25.52	25.46
Panel E: Statistics for ages 71-84							
Participation	16.60%	19.35%	16.76%	19.52%	16.10%	17.32%	18.64%
Hours of workers	0.2893	0.3061	0.2899	0.3064	0.3140	0.3008	0.2860
Efficiency units		+27.68%	+0.77%	+28.64%	+14.29%	+11.16%	+9.16%
Mean assets ($000s)	174.66	184.21	174.30	187.50	172.73	178.56	178.34
Mean consumption ($000s)	23.11	24.20	23.12	24.19	23.26	23.49	23.51

Appendix D: Robustness Checks

For the first five alternative specifications, we recalibrate the model upon making the specified changes. The changes we assess in this way are: (1) altering the persistence and volatility of the wage shock η; (2) cutting the risk-aversion parameter σ in half; (3) eliminating the fixed time cost of working, ϕ_n; (4) eliminating the wage penalty associated with part-time work; and (5) replacing the benchmark income tax function, a simplified application of the 2006 tax code, with the tax function developed by Gouveia and Strauss (1994). Table A5 shows the calibrated parameter values for each of these specifications, while Table A6 shows some model results.

Table A5: Calibrated Parameter Values under Alternative Model Assumptions

Parameter	Baseline (0)	Persistent Wage Shocks (1)	Lower Coefficient of RRA (2)	No Fixed Cost of Work (3)	No Part-time Wage Penalty (4)	G&S Tax Function (5)
β	0.98	0.99	0.97	0.87	0.96	0.98
γ	0.34	0.32	0.34	0.32	0.41	0.34
ϕ_n	0.06	0.03	0.05	0.00	0.11	0.06
ϕ_h	0.13	0.11	0.14	0.41	0.14	0.13
ϕ_{re}	0.06	0.04	0.05	0.34	0.05	0.06
ψ_1 (000s)	48.18	33.86	0.42	201.59	512.73	49.15
w (000s)	98.13	90.58	95.84	104.94	100.65	96.48

Note: Table reports the calibrated parameters for the following specifications: column (0) is the baseline specification; in column (1) the persistence parameter of the idiosyncratic productivity process is increased to 0.999; in column (2) the parameter σ is reduced by 50 percent; in column (3) the fixed cost of participation ϕ_n is set to zero; in column (4) there is no wage penalty for part-time work; and in column (5) the income tax function is that of Gouveia and Strauss (1994).

D1 Persistent Wage Shocks

In this exercise, we increase the autocorrelation parameter for the log of the wage shock η from its benchmark value of 0.97 to 0.999, a near random walk. We also change the unconditional variance of the process from an age-invariant value of 0.3046 to the age-increasing function described in Li (2017). With wage shocks having near permanent

Table A6: Benchmark Economy and Policy Experiments under Alternative Model Assumptions

	Baseline (0)	Persistent Wage Shocks (1)	Lower Coeff. of RRA (2)	No Fixed Cost of Work (3)	No Part-time Wage Penalty (4)	G&S Tax Function (5)
Panel A: Benchmark Economy						
Employment	80.37%	81.54%	79.68%	85.97%	80.94%	80.22%
Hours of workers	0.3349	0.3321	0.3406	0.3135	0.3450	0.3399
Beneficiaries paying taxes on benefits	30.24%	39.22%	29.96%	38.62%	26.42%	33.45%
Taxes/SS Benefits	2.13%	4.12%	1.97%	4.38%	1.18%	2.20%
Receiving SS at 62	22.09%	18.81%	20.25%	67.10%	50.22%	24.67%
Receiving SS at 66	86.92%	87.86%	85.14%	99.97%	99.23%	92.11%
Panel B: Policy Reforms – Proportional Changes from the Benchmark Economy						
SS benefits not taxable						
Efficiency units	1.17%	1.22%	1.09%	0.94%	0.46%	0.95%
OASDI tax	-0.18%	2.11%	-0.31%	3.98%	0.24%	0.62%
Bequests	4.43%	5.73%	5.33%	8.29%	2.73%	3.38%
CEV	0.52%	0.87%	0.59%	0.97%	0.31%	0.37%
SSB not taxable + No Earnings Test						
Efficiency units	1.26%	1.32%	1.13%	1.62%	0.53%	1.05%
OASDI tax	-1.03%	1.03%	-0.95%	-1.23%	-1.50%	-0.38%
Bequests	5.01%	6.18%	6.02%	8.44%	3.26%	4.04%
CEV	0.66%	1.02%	0.70%	1.38%	0.51%	0.53%
SS Benefits always taxable						
Efficiency units	0.76%	0.80%	0.73%	0.87%	0.47%	0.84%
OASDI tax	-13.86%	-13.09%	-13.83%	-12.44%	-12.95%	-14.51%
Bequests	-2.97%	1.38%	-4.63%	-2.71%	-3.95%	-0.95%
CEV	0.60%	0.99%	0.41%	0.49%	0.45%	0.84%

Note: Table reports the statistics about the benchmark economy and five counterfactual economies for the following specifications: column (0) is the baseline specification; in column (1) the persistence parameter of the idiosyncratic productivity process is increased to 0.999; in column (2) the parameter σ is reduced by 50 percent; in column (3) the fixed cost of participation ϕ_n is set to zero; in column (4) there is no wage penalty for part-time work; and in column (5) the income tax function is that of Gouveia and Strauss (1994).

effects, under this specification the wages of older workers are much more closely correlated with their lifetime earnings. Relative to the baseline specification, older workers with high wages are more likely to have high Social Security benefits. As shown in column (1) of Table A6, this raises the incidence of benefit taxation from 30.2% to 39.2% and nearly doubles the amount of benefit-related taxes, from 2.1% to 4.1% of benefits. In most other respects, however, the model's predictions change little. The model now predicts that eliminating benefit taxation generates a small increase, rather than a small decrease in payroll taxes. But eliminating the tax still leads to increases in labor supply, bequests and welfare; the increases are in fact bigger than under the baseline specification. Likewise, making benefits fully taxable still causes a large decrease in payroll taxes, leading to a welfare gain.

D2 Lower Coefficient of Relative Risk Aversion

Next, we consider the effect of cutting σ, the curvature parameter for the consumption-leisure composite, in half. This causes the coefficient of relative risk aversion for consumption, $(1 - \gamma(1 - \sigma))$, to fall from 3.19 to 1.92. As shown in Column (2) of Table A5, imposing this specification produces dramatic changes in the bequest intensity parameter ψ_1; but the other calibrated parameters change only modestly. Turning to model results, perhaps the largest difference between this specification and the baseline is the relative sizes of the welfare gains. In the baseline case, the CEV of unconditional benefit taxation, 0.60%, was bigger than than the CEV of eliminating benefit taxation, 0.52%. The corresponding values for the low-curvature case are 0.41% and 0.59%. This reversal of rank suggests that the redistribution induced by unconditional benefit taxation – through lower payroll taxes – is less beneficial when σ is reduced.

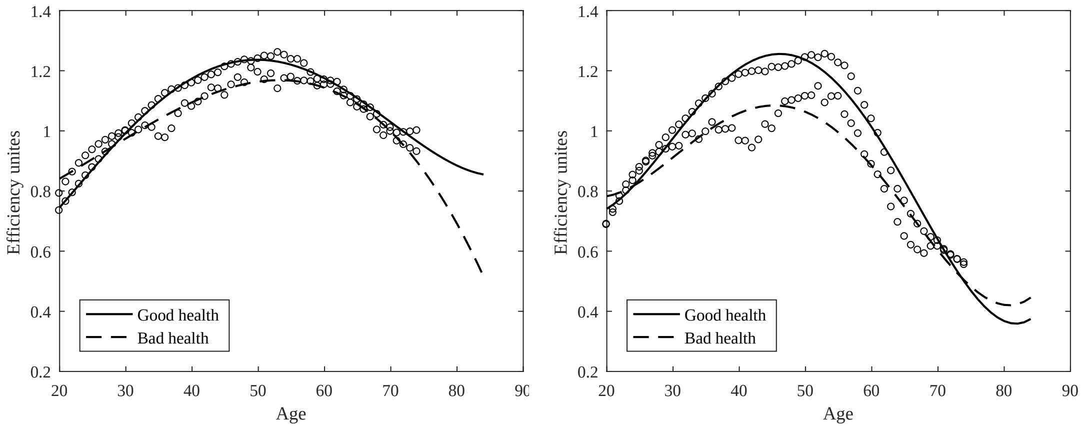
D3 No Fixed Time Cost of Work

In column (3) of Tables A5 and A6, we consider a specification where the fixed cost of participation ϕ_n is set to zero. This is arguably the most consequential change we consider. The time cost of bad health ϕ_h triples, while the reentry cost ϕ_{re} quintuples. The discount factor β falls markedly, from 0.98 to 0.87. These changes help the model continue to match the sharp decline in labor supply at older ages; in the absence of the fixed cost the model will need other mechanisms with similar effects. Perhaps not surprisingly, workers claim Social Security at much younger ages: the fraction of workers claiming Social Security at the Early Retirement Age of 62 rises from 22.1% to 67.1%. With workers receiving Social Security at younger ages, the incidence of the benefit tax rises, and the quantity of taxes collected doubles. The fraction of workers affected by the Earnings Test rises as well. The CEV associated with eliminating benefit taxation, and the incremental CEV gain from eliminating the Earnings test ($1.38\% - 0.97\% = 0.41\%$) both rise significantly relative to the baseline specification. In contrast, the CEV for unconditional benefit taxation falls by 0.11 pp.

D4 No Wage Penalty for Part-time Work

In our baseline specification, those working less than full time receive lower wages: see equation (2). As French (2005) points out, a large portion of the wage decline after age 60 can be explained by the penalty for part-time work. Eliminating the part-time penalty thus requires us to change the life-cycle wage profiles: we replace the baseline profiles with the profiles from French (2005) that do not account for "tied" wage-hours offers. Figure A2, which compares the two sets of profiles, shows that removing the part-time wage penalty causes wages to decline more quickly at older ages. French (2005) also notes that without the part-time wage penalty the model will understate hours of work unless the fixed time cost is increased. Column (4) of Table A5 shows that the calibrated value of ϕ_n nearly doubles.

Nonetheless, removing the part-time wage penalty makes it less expensive for workers to adjust their labor supply along the intensive margin. It is perhaps not surprising that fewer people have their benefits taxed, and that the effects of the policy reforms, in terms of efficiency units and CEV, are smaller than under the baseline specification. On the other hand, the pattern of these effects is very similar to that of the baseline.



(a) Baseline: with part-time penalty (b) Alternative: without part-time penalty

Figure A2: Wage Profiles with and without the Part-time Wage Penalty

D5 Alternative Income Tax Function

The baseline income tax function is a simplified application of the 2006 Federal Income Tax code, using the personal exemption and standard deduction and not accounting for credits or itemized deductions or other complications. In column (5) of Tables A5 and A6, we consider the tax function developed by Gouveia and Strauss (1994), where the income tax liability of a household with total income y is given by:

$$\widetilde{T}(y) = \lambda_0[y - (y^{-\lambda_1} + \lambda_2)^{-1/\lambda_1}].$$

We use the values of λ_0 and λ_1 estimated by Gouveia and Strauss (1994), and we set λ_2 so that in a balanced budget equilibrium direct government spending (G) equals about 23% of total earned income.[33]

Being estimated from IRS data, the Gouveia and Strauss (1994) approach reflects the actual application of the tax code. On the other hand, the Gouveia and Strauss (1994) approach tends to understate marginal tax rates. To see the latter point, note that the tax code can be approximated as $T(y, D(y))$, where $D(y)$ reflects income-related differences in the composition of income, use of itemized deductions, etc. Assuming that small changes in earnings do not affect $D(y)$, the marginal tax rate for earnings is $MTR(y) = \frac{\partial}{\partial x}\Big|_{x=y} T(x, D(y))$. Gouveia and Strauss (1994), however, find tax liabilities as a function of income, $\widetilde{T}(y)$. The marginal tax rate implied by the latter function is $\widetilde{MTR}(y) = MTR(y) + \frac{\partial}{\partial D} T(y, D(y)) \frac{dD}{dy}$. The second term in this sum is generally thought to be negative, implying that the Gouveia-Strauss approach understates marginal tax rates.[34]

Figure A3 compares tax liabilities under the two systems. Although the two systems imply similar total liabilities, for income at or above $40,000 the statutory taxes have a higher marginal rate.

In any event, changing the tax function has little effect on the calibrated parameters or the model fit. Perhaps the most notable deviation from the baseline specification is that the welfare gains from making benefits unconditionally taxable now exceed the gains from the joint elimination of benefit taxation and the Earnings Test. This may reflect the switch from the piecewise linear baseline tax function to the differentiable Gouveia and Strauss (1994) function. Under the baseline tax specification, making benefits fully taxable can push individuals into higher tax brackets, significantly raising their marginal

[33] Direct spending is about 15% of GDP (The World Bank, 2016), and labor income comprises about two-thirds of GDP, consistent with the baseline specification. The consumption tax is set to 6%, the value found by Mendoza et al. (1994).

[34] We are grateful to the editor for this insight.

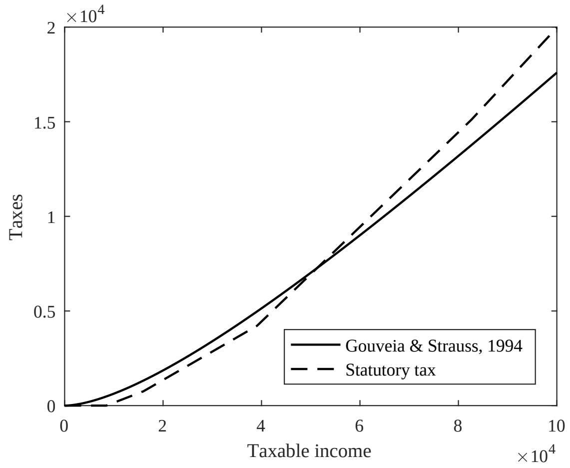


Figure A3: Comparison of Income Tax Functions

rates. Under the Gouveia and Strauss (1994) approach, making benefits fully taxable will raise eveyone's marginal tax rate, but the rate changes are smaller.

D6 Institutional Knowledge

Our baseline assumption is that individuals have a full understanding of how their Social Security benefits will be taxed. To assess the importance of the full-information assumption, we simulate a limited-information version of the model where individuals first learn about Social Security benefit taxation the year after they claim benefits. To isolate the effect of information, throughout the experiment we hold all general equilibrium variables at their benchmark economy values.

Table A7 presents the results. Column (0) is for the baseline economy, while column (1) is for an economy with no benefit taxation. Column (2) presents results for the case where individuals learn about benefit taxes only after they claim benefits. Being unaware of the taxes, they make the same claiming decisions as in the no-benefit tax economy of column (1) and thus claim earlier than in the benchmark economy. As expected, this increases their exposure to the tax. The percentage of Social Security recipients who pay taxes on their benefits rises from 30.2% to 32.0%, and the ratio of benefit taxes to total benefits

Table A7: Partial Equilibrium Effects of Changing Institutional Knowledge

	Full Information		Limited Information	
		SSB Taxes	SS Benefit	Earnings
	Baseline	Eliminated	Taxation	Test
	(0)	(1)	(2)	(3)
Beneficiaries paying taxes on benefits	30.24%	0.00%	32.01%	28.80%
Taxes/SS Benefits	2.13%	0.00%	2.55%	2.01%
Receiving SS at 62	22.09%	28.01%	28.01%	10.54%
Receiving SS at 66	86.92%	98.63%	98.63%	79.68%
Efficiency units		+1.33%	+0.21%	-0.12%
Median assets at age 60	139.0	135.0	135.0	139.8
Median assets at age 80	154.2	163.5	151.3	152.6

Note: Table reports the statistics about the benchmark economy and three counterfactual economies for the following specifications: column (0) is the baseline specification; in column (1) benefit taxes are eliminated; in column (2) individuals are unaware of Social Security benefit taxation until they claim benefits; and in column (3) individuals are unaware of the crediting component of the Earnings Test. Columns (1)-(3) are all partial equilibrium analyses, with bequests and payroll taxes held at their baseline values (column (0)).

rises by 0.4 pp. Not anticipating the benefit taxes, agents save less. For those who have to pay it, the unanticipated benefit tax is a negative wealth shock and also a reduction in the after-tax returns to working. Efficiency units rise by 0.21%, suggesting that the wealth effects dominate. The change in labor supply between the benchmark economy and the economy with limited information is much smaller, however, than the change between the economy with limited information and the economy without benefit taxation. Note that the latter difference is the labor gain from eliminating the tax in the limited information economy. In short, eliminating the taxation of benefits is nearly as important in the limited information economy as in the baseline specification.

Another potentially confusing aspect of the Social Security system is the way in which benefits withheld via the Earnings Test are credited to future benefits. Column (3) of Table A7 presents results for a specification where beneficiaries are unaware of the credits. This change leads to a small reduction in labor supply. One important reason the effects are not bigger is that workers avoid the strengthened Earnings Test by delaying their benefit claims. Under the misinterpreted Earnings Test specification, only 10.5% of workers claim benefits at age 62, less than half the benchmark rate of 22.1%.

D7 Other Exercises

Finally, we assess the sensitivity of our findings to assumptions about health insurance and population growth. Table A8 presents the results. Column (1) shows the results for a specification where individuals under the age of 65 bear their full medical expenses, while column (2) shows the results for a specification with no population growth. All three columns use the parameter values found through the baseline calibration. Comparing columns (1) and (0) shows that eliminating private insurance reduces the welfare gains from the policy reforms, while column (3) shows that eliminating population growth leads to higher welfare gains. Nonetheless, in all cases the reforms result in higher labor supply and higher welfare.

Table A8: Effect of Policy Reforms under Alternative Assumptions (Baseline Values of Calibrated Parameters)

	Baseline (0)	No Health Insurance (1)	No Population Growth (2)
SS benefits not taxable			
Efficiency units	1.17%	1.09%	1.58%
CEV	0.52%	0.21%	0.63%
SSB benefits not taxable + No Earnings Test			
Efficiency units	1.26%	1.29%	1.65%
CEV	0.66%	0.34%	0.93%
SS Benefits always taxable			
Efficiency units	0.76%	0.78%	1.09%
CEV	0.60%	0.37%	0.72%

Note: Table reports the effects of three policy reforms under alternative model assumptions: column (0) with the baseline specification; column (1) with no private health insurance for individuals younger than 65; and column (2) with no population growth. In all cases, the parameter values are set to those of the baseline calibration.

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