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The Costs to Different Generations of Policies That Close the Fiscal Gap

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Abstract

Based on the projections in CBO's *The 2014 Long-Term Budget Outlook*, we analyze five stylized changes in federal fiscal policy that would close a fiscal gap of 1.8 percent of GDP by immediately and permanently increasing tax revenues or decreasing spending. Those policy changes would stabilize the debt-to-GDP ratio at the 2014 level of 74 percent. We conduct our analysis using a heterogeneous-agent overlapping-generations model of the U.S. economy and examine how the stylized policy changes would affect the economy over time and the well-being of different generations. Importantly, the significant benefits of stabilizing the debt-to-GDP ratio do not depend on the specific policy used. As a result, we focus on measuring the costs that the stylized policies would impose on different generations. We find that for households containing working-age adults or retirees, tax increases are less costly than benefit cuts, whereas for future generations, cuts to Social Security and Medicare benefits are the least costly of the options we analyze. The choice of policy has a relatively small effect on the economy's output in the long run, and a policy's effect on output is a poor predictor of how its implementation would affect households' well-being.

1 Introduction

In 2014, the U.S. government’s accumulated debt equaled 74 percent of the nation’s gross domestic product (GDP), and it remains at about that percentage today. In the long-term budget projections issued by the Congressional Budget Office (CBO) in 2014, under then-current laws future spending was projected to exceed future revenues, and debt held by the public was projected to increase to 225 percent in 2089.¹ A common measure of the government’s fiscal imbalance is the fiscal gap—the size of the changes in noninterest spending or revenues that would be needed to make federal debt equal its current percentage of GDP at a specific date in the future. In 2014, CBO estimated that the 75-year fiscal gap was 1.8 percent of GDP; in other words, a permanent increase in federal revenues or reduction in federal spending equal to 1.8 percent of GDP each year starting in 2015 would cause debt to equal 74 percent of GDP, its 2014 level, in 2089.²

This analysis examines five stylized changes in fiscal policy designed to close a fiscal gap of 1.8 percent of GDP and keep the debt-to-GDP ratio at 74 percent. The analysis looks at how the policies’ costs to households in terms of higher taxes or lower transfers would affect the U.S. economy, aggregate net income, and the well-being (or welfare) of individual households. Policy changes designed to prevent unsustainable growth in debt would affect different types of households differently. For example, the effects of tax increases or benefit cuts would be different for low-income households than for high-income households, and different for poor households than for wealthy households. This analysis examines the effects of policy changes on different generations of households.

There are many possible combinations of fiscal policy changes that would close the fiscal gap and return debt as a percentage of GDP to a sustainable path. The benefits of closing the fiscal gap would be identical for all policies.³ However, it is not possible to measure any of the gains from moving from an unsustainable to a sustainable policy because an unsustainable policy—by definition—cannot be maintained indefinitely. In contrast, the costs imposed on different generations would depend on the specific policy chosen, and those differences in costs can be measured by CBO’s overlapping-generations model. For those reasons, we focus on analyzing the costs to households, and the resulting effects on the macroeconomy, of implementing different policies to close the fiscal gap. That analysis allows us to answer the question of how policies rank in terms of costs imposed on different cohorts. (And because the benefits of closing the fiscal gap are the same

¹In the most recent update to its long-term budget outlook, the Congressional Budget Office projected that if current laws remained generally unchanged, federal debt would equal 181 percent of GDP in 2090 and the 75-year fiscal gap would be 1.4 percent of GDP. (See [Congressional Budget Office, 2015](#).) If our analysis was based on those updated numbers, the costs of closing the fiscal gap would be lower, but the ranking of the policy changes in terms of costs they would impose on different generations would remain the same.

²See [Congressional Budget Office \(2014a\)](#). [Auerbach and Gale \(2012\)](#) define the long-term fiscal gap as “the immediate and permanent increase in taxes or reduction in spending that would keep the long-term debt-to-GDP ratio at its current level.” In Section 5, we show the results of policy experiments to close a long-term fiscal gap of 1.8 percent of GDP rather than a 75-year fiscal gap of that magnitude.

³CBO’s *The 2015 Long-Term Budget Outlook* describes a large and growing federal debt as having “significant negative consequences for the economy in the long term” and as “imposing significant constraints on future budget policy.” In particular, the projected amounts of debt would reduce the total amounts of national saving and income in the long term; increase the government’s interest payments, thereby putting more pressure on the rest of the budget; limit lawmakers’ flexibility to respond to unforeseen events; and increase the likelihood of a fiscal crisis. ([Congressional Budget Office, 2015](#), p.16.) Because each of our stylized policy changes would close the fiscal gap, the benefits of avoiding those negative consequences would be the same for each policy change.

for all policies, that analysis also provides a ranking of the overall effects of policies on different households.) Thus, our results provide information to lawmakers choosing among policies to close the fiscal gap. However, our results do not provide answers about who would benefit from closing the fiscal gap, whether closing the fiscal gap should be a priority, or whether lawmakers should start closing the gap now or later.⁴

1.1 Analytic Approach

We use a dynamic general-equilibrium overlapping-generations (OLG) model with heterogeneous households—CBO’s “life-cycle growth model”—to analyze the costs that fiscal policy changes would impose on different generations as well as the relative macroeconomic effects of those changes. However, a dynamic general-equilibrium model with forward-looking (rational) households cannot be used to estimate the effects of a policy that is permanently unsustainable. The reason is that an ever-increasing debt level would lead to higher interest rates and increases in the government’s debt-service costs. Those costs would eventually grow so large that the resources of U.S. households could no longer cover them. Predicting that, forward-looking households would stop purchasing government bonds, and as a result, the government would have to change its fiscal policies.

Because we cannot construct an economy in which an unsustainable fiscal policy lasts permanently, we instead create a benchmark economy with a sustainable fiscal policy and a constant debt-to-GDP ratio in the long run. We then introduce a fiscal gap by increasing the government’s purchases by 1.8 percent of GDP as measured in the benchmark economy and then eliminate that gap using one of five stylized policy changes. That approach allows us to investigate the effects of different policies relative to the benchmark economy, including effects on the overall economy, households’ labor supply and saving, and the welfare of households in different age cohorts. Therefore, the estimates in this paper illustrate the *relative* effects of the different policies, but not the *overall* effects of policies to stabilize the debt-to-GDP ratio. For example, some households would be affected much more than others by policies that close the fiscal gap by raising taxes or reducing transfers, with the precise relative effects depending on the details of the policies. (Policies to eliminate the fiscal gap would have other beneficial effects on households’ well-being and the economy, but—as described above—those effects would be the same across policies and therefore would not affect the relative ranking of the policies in terms of their effect on different cohorts.)

This paper provides insights about the relative effects of different policy changes on the following factors:

- Households’ labor supply and saving behavior,
- The overall economy,
- The amount of net transfers that households receive, and

⁴For example, although some generations would incur costs from policy changes that aimed to stabilize the debt-to-GDP ratio now, they would also receive benefits from having the fiscal gap closed now rather than in the future. However, other generations, such as current retirees, would probably not see most of the benefits of closing the fiscal gap because they would not live long enough for those benefits to be substantial (see [Congressional Budget Office, 2010](#)). However, because we are unable to calculate the benefits to different generations from closing the fiscal gap, we cannot judge which cohort would ultimately benefit from our stylized policy changes.

- Households' economic well-being.

In the model economy, households are different (heterogeneous) with respect to their age, hourly wage, wealth, and the average historical earnings used to calculate their future Social Security benefits. Households may experience uninsurable wage shocks each year, which produces inequalities not only in annual income but also in wealth and lifetime income.

1.2 Policy Changes Analyzed

The five stylized fiscal policies that we study include two policy changes that would decrease federal transfers relative to what would occur in the benchmark economy:

- A uniform cut in lump-sum transfers (fixed-amount transfers that do not depend on a household's income or wealth),⁵ and
- A uniform percentage cut in Social Security's Old-Age, Survivors, and Disability Insurance benefits and Medicare's Hospital Insurance benefits (referred to collectively as OASDI/HI benefits).

The stylized policies also include three policy changes that would raise federal taxes:

- An increase in the payroll tax rate for Medicare's Hospital Insurance program (taxes on labor income to help finance Medicare),
- A uniform percentage increase in marginal income tax rates (the percentage of an additional dollar of income that is paid in taxes), and
- An increase in the rate of a flat consumption tax (which approximates excise and other taxes).

Those five policies roughly correspond to various options discussed in CBO's 2014 publication *Options for Reducing the Deficit: 2015 to 2025* ([Congressional Budget Office, 2014c](#)). The policies were chosen because of their differential effects on age groups. Cuts in lump-sum transfers are the same across all households, whereas cuts in OASDI/HI benefits only apply to cohorts ages 65 and older. Increases in payroll taxes fall almost entirely on working-age households, because they are levied on labor earnings; increases in income taxes fall on the elderly to some extent, because they apply to asset income, but they fall more heavily on working-age households; and consumption taxes affect both the young and the old, because people continue to consume goods and services after retirement.

Those policy changes would affect the amount of transfers, net of taxes, received by different cohorts relative to what they receive in the benchmark economy and would alter their incentives to work and save. As a result of those changes in incentives, economic outcomes would be different than under the benchmark. In addition, the differences in transfers and taxes, together with effects

⁵This policy option was chosen for analytical reasons, because it decreases transfers to each household equally without directly changing a household's incentives to work or save. This policy can be approximated with a combination of transfers that different groups of people receive, such as Medicare and Medicaid benefits, Supplemental Nutrition Assistance Program benefits, tax deductions for mortgage interest, and others. To cut lump-sum transfers uniformly would require that the benefits of different programs be adjusted in such a way that each household experienced the same decrease in disposable income.

on incentives and the impact on the economy, would affect the well-being of different cohorts (relative to their well-being under the benchmark) in different ways.

In general, if the government cut spending on transfers—either lump-sum transfers or OASDI/Hi benefits—households would choose to work and save more to compensate for the reduction in transfers. As a result, cuts in transfers would increase the aggregate labor supply, the capital stock, and the total output of the economy relative to the benchmark economy. The effect on households' saving would be particularly large if the transfers that were cut were OASDI/Hi benefits, because households would want to accumulate more wealth to insure against outliving their assets during retirement.

If the government instead increased payroll or marginal income tax rates, households would work and save less, which would decrease the aggregate labor supply, the capital stock, and the total output of the economy. Of those two policies, the negative effect on households' saving would be larger with an increase in income tax rates, because the income tax applies to capital income as well as labor income and therefore affects the after-tax return on saving. Because of the progressivity of income tax rates, any proportional increase would raise top marginal tax rates the most. Furthermore, because the top marginal rates are already higher than other marginal tax rates, even the same absolute change in marginal tax rates would produce a larger percentage change in the after-tax rate of return on saving for high-income households, which are the biggest savers in the model economy (consistent with empirical evidence).

If the government increased a flat-rate consumption tax, the impact on the overall economy would be neutral in the sense that output would remain unchanged.⁶ An unanticipated increase in the consumption tax rate would have no effect on households' labor supply and saving because it would proportionally decrease the purchasing power of households' future labor income (the substitution effect) and current wealth (the wealth effect). Those two effects would cancel each other out, so that there would be no effect on households' behavior (working and saving), although households would decrease their consumption.⁷

1.3 Main Findings

We use two approaches to measure the relative costs that the stylized policies would impose on different age cohorts. The first approach is to calculate the impact of a policy on the amount of transfers that different cohorts receive, net of the amount of taxes they pay. We measure that cost as the annuitized value of the net present value (NPV) of net transfers at the time of the policy change. (The NPV adjusts future payments for the time value of money to make them comparable with payments today.) The second approach is to estimate the change in households' well-being because of the policy change. For that purpose, we use the consumption-equivalence measure of welfare, which assesses the percentage by which a household's consumption in the benchmark economy would have to change each year of the household's remaining life—at the time of the policy change—to make the household just as well off as under the new policy.

On the basis of those measures, we find that all five policies would reduce households' net

⁶Although currently there is no federal flat-rate consumption tax, we treat all revenues other than those from the income and payroll taxes—such as revenues from excise taxes and custom duties—as proceeds of a flat-rate consumption tax.

⁷The effects of an unanticipated increase in a consumption tax differ from the impact of an increase in the payroll tax rate because changes to the payroll tax rate leave unaffected the purchasing power of households' assets.

transfers and well-being relative to the benchmark economy—an expected result, because only the costs and not the benefits of the policies are incorporated. The spending policies would have different effects on the macroeconomy than the tax policies would; for example, spending cuts lead to higher output than tax increases do. However, given that all of the policies would create a stable and sustainable fiscal policy, the particular choice of policy has only a small effect on output in the long run.

We also find that a policy’s effect on output is a poor predictor of how it would affect households’ well-being. One reason is that households are assumed to be risk-averse, so policies that provide insurance against fluctuations in consumption are valued more than policies that expose households to more risk of such fluctuations, all else being equal. Similarly, policies that induce households to work more decrease their welfare, all else being equal. Thus, although cuts to lump-sum transfers and OASDI/HI benefits lead to higher output in the long run (largely because households work and save more), the well-being of working-age households and retirees is greater when payroll or income taxes are increased instead.

Our main results by cohort are the following:

- Retirees (age 65 and older) and older workers (ages 41 to 64) experience the smallest reduction in net transfers and welfare from the payroll tax increase and the largest reduction in net transfers and welfare from the cuts to OASDI/HI benefits.
- Younger workers (ages 21 to 40) experience the smallest reduction in net transfers from the cuts to OASDI/HI benefits or lump-sum transfers and the largest reduction in net transfers from the increase in income tax rates. In terms of their welfare, by contrast, younger workers tend to fare better under the increases in payroll or income taxes than under the cuts in transfers or increases in consumption taxes.
- Very young people (up to age 20) and future generations experience the smallest reduction in net transfers and welfare from the cuts to OASDI/HI benefits and the largest reduction in net transfers and welfare from the increases in income tax rates or the cuts to lump-sum transfers.

The rest of this paper is laid out as follows: Section 2 provides an overview of the heterogeneous-agent OLG model, Section 3 describes technical details of the model economy, and Section 4 explains how we calibrated the model to the 2013 U.S. economy. Section 5 describes how we generated the benchmark economy with a fiscal gap and provides the results of our main stylized policy experiments to close the fiscal gap. The paper concludes with sensitivity analyses that examine the costs of closing the fiscal gap under alternative modeling assumptions and different values for some key parameters.

2 Overview of the Model

CBO’s life-cycle growth model is a general-equilibrium model in the sense that people make decisions in response to prices—such as wages and rates of return on saving—that are themselves determined by the decisions those people make.⁸ The model includes different cohorts of households, also known as overlapping generations, that are forward-looking in their behavior. People in

⁸Several paragraphs in this section are taken directly from [Congressional Budget Office \(2014b\)](#).

the life-cycle model are assumed to make choices about working and saving in response to current and anticipated future after-tax wages, after-tax rates of return, and transfer payments. The extent to which households can correctly anticipate those factors varies: They are assumed to know precisely how fiscal policy and the economy as a whole will evolve in the future, but they face uncertainty about their own future income. In addition, households in the life-cycle model can become credit-constrained if their current income falls significantly below their expected future income—that is, borrowing limits may prevent them from borrowing enough to maintain their desired level of consumption given their expected lifetime income.

In the life-cycle growth model, the estimated effects of changes in fiscal policies depend on the degree to which the labor supply, private saving, and net inflows of foreign capital respond to those policy changes. This analysis incorporates the assumption that interest rates are determined entirely in the domestic economy (effectively assuming a closed economy).⁹

The responses of the labor supply and private saving to changes in fiscal policies are more complicated. Both variables are influenced by the current values and future anticipated values of households' after-tax wages, after-tax rate of return on saving, and disposable income, among other factors.¹⁰ Because of the uncertainty that households in this model face about their future income, they take the precaution of keeping additional savings as a buffer against potential drops in income. That precautionary motive to save is not strongly affected by changes in the after-tax rate of return on saving; as a result, households' saving does not respond as much to changes in marginal tax rates on capital income as it does in models that do not include a precautionary motive of that sort.

The government's consumption does not affect households' decisions about private consumption and labor supply in the model economy, but lump-sum transfers directly affect households' decisions through their intertemporal budget constraint.¹¹ In the model economy, the government's consumption is roughly equivalent to the government's purchases of goods and services in the data. Such government consumption might have a variety of effects on behavior and well-being, but modeling those effects is beyond the scope of this analysis. In this paper, therefore, we do not include government consumption in a household's utility function or budget constraint. Thus, in this analysis, government consumption generates no behavioral and utility effects, in keeping with the standard assumption in the macroeconomic public finance literature.

The model incorporates the assumption that people decide how much to work and save to make themselves as well off as possible over their lifetime but do not consider the well-being of their children. Therefore, older generations know that they could retire or die before a policy change occurs and tend to be less responsive to future policy changes than younger generations are. Given the forward-looking behavior of households in the life-cycle model, estimating the effects of changes in fiscal policies requires CBO to make assumptions about future policies—not only during the period when the proposed policy changes are explicitly in effect but also into the distant

⁹In Appendix A.4, we present results that alternatively incorporate the assumption of a small open economy, in which net capital inflows change to offset any effect of changes in fiscal policies on interest rates.

¹⁰For example, if households expect the after-tax rate of return on saving to be higher in the near future, they may increase their saving and labor supply now so they can build up more assets. If they expect their after-tax wages to be higher in the future, they may decrease their labor supply and saving now. For a discussion of CBO's estimates of how the supply of labor responds to changes in after-tax wages in the life-cycle growth model, see [Reichling and Whalen \(2012\)](#).

¹¹An intertemporal budget constraint is a constraint faced by households that make choices about how much to consume and work in the present and the future. It generally says that the present value of current and future spending cannot exceed the present value of current and future income.

future. Moreover, because households in the model are assumed to know how fiscal policy will evolve in the future, the assumed policy must put federal debt on a sustainable path over the long run; forward-looking households would not hold government bonds if they expected that debt as a percentage of GDP would rise without limit.

3 Technical Description of the Model

The model economy consists of a large number of heterogeneous and overlapping-generations households, a perfectly competitive representative firm with constant-returns-to-scale technology, and a government that can credibly commit to a fiscal policy.¹² The time is discrete, and one model period is a year, which is denoted by t . In a stationary (steady-state) equilibrium of the model, the economy is assumed to be on a balanced-growth path with a constant labor-augmenting productivity growth rate, μ , and a constant population growth rate, ν .¹³

In the following description of the model, individual variables other than working hours are growth-adjusted by $(1 + \mu)^{-t}$, the population measure (number) of households is adjusted by $(1 + \nu)^{-t}$, and aggregate variables are adjusted by $[(1 + \mu)(1 + \nu)]^{-t}$.¹⁴

3.1 Households

Households in the model economy are heterogeneous with respect to the age of the household's head, $i = 21, \dots, I$; wealth at the beginning of the year (net worth), $a \in A = [a_{\min}, a_{\max}]$; average historical earnings used to calculate Social Security Old-Age and Survivors Insurance (OASI) benefits, $b \in B = [0, b_{\max}]$; and labor productivity, $e \in E = [0, e_{\max}]$.¹⁵ The household's hourly

¹²The heterogeneous-agent OLG model described in this section is a simplified version of the models in [Nishiyama \(2011, 2013\)](#). The detailed computational procedure to solve those models is described in [Nishiyama and Smetters \(2014\)](#). The previous version of CBO's life-cycle model (used in 2012 and earlier) is based on the models described in [Nishiyama \(2003\)](#) and [Nishiyama and Smetters \(2007\)](#). Versions of the model have been used in CBO's analyses of the economic effects of the President's budget since 2003.

¹³The economy we analyze, in general, grows over time in real terms. (There is no inflation in the model economy.) We assume that individual labor productivity grows, on average, at $\mu = 1.8\%$ each year and that the population grows at $\nu = 1.0\%$ each year. When a household's individual working hours for each age and the wage rate are unchanged over time, the aggregate labor supply in efficiency units grows at $(1 + \mu)(1 + \nu) - 1 = 2.8\%$ each year because of the labor productivity growth and population growth. When the economy's capital stock grows at that same rate, the total output of the economy also grows by 2.8 percent each year. The economy is said to be on a balanced-growth path when the capital stock, the effective labor supply, and total output grow at the same rate as shown in this example.

¹⁴One usually needs to solve a growth model for an equilibrium transition path backward from the long-run equilibrium (in the infinite future) to the current year, because households in the model economy are assumed to be forward-looking. In the growth economy, however, we cannot define and obtain the long-run equilibrium because the economy grows indefinitely. Thus, it is common practice to adjust the economic variables and the size of the population by the productivity and population growth rates, which means that time trends resulting from those growth rates are removed in the model economy. With that adjustment, all economic variables and the population distribution are constant in the final steady-state equilibrium.

¹⁵The upper bound of a household's labor productivity, e_{\max} , is set at a reasonably high level for computational convenience, which excludes the possibility that any household can earn an infinite amount of money. The upper bound of a household's wealth is also set at a reasonably high level so that the constraint, $a \leq a_{\max}$, will never be binding. Because both the labor productivity and the lifespan of the household are finite, there is an upper bound on the wealth that the household wants to hold. That finiteness of the household's wealth ensures the existence of competitive general equilibrium, as defined in Section 3.4. As explained below, the household's average historical

wage is shown by $w_t e$, where w_t is the wage rate per unit of productivity, which is determined by the labor market. Households enter the economy and start working at age $i = 21$, and they can live to age $i = I = 100$. For simplicity, households are assumed to start receiving OASI benefits at the current full retirement age, $i = I_{\bar{R}} = 66$, although they are also assumed to continue working after that age if they find it optimal. Average historical earnings, b , are used to approximate the household's average indexed monthly earnings (AIME) needed to determine OASI benefits.¹⁶ Individual labor productivity, e , follows a first-order Markov process. In each year, t , households receive idiosyncratic and age-dependent shocks to their working ability, e , and they each choose their consumption, c , working hours, h , and thus wealth at the beginning of the next year, a' , to maximize their expected (remaining) lifetime utility.¹⁷

3.1.1 State Variables

Let \mathbf{s} and \mathbf{S}_t denote the individual state of the household and the aggregate state of the economy in year t , respectively,

$$\mathbf{s} = (i, a, b, e), \quad \mathbf{S}_t = (x_t(\mathbf{s}), d_{G,t}),$$

where $x_t(\mathbf{s})$ is the growth-adjusted population distribution (density) function of households, and $d_{G,t}$ is the government's debt (held by the public) per household at the beginning of year t . Let p_i be the growth-adjusted population of age- i households.¹⁸ The population distribution function, $x_t(\mathbf{s})$, and the corresponding cumulative distribution function, $X_t(\mathbf{s})$, satisfy

$$\int_{A \times B \times E} x_t(i, a, b, e) da db de = \int_{A \times B \times E} dX_t(i, a, b, e) = p_i.$$

Let Ψ_t be the government's policy schedule at the beginning of year t ,

$$\Psi_t = \left\{ c_{G,s}, tr_{LS,s}, \tau_{I,s}(\cdot), \tau_{P,s}(\cdot), tr_{SS,s}(\cdot), \tau_{C,s}, d_{G,s+1} \right\}_{s=t}^{\infty},$$

where $c_{G,t}$ is the government's consumption per household, $tr_{LS,t}$ is a lump-sum transfer per household, $\tau_{I,t}(\cdot)$ is a progressive income tax function, $\tau_{P,t}(\cdot)$ is a Social Security Old-Age, Sur-

earnings, b , are introduced into the model to approximate the household's average indexed monthly earnings for the OASI benefit calculation. Thus, the upper bound, b_{\max} , is equal to the maximum taxable earnings for the OASDI payroll tax, ϑ_{\max} , in the model economy, which was \$113,700 in 2013.

¹⁶See [Social Security Administration \(2014\)](#) for the exact calculations of the AIME and the primary insurance amount (PIA).

¹⁷The rate of return on capital, r_t , is endogenous but deterministic because there are no aggregate productivity shocks assumed in the model economy. The average wage rate (the wage rate per efficiency unit of labor), w_t , is also endogenous but deterministic, although the individual wage rate, $w_t e$, is stochastic.

¹⁸Footnotes 13 and 14 explain why the economic variables and the population are growth-adjusted in the model economy (economic variables are adjusted by growth in population and in productivity, while population is adjusted only by growth in population). When the actual population of age i in year t is denoted by $\hat{p}_{i,t}$, the actual population of this age cohort in the next year is $\hat{p}_{i+1,t+1} = \phi_i \hat{p}_{i,t}$, where ϕ_i is the survival rate at the end of age i . When the growth-adjusted population of age i in year t is denoted by $p_{i,t}$, the growth-adjusted population of this age cohort in the next year is calculated as $p_{i+1,t+1} = \phi_i p_{i,t} / (1 + \nu)$, where ν is the long-run population growth rate. In this paper, for simplicity, we assume the economy has a stationary population distribution, where the growth-adjusted population by age, $\{p_{i,t}\}_{i=1}^I$, is time-invariant; that is, the actual population by age, $\{\hat{p}_{i,t}\}_{i=1}^I$, expands at a constant rate, ν , every year. Equation (7) below uses the same formula generalized to apply to heterogeneous households.

vivors, and Disability Insurance and Medicare Hospital Insurance (OASDI/HI) payroll tax function, $tr_{SS,t}(\cdot)$ is an OASDI/HI benefit function, $\tau_{C,s}$ is a flat consumption tax rate, and $d_{G,t+1}$ is the government's debt per household at the beginning of the next year. The government's consumption does not affect the household's decisions on private consumption and labor supply in the model economy, while lump-sum transfers directly affect the household's decisions through the intertemporal budget constraint. The proceeds from the flat consumption tax (with rate $\tau_{C,s}$) in the model economy are assumed to approximate federal tax revenues other than those from the income and payroll taxes, such as revenues from excise taxes and customs duties.

3.1.2 Households' Optimization Problem

Let $v(\mathbf{s}, \mathbf{S}_t; \Psi_t)$ be the value function of a household at the beginning of year t . Then, the household's optimization problem is

$$(1) \quad v(\mathbf{s}, \mathbf{S}_t; \Psi_t) = \max_{c, h, a'} \left\{ u(c, h) + \tilde{\beta} \phi_i E \left[v(\mathbf{s}', \mathbf{S}_{t+1}; \Psi_{t+1}) \mid \mathbf{s} \right] \right\}$$

subject to the constraints for the decision variables,

$$(2) \quad c > 0, \quad 0 \leq h < h_{\max}, \quad a' \geq a'_{\min}(\mathbf{s}),$$

and the law of motion of the individual state,

$$(3) \quad \mathbf{s}' = (i + 1, a', b', e'),$$

$$(4) \quad a' = \frac{1}{1 + \mu} \left[(1 + \bar{r}_t) a + w_t e h + tr_{SS,t}(i, b) + tr_{LS,t} + q_t(i) - \tau_{I,t}(w_t e h, \bar{r}_t a, tr_{SS,t}(i, b)) - \tau_{P,t}(w_t e h) - (1 + \tau_{C,t}) c \right],$$

$$(5) \quad b' = \mathbf{1}_{\{i < I_R\}} \frac{1}{i - 20} \left[(i - 21) b \frac{w_t}{w_{t-1}} + \min(\eta w_t e h, \vartheta_{\max}) \right] + \mathbf{1}_{\{i \geq I_R\}} b,$$

where $u(\cdot)$ is a period utility function, a combination of Cobb–Douglas and constant relative risk aversion (CRRA),

$$(6) \quad u(c, h) = \frac{[c^\alpha (h_{\max} - h)^{1-\alpha}]^{1-\gamma}}{1 - \gamma},$$

$\tilde{\beta}$ is a growth-adjusted discount factor (explained below), ϕ_i is a conditional survival rate at the end of age i given that the household is alive at the beginning of age i , and $E[\cdot \mid \mathbf{s}]$ denotes the conditional expected value given the household's current state. The household's decision variables are constrained: consumption, c , is strictly positive; working hours, h , are nonnegative and are less than a time endowment, h_{\max} ; and wealth at the beginning of the next year, a' , satisfies a borrowing constraint, $a' \geq a'_{\min}(\mathbf{s})$.¹⁹

In the law of motion, \bar{r}_t is the interest rate (which is a weighted average of the rate of return on

¹⁹We assume, for simplicity, that the borrowing limit (the lowest possible wealth level) depends only on the household's age i . See Section 4.2 for an explanation of the assumed value of $a'_{\min}(\mathbf{s})$.

capital, r_t , and the average government bond yield, $r_{D,t}$, as explained below); w_t is the wage rate per efficiency unit of labor; q_t is the amount of accidental bequests received (explained below); $\mathbf{1}_{\{\cdot\}}$ is an indicator function that returns 1 if the condition in $\{\cdot\}$ holds and 0 otherwise; I_R is set at 65 so that the household's OASI benefits are calculated on the basis of its growth-adjusted earnings between ages 21 and 64;²⁰ η is the ratio of taxable labor income to total labor income; and ϑ_{\max} is the maximum taxable earnings for OASI taxes. The household's wealth at the beginning of the next year, a' , is adjusted by the productivity growth rate, $1 + \mu$. The average historical earnings for a household at the beginning of the following year, b' , are calculated recursively as a weighted average of its current (beginning-of-year) average historical earnings, b , adjusted by the growth in the wage, w_t/w_{t-1} (that is, wage-indexed), and of the current OASDI taxable earnings, $\min(\eta w_t e h, \vartheta_{\max})$. (Average historical earnings are assumed to remain constant after age 65).²¹

3.1.3 The Distribution of Households

Solving the household's problem for c , h , and a' for all possible states,²² we obtain the household's decision rules and average historical earnings in the next year as $c(\mathbf{s}, \mathbf{S}_t; \Psi_t)$, $h(\mathbf{s}, \mathbf{S}_t; \Psi_t)$, and

$$\begin{aligned} a'(\mathbf{s}, \mathbf{S}_t; \Psi_t) &= \frac{1}{1 + \mu} \left[(1 + \bar{r}_t)a + w_t e h(\mathbf{s}, \mathbf{S}_t; \Psi_t) + tr_{SS,t}(i, b) + tr_{LS,t} + q_t(i) \right. \\ &\quad \left. - \tau_{I,t}(w_t e h(\mathbf{s}, \mathbf{S}_t; \Psi_t), \bar{r}_t a, tr_{SS,t}(i, b)) - \tau_{P,t}(w_t e h(\mathbf{s}, \mathbf{S}_t; \Psi_t)) \right. \\ &\quad \left. - (1 + \tau_{C,t})c(\mathbf{s}, \mathbf{S}_t; \Psi_t) \right], \\ b'(\mathbf{s}, \mathbf{S}_t; \Psi_t) &= \mathbf{1}_{\{i < I_R\}} \frac{1}{i - 20} \left[(i - 21) b \frac{w_t}{w_{t-1}} + \min(\eta w_t e h(\mathbf{s}, \mathbf{S}_t; \Psi_t), \vartheta_{\max}) \right] + \mathbf{1}_{\{i \geq I_R\}} b. \end{aligned}$$

Households are assumed to enter the economy at age 21 without any assets and working histories, thus,

$$\int_{A \times B \times E} dX_t(21, a, b, e) = \int_E dX_t(21, 0, 0, e) = p_{21} = 1.0,$$

where the growth-adjusted population measure (number) of age-21 households, p_{21} , is normalized to unity in the model economy. The distribution of households across states s' at age $i + 1$ in year $t + 1$ depends on the population distribution over s at age i in year t as well as on households'

²⁰In the current Social Security system, AIME is calculated as the average of the highest 35 years of growth-adjusted earnings. However, keeping the previous 35 highest earnings as the household's state variables would make the household problem computationally intractable. In the model economy, therefore, AIME is approximated by the average of growth-adjusted earnings of all ages before $I_R = 65$.

²¹In the actual calculation of AIME, a worker's annual taxable earnings are indexed to reflect the general earnings level in the indexing year, which is age 60 for most workers, and the worker's earnings in years after the indexing year are not indexed. See [Social Security Administration \(2014\)](#) for more information.

²²Because the household's individual state vector, \mathbf{s} , includes three continuous variables, a , b , and e , the number of possible states is infinite. Therefore, we discretize the state space and solve the optimization for all nodes in each year. The aggregate state of the economy, \mathbf{S}_t , consists of a continuous function, $x_t(\mathbf{s})$, and thus the aggregate state space is infinitely dimensional. When there are no aggregate shocks in the model economy, however, there is a way to avoid this dimensionality problem. See [Nishiyama \(2013\)](#) and [Nishiyama and Smetters \(2014\)](#) for the computational algorithm.

decisions that influence assets and earnings, as follows, for $i = 21, \dots, I$,

$$(7) \quad x_{t+1}(\mathbf{s}') = x_{t+1}(i+1, a', b', e') \\ = \frac{\phi_i}{1+\nu} \int_{A \times B \times E} \mathbf{1}_{\{a'=a'(\mathbf{s}, \mathbf{S}_t; \Psi_t), b'=b'(\mathbf{s}, \mathbf{S}_t; \Psi_t)\}} \pi_i(e' | e) dX_t(\mathbf{s}),$$

where ν is the population growth rate, and $\pi_i(e' | e)$ is a probability density function of working ability e' at age $i+1$ given that the working ability is e at age i .²³ By dividing the population in $t+1$ by $1+\nu$, the model detrends population growth and expresses the growth economy as a stationary economy.

3.1.4 Aggregation

Total private wealth, $W_{P,t}$, federal debt held by the public, $D_{G,t}$, national wealth, W_t , domestic capital stock, K_t , and labor supply in efficiency units, L_t , are

$$(8) \quad W_{P,t} = \sum_{i=21}^I \int_{A \times B \times E} a dX_t(\mathbf{s}),$$

$$(9) \quad D_{G,t} = \sum_{i=21}^I \int_{A \times B \times E} d_{G,t} dX_t(\mathbf{s}) = d_{G,t} \sum_{i=21}^I p_i,$$

$$(10) \quad W_t = W_{P,t} - D_{G,t},$$

$$(11) \quad K_t = W_t + W_{F,t},$$

$$(12) \quad L_t = \sum_{i=21}^I \int_{A \times B \times E} eh(\mathbf{s}, \mathbf{S}_t; \Psi_t) dX_t(\mathbf{s}),$$

where $W_{F,t}$ is net foreign wealth, which is assumed to be exogenous and constant after growth adjustments. In other words, actual net foreign wealth is modeled to grow at $(1+\mu)(1+\nu) - 1$, the same rate as output, in all states of the economy.

3.2 The Firm

In each year, the representative firm chooses the capital input, \tilde{K}_t , and efficiency labor input, \tilde{L}_t , to maximize its profit, taking factor prices, r_t and w_t , as given, where r_t is the rate of return on capital. The firm's optimization problem is

$$(13) \quad \max_{\tilde{K}_t, \tilde{L}_t} F(\tilde{K}_t, \tilde{L}_t) - (r_t + \delta)\tilde{K}_t - w_t\tilde{L}_t,$$

²³The integrand on the right-hand side is the conditional density function of the household's state at age $i+1$ given the state at age i —that is, $f(i+1, a', b', e' | i, a, b, e) = \mathbf{1}_{\{a'=a'(\mathbf{s}, \mathbf{S}_t; \Psi_t), b'=b'(\mathbf{s}, \mathbf{S}_t; \Psi_t)\}} \pi_i(e' | e)$. Multiplying the density function, $x(i, a, b, e)$, gives us the two-year joint density function of the state, $f(i, a, b, e, i+1, a', b', e')$. Integrating the joint density function with respect to a, b , and e provides the marginal density function, $x(i+1, a', b', e')$, at age $i+1$.

where $F(\cdot)$ is a constant-returns-to-scale production function, $F(\tilde{K}_t, \tilde{L}_t) = A\tilde{K}_t^\theta \tilde{L}_t^{1-\theta}$, with total factor productivity A , and δ is the depreciation rate of capital. The firm's profit-maximizing conditions are

$$(14) \quad F_K(\tilde{K}_t, \tilde{L}_t) = r_t + \delta, \quad F_L(\tilde{K}_t, \tilde{L}_t) = w_t,$$

and the factor markets are cleared when²⁴

$$(15) \quad K_t = \tilde{K}_t, \quad L_t = \tilde{L}_t.$$

This paper assumes that the factor markets are cleared in each year. Thus, there is no frictional (or involuntary) unemployment in the model economy.

3.3 The Government

We assume that the government's policy schedule, Ψ_t , which determines both current and future policy as of year t , is credible. The government collects taxes and makes its consumption and transfer spending as scheduled in Ψ_t . In addition, the government collects wealth left by deceased households (accidental bequests) and distributes that wealth uniformly to working-age households.

The government's income tax revenue, $T_{I,t}$, payroll tax revenue for Social Security, $T_{P,t}$, and consumption (or other) tax revenue, $T_{C,t}$, are

$$(16) \quad T_{I,t}(\varphi_t) = \sum_{i=21}^I \int_{A \times B \times E} \tau_{I,t}(w_t e h(\mathbf{s}, \mathbf{S}_t; \Psi_t), \bar{r}_t a, tr_{SS,t}(i, b); \varphi_t) dX_t(\mathbf{s}),$$

$$(17) \quad T_{P,t}(\tau_{O,t}, \tau_{D,t}, \tau_{H,t}) = \sum_{i=21}^I \int_{A \times B \times E} \tau_{P,t}(w_t e h(\mathbf{s}, \mathbf{S}_t; \Psi_t); \tau_{O,t}, \tau_{D,t}, \tau_{H,t}) dX_t(\mathbf{s}),$$

$$(18) \quad T_{C,t}(\tau_{C,t}) = \sum_{i=21}^I \int_{A \times B \times E} \tau_{C,t} c(\mathbf{s}, \mathbf{S}_t; \Psi_t) dX_t(\mathbf{s}),$$

where φ_t is one of the parameters of the income tax function, $\tau_{O,t}$ is an OASI payroll tax rate, $\tau_{D,t}$ is a Disability Insurance (DI) tax rate, and $\tau_{H,t}$ is a Hospital Insurance (HI) tax rate. The government's consumption spending, $C_{G,t}$, non-Social Security transfer spending, $TR_{LS,t}$, and Social Security transfer spending, $TR_{SS,t}$, are

$$(19) \quad C_{G,t}(c_{G,t}) = \sum_{i=21}^I \int_{A \times B \times E} c_{G,t} dX_t(\mathbf{s}) = c_{G,t} \sum_{i=21}^I p_i,$$

$$(20) \quad TR_{LS,t}(tr_{LS,t}) = \sum_{i=21}^I \int_{A \times B \times E} tr_{LS,t} dX_t(\mathbf{s}) = tr_{LS,t} \sum_{i=21}^I p_i,$$

²⁴In an equilibrium, the factor markets are always cleared. Private wealth, $W_{P,t}$, and labor supply in efficiency units, L_t , are determined by the household's optimization problem; federal debt, $D_{G,t}$, is determined by the government; and the domestic capital stock, K_t , is determined by total wealth, $W_{P,t} - D_{G,t} + W_{F,t}$. Equilibrium factor prices, r_t and w_t , are then determined by the capital stock and labor supply in the economy.

$$(21) \quad TR_{SS,t}(\psi_{O,t}, \psi_{D,t}, \psi_{H,t}) = \sum_{i=21}^I \int_{A \times B \times E} tr_{SS,t}(i, b; \psi_{O,t}, \psi_{D,t}, \psi_{H,t}) dX_t(\mathbf{s}),$$

where $\psi_{O,t}$ is a parameter of the OASI benefit function, $\psi_{D,t}$ is the DI benefit per working-age household, and $\psi_{H,t}$ is the HI benefit per eligible household.

For simplicity, we assume that the government collects wealth left by deceased households at the end of year t and distributes it in a lump-sum manner to all working-age households in the same year. Because there are no aggregate shocks in the model economy, the government can perfectly predict the sum of accidental bequests (at the end of the year) and distribute it during the year.²⁵ The government's revenue from those accidental bequests, Q_t , is

$$(22) \quad Q_t = \sum_{i=21}^I \int_{A \times B \times E} (1 - \phi_i)(1 + \mu)a'(\mathbf{s}, \mathbf{S}_t; \Psi_t) dX_t(\mathbf{s}).$$

The bequest received by each working-age household is

$$(23) \quad q_t(i) = \left(\sum_{i=21}^{I_R-1} \int_{A \times B \times E} dX_t(\mathbf{s}) \right)^{-1} Q_t,$$

for $i = 21, \dots, I_R - 1$.

The law of motion of the government's debt held by the public, $D_{G,t}$, is

$$(24) \quad D_{G,t+1}(d_{G,t+1}) = \frac{1}{(1 + \mu)(1 + \nu)} \left[(1 + r_{D,t})D_{G,t}(d_{G,t}) - T_{I,t}(\varphi_t) - T_{P,t}(\tau_{O,t}, \tau_{D,t}, \tau_{H,t}) \right. \\ \left. - T_{C,t}(\tau_{C,t}) + C_{G,t}(c_{G,t}) + TR_{LS,t}(tr_{LS,t}) + TR_{SS,t}(\psi_{O,t}, \psi_{D,t}, \psi_{H,t}) \right],$$

where $r_{D,t}$ is the average government bond yield such that $r_{D,t}D_{G,t}$ is the government's debt-service cost. Government bond yields are, on average, significantly lower than the average rate of return on capital. We assume that the average government bond yield, $r_{D,t}$, is a fraction of the rate of return on capital,

$$r_{D,t} = (1 - \xi)r_t,$$

where $\xi r_t \geq 0$ is the wedge between the market rate of return and the government bond yield. We also assume that government bonds are held by domestic households and foreign investors in proportion to their wealth holdings.²⁶ Then, the average interest rate on household wealth, \bar{r}_t , is

²⁵If we instead assumed that the government collects accidental bequests at the end of each year and distributes them to surviving households during (or at the beginning of) the next year, there would be additional interest income received by the government (or the households).

²⁶By assumption, net foreign wealth, $W_{F,t}$, is exogenous and constant (after growth adjustment). Now suppose that the share of net foreign wealth in total private wealth, $W_{F,t}/(W_{P,t} + W_{F,t})$, is 10 percent. If the government's debt increased by \$10 billion, foreign investors would hold 10 percent, or \$1 billion, of the new government bonds and would reduce their holdings of other U.S. assets by \$1 billion, leaving net foreign wealth unchanged. Ninety percent, or \$9 billion, of the newly issued government bonds would be purchased by domestic households. Thus, the initial reduction in demand for private U.S. assets would be the same as under a standard closed-economy assumption.

the weighted average of the market rate of return and the government bond yield,

$$\bar{r}_t = \frac{K_t}{W_{P,t} + W_{F,t}} r_t + \frac{D_{G,t}}{W_{P,t} + W_{F,t}} r_{D,t} = \left(1 - \frac{D_{G,t}}{W_{P,t} + W_{F,t}} \xi\right) r_t,$$

which is lower than the market rate of return, r_t , when the government holds debt, or $D_{G,t} > 0$.

3.4 Recursive Competitive Equilibrium

This section defines a recursive competitive equilibrium for the model economy.

Let $\mathbf{s} = (i, a, b, e)$ be the individual state of households, $\mathbf{S}_t = (x(\mathbf{s}), d_{G,t})$ be the state of the economy, and Ψ_t be the government policy schedule committed to at the beginning of year t ,

$$\Psi_t = \left\{ c_{G,s}, tr_{LS,s}, \tau_{I,s}(\cdot), \tau_{P,s}(\cdot), tr_{SS,s}(\cdot), \tau_{C,s}, d_{G,s+1} \right\}_{s=t}^{\infty}.$$

A time series of factor prices and the government policy variables,

$$\Omega_t = \left\{ r_s, w_s, c_{G,s}, tr_{LS,s}, \varphi_s, \tau_{O,s}, \tau_{D,s}, \tau_{H,s}, \psi_{O,s}, \psi_{D,s}, \psi_{H,s}, \tau_{C,s}, d_{G,s+1} \right\}_{s=t}^{\infty},$$

the value functions of households, $\{v(\mathbf{s}, \mathbf{S}_s; \Psi_s)\}_{s=t}^{\infty}$, the decision rules of households,

$$\mathbf{d}(\mathbf{s}, \mathbf{S}_s; \Psi_s) = \left\{ c(\mathbf{s}, \mathbf{S}_s; \Psi_s), h(\mathbf{s}, \mathbf{S}_s; \Psi_s), a'(\mathbf{s}, \mathbf{S}_s; \Psi_s) \right\}_{s=t}^{\infty},$$

and the distribution of households, $\{x_s(\mathbf{s})\}_{s=t}^{\infty}$, are in a recursive competitive equilibrium if, for all $s = t, \dots, \infty$, each household solves the optimization problem of equations (1) through (5), taking \mathbf{S}_s and Ψ_s as given; if the firm solves its profit maximization problem of equations (13) and (14); if the government policy schedule satisfies equations (16) through (24); and if the goods and factor markets clear, thus satisfying equations (8) through (12) and equation (15). The economy is in a stationary (steady-state) equilibrium—and therefore on the balanced-growth path—if, in addition, $\mathbf{S}_s = \mathbf{S}_{s+1}$ and $\Psi_{s+1} = \Psi_s$ for all $s = t, \dots, \infty$.²⁷

4 Calibration

The model is calibrated to the 2013 U.S. economy with a fiscal policy that is close to the policy prevailing in 2013. That benchmark economy is assumed to be in a stationary equilibrium and thus on a balanced-growth path.²⁸

Table 1 shows the target variables and values in the benchmark economy. The discount factor, β , of households is set at 1.0266 so that the capital-output ratio, K_t/Y_t , is 2.49 in the benchmark economy (see Section 4.2). The share parameter of consumption, α , and maximum working hours

²⁷To solve the model for a stationary (steady-state) equilibrium, the population distribution needs to be constant, after the growth adjustment, in the long run. Even if we assume that fertility rates are constant after 2100 (because the number of newborns depends on the distribution of the female population ages 15–50), it takes several hundred years before the population distribution stabilizes.

²⁸This assumption is necessary for technical reasons and means that, in the benchmark economy, the debt-to-GDP ratio is constant and that there is no aging population and thus no growth in Social Security and Medicare spending as a share of GDP.

Table 1: Target Variables and Values in the Benchmark Economy

Target variables	Target and benchmark values	Most influential parameter ^a
Capital–output ratio K_t/Y_t	2.49	Discount factor β
Interest rate r_t	0.05	Depreciation rate δ
Wage rate w_t	1.00	Total factor productivity A
Frisch elasticity of working hours	0.50	Consumption share parameter α
Average working hours	1.00	Maximum working hours h_{\max}
Effective labor income tax rate	20.2%	Income tax adjustment factor φ_t
Effective capital income tax rate	17.8%	Flat capital income tax rate $\tau_{K,t}$
Income tax revenue / GDP	10.2%	Lump-sum portion of income tax $\tau_{LS,t}$
Payroll tax revenue / GDP	6.4%	Taxable labor income ratio η
Other tax revenue / GDP	1.4%	Consumption tax rate $\tau_{C,t}$
Transfer spending / GDP	12.4%	Lump-sum transfers $tr_{LS,t}$
Government debt / GDP	74.0%	Government debt $d_{G,t}$

^a The 12 benchmark values are set to their target values by choosing 12 parameters for preferences, technology, and government policy shown in this table as just-identifying restrictions. However, each target value is mainly determined by the parameter listed in this column. See Sections 4.1–4.6 of the text for detailed explanation.

(time endowment), h_{\max} , are jointly set so that the Frisch elasticity of the average household is 0.5 and average working hours are normalized to 1.0 (see Section 4.2). The depreciation rate of the capital stock, δ , is set at 9.0 percent so that the rate of return on capital, r_t , is 5.0 percent. The growth-adjusted total factor productivity, A , of the production function is set at 0.9621 to normalize the wage rate, w_t , to unity in the benchmark economy (see Section 4.3).

Among the government’s policy variables, the individual income tax adjustment factor, φ_t , is set at 0.9900 so that the average effective marginal tax rate on labor income is 20.2 percent;²⁹ and the flat capital income tax rate, $\tau_{K,t}$, is set so that the effective tax rate on capital income is 17.8 percent in the benchmark economy (see Section 4.4). The lump-sum tax portion of the income tax, τ_{LS} , is set so that total federal income tax revenue is 10.2 percent of GDP; the share of total labor income that is taxable, η , is set at 0.8040 so that total OASDI/HI payroll tax revenue is 6.4 percent of GDP;³⁰ and the consumption tax rate, $\tau_{C,t}$, is set at 2.5 percent so that the revenue from that tax is 1.4 percent of GDP in the benchmark economy (see Sections 4.4 and 4.6). Lump-sum transfers, $tr_{LS,t}$, are set so that the government’s total transfer spending (including for Social Security) is 12.4 percent of GDP; and the government’s consumption, $c_{G,t}$, and debt, $d_{G,t}$, are set so that the

²⁹That average of the effective marginal tax rates on labor income does not include the effective rate of the Social Security payroll tax. With that tax rate included, the average effective marginal tax rate on labor income is about 30 percent.

³⁰For simplicity, we assume that the OASDI/HI programs are pay-as-you-go and thus unfunded. In 2012, the programs’ revenue, including interest income from their trust funds, equaled 6.4 percent of GDP, and spending for OASDI/HI benefits was also 6.4 percent of GDP. In that year, however, revenue from the OASDI/HI payroll tax equaled about 5.4 percent of GDP, smaller than what we assumed in the model.

debt-to-GDP ratio is stable at 74 percent in the benchmark economy (see Section 4.6).

Table 2 shows the values of the main preference and technology parameters in the model economy, and Table 3 (on page 24) shows the values of the government policy parameters in the benchmark economy. All of the parameter values in Table 2 are fixed all of the time, but some of the policy parameter values in Table 3 are changed over time, exogenously and endogenously, in the policy experiments discussed in Section 5.

4.1 Demographics

The maximum possible age of a household’s head in the model economy, I , is 100. In the model economy, households that are headed by people ages 21 to 64 are called working-age households, and households that are headed by people age $I_R = 65$ or older are called elderly households, even though they can possibly work until age 75. For simplicity, we assume that all households start receiving Social Security (OASI) benefits at the current full retirement age, $I_{\bar{R}} = 66$, which is the full retirement age for people born between 1943 and 1954.

The labor-augmenting productivity growth rate, μ , is set at 1.8 percent, which is close to the average growth rate of real GDP per capita over the 1981–2013 period. That assumption is consistent with CBO’s projection that labor productivity (real output per hour worked) will grow at an average rate of 1.9 percent a year over the 2014–2024 period and 1.8 percent a year thereafter (Congressional Budget Office, 2014a). For simplicity, the population growth rate, ν , is set at a constant 1.0 percent, which is close to the average population growth rate over the 1981–2013 period. The conditional survival rate, ϕ_i , at the end of age i , given that households are alive at the beginning of age i , is calculated from the Social Security Administration’s 2009 period life table (Social Security Administration, 2014, Table 4.C6). We use the weighted averages of male and female survival rates; the survival rate at the end of age $I = 100$ is replaced with zero. When the population (the number of households) for age-21 households is normalized to unity, and the population growth rate is 1.0 percent, the total population of households in the model economy becomes 44.03, and the population of working-age households (ages 21–64) becomes 34.51.³¹

4.2 Preferences

Households in the model economy are assumed to be a mixture of married (60 percent) and single (40 percent) households.³² A household’s period utility function is a combination of Cobb–Douglas and constant relative risk aversion,

$$u(c, h) = \frac{[c^\alpha (h_{\max} - h)^{1-\alpha}]^{1-\gamma}}{1 - \gamma},$$

which is consistent with a growth economy, because productivity growth leaves hours worked unchanged.³³ The coefficient of relative risk aversion, γ , for the combination of consumption and

³¹According to the U.S. Census Bureau (2013), the total number of households in 2011 was about 115 million. Thus, one unit of population measure in the model economy represents about $115/44.03 = 2.6$ million households.

³²In the 2010 Survey of Consumer Finances sponsored by the Board of Governors of the Federal Reserve System (2012), 61 percent of households ages 21–65 and 58 percent of all households are married.

³³The intuitive explanation is as follows. Suppose a household maximizes its lifetime utility, $u(c, h) = [c^\alpha (h_{\max} - h)^{1-\alpha}]^{1-\gamma}/(1 - \gamma)$, subject to the lifetime budget constraint, $c \leq w_t h$, where c , h , and w_t are the household’s lifetime

Table 2: Values of the Main Preference and Technology Parameters in the Benchmark Economy

Parameter		Value	Comment ^a
<i>Demographics</i>			
Maximum age	I	100	
Maximum age households can work		75	
Minimum age to receive OASI benefits	$I_{\bar{R}}$	66	Full retirement age for OASI benefits
Minimum age to receive HI benefits	I_R	65	Medicare eligibility age
Productivity growth rate	μ	0.0180	Growth of real GDP per capita in 1981–2013
Population growth rate	ν	0.0100	Population growth in 1981–2013
Conditional survival rates	ϕ_i		SSA's period life table for 2009
Total population		44.0334	When $p_{21,t} = 1.0$
Working-age population (ages 21–64)		34.5097	When $p_{21,t} = 1.0$
<i>Preferences</i>			
Coefficient of relative risk aversion	γ	3.0000	Commonly used in the literature
Consumption share parameter	α	0.6906	Target: Frisch elasticity = 0.5
Maximum working hours	h_{\max}	1.6299	Target: average work hours = 1.0
Discount factor	β	1.0266	Target: $K_t/Y_t = 2.49$
Growth-adjusted discount factor	$\tilde{\beta}$	1.0016	$\tilde{\beta} = \beta(1 + \mu)^{\alpha(1-\gamma)}$
<i>Production technology, wage process</i>			
Share parameter of capital stock	θ	0.3485	NIPA data in 2009–2013
Depreciation rate of capital stock	δ	0.0900	Target: $r_t = 0.05$
Total factor productivity	A	0.9621	Target: $w_t = 1.0$
Autocorrelation parameter of log wage	ρ	0.9500	Commonly used in the literature
Standard deviation of log wage shocks	σ	0.2600	Target: variance of log earnings by age in the 2010 SCF
Median working ability	\bar{e}_i		Estimated by OLS

^a See Sections 4.1–4.3 of the text for detailed explanations. Targets are the values calibrated in the benchmark economy.

Notes: OASI = Old-Age and Survivors Insurance; HI = Hospital Insurance; GDP = gross domestic product; SSA = Social Security Administration; NIPA = national income and product accounts; SCF = Survey of Consumer Finances; and OLS = ordinary least squares.

consumption, working hours, and wage rate, respectively. When the utility function is one of Cobb-Douglas, like the above, the household's optimal decision is obtained as $c = \alpha w_t h_{\max}$ and $h = \alpha h_{\max}$. Thus, the household's lifetime consumption grows as its lifetime wage rate grows, but working hours are independent of the lifetime wage rate. When

leisure is set at 3.0, which is roughly in the middle of the range typically used in the macroeconomic public finance literature.³⁴ The share parameter of consumption, α , and maximum working hours, h_{\max} , are set at 0.6906 and 1.6299, respectively, so that the benchmark economy satisfies the following two conditions.³⁵ First, the average working hours of working-age households (those ages 21–64), \bar{h}_0 , is normalized to unity. Second, the Frisch elasticity of working hours of the average household (a household whose working hours are the average of those of all working-age households) is set to be 0.5, where the elasticity is calculated as

$$\frac{h_{\max} - \bar{h}_0}{\bar{h}_0} \frac{1 - \alpha(1 - \gamma)}{\gamma} = 0.5.$$

When $\alpha = 0.6906$, $h_{\max} = 1.6299$, and $\bar{h}_0 = 1.0$, the Frisch elasticity of total labor supply (in efficiency units) is calculated as 0.38, and the income-compensated (substitution) elasticity of labor supply is calculated as 0.29. Those numbers are consistent with CBO’s review of the empirical labor literature.³⁶

The discount factor, β , is chosen so that the capital–output ratio, K_t/Y_t , in the benchmark economy is consistent with the data. According to the national income and product accounts (NIPAs), during the 2009–2013 period, labor income averaged 58.9 percent of GDP, and gross capital income averaged 31.5 percent of GDP.³⁷ The remaining 9.6 percent of GDP represents taxes on production and imports minus subsidies (6.6 percent) and depreciation of the government’s fixed assets (3.0 percent). We define output in the model economy as

$$Y_t = F(K_t, L_t) = 0.904 Y_{GDP,t},$$

excluding the previously mentioned 9.6 percent.³⁸ In the fixed assets accounts (FAA) data, the ratio of private fixed capital stock (at the beginning of the year), K_t , to GDP averages about 2.25 over the 2009–2013 period.³⁹ Thus, the capital–output ratio, K_t/Y_t , in the benchmark economy is

the utility function is one of constant elasticity of substitution (CES) with the elasticity less than unity, the household’s lifetime working hours decrease by age cohort as its lifetime wage rate grows, which is not consistent with a growth economy.

³⁴For example, [Domeij and Heathcote \(2004\)](#) use 1.0; [İmrohoroğlu, İmrohoroğlu and Joines \(1995\)](#) use 2.0; and [Auerbach and Kotlikoff \(1987\)](#) and [Conesa, Kitao and Krueger \(2009\)](#) use 4.0.

³⁵Parameter α affects average working hours positively and the Frisch elasticity negatively, whereas parameter h_{\max} affects both average working hours and the Frisch elasticity positively. As a result, we need to determine those two parameter values concurrently by using two target conditions.

³⁶See [Congressional Budget Office \(2012\)](#). Those elasticities are calculated in the model by changing the wage rate of all heterogeneous households by the same percentage temporarily (the Frisch elasticity) and permanently (the substitution elasticity), keeping the income of all households unchanged. The wage elasticity of the total labor supply is generally smaller than the elasticity of working hours, because labor supply is productivity-weighted, and high-productivity workers who already work full-time tend to react less to changes in wages than low-productivity workers do.

³⁷See NIPA Tables 1.1.5. and 1.10. at http://www.bea.gov/iTable/index_nipa.cfm. In calculating those income shares, we allocate proprietors’ income proportionally among labor income and capital income.

³⁸Here, we define the model output, Y_t , as the sum of labor income and gross capital income, which is smaller than GDP. We exclude taxes on production and imports from Y_t because those taxes are mostly held by state and local governments, and the model abstracts from those governments and international trade. We also exclude depreciation of the government’s capital stock from Y_t because it cannot be accounted for using the simple Cobb–Douglas production function explained below.

³⁹See FAA Table 1.1. at http://www.bea.gov/iTable/index_FA.cfm. To calculate that ratio, we convert end-of-year

targeted at $2.25/0.904 = 2.49$.⁴⁰ In this benchmark economy, the ratio of federal debt held by the public (at the beginning of the year), $D_{G,t}$, to GDP is set at 0.74, which is close to the level at the beginning of 2015. The ratio of net foreign wealth (at the beginning of the year), $W_{F,t}$, to GDP in the benchmark economy is set at 0.30, which is consistent with the United States' net investment position, $-\$5.4$ trillion, at the end of 2013.⁴¹

In that setting, the ratio of national wealth, W_t , to GDP in the benchmark economy is $2.25 - 0.30 = 1.95$, and the ratio of private wealth (held by U.S. residents), $W_{P,t}$, to GDP is $1.95 + 0.70 = 2.65$. The discount factor, β , of households is set at 1.0266 so that the ratio of private wealth to GDP in the benchmark economy is 2.65—or, equivalently, the capital–output ratio, K_t/Y_t , is 2.49.⁴² The growth-adjusted discount factor is calculated as

$$\tilde{\beta} = \beta(1 + \mu)^{\alpha(1-\gamma)} = 1.0016.$$

We assume that a household's minimum wealth level (≤ 0) depends only on its age, as $a' \geq a'_{\min}(i, a, b, e) \equiv a_{\min}(i + 1)$, and

$$a_{\min}(i) = \begin{cases} 0 & \text{if } i = 21 \text{ or } I + 1, \\ [(1 + \mu)a_{\min}(i + 1) - 0.1 \times w_0 e_{\min}(i) \bar{h}_0] / (1 + r_0) & \text{if } i = 22, \dots, I, \end{cases}$$

where $e_{\min}(i)$ is the lowest working ability for age i , and r_0 , w_0 , and \bar{h}_0 are the interest rate, wage rate, and average working hours, respectively, in the benchmark economy.⁴³ According to the 2010 Survey of Consumer Finances (SCF) sponsored by the Board of Governors of the Federal Reserve System (2012), 11.0 percent of households have negative net worth, and the average net worth of those households is $-\$31,447$. (In other words, their debt exceeds their assets by $\$31,447$, on average.) In the model economy, 23.7 percent of households have negative wealth, and their average debt corresponds to $\$11,476$ in 2013 dollars. In the model, a_{\min} varies from $-\$17,845$ at age 22 to $-\$174$ at age 65 (and zero at ages 66 and older) in 2013 dollars.

4.3 The Production Technology and the Wage Process

The production function of the representative firm is one of Cobb–Douglas,

$$Y = F(K, L) = AK^\theta L^{1-\theta} = 0.904 Y_{GDP}.$$

As explained above, according to the NIPA data, the shares of labor income and gross capital income (including the depreciation of capital stock) in GDP averaged 58.9 percent and 31.5 percent, respectively, in the 2009–2013 period. Consequently, the share parameter of capital stock, θ , is set equal to $0.315 / (0.589 + 0.315) = 0.3485$. When the production function is Cobb–Douglas, gross

estimates of fixed assets to beginning-of-year values.

⁴⁰We do not include the government's fixed assets in the production function because most of the government's capital income is not counted in GDP or government revenue.

⁴¹See International Investment Position Table 1.1. at http://bea.gov/iTable/index_ita.cfm.

⁴²The discount factor tends to be calibrated at a higher level in an overlapping-generations model than in an infinite-horizon model. That is partly because a household actually discounts its utility of the next year by $\beta\phi_i$, where $\phi_i < 1$ is the survival rate of the age i household at the end of this year.

⁴³Under the assumption explained in Section 4.3 below, $e_{\min}(i)$ averages 12.7 percent of the median working ability of the same age; and \bar{r} , \bar{w} , and \bar{h} are calibrated to be 0.05, 1.0, and 1.0, respectively.

capital income is $(r_t + \delta)K_t = \theta Y_t$; thus, the rental rate of capital is

$$r_t + \delta = \theta \frac{Y_t}{K_t} = 0.3485 \frac{1}{2.49} = 0.140,$$

or 14.0 percent. The real rate of return on private fixed assets, defined as capital income divided by private fixed assets at the beginning of the year, is calculated from data in the U.S. fixed assets accounts as averaging 8.4 percent in the 2009–2013 period. However, because most households do not hold portfolios that generate that rate of return, we assume a real rate of return, r_t , of 5.0 percent in the benchmark economy and set the depreciation rate of capital, δ , at 9.0 percent.⁴⁴ We also normalize the wage rate per efficiency unit of labor, w_t , to be unity in the benchmark economy. Thus, total factor productivity, A , is set to be 0.9621 as

$$\begin{aligned} w_t &= A(1 - \theta) \left(\frac{K_t}{L_t} \right)^\theta = A(1 - \theta)^{1-\theta} \left(\frac{K_t}{Y_t} \right)^\theta = (1 - 0.3485)^{1-0.3485} 2.49^{0.3485} A = 1.0 \\ \implies A &= 0.9621. \end{aligned}$$

The working ability, e_i , of an age- i household in the model economy is assumed to satisfy

$$\ln e_i = \ln \bar{e}_i + \ln z_i$$

for $i = 21, \dots, 75$, where \bar{e}_i is the median working ability at age i , and z_i is the persistent shock that follows an AR(1) process,

$$\ln z_i = \rho \ln z_{i-1} + \epsilon_i$$

for $i = 21, \dots, 75$. The temporary shock, ϵ_i , is normally distributed, $\epsilon_i \sim N(0, \sigma^2)$, and the initial distribution of the log-persistent shock satisfies $\ln z_{20} \sim N(0, \sigma_{\ln z_{20}}^2)$.

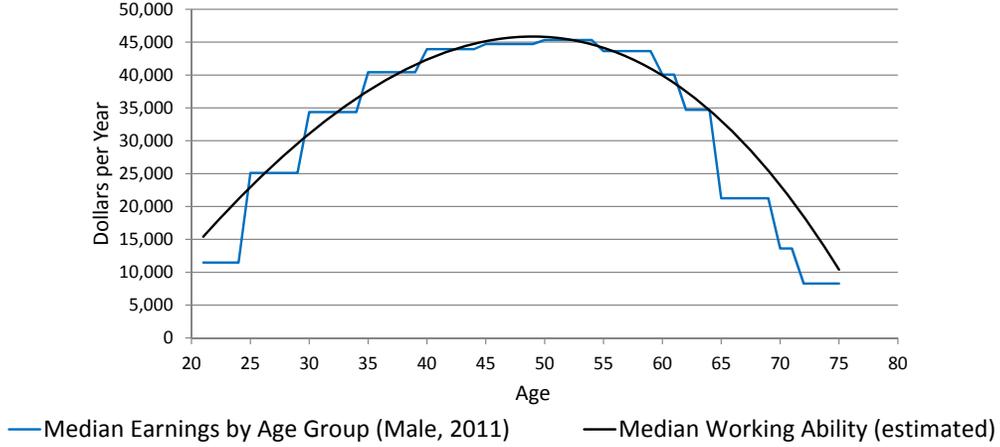
The median working ability, \bar{e}_i , for ages 21 to 75 is constructed from the 2011 Median Earnings of Workers by Age table (Table 4.B6, male workers) in [Social Security Administration \(2014\)](#). Under the assumption that those male median workers are mostly full-time workers, the profile of median working ability by age is estimated by using ordinary least squares (OLS) to regress the median earnings on age for ages 25 to 64 and is extrapolated for ages 21 to 24 and 65 to 75.⁴⁵ Figure 1 shows the original data and estimated values. The population-weighted average of the median working ability, \bar{e}_i , for ages 21 to 64 is also normalized to unity.⁴⁶

⁴⁴According the 2013 Survey of Consumer Finances, about 40 percent of families' portfolios are financial assets and 60 percent non-financial assets (mostly residential property). Furthermore, only about half of all families own stocks, and stock holdings account for only about half of families' total financial assets ([Board of Governors of the Federal Reserve System, 2014](#)). The depreciation rate of private fixed assets, defined as the consumption of private fixed capital divided by private fixed assets at the beginning of the year, is equal to 5.7 percent, on average, in the 2009–2013 period, according to the U.S. fixed assets accounts. In this paper, we raise the depreciation rate to 9.0 percent so that the real rate of return to capital is lowered to the target value of 5.0 percent.

⁴⁵We use the male median earnings data to estimate the shape of the age–working ability profile because a larger proportion of female workers choose not to work full time, meaning that their actual earnings are not a good representation of their earnings ability. Thus we implicitly assume that the lifecycle pattern of potential earnings of women matches that of men. We extrapolate rather than using the actual data on individuals ages 21 to 24 and 65 to 75 because they are more likely to be in school or voluntarily retired.

⁴⁶The wage rate per efficiency unit of labor, w_t , is normalized to unity in the benchmark economy. Thus, the

Figure 1: The Median Earnings of Male Workers by Age



Sources: Authors' calculations and [Social Security Administration \(2014\)](#).

The autocorrelation parameter, ρ , of the log-persistent shock is set at 0.95, which is approximately in the middle of the range in the literature.⁴⁷ Given the initial variance, $\sigma_{\ln z_{20}}^2$, the variance of the log-persistent shock, $\ln z_i$, is calculated recursively as

$$\sigma_{\ln z_i}^2 = \rho^2 \sigma_{\ln z_{i-1}}^2 + \sigma^2$$

for $i = 21, \dots, 75$. To align the wage process to the U.S. data, the standard deviation, σ , of the transitory shock, ϵ_i , is set at 0.260, and the initial variance, $\sigma_{\ln z_{20}}^2$, of the log-persistent shock is set at a fraction of its limiting variance,

$$\sigma_{\ln z_{20}}^2 = 0.40 \lim_{i \rightarrow \infty} \sigma_{\ln z_i}^2 = 0.40 \times \frac{\sigma^2}{1 - \rho^2} = 0.40 \times 0.6933 = 0.2773.$$

The coefficient $0.40 < 1$ is chosen so that the variance of log earnings increases with the age of the household (at least until about full retirement age). Figure 2 shows that the variances of log labor income calculated using the 2010 SCF data ([Board of Governors of the Federal Reserve System, 2012](#)) and those in the benchmark economy are quite similar.

The log-persistent shock is first discretized into 13 nodes for each age by using Gauss–Hermite quadrature; then the number of nodes for $\ln z_i$ is reduced to 7 by combining 4 nodes in each tail distribution into one node. The unconditional probability distribution of the 7 nodes is

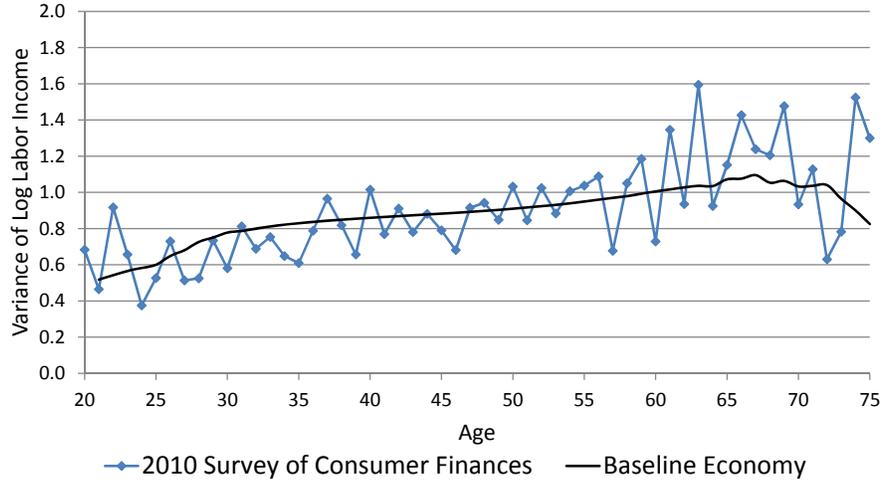
$$\pi_i = (0.0125 \quad 0.0792 \quad 0.2379 \quad 0.3410 \quad 0.2379 \quad 0.0792 \quad 0.0125)$$

for $i = 21, \dots, 75$. The Markov transition matrix of an age- i household, $\Pi_i = [\pi(e_{i+1}^j | e_i^j)]$, that

average of the median wage per hour, $w_t \bar{e}_i$, is also 1.0 in the benchmark economy.

⁴⁷For example, [Domeij and Heathcote \(2004\)](#) use 0.90; [Huggett \(1996\)](#) uses 0.96; and [Conesa, Kitao and Krueger \(2009\)](#) use 0.98.

Figure 2: The Variance of Log Labor Income by Age



Sources: Authors' calculations and the 2010 Survey of Consumer Finances ([Board of Governors of the Federal Reserve System, 2012](#)).

corresponds to $\rho = 0.95$ is calculated by using the bivariate normal distribution function as

$$\Pi_i = \begin{pmatrix} 0.8460 & 0.1540 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 0.0243 & 0.8517 & 0.1240 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.0413 & 0.8678 & 0.0909 & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.0634 & 0.8732 & 0.0634 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.0909 & 0.8678 & 0.0413 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.1240 & 0.8517 & 0.0243 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.1540 & 0.8460 \end{pmatrix}$$

for $i = 21, \dots, 74$.

4.4 The Progressive Income Tax Function

The average (taxable) household labor income for people ages 21 to 64 is \$64,162 in the 2010 Survey of Consumer Finances ([Board of Governors of the Federal Reserve System, 2012](#)).⁴⁸ Because labor income per capita increased by 12.8 percent between 2010 and 2013 according to the NIPA data, the average (taxable) labor income is estimated at \$72,375 in 2013. In the units used in the model economy, the average labor income of households ages 21–64 is calculated as 1.5092 in the benchmark economy.⁴⁹ We assume that a fraction, $\eta < 1$, of labor income (compensation and

⁴⁸The model in this paper was constructed and calibrated before the Federal Reserve Board released the 2013 SCF in September 2014.

⁴⁹That value means that average labor income in the model economy is roughly 51 percent larger than median labor income of people ages 21–64. However, the average working ability in the model is only about 36 percent higher than the median working ability. That means that—in the model economy—those with higher working ability also

part of proprietors' income) in the NIPA data is taxable for the individual income tax and Social Security payroll tax. That parameter, η , is set at 0.8040 so that the ratio of OASDI/HI payroll tax revenue to GDP is 0.064 (6.4 percent) in the benchmark economy. Under that assumption, one model unit corresponds to $\$72,375 / (1.5092 \times 0.8040) \approx \$59,646$ in the 2013 U.S. economy. The model uses that ratio to convert some policy variables into the model parameters.

The income tax function in the model economy includes both the individual income tax and the corporate income tax. We assume it is a combination of a smooth progressive labor income tax function, a flat capital income tax function, and a lump-sum tax (constant),

$$\begin{aligned}\tau_{I,t}(r_t a, w_t e h, tr_{SS,t}) &= \tau_{L,t}(w_t e h) + \tau_{K,t} r_t a + \tau_{LS,t} \\ &= \varphi_t \left\{ \varphi_0 \left[(y_L - d) - \left((y_L - d)^{-\varphi_1} + \varphi_2 \right)^{-1/\varphi_1} \right] + \tau_{K,t} y_K \right\} + \tau_{LS,t},\end{aligned}$$

where $y_L - d = \eta \cdot w_t e h - d$ is the household's taxable labor income after approximated deductions and exemptions, and $y_K = r_{N,t} a = (\bar{r}_t + \pi_e) a$ is capital income that includes corporate income and imputed rent from owner-occupied housing.⁵⁰ The expected inflation rate, π_e , is set at 2.0 percent. The functional form of a smooth progressive labor income tax is taken from [Gouveia and Strauss \(1994\)](#).

We obtain the parameters, φ_0 , φ_1 , and φ_2 , of the Gouveia–Strauss function as well as deductions and exemptions, d , by OLS with the 2014 effective labor income tax schedule estimated by [Congressional Budget Office \(2014e\)](#). The first parameter, $\varphi_0 = 0.3780$, shows the limit of the effective marginal labor income tax rate as taxable income goes to infinity; the second parameter, $\varphi_1 = 0.4528$, shows the curvature of the tax function; and the third parameter, $\varphi_2 = 0.2203$, is used to adjust the scale of the tax function.⁵¹ The additional parameter, φ_t , is set at 0.9900 so that the effective marginal tax rate on labor income (excluding the payroll tax rate for Social Security) is, on average, 20.2 percent in the benchmark economy as estimated by CBO. Figure 3 shows the marginal labor income tax rates estimated by CBO, approximated by using the Gouveia–Strauss function, and used in the benchmark economy (after the adjustment factor, φ_t , is applied). The flat capital income tax rate, $\tau_{K,t}$, is set to 17.8 percent, the effective tax rate on real capital income.⁵² The lump-sum income tax parameter, $\tau_{LS,t}$, is set to make income tax revenue (the sum of revenues from the individual income tax and corporate income tax) equal to 10.2 percent of GDP in the benchmark economy. The values for the effective marginal tax rate on labor income, the flat capital income tax rate, and the ratio of income tax revenue to GDP are estimated by [Congressional Budget Office \(2014e\)](#) for 2014.

4.5 The Social Security and Hospital Insurance System

We refer to Social Security's Old-Age, Survivors, and Disability Insurance benefits and Medicare's Hospital Insurance benefits collectively as OASDI/HI benefits and define the OASDI/HI

work more. In particular, those with an average working ability work approximately 11 percent more than those with a median working ability ($1.36 \times 1.11 = 1.51$).

⁵⁰For simplicity, we assume that OASI benefits are not taxed. If taxes on OASI benefits were considered, the losses under the income tax policy for retirees and those close to retirement would be slightly larger.

⁵¹The third parameter, φ_2 , is initially estimated as 0.0346 by using labor income in thousands of dollars. Then, the Gouveia–Strauss tax function is rescaled to the model unit as $\varphi_2 = 0.0346 \times 59.646^{\varphi_1} = 0.2203$.

⁵²For details on how this rate was calculated, see [Congressional Budget Office \(2014d\)](#).

Table 3: Values of the Government Policy Parameters in the Benchmark Economy

Parameter		Value	Comment ^a
<i>Model units</i>			
Taxable labor income ratio	η	0.8040	Target: $T_{P,t}/GDP_t = 6.4\%$
Scale adjustment ^b		59.6461	Average earnings \$72,375 in 2013
<i>Progressive income tax</i>			
Income tax adjustment factor	φ_t	0.9900	Target: avg. labor inc. tax rate 20.2%
Labor income tax: tax rate limit	φ_0	0.3780	} Estimated by OLS
: curvature	φ_1	0.4528	
: scale	φ_2	0.2203	
: deduction/exemptions	d	0.1677	
Capital income tax rate	$\tau_{K,t}$	0.2592	Target: avg. cap. inc. tax rate 25.6%
Lump-sum tax portion of income tax	τ_{LS}	0.0089	$T_{I,t}/GDP_t = 0.102$
<i>Social Security system</i>			
Social Security payroll tax rate: OASI	$\tau_{O,t}$	0.1060	} Current-law tax rates
: DI	$\tau_{D,t}$	0.0180	
Medicare payroll tax rate: HI	$\tau_{H,t}$	0.0290	
: HI surtax	τ_{H2}	0.0090	
Maximum taxable earnings ^c	ϑ_{\max}	2.6687	$1.4 \times \$113,700 = \$159,180$ in 2013
HI surtax threshold ^d	ϑ_H	3.8632	$0.4 \times \$200,000 + 0.6 \times \$250,000$
OASI benefit adjustment factor	$\psi_{O,t}$	1.3360	Target: $TR_{SS,t} = T_{P,t}$
PIA bend points: 0.90 - 0.32 ^c	ϑ_1	0.2228	$1.4 \times \$791 \times 12 = \$13,289$ in 2013
: 0.32 - 0.15 ^c	ϑ_2	1.3430	$1.4 \times \$4,517 \times 12 = \$80,102$ in 2013
Social Security benefits: DI	$\psi_{D,t}$	0.0199	Budget balanced given DI tax rate
Medicare benefits: HI	$\psi_{H,t}$	0.1359	Budget balanced given HI tax rate
<i>Other policy variables</i>			
Govt. consumption per household	$c_{G,t}$	0.1185	Target: $D_{G,t}/GDP_T = 74\%$
Lump-sum transfers per household	$tr_{LS,t}$	0.1282	Target: transfers/ $GDP_t = 12.4\%$
Consumption tax rate	$\tau_{C,t}$	0.0250	Target: $T_{C,t}/Y_t = 1.4\%$
Government debt per household	$d_{G,t}$	1.4984	Target: $D_{G,t}/GDP_t = 74\%$
Accidental bequests per household	q_t	0.0955	Q_t /working-age population
Wealth held by foreigners	$W_{F,t}$	28.2773	Target: $W_{F,t}/GDP_t = 0.30$
Ratio of risk premium to interest rate	ξ	0.4000	Target: $r_t(1 - \xi) = 0.03$

^a See Sections 4.4–4.6 of the text for detailed explanations. Targets are the values that the benchmark economy is calibrated to.

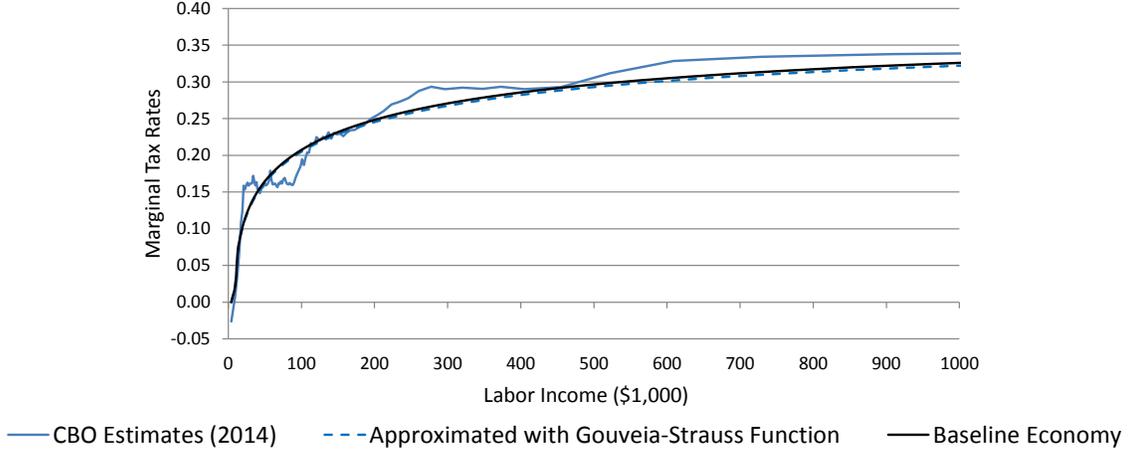
^b A unit of income or assets in the model economy corresponds to \$59,646 in 2013 dollars.

^c 40 percent of all households are assumed to be two-earner households, and 60 percent are assumed to be one-earner households. The thresholds are multiplied by the average number of workers, $0.40x2 + 0.60x1 = 1.4$, in a working-age household.

^d 40 percent are assumed to be single taxpayers and 60 percent married couples filing jointly.

Notes: OLS = ordinary least squares; OASI = Old-Age and Survivors Insurance; DI = Disability Insurance; HI = Hospital Insurance; PIA = primary insurance amount.

Figure 3: The Schedule of Marginal Tax Rates on Households' Labor Income



Sources: Authors' calculations and [Congressional Budget Office \(2014e\)](#).

payroll tax function to be

$$\begin{aligned} \tau_{P,t}(w_t e h) = & (\tau_{O,t} + \tau_{D,t}) \min(\eta \cdot w_t e h, \vartheta_{\max}) \\ & + \tau_{H,t} \eta \cdot w_t e h + \tau_{H2} \max(\eta \cdot w_t e h - \vartheta_H, 0), \end{aligned}$$

where $\tau_{O,t}$ is the flat Old-Age and Survivors Insurance tax rate, $\tau_{D,t}$ is the flat Disability Insurance tax rate, $\tau_{H,t}$ is a Hospital Insurance (Part A of Medicare) tax rate, and τ_{H2} is an HI surtax rate for households with high labor income (covered earnings greater than \$200,000 for single taxpayers and \$250,000 for married couples filing jointly). The first three tax rates include the portion paid by employers. When labor income is below the threshold of maximum taxable earnings, the statutory OASI tax rate is 10.6 percent, including 5.3 percent paid by employers; thus, $\tau_{O,t} = 0.106$. The effective DI tax, HI tax, and HI surtax rates are set at $\tau_{D,t} = 0.018$, $\tau_{H,t} = 0.029$, and $\tau_{H2} = 0.009$, respectively. The maximum taxable earnings per worker for the OASDI payroll tax were \$113,700 in 2013 ([Social Security Administration, 2014](#)). Because the model is based on household units, that single-worker figure must be translated to apply to households. We assume that 60 percent of households are married households, of which two-thirds are two-earner households—meaning that 40 percent of all households are two-earner households. Thus, in the model economy, maximum taxable earnings for the OASDI payroll tax, ϑ_{\max} , are the weighted average of the maximums for two-earner households and one-earner households, or $0.4 \times 2 \times \$113,700 + 0.6 \times \$113,700 = \$159,180$ in 2013, or 2.6687 in model units. We also set the threshold for the HI surtax at $0.4 \times \$200,000 + 0.6 \times \$250,000 = \$230,000$ in 2013, which corresponds to 3.8632 in model units.

The OASDI/HI benefit function is

$$\begin{aligned} tr_{SS,t}(i, b) = & \mathbf{1}_{\{i \geq I_R\}} \psi_{O,t} \frac{1}{(1 + \mu)^{i-60}} \{0.90 \min(b, \vartheta_1) + 0.32 \max[\min(b, \vartheta_2) - \vartheta_1, 0] \\ & + 0.15 \max(b - \vartheta_2, 0)\} + \mathbf{1}_{\{i < I_R\}} \psi_{D,t} + \mathbf{1}_{\{i \geq I_R\}} \psi_{H,t}, \end{aligned}$$

where the full retirement age, $I_{\bar{R}}$, is set at 66 in the stationary-population economy, ϑ_1 and ϑ_2 are the thresholds for the three replacement-rate brackets (90 percent, 32 percent, and 15 percent) used to calculate a household’s OASI benefit from its average historical earnings, $\psi_{O,t}$ is an adjustment factor that ensures that OASI expenditures equal OASI payroll tax revenues, $\psi_{D,t}$ is a household’s DI benefit, and $\psi_{H,t}$ is a household’s HI benefit.⁵³ In the current U.S. Social Security system, the thresholds to calculate primary insurance amounts are set for each age cohort when a worker reaches age 62. In the model economy, the growth-adjusted thresholds are fixed for all age cohorts, and the PIA is adjusted later by using the long-term productivity growth rate and the number of years after age 60. Thus, the model simply uses the thresholds for the age 62 cohort in 2011 after scale adjustment.

We assume that the Social Security and Hospital Insurance systems are pay-as-you-go and that their outlays equal their payroll tax revenues in the benchmark economy. The OASI benefit parameter, $\psi_{O,t}$, is set at 1.3360 to ensure that OASI expenditures equal OASI payroll tax revenues, which is roughly consistent with the data when benefits include survivors’ and spousal benefits. We also assume, for simplicity, that DI benefits are received only by working-age households (ages 21 to 64) and that HI benefits are received only by elderly households (ages 65 to 100).⁵⁴ The benefit parameters, $\psi_{D,t}$ and $\psi_{H,t}$, are set at 0.0199 and 0.1359, respectively, to ensure that benefits paid by the DI and HI programs equal their respective payroll tax receipts in the benchmark economy.⁵⁵

4.6 The Other Policy Variables

We assume that 44 percent of the federal government’s non-Social Security spending is government consumption and 56 percent is lump-sum transfers. That allocation is consistent with the average shares in the NIPA data for the 2009–2013 period. Government consumption per household, $c_{G,t}$, and the lump-sum transfers per household, $tr_{LS,t}$, are set at 0.1185 and 0.1282, respectively, in the benchmark economy.

The rate of the national consumption tax—which approximates excise and other taxes—is set at $\tau_{C,t} = 0.025$ so that consumption tax revenue is 1.4 percent of GDP in the benchmark economy. Federal debt per household, $d_{G,t}$, is set so that, as explained above, the debt-to-GDP ratio is equal to 0.74 in the benchmark economy. Also, net foreign wealth, $W_{F,t}$, is set so that the ratio of that wealth (which is equivalent to the negative of the U.S. investment position) to GDP is 0.30. Accidental bequests per working-age household are calculated as 0.0955 (or about \$5,700 per household per year in 2013 dollars). Finally, the ratio of risk premium to interest rate, ξ , is assumed to be 0.4 so that the average government bond yield is 3.0 percent in the benchmark economy.⁵⁶

⁵³Average indexed monthly earnings for people age 60 or older are indexed to changes in prices rather than to changes in wages, and the thresholds for the three replacement-rate brackets are also price-indexed for each age cohort. To simplify the computation in the growth economy, the model first assumes that all of the above variables are wage-indexed, and then it converts Social Security benefits to be price-indexed by dividing the benefits by $(1 + \mu)^{i-60}$.

⁵⁴As Table 4 below shows, those assumptions cause the share of transfers going to elderly households to be 56.2 percent, which is close to the share in the data.

⁵⁵The model does not incorporate risks of disability or ill health. Instead, DI benefits are uniformly distributed to working-age households and HI benefits to elderly households. The model implicitly assumes that the government transfers the actuarially fair insurance premium values of DI and HI to those households.

⁵⁶That rate is similar to the 3.1 percent average rate on 10-year Treasury notes for the 1965–2007 and 1990–2007 periods, but it is somewhat higher than the long-term interest rate on government debt projected in CBO’s *The 2015 Long-Term Budget Outlook* (Congressional Budget Office, 2015). Incorporating a lower interest rate would have

Table 4: The Government’s Budget in the Benchmark Economy (Percentage of GDP)

Revenue	Total	Expenditure	Working Age (ages 21–64)	Elderly (ages 65+)	Total
Individual and corporate income tax	10.2	Govt. transfers (% of transfers)	5.4 43.8	7.0 56.2	12.4
Social Security payroll tax ^a	5.0	Social Security	0.7	4.3	5.0
OASI	4.3	OASI	0.0	4.3	4.3
DI	0.7	DI	0.7	0.0	0.7
Medicare (HI) payroll tax ^a	1.4	Medicare (HI)	0.0	1.4	1.4
Consumption tax	1.4	Other transfers	4.7	1.3	6.0
		Govt. consumption			5.5
		Interest payments			2.2
Total revenue ^b	18.1	Total expenditure ^b			20.1

^a OASDI/HI payroll tax revenue was 5.6 percent of GDP in 2012 including reimbursement from the general fund of the Treasury (because of a temporary statutory reduction in the tax rate, or payroll tax holiday). The total revenue of the OASDI/HI programs was close to 6.4 percent of GDP in 2012 if interest income in the programs’ trust funds is included.

^b With a government-debt-to-GDP ratio of 0.74, a productivity growth rate of 1.8 percent, and a population growth rate of 1.0 percent, the total budget deficit that keeps the debt-to-GDP ratio constant is $0.74 \times (1.8 + 1.0) = 2.1$ percent of GDP in the benchmark economy, which equals the difference between total revenue and expenditure (after accounting for rounding).

Notes: GDP = gross domestic product; OASI = Old-Age and Survivors Insurance; DI = Disability Insurance; and HI = Hospital Insurance.

Table 4 shows the government’s revenue and spending in the stationary-population benchmark economy. The government’s revenue is roughly matched with the 2014 U.S. tax revenue projected by the [Congressional Budget Office \(2014e\)](#). The government’s spending in the benchmark economy is adjusted so that the government’s budget is sustainable with the debt-to-GDP ratio of 74 percent.⁵⁷

The share of government transfers going to elderly households is 56.2 percent in the model economy, which is very close to the share, 55.2 percent, calculated from the data in [Congressional Budget Office \(2013\)](#). Total government transfers are 12.4 percent of GDP in the model economy, which is also very close to the size of mandatory government spending, 12.3 percent of GDP, in [Congressional Budget Office \(2014e\)](#).

modest effects on our quantitative results and would leave the relative ranking of our stylized policies unchanged.

⁵⁷In [Congressional Budget Office \(2014e\)](#), the debt-to-GDP ratio (measured at the end of each fiscal year) was projected to fall to 72.3 percent by 2017 and then rise to 79.2 percent by 2024. In this paper, to show the effects of fiscal policies more clearly, the benchmark economy is assumed to be stationary; that is, the debt-to-GDP ratio (measured at the beginning of each calendar year) is kept at 74 percent by decreasing government consumption from 6.9 percent of GDP to 5.5 percent.

4.7 The Measures of Transfers and Well-Being

The cost that policies impose on different generations can be measured in a number of ways. We present two different measures. The first one calculates the annuity stream of net transfers (transfers received minus taxes paid) that a household forgoes as a result of a policy change. The second measure estimates how households' changes in consumption and labor supply in response to that forgone stream of net transfers affect their well-being.

4.7.1 Annuitized Net Transfers

One way of gauging a policy's cost to different generations is by measuring the change in the annuity stream of net transfers—the *constant (nominal) dollar amount per year over the remaining life of a household that is equivalent to the present discounted value of the change in net transfers stemming from the policy*. To calculate a measure of annuitized net transfers by cohort, we start by calculating the average change in the net present value of rest-of-lifetime net transfers by age cohort.

Let total growth-adjusted net transfers to age- i households in period t be $N(i, \mathbf{S}_0; \Psi_0)$ before the policy change and $N(i, \mathbf{S}_t; \Psi_t)$ for $t = 1, \dots, \infty$ after the policy change. Then,

$$N(i, \mathbf{S}_t; \Psi_t) = \int_{A \times B \times E} [tr_{SS,t}(i, b) + tr_{LS,t} - \tau_{I,t}(w_t eh(\mathbf{s}, \mathbf{S}_t; \Psi_t), \bar{r}_t a, tr_{SS,t}(i, b)) - \tau_{P,t}(w_t eh(\mathbf{s}, \mathbf{S}_t; \Psi_t)) - \tau_{C,t}c(\mathbf{s}, \mathbf{S}_t; \Psi_t)] dX_t(\mathbf{s}_i).$$

The average change in the net present value of rest-of-lifetime net transfers by age cohort is calculated as

$$\lambda_{21,t}^N = \frac{1}{p_{21}} \sum_{j=21}^I \left(\frac{(1+\mu)(1+\nu)}{1+r_{D,0}} \right)^{j-21} [N(j, \mathbf{S}_{t+j-21}; \Psi_{t+j-21}) - N(j, \mathbf{S}_0; \Psi_0)],$$

$$\lambda_{i,1}^N = \frac{1}{p_i} \sum_{j=i}^I \left(\frac{(1+\mu)(1+\nu)}{1+r_{D,0}} \right)^{j-i} [N(j, \mathbf{S}_{1+j-i}; \Psi_{1+j-i}) - N(j, \mathbf{S}_0; \Psi_0)],$$

for $t = 1, \dots, \infty$ and $i = 22, \dots, I$, where we use the average government bond yield in the benchmark economy, $r_{D,0}$, as a discount rate to calculate the present discounted value of net transfers.⁵⁸ The average change for future households, $\lambda_{21,t}^N$ for $t = 2, \dots, \infty$, is growth-adjusted with $1 + \mu$.

The annuitized value of changes in the rest-of-lifetime net transfers by age cohort is then calculated as

$$\lambda_{21,t}^A = \left[\sum_{j=21}^I (1+r_{D,0})^{21-j} \prod_{k=21}^{j-1} \phi_k \right]^{-1} \lambda_{21,t}^N,$$

$$\lambda_{i,1}^A = \left[\sum_{j=i}^I (1+r_{D,0})^{i-j} \prod_{k=i}^{j-1} \phi_k \right]^{-1} \lambda_{i,1}^N.$$

⁵⁸Because $N(i, \mathbf{S}_t; \Psi_t)$ denotes total net transfers to age- i households in period t instead of net transfers per household of age i , here we do not have to discount future net transfers further using survival rates.

4.7.2 Consumption Equivalence

Measures of the impact of various policies on net transfers are informative, but they leave out some important ways in which people are affected by policy changes. For example, an increase in marginal tax rates may induce people to work less, which on the one hand lowers the labor income they receive but on the other hand increases the amount of leisure they enjoy. The change in net transfers does not account for those effects. Similarly, reductions in government transfers can increase the risk of large declines in consumption, thereby making people, who are assumed to be risk averse, worse off in a way not captured by the change in net transfers.

Using the assumptions of the model, it is possible to construct measures of well-being that include those types of effects. Such measures should be interpreted with care; they are necessarily more speculative than measures of net transfers because they depend directly on assumptions about how differences in circumstances affect people's welfare. Nonetheless, measures of well-being can potentially provide important information about the ways in which policy changes may affect different generations.

To examine the change in households' well-being, CBO uses a consumption-equivalence (CE) measure of welfare. CE measures the *percentage by which a household's consumption would have to change each year (of the household's remaining life, beginning in the year of the policy change) under the benchmark policy in order to make a household just as well off as under the new policy.* CE therefore measures the burden or gain from a policy change on an annual basis. The measure is calculated as follows:

Welfare gains or losses of households who enter the economy at age $i = 21$ and at the beginning of $t = 1, \dots, \infty$ are calculated by uniform percentage changes, $\lambda_{21,t}$, in the benchmark consumption path that would make their expected lifetime utility equivalent to their expected utility after the policy change—that is,

$$\lambda_{21,t} = \left[\left(\frac{E[v(\mathbf{s}_{21}, \mathbf{S}_t; \Psi_t)]}{E[v(\mathbf{s}_{21}, \mathbf{S}_0; \Psi_0)]} \right)^{\frac{1}{\alpha(1-\gamma)}} - 1 \right] \times 100,$$

where the expected lifetime utility of the age cohort of age i in year t is, in general, calculated as

$$E[v(\mathbf{s}_i, \mathbf{S}_t; \Psi_t)] = \int_{A \times B \times E} v(i, a, b, e, \mathbf{S}_t; \Psi_t) dX_t(\mathbf{s}_i) \times \frac{1}{p_i}.$$

The calculation of $\lambda_{i,t}$ depends on the period utility function. With the Cobb–Douglas and CRRA utility function (equation (6) on page 9), when consumption proportionally increases by $\lambda_{i,t}/100$, a household's expected lifetime utility increases by $(1 + \lambda_{i,t}/100)^{\alpha(1-\gamma)} - 1$.

Similarly, the average welfare changes of households of age $i = 22, \dots, I$ at the time of the policy change ($t = 1$) are calculated by the uniform percentage changes, $\lambda_{i,1}$, required in the benchmark consumption path so that the rest of their expected lifetime utility would be equal to the rest of their expected lifetime utility after the policy change—that is,

$$\lambda_{i,1} = \left[\left(\frac{E[v(\mathbf{s}_i, \mathbf{S}_1; \Psi_1)]}{E[v(\mathbf{s}_i, \mathbf{S}_0; \Psi_0)]} \right)^{\frac{1}{\alpha(1-\gamma)}} - 1 \right] \times 100.$$

Note that $\lambda_{i,1}$ for $i = I, \dots, 21$ shows the average welfare changes per age cohort of all current

households alive at the time of the policy change, and $\lambda_{21,t}$ for $t = 2, \dots, \infty$ shows the average welfare changes per age cohort of age-21 households in the future.

4.8 Discount Rates

The discount rates used in those calculations have important effects on the magnitude of the results. The discount rates we use to calculate the net present value and utility-based measures differ, so a quantitative comparison of the levels might be misleading. The NPV measures use a discount rate of 3 percent, which is the average cost of the government's debt service in the benchmark economy. The implicit discount rate used to calculate the CE measure depends on the household's state, but it averages more than 5 percent, because about 10 percent of households are liquidity-constrained in the model economy, and their risk-adjusted discount rates become higher than the market interest rate.

5 Effects of Illustrative Policy Changes

We assess how five stylized policy changes—each of which is introduced to close a fiscal gap that [Congressional Budget Office \(2014a\)](#) estimates to be 1.8 percent of GDP over the next 75 years—would affect the overall economy and different age cohorts.⁵⁹ The stylized policies, which are introduced permanently and immediately (rather than being preannounced), consist of two changes that decrease transfers and three changes that increase taxes equal to 1.8 percent of GDP each year relative to the benchmark economy to ensure that the debt-to-GDP ratio remains constant.⁶⁰

- A uniform cut in lump-sum transfers,
- A proportional (uniform percentage) cut in OASDI/HI benefits,
- An increase in the HI payroll tax rate,
- A proportional (uniform percentage) increase in marginal income tax rates, and
- An increase in a flat consumption tax rate, which approximates excise and other taxes.

5.1 Benchmark Economy with Fiscal Gap

Because we cannot construct an economy in which an unsustainable fiscal policy lasts permanently, we created a benchmark economy with a sustainable fiscal policy and a constant debt-to-GDP ratio in the long run (see Sections 3 and 4). Here we introduce a fiscal gap by increasing the government's purchases by 1.8 percent of GDP and eliminate that gap through one of our five stylized policy changes. Increasing the government's purchases is an analytically convenient way

⁵⁹As described earlier, that estimate of the fiscal gap means that, starting from CBO's extended-baseline projection (which generally follows current law), a combination of cuts in noninterest spending and increases in revenues that totaled 1.8 percent of GDP in each year beginning in 2015 would result in a ratio of debt to GDP in 2089 equal to today's ratio, excluding the economic effects of the policy changes. We assume that the debt-to-GDP ratio in the benchmark economy is 0.74, the actual 2014 ratio.

⁶⁰Those policies roughly correspond to various options discussed in [Congressional Budget Office \(2014c\)](#).

to introduce a fiscal gap because it does not alter current tax rates and scheduled transfers per household, and thus it does not directly affect households' behavior.⁶¹

We generate a fiscal gap in the benchmark economy by increasing productivity-adjusted government purchases per household, $c_{G,t}$, by 1.8 percent of benchmark GDP:

$$c_{G,t} = c_{G,0} + 0.018 \frac{Y_{GDP,0}}{\sum_{i=21}^{100} p_i},$$

for $t = 1, \dots, \infty$, where p_i represents the number of households at each age from 21 to 100, and $Y_{GDP,0}/\sum_{i=21}^{100} p_i$ is GDP per household in the benchmark economy.

The steady-state benchmark economy differs in important ways from CBO's extended baseline, which incorporates the assumption that current laws and policies are generally extended beyond the 10-year horizon of CBO's baseline budget projection. That 10-year projection incorporates rising marginal tax rates (due to bracket creep), rising federal spending on health and retirement transfers, and rising primary (noninterest) deficits. The benchmark economy introduced in this paper, by contrast, has constant tax rates and transfers. Nonetheless, it provides a consistent basis to evaluate the policies required to close the fiscal gap as projected by CBO.⁶²

Given that an unsustainable policy cannot be analyzed using a dynamic general-equilibrium model, our approach means that we cannot measure the benefits to individual households' well-being and the macroeconomy that result from moving from an unsustainable policy (such as in an economy with a fiscal gap unaddressed by policy changes, as under CBO's extended baseline) to a sustainable policy. We can only answer the question of which policy designed to close the fiscal gap is the least costly for current and future generations—not whether, or for which generations, a policy improves people's welfare.⁶³ The broad benefits of closing the fiscal gap are the same for all policies, however, so our general-equilibrium approach allows us to shed light on the relative effects that our five stylized policy changes would have on the benchmark economy and on the welfare of households in different age cohorts.

Besides reflecting the assumption that the government's fiscal policy is sustainable and achieves a constant debt-to-GDP ratio in the long run, our benchmark economy also incorporates the assumption that there is no uncertainty about future policy changes. If households were assumed to be uncertain about future policy action and one of our stylized policy changes resolved that uncertainty, households might respond differently—depending on their prior expectations—and the effects on well-being might differ significantly from those we calculate here. For example, if households had thought that the government might cut OASDI/HI benefits to close the fiscal gap but instead the government raised income tax rates, retirees and workers close to retirement would see a large increase in their welfare.⁶⁴ Modeling policy uncertainty is difficult, however,

⁶¹In the model economy, government purchases are assumed not to affect an individual household's behavior or well-being. In the real economy, an increase in government purchases (such as spending on national security) is likely to affect the behavior and well-being of households, but those effects are very difficult to evaluate. Thus, they are not incorporated in this analysis.

⁶²CBO's extended baseline might be a preferable benchmark to use, but its implementation is currently not feasible in a closed economy because of the quickly and constantly rising levels of debt.

⁶³Thus, in this paper we do not answer the question of whether a generation would actually benefit from closing the fiscal gap, nor do we analyze the benefits of keeping the debt-to-GDP ratio at current levels rather than allowing it to increase further.

⁶⁴How many working-age generations would see an increase in welfare would depend on households' expectations

for a number of reasons, including computational issues (modeling expectations about uncertain future policies is akin to modeling aggregate shocks, which CBO’s OLG model, like most other OLG models, has not incorporated) and conceptual issues (it is not clear what households actually believe about future government policy and whether those beliefs are rational).⁶⁵ Our benchmark economy implicitly reflects the assumption that households expect that future government actions to close the fiscal gap would not change their well-being.⁶⁶

5.2 Overview of the Policies’ Effects on the Economy

Our five stylized policy changes affect the amount of net transfers received by people in different age cohorts and thus alter their incentives to work and save relative to the incentives in the benchmark economy. As a result of those changes in incentives, economic outcomes are different than those in the benchmark economy. In addition, the changes in net transfers and the resulting impact on the economy affect the well-being of different cohorts, relative to their well-being under the benchmark economy, in varying ways (as discussed below).

In general, if the government cut spending on transfers—either lump-sum transfers or OASDI/HI benefits—households would choose to work and save more in order to compensate for the reduction in transfers. As a result, cuts to transfers tend to *increase* the total labor supply, capital stock, and output of the economy. The effect on households’ saving would be larger if OASDI/HI benefits were cut, because households would want to accumulate more wealth to insure against outliving their assets during retirement.

If the government instead increased payroll or income tax rates, households would work and save less, which would *reduce* the total labor supply, capital stock, and output of the economy. The negative effect on households’ saving would be larger in the case of a proportional increase in progressive income tax rates, because the income tax also applies to capital income. Any proportional increase would increase top marginal rates the most, and those rates apply to high-income households, the biggest savers in the economy.⁶⁷

If the government increased a flat consumption tax rate, the economy’s total labor supply, capital stock, and hence GDP would be unaffected. An unannounced increase in the consumption tax rate would have no impact on the labor supply and saving of households, because it would proportionally decrease the purchasing power of households’ current and future labor income (the substitution effect) and of their wealth (the wealth effect). Under the assumptions of the model, those two effects cancel each other out, so overall, households’ working and saving behaviors

about the timing of the anticipated and actual policy changes.

⁶⁵The difficulty of modeling expectations was highlighted in Peter Diamond’s Presidential Address at the 2004 meeting of the American Economic Association. He expressed surprise that many young economists and economics students “expect to get no benefits at all from Social Security” while “the estimate for the 75-year projection period shows enough revenue to pay roughly two-thirds of scheduled benefits,” which is a “far cry from no benefits” (Diamond, 2004, p. 1).

⁶⁶Alternative assumptions about what policies households expect to close the fiscal gap in the benchmark economy would generate different estimated effects on the economy and well-being from the policies examined here. It is easy to calculate those effects on the basis of our results. For example, if the alternative assumption is that in the benchmark the fiscal gap would be closed by raising consumption taxes, one would simply subtract the results of the consumption tax increase from all columns in Panels A and B of Table 5 on page 35.

⁶⁷Because top marginal tax rates are higher than lower rates, even the same absolute change in tax rates would produce a larger percentage drop in the after-tax rate of return for high-income households.

would be unaffected, although households would decrease their consumption.

5.3 Overview of the Policies' Costs to Different Cohorts

Closing the fiscal gap by implementing any of the five stylized policies entails a cost to households relative to their situation under the benchmark economy. As explained in Section 4.7, we calculate two measures of the effects of the stylized policies on different age cohorts. The first measure is the net present value of changes in net transfers to each age cohort, expressed in terms of an annuity stream—a fixed amount of money that a household would lose every year until the end of its life. (See Section 4.7.1 for details of how that measure is computed.) The annuities measure shows the magnitude of the annual financial burden to households of implementing a policy (with that burden measured beginning at the date of implementation).⁶⁸

Our second measure of the relative impact of policies is the estimated change in a household's well-being because of the policy. CBO uses the consumption-equivalence measure of welfare, which measures the constant change in consumption—in our case a decrease—that is necessary under the benchmark policy to make a household just as well off as under the new policy. (See Section 4.7.2 for details of how that measure is computed.) The CE measure therefore indicates the cost that a policy change places on households in terms of lost consumption per year.

Using those measures, we find that—as expected—all five policies impose a cost on households as measured by a reduction in net transfers and a reduction in well-being relative to the benchmark economy (see Panels A and B of Table 5 and Figure 4). As noted above, the spending and tax policies have opposing effects on the macroeconomy, with spending cuts tending to increase output and tax increases tending to reduce output. However, those macroeconomic effects are an imperfect predictor of which policy change would be best for households according to the welfare measure. In fact, a majority of cohorts would fare better with an increase in income or payroll taxes than with an increase in consumption taxes or a cut in transfers or OASDI/HI benefits, despite the fact that output would be highest under a cut in OASDI/HI benefits and lowest under an increase in income tax rates.

Similarly, the most preferable policies based on the annuitized-value measure of net transfers and the CE measure of well-being are identical for only roughly 40 percent of cohorts. For the other roughly 60 percent of cohorts, the option that reduces their well-being the least according to the CE welfare measure is not the policy that minimizes the decrease in their annuitized value measure.

The ranking of the policies based on their effect on well-being differs from rankings based on their effect on output or on net transfers for two main reasons. First, households value leisure, and increases in GDP or net transfers are partially the result of a decrease in leisure (increase in hours worked). Second, households put a higher value on policies that allow them to maintain a relatively smooth path of consumption. For that reason, policies that reduce the variability of disposable income tend to be preferred over policies that leave that variability unchanged or increased. OASDI benefits and lump-sum transfers both lessen the decline in consumption for those who outlive their

⁶⁸Appendix B shows results for the estimated change in the net present value of net transfers not expressed in terms of an annuity stream. The NPV measure and the annuitized-value measure provide answers to different questions. The NPV measure of net transfers answers the question of how much do members of a cohort contribute to closing the fiscal gap in terms of total net present value. That measure is generally larger for younger people than for older people because they are affected by the policy change for more years.

savings. Lump-sum transfers also reduce the relative decline in disposable income when earnings drop. Thus, OASDI benefits and lump-sum transfers tend to reduce the variability of disposable income over a lifetime, and cutting those benefits increases that variability while reducing the amount of disposable income. By contrast, income and payroll tax liabilities are higher when income is high, and lower when income is low. Therefore, increasing payroll or income tax rates reduces both the amount of disposable income and its variability.

The following are our main results by cohort:

- Households that are headed by retirees (ages 65 and over) or older workers (ages 41 to 64) when the policy change goes into effect experience the smallest reduction in net transfers and welfare from the increase in payroll or income tax rates; they experience the largest reduction in net transfers and welfare from the cuts to OASDI/HI benefits.
- Households headed by younger workers (ages 21 to 40) experience the smallest reduction in net transfers from the cuts to OASDI/HI benefits or lump-sum transfers; they experience the largest reduction in net transfers from the increase in income tax rates. In terms of welfare, by contrast, those younger workers fare best under the increase in income tax rates.
- People under age 21 or not yet born when the policy is implemented experience the smallest reduction in net transfers and welfare from the cuts to OASDI/HI benefits; they experience the largest reduction in net transfers from the increase in income tax rates and the largest reduction in welfare from the cuts to lump-sum transfers.

Those results reflect the fact that older cohorts will pay less in taxes in the future (so tax increases have relatively small effects on their net transfers and welfare) and have less time to adjust their saving to counteract any cuts to transfers or OASDI/HI benefits (so such cuts have relatively large effects). The results also reflect the fact that although any positive effects from closing the fiscal gap by cutting transfers or benefits would increase the capital stock, and hence wages, that process takes time because the capital stock is large relative to the increases in saving prompted by the policy change. In fact, that process takes so much time that many working-age households would not substantially benefit from the positive effects of cuts to transfers or benefits before they retired.

Our results are robust to changes in important parameter choices and modeling assumptions. In Appendix A we show the results under four alternative conditions:

- Different choices for the Frisch elasticity of labor supply (0.25 and 1.0, compared with 0.5 in our benchmark economy),
- A small open economy in which interest rates are determined in global financial markets (rather than the closed economy of our benchmark model),
- Households that are less averse to risk (a constant relative risk aversion of 2.0, compared with 3.0 in the benchmark economy), and
- An economy in which policy changes are announced 15 years ahead of their implementation (rather than taking effect immediately).

The results of that sensitivity analysis show that although the size of the policies' effects on well-being differ slightly, the ranking of the different policies does not change significantly.

Table 5: Changes in Net Transfers and Welfare Under Various Policies in the Benchmark Economy

Panel A: Annuitized Value of the Change in Households' Net Transfers (As a percentage of GDP per household)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-1.7	-5.9	-0.1	-0.5	-1.5
41-64	-2.1	-4.2	-1.6	-2.5	-2.6
21-40	-2.4	-2.4	-2.9	-3.4	-2.7
0-20	-2.5	-2.2	-2.9	-3.2	-2.6
Unborn	-2.5	-2.2	-2.9	-3.1	-2.6

Panel B: Consumption-Equivalence Measure of Households' Welfare (Percentage change in consumption equivalence)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-5.3	-14.6	-0.1	-0.3	-3.1
41-64	-4.6	-6.9	-1.6	-1.4	-3.1
21-40	-4.7	-2.9	-3.0	-2.5	-3.1
0-20	-4.7	-1.6	-3.7	-3.5	-3.1
Unborn	-4.7	-1.3	-4.1	-4.2	-3.1

Notes: Panel A shows the annuitized value of the change in net transfers that a household (with an average size of 2.6 people) experiences relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—expressed as a percentage of GDP per household. In 2014, GDP per household was roughly \$141,000.

Panel B shows how a household's well-being would change relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—measured as a percentage decrease in the household's lifetime consumption.

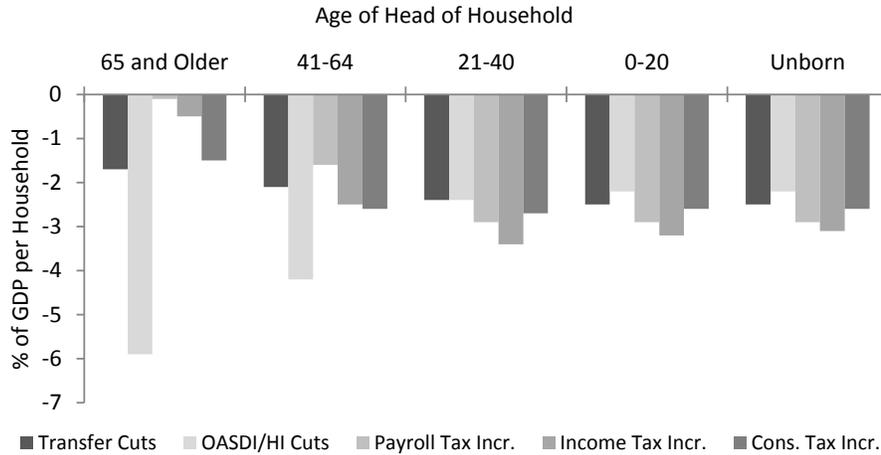
For households headed by someone age 21 or older, the policy changes are evaluated at the time of their implementation. For people under age 21 or not yet born, the policy changes are evaluated at the time they turn 21. The Unborn category represents generations that are born into an economy that has fully adjusted to the policy changes (in other words, that has reached steady state).

The five stylized policy changes are described in Sections 5.4 and 5.5 of the text.

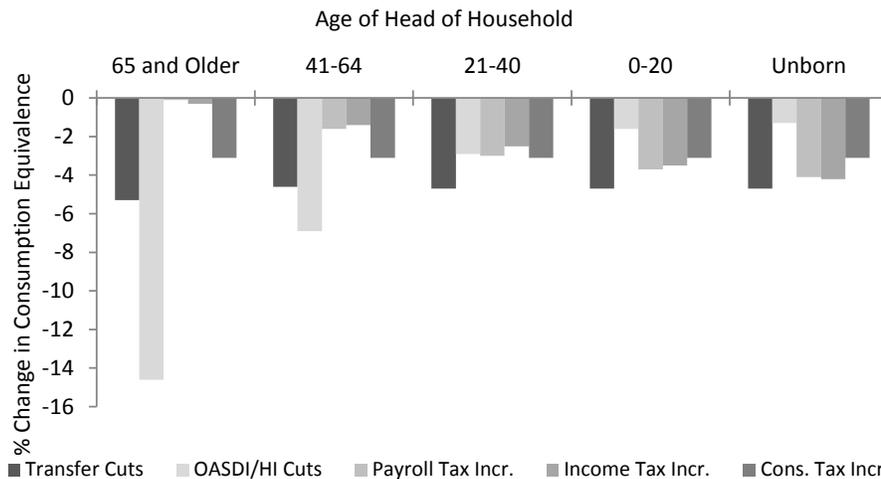
GDP = gross domestic product; OASDI/HI = Old-Age, Survivors, Disability, and Hospital Insurance.

Figure 4: Changes in Net Transfers and Welfare Under Various Policies in the Benchmark Economy

Panel A: Annuitized Value of the Change in Households' Net Transfers (As a percentage of GDP per household)



Panel B: Consumption-Equivalence Measure of Households' Welfare (Percentage change in consumption equivalence)



Notes: Panel A shows the annuitized value of the change in net transfers that a household (with an average size of 2.6 people) experiences relative to the benchmark economy expressed as a percentage of GDP per household. In 2014, GDP per household was roughly \$141,000.

Panel B shows how a household's well-being would change relative to the benchmark economy measured as a percentage decrease in the household's lifetime consumption.

For households headed by someone age 21 or older, the policy changes are evaluated at the time of their implementation. For people under age 21 or not yet born, the policy changes are evaluated at the time they turn 21. The Unborn category represents generations that are born into an economy that has fully adjusted to the policy changes (in other words, that has reached steady state).

The five stylized policy changes are described in Sections 5.4 and 5.5 of the text.

GDP = gross domestic product; OASDI/HI = Old-Age, Survivors, Disability, and Hospital Insurance.

5.4 Details of the Effects of Cutting Lump-Sum Transfers or OASDI/HI Benefits

Our first policy experiments examine the cost of closing the fiscal gap through two policies that reduce the government's spending on lump-sum transfers to households or on Old-Age, Survivors, Disability, and Hospital Insurance benefits (Social Security and Part A of Medicare). Under both policies, the government decreases a particular type of spending to close the fiscal gap. Those transfers are cut by 1.8 percent of benchmark GDP.⁶⁹ In the first policy, the government cuts its lump-sum transfer spending per household, $tr_{LS,t}$, uniformly. In the second policy, the government instead cuts OASDI/HI benefits by proportionally reducing the three benefit parameters, for OASI benefits ($\psi_{O,t}$), DI benefits ($\psi_{D,t}$), and HI benefits ($\psi_{H,t}$).

The two stylized spending cuts analyzed here differ primarily by whom they affect directly. The uniform cuts in lump-sum transfers apply to all age cohorts equally, whereas the cuts in OASDI/HI benefits mostly apply to retirees (and, to a far lesser extent, to younger households through cuts in DI benefits). In order to eliminate the fiscal gap of 1.8 percent, lump-sum transfers (as specified in the model) would have to be reduced by about 29 percent per household in the short term and by about 27 percent in the long term, relative to 2013 benefits. OASDI/HI benefits would have to be reduced by about 26 percent in the short term and by about 19 percent in the long run, relative to the 2013 benefit schedule.⁷⁰

5.4.1 Economic Effects

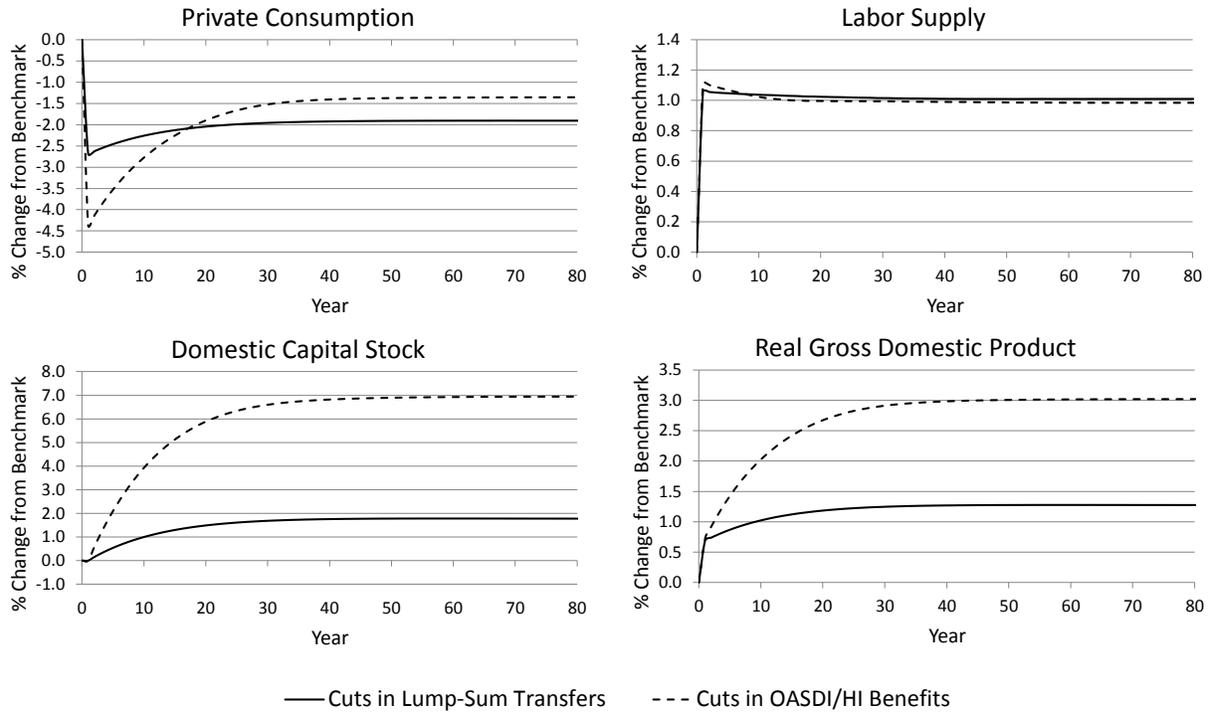
A decrease in lump-sum transfers or OASDI/HI benefits affects households in several ways: It reduces their disposable income each year, and it thus reduces their lifetime wealth—current wealth plus the present value of their future noninterest disposable income—and decreases the amount of insurance that the government provides to households against falling to very low levels of consumption. (OASDI/HI benefits, for example, insure retirees against having very low consumption when they outlive their assets, and lump-sum transfers insure working-age households against having very low income because of unemployment or disability.) In reaction to cuts in transfer programs, households increase their labor supply and reduce their consumption in order to increase their earnings and saving—both saving for retirement (life-cycle saving) and additional saving to guard against future uncertainties (precautionary saving). The increase in saving and labor supply increases the capital stock, GDP, and wages relative to the benchmark economy, and also relative to the stylized policies that raise taxes (as explained below in Section 5.5).

Figure 5 shows some of the economic effects of these two policy experiments. Relative to the benchmark economy, consumption drops by 2.7–4.4 percent immediately (in the first year of the policy change) and is 1.4–1.9 percent lower in the long term (after the economy has reached its new steady state). In the short term (the first 5 to 10 years), private consumption declines

⁶⁹Technically, given the law of motion for government debt described by equation (24) on page 13, the growth-adjusted debt per household is kept constant; that is, $d_{G,t} = d_{G,0}$ for all $t \geq 1$.

⁷⁰Because both of those cuts in transfers would increase GDP and tax revenue relative to benchmark levels, the cuts required to close the same-sized fiscal gap would be smaller in the long term than in the short term, whether in 2013 growth-adjusted dollars or in percentage terms. The decrease in benefit cuts from the short to the long run is much larger when OASDI/HI benefits are cut, because GDP increases more in response to OASDI/HI benefit cuts than when lump-sum transfers are cut.

Figure 5: Macroeconomic Effects of Closing a Fiscal Gap of 1.8 Percent Through Spending Cuts (Changes from the benchmark economy)



Notes: The figures show how the changes in transfer policies described in Section 5.4 of the text would affect the economy from the time the policy change occurred until 80 years later.

OASDI/HI = Old-Age, Survivors, Disability, and Hospital Insurance.

more in response to the cuts in OASDI/HI benefits than it does in response to the cuts in lump-sum transfers. The reason is that when OASDI/HI benefits are reduced, not only do current retirees decrease their consumption by almost as much as the decrease in OASDI/HI benefits, but working-age households also lower their consumption (and increase their saving) to prepare for cuts to the Social Security and Medicare benefits that they expect to receive in the future.

Those decreases in consumption, together with an immediate increase of about 1 percent in the labor supply, lead to an increase in the private saving rate (the average percentage of its annual income that a household saves). That rate initially rises by 0.3 percentage points under the cuts in lump-sum transfers and by 1.3 percentage points under the cuts in OASDI/HI benefits, but that impact declines to about 0.1 percentage point and 0.4 percentage points, respectively, in the long term. In the short run, that increase in the saving rate leads to an increase in the stock of capital of roughly 1 percent after 10 years under the cuts in lump-sum transfers and of about 4 percent under the cuts in OASDI/HI benefits. In the long run, consumption by the elderly does not fall as sharply as it does at first because in the long run, retirees are able to plan ahead for the lower benefits. The private saving rate rises more when OASDI/HI benefits are cut than when lump-sum transfers are cut because those particular benefits are close substitutes for households' life-cycle savings. Since

most retirees rely heavily on Social Security benefits, working-age households—especially those nearing retirement—increase their saving rates in response to cuts to OASDI/HI benefits to offset the associated losses in future retirement income. Cuts in lump-sum transfers, by contrast, are akin to permanent cuts in disposable income. In response to cuts in lump-sum transfers, households tend to reduce their consumption almost as much as the amount of the cuts. Moreover, households also tend to increase their saving to protect themselves from negative shocks in the future.

Those increases in the private saving rate, together with the larger supply of labor, boost the capital stock in the long term by 1.9 percent under the cuts in lump-sum transfers and by 7.0 percent under the cuts in OASDI/HI benefits. (The rise in the capital stock is larger when OASDI/HI benefits are cut because of the greater impact on saving.) In the long term, the increases in the capital stock and the labor supply gradually raise GDP. Fifty years after the policy change, real (inflation-adjusted) GDP is 1.3 percent larger under the cuts in lump-sum transfers, and 3.0 percent larger under the cuts in OASDI/HI benefits, relative to the benchmark economy. To put those increases in context, real GDP per capita grows by 144 percent over that 50-year period in the model economy. In other words, given that real GDP per capita grows by 1.8 percent per year in the benchmark economy, after 50 years the increase in GDP per capita resulting from cuts to lump-sum transfers or OASDI/HI benefits is equivalent to between less than one year and about one and a half years of GDP growth. Of course, these results only indicate that the choice of policy to close the fiscal gap has a relatively small effect on the economy's output in the long run. However, the effect on the economy's output of closing the fiscal gap versus continuing to increase the federal debt is likely to be much bigger.

In the short term, the immediate increase in the labor supply reduces the ratio of capital to labor slightly, thus lowering wages by about 0.4 percent and increasing the interest rate r by 10 basis points (0.1 percentage point) in both policy experiments. In the medium and long term, however, the capital-labor ratio increases as the capital stock gradually grows, boosting wages and reducing the interest rate. Under the uniform cuts in lump-sum transfers, wages rise by 0.3 percent in the long term, and the interest rate falls by 7 basis points. Under the proportional cuts in OASDI/HI benefits, the increase in the capital stock is much larger and therefore so is the impact on wages and the interest rate: Wages rise by 2.0 percent and the interest rate falls by 51 basis points in the long term. Those changes in turn affect labor supply and saving in the long term.

5.4.2 Effects on the Annuitized Value of Households' Net Transfers

The two stylized cuts in government transfers have differing effects on households when they are measured by the change in the annuitized value of net transfers (transfers minus taxes) expressed as a fraction of GDP per household (which was roughly \$141,000 in 2014). The annuitized value shows the change in net transfers that households would face each year if the total change in the net present value of net transfers was paid as a constant amount each year of a household's remaining life. The cuts in lump-sum transfers have a greater effect on that measure for those who are currently young workers, children, or unborn than they do for current retirees; the opposite is true for cuts in OASDI/HI benefits (see Panel A of Table 5 on page 35 and Figure 4 on page 36). When lump-sum transfers are cut uniformly for all households, young workers (ages 21–40) lose, on average, 2.4 percent of initial GDP per household each year in net transfers, whereas re-

tree households lose, on average, 1.7 percent of initial GDP per household each year.⁷¹ When OASDI/HI benefits are cut proportionally, young workers similarly lose, on average, 2.4 percent of initial GDP per household each remaining year of their life, whereas retirees lose, on average, 5.9 percent of initial GDP per household each year.

As measured by the annuitized value, the cuts in OASDI/HI benefits—which, aside from DI benefits, only apply to cohorts age 65 and older—impose a much larger annual burden on retiree households than on any other cohort. By comparison, the annual burden imposed by the cuts in lump-sum transfers is much more evenly distributed among cohorts.

5.4.3 Effects on the Consumption-Equivalence Measure of Households' Welfare

Another way to calculate the annual burden that a policy change places on households is with the consumption-equivalence measure of changes in welfare. Whereas the annuitized-value measure shows the annual dollar amount (expressed as a percentage of GDP per household) that a household would lose in net transfers as a result of a policy change, the CE measure of welfare shows the percentage by which a household's consumption would have to change every year in the baseline economy in order to achieve the same level of well-being as under the policy change. The CE measure also accounts for changes in welfare from adjustments in hours of work and the value of the insurance that those transfers provide.⁷² According to the CE welfare measure, retirees and households approaching retirement age (ages 41-64) fare better under the cuts in lump-sum transfers, but households under age 41 and future generations fare better under the cuts in OASDI/HI benefits (see Panel B of Table 5 on page 35 and Figure 4 on page 36).

Which spending-cut policy is preferable for a given cohort is generally the same under either measure, but the relative size of the policies' effects on different cohorts varies substantially depending on which measure is used. For example, retirees prefer lump-sum transfer cuts to OASDI/HI benefit cuts under both measures. But how they fare relative to young workers (ages 21-40) is very different under the two measures. By the CE welfare measure, retirees lose almost 15 percent *more* than workers ages 21-40 do from those cuts to lump-sum transfers (5.3 percent of their remaining lifetime consumption, versus 4.7 percent), whereas they lose about 30 percent *less* than those young workers do according to the annuitized-value measure (1.7 percent of initial GDP per household each year, versus 2.4 percent). Even though the monetary (annuitized-value) loss is smaller for retirees than for young workers, their welfare loss is larger because most retirees rely heavily on lump-sum transfers and OASDI/HI benefits, and they cannot increase their disposable income in response to reductions in government transfer payments as easily as young working-age households can.

The difference between the two measures is even more striking for the cuts in OASDI/HI benefits. By the annuitized-value measure, retirees lose about 2.5 times as much as young workers do (5.9 percent of initial GDP per household each year, compared with 2.4 percent). But by the

⁷¹The annuitized value of the change in the NPV of net transfers is calculated at the time of the policy change and remains constant throughout a household's life. In particular, the annuitized value does not grow with increases in productivity, as lump-sum transfers per person do, for example. In other words, lump-sum transfers are the same for every household in a given year, but they grow with productivity over time. For that reason, the annuitized value of the changes in lump-sum transfers is larger for younger generations.

⁷²The CE measure used here is a purely utilitarian measure and does not account for intergenerational altruism—the fact that parents or grandparents might prefer policy changes that do not benefit them directly if the policy changes increase the well-being of their children or grandchildren.

CE measure, retirees lose 5 times as much as young workers do (14.6 percent of their remaining lifetime consumption, compared with just 2.9 percent). As with the cuts to lump-sum transfers, the fact that retirees experience a much bigger drop in welfare than in net transfers under the cuts to OASDI/HI benefits (relative to young workers) reflects their relative inability to adjust their income and saving. Young workers have plenty of time to work longer hours and to modify their life-cycle consumption plan after the policy change, whereas retirees are much less able to increase their financial resources and modify their consumption path.

5.5 Details of the Effects of Raising Payroll, Income, or Consumption Taxes

The next set of policy experiments involves examining the effects of closing the fiscal gap by increasing federal revenues in one of three ways:

- In the first policy, the government raises the payroll tax rate for Medicare’s Hospital Insurance program, $\tau_{H,t}$. (Unlike Social Security payroll taxes, the HI tax does not have a maximum level of taxable earnings above which it is no longer levied, so it represents a flat tax on all labor income.)⁷³
- In the second policy, the government raises all marginal income tax rates, φ_t , by an equal percentage.
- In the third policy, the government instead increases the flat consumption tax rate, $\tau_{C,t}$ (that tax is assumed to approximate federal taxes other than income and payroll taxes, such as excise taxes and customs duties).

For each of those policy changes, the government raises a particular type of tax rate to close the fiscal gap created by increased government purchases. The tax rates are raised such that growth-adjusted debt per household (as defined in equation (24) above) is kept constant; that is, $d_{G,t} = d_{G,0}$ for all $t \geq 1$.

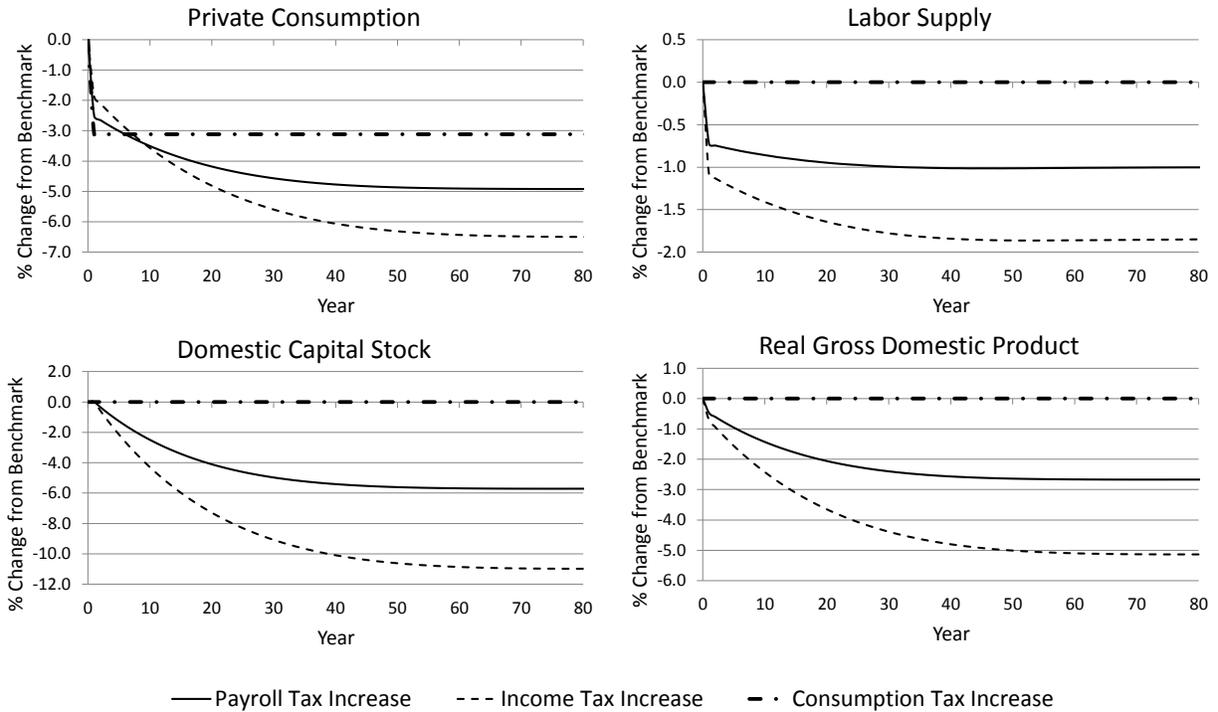
Those three stylized tax increases apply to different tax bases, which determines whom they affect directly. (Ultimately, the tax increases also affect households through their general-equilibrium effects on wages and interest rates.) Changes in payroll tax rates affect nonretirees who earn labor income. Changes in income tax rates largely fall on nonretirees too; but because income taxes also apply to capital income, retirees with assets are directly affected as well. Changes in consumption tax rates affect retirees and nonretirees alike.

In order to close a fiscal gap of 1.8 percent, the HI payroll tax rate of 2.9 percent would have to rise by about 4 percentage points in the short term and 5.1 percentage points in the long term. Marginal income tax rates would have to increase by about 20 percent in the short term—or between 2 percentage points (for a household in the 10 percent tax bracket) and 7.9 percentage points (for a household in the 39.6 percent tax bracket). In the long term, the necessary increase in marginal income tax rates would rise to 31 percent—or between 3.1 percentage points and 12.3 percentage points. The consumption tax rate of 2.5 percent would have to increase by 3.3 percentage points in both the short and long terms.⁷⁴

⁷³Revenues from OASDI taxes or a higher HI tax would be credited to the OASDI or Medicare Part A trust funds.

⁷⁴The payroll and income tax rates would have to be higher in the long term because, as discussed below, those policies would lead to decreases in the labor supply and wages, which in turn would reduce tax revenue.

Figure 6: Macroeconomic Effects of Closing a Fiscal Gap of 1.8 Percent Through Tax Increases (Changes from the benchmark economy)



Note: The figures show how the changes in tax policies described in Section 5.5 of the text would affect the economy from the time the policy change occurred until 80 years later.

5.5.1 Economic Effects

These stylized tax policy changes affect households in several ways. The increase in the payroll tax rate lowers the after-tax wage that workers receive, which can reduce their incentives to work (the substitution effect). At the same time, the tax increase lowers workers' income, which can increase their incentives to work (the income effect). The first effect predominates in these estimates, causing the total labor supply to decline by 0.7 percent initially and by 1.0 percent in the long term (see Figure 6). Because of the decrease in labor supply and the increase in tax liabilities, households' disposable income drops by 3.4 percent initially and by 4.9 percent in the long term. Faced with less disposable income, households reduce both their saving and consumption. The aggregate saving rate declines by 0.7 percentage points initially and by 0.3 percentage points in the long term. Total consumption drops by 2.5 percent initially and by 4.9 percent in the long term. As a result of the decrease in labor supply and the saving rate, the capital stock shrinks by 2.5 percent in the short term (the first 10 years) and by 5.7 percent in the long term. With the supply of labor and capital decreasing, GDP declines by 1.4 percent in the short term and by 2.7 percent in the long term. The economic effects are larger in the long term than the short term because the capital stock adjusts to the policy changes slowly (by contrast, the labor supply adjusts instantaneously in

the model).

The proportional increase in income tax rates has macroeconomic effects that are similar to those of the increase in the payroll tax rate—except that the former are almost twice as large, despite the fact that the average increase in income taxes in our policy experiments is smaller than the average increase in the payroll tax (because income taxes apply to a broader tax base). One reason the income tax increase has much larger effects is that it applies to capital income as well as to labor income. Because the income tax lowers the return on capital, an increase in that tax reduces households' incentives to save, which in turn reduces the capital stock in the long run. Another reason the income tax increase has much larger effects is that it raises the tax rates on the labor income of higher-income earners by more than the payroll tax increase does. Because of the progressivity of the income tax system, high-income earners pay a higher tax rate on each additional dollar earned than low-income earners do. A proportional increase in income tax rates thus raises tax rates for high-income earners by more than rates for low-income earners. Additionally, because increasing tax rates lowers output, those rates have to increase over time in order to close the fiscal gap, as described above. As a result, in our projections tax rates on labor income rise more under the income tax increase than under the payroll tax increase for households with marginal income tax rates of 25 percent and above in the short run and for households with marginal tax rates of 20 percent and above in the long run.⁷⁵

For those reasons, with the proportional increase in income tax rates analyzed here, aggregate labor supply declines by 1.1 percent immediately and by 1.8 percent in the long term. Disposable income falls by 3.7 percent immediately and by 6.8 percent in the long term, and the aggregate saving rate decreases by 1.3 percentage points immediately and by 0.7 percentage points in the long term. Total consumption drops by 1.9 percent immediately and by 6.5 percent in the long term. As a result of the larger decreases in the labor supply and the saving rate, the capital stock and output also decline more than they do under the payroll tax policy: The capital stock drops by 4.3 percent in the short term and 11.0 percent in the long term, and GDP decreases by 2.4 percent in the short term and 5.1 percent in the long term.

The increase in the consumption tax rate reduces disposable income by 2.8 percent and consumption by 3.1 percent in both the short and long terms, but it does not affect the labor supply, the capital stock, or GDP.⁷⁶ When the national consumption tax rate is increased immediately and permanently by 3.3 percentage points, the purchasing power of households' current *and* future labor income and wealth is lowered equally by 3.1 percent, and thus the trade-off between consumption today and consumption tomorrow remains unchanged.⁷⁷ As a result, households' labor supply and

⁷⁵In the short run, the income tax rate for households at or above the 25 percent tax bracket would increase by between 5.0 percentage points and 7.9 percentage points (compared with 4 percentage points under the payroll tax increase). In the long run, the income tax rate for households at or above the 20 percent tax bracket would increase by between 6.2 percentage points and 12.3 percentage points (compared with 5.1 percentage points under the payroll tax increase).

⁷⁶Because disposable income equals consumption *plus* saving, when consumption is reduced as a result of an increase in the consumption tax, the percentage change in disposable income is smaller than the percentage change in consumption.

⁷⁷Suppose, for example, the consumption tax rate is increased from zero to 3 percent immediately and permanently. In that case, a household's purchasing power of wealth as well as all of its future income would decrease proportionally by about 3 percent, because $1/(1+0.03) - 1 \approx 0.03$. Since that change is permanent and proportional under the Cobb-Douglas utility function with unit elasticity of intratemporal substitution, it is optimal for the household to reduce its real consumption permanently by about 3 percent without changing nominal consumption, labor supply, and saving.

saving decisions also remain unchanged, but (real) consumption today and in the future drops by 3.1 percent.⁷⁸

Fifty years after the policy change, GDP is 2.6 percent smaller under the payroll tax increase, 5.0 percent smaller under the income tax increase, and unchanged under the consumption tax increase, relative to the benchmark economy.⁷⁹ To put those declines into context, real GDP per capita grows by 144 percent over that 50-year period in the model economy. In other words, given that GDP per capita grows by 1.8 percent per year in the benchmark economy, after 50 years the decrease in GDP per capita resulting from increases in payroll or income taxes is equivalent to a loss of between about one and a half years and less than three years of GDP growth. Again, these results only indicate that the choice of policy to close the fiscal gap has a relatively small effect on the economy's output in the long run. However, the effect on the economy's output of closing the fiscal gap versus continuing to increase the federal debt is likely to be positive and much bigger.

5.5.2 Effects on the Annuitized Value of Households' Net Transfers

The three stylized tax increases have differing effects on households, as measured by the change in the annuitized value of net transfers (transfers minus taxes), expressed as a percentage of GDP per household (which was roughly \$141,000 in 2014). Like the spending cuts discussed above, the three tax increases reduce the annuitized value of households' net transfers. The reason is that under those policies, households pay higher taxes and receive fewer transfers (as a result of lower labor supply and wages) than they do in the benchmark economy (in which, by assumption, fiscal tightening occurs through changes that do not affect households).⁸⁰

The tax increases generally have a greater impact on younger households than on older ones. For example, retirees (ages 65 and older) would lose, on average, 0.1 percent of initial GDP per household each year under the payroll tax increase, 0.5 percent under the income tax increase, and 1.5 percent under the consumption tax increase (see Panel A of Table 5 on page 35 and Figure 4 on page 36). By comparison, young workers (ages 21–40) would lose, on average, 2.9 percent of initial GDP per household each year under the payroll tax increase, 3.4 percent under the income tax increase, and 2.7 percent under the consumption tax increase.

Raising the payroll tax rate has a smaller effect on the annuitized value of net transfers than raising income tax rates does, for several reasons. First, GDP drops more under the income tax policy than under the payroll tax policy, so the government has to raise more revenue from the income tax increase than from the payroll tax increase to keep the ratio of debt to benchmark GDP constant. Second, retirees and households nearing retirement tend to have relatively large capital income, which is subject to the income tax but not the payroll tax.

⁷⁸If the tax increase was announced ahead of time rather than implemented immediately, the value of households' future labor income and wealth would depreciate by the amount of the consumption tax increase. In response, households would boost their labor supply and saving prior to the tax increase, which would increase saving, the capital stock, and output in the short run.

⁷⁹The economy is unaffected by an increase in the consumption tax because of our specification of household preferences. That specification implies that the wealth and substitution effects cancel each other out. More technically, the household's Euler equation is $u_c(c_t, h_t) = \beta(1 + \tau_{c,t})/(1 + \tau_{c,t+1})E[(1 + r_{t+1})u_c(c_{t+1}, h_{t+1})]$, where $u_c(\cdot, \cdot)$ is the marginal utility of consumption, c_t and c_{t+1} are current-period and next-period consumption, and $\tau_{c,t}$ and $\tau_{c,t+1}$ are current and future tax rates on consumption. If the change in the consumption tax rate is immediate and permanent, then $\tau_{c,t} = \tau_{c,t+1}$, and the Euler equation will not change. Thus, the household's saving will not change unless its labor supply changes for other reasons.

⁸⁰Lower labor supply and wages decrease the size of the OASI benefits a worker receives, on average, in retirement.

The annuitized-value measure indicates that the three tax increases impose a much smaller annual burden on retiree households than on any other cohort. That measure also indicates that the annual burden imposed on cohorts that have not yet retired (including the unborn) tends to be larger when taxes are increased than when lump-sum transfers or OASDI/HI benefits are cut.

5.5.3 Effects on the Consumption-Equivalence Measure of Households' Welfare

For the payroll and income tax policies, the percentage changes in the CE measure of welfare (the percentage by which a household's annual consumption would have to change in the baseline economy to achieve the same level of well-being as under the policy change) are similar to the changes in the annuitized-value measure, except that very young people and those not yet born generally experience greater losses relative to older households under the CE measure than under the annuitized-value measure (see Panel B of Table 5 on page 35 and Figure 4 on page 36). For example, by the annuitized-value measure, an increase in payroll taxes causes very young people (ages 0-20) and future generations to lose about 29 times as much as retirees (2.9 percent of GDP per household each year, compared with 0.1 percent). But by the CE welfare measure, the payroll tax increase causes very young people and future generations to lose roughly 39 times as much as retirees (3.7 percent to 4.1 percent of their remaining lifetime consumption, compared with 0.1 percent).

The differences between the two measures are more similar for the income tax increase. That policy causes very young people and future generations to lose 6 times as much as retirees by the annuitized-value measure (between 3.1 percent and 3.2 percent of initial GDP per household each year, versus 0.5 percent) and 12 to 14 times as much as retirees by the CE welfare measure (3.5 percent to 4.2 percent of their remaining lifetime consumption, versus 0.3 percent).

In the case of an increase in consumption taxes, very young people and future generations lose only about 1.7 times as much as retirees by the annuitized-value measure (2.6 percent of initial GDP per household each year, compared with 1.5 percent). By the CE welfare measure, all cohorts lose the same amount (3.1 percent of their remaining lifetime consumption). The reason that the results are so different for the consumption tax policy is that consumption follows a hump-shaped pattern over people's lifetime (smaller near the beginning and end of life and much greater in the middle). The annuitized-value measure is lower for retirees than for younger households because retirees have less consumption remaining, so they pay less in the form of consumption taxes. The CE measure, however, measures a loss of welfare relative to each household's remaining lifetime consumption, which means that a proportional tax on consumption decreases every household's (and thus every generation's) welfare equally.

6 Conclusion

Although it is not possible to measure all the gains from moving from an unsustainable to a sustainable policy (because an unsustainable policy, by definition, cannot be maintained indefinitely), we are able to rank different policies designed to close the fiscal gap of 1.8 percent of GDP based on the costs those policy changes impose on different cohorts (measured by the change in the net present value of future net transfers and the change in remaining lifetime consumption that each generation would experience under our five stylized policies). We find that the policies

with the largest positive impact on economic output—cuts to lump-sum transfers or to OASDI/HI benefits—are not the most preferable policies for the majority of households currently alive, as measured by the annuitized value of the change in net transfers or the consumption-equivalence measure of welfare. Instead, based on those two measures, the majority of households currently alive would experience smaller losses if the fiscal gap was closed through increases in payroll or income taxes. Currently young and future households would experience the smallest losses from cuts to OASDI/HI benefits. Those results hold true under a wide range of values for important parameters of the analysis and key modeling assumptions.

Appendixes

A Sensitivity Analysis

This appendix provides results for our measures of the cost of closing the fiscal gap using alternative parameter values and modeling assumptions. The effects of changing those values and assumptions can be seen by comparing the tables in this appendix with Panels A and B of Table 5 on page 35. We analyzed five alternative conditions:

1. **A Frisch elasticity of labor supply equal to 0.25 instead of 0.5:** With a lower Frisch elasticity, tax increases have a smaller negative impact—and cuts in transfers or benefits have a smaller positive impact—on the labor supply, the capital stock, and output. See Table 6.
2. **A Frisch elasticity of labor supply equal to 1.0 instead of 0.5:** With a higher Frisch elasticity, tax increases have a greater negative impact—and cuts in transfers or benefits have a greater positive impact—on the labor supply, the capital stock, and output. See Table 7.
3. **Risk aversion of 2.0 instead of 3.0:** When households are less averse to risk than assumed for the benchmark economy, the labor supply, the capital stock, and output change less in response to policy changes. See Table 8.
4. **A small open economy instead of a closed economy:** In a small open economy, interest rates are determined by the world economy and thus do not change in response to domestic policy changes. As a result, the labor supply, the capital stock, and output change less than in the benchmark economy. See Table 9.
5. **Policy changes that take effect 15 years after they are announced instead of immediately:** When the policy changes are announced ahead of time, households will adjust their behavior in the opposite direction of what they will do after the policy changes (for example, in response to a preannounced increase in tax rates, households will increase their labor supply until the policy change takes effect and decrease it thereafter). Under this assumption, the labor supply, the capital stock, and output change more in the long run than they do in the benchmark economy. The reason is that government debt accumulates for an additional 15 years, so the policy change needed to stabilize debt has to be larger. See Table 10.

For the first four of those alternatives, the estimated costs to households in different cohorts of the various policy changes are quite similar to those reported earlier. The estimated costs to households when policy changes are assumed to be implemented 15 years into the future differ more.

A.1 Frisch Elasticity of Labor Supply of 0.25

Table 6: Changes in Net Transfers and Welfare Under Various Policies With a Lower Frisch Elasticity of Labor Supply

Panel A: Annuitized Value of the Change in Households' Net Transfers (As a percentage of GDP per household)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-1.8	-6.2	-0.2	-0.7	-1.7
41-64	-2.2	-4.3	-2.5	-2.7	-2.1
21-40	-2.5	-2.5	-1.8	-1.2	-1.4
0-20	-2.6	-2.2	-0.7	-0.1	-1.0
Unborn	-2.6	-2.2	-0.7	-0.1	-1.0

Panel B: Consumption-Equivalence Measure of Households' Welfare (Percentage change in consumption equivalence)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-5.5	-14.7	-0.1	-0.3	-3.1
41-64	-4.8	-6.9	-1.6	-1.3	-3.1
21-40	-4.9	-2.9	-2.9	-2.3	-3.1
0-20	-4.9	-1.4	-3.6	-3.2	-3.1
Unborn	-4.8	-1.1	-4.0	-3.9	-3.1

Notes: Panel A shows the annuitized value of the change in net transfers that a household (with an average size of 2.6 people) experiences relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—expressed as a percentage of GDP per household. In 2014, GDP per household was roughly \$141,000.

Panel B shows how a household's well-being would change relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—measured as a percentage decrease in the household's lifetime consumption.

For households headed by someone age 21 or older, the policy changes are evaluated at the time of their implementation. For people under age 21 or not yet born, the policy changes are evaluated at the time they turn 21. The Unborn category represents generations that are born into an economy that has fully adjusted to the policy changes (in other words, that has reached steady state).

The five stylized policy changes are described in Sections 5.4 and 5.5 of the text.

GDP = gross domestic product; OASDI/HI = Old-Age, Survivors, Disability, and Hospital Insurance.

A.2 Frisch Elasticity of Labor Supply of 1.0

Table 7: Changes in Net Transfers and Welfare Under Various Policies With a Higher Frisch Elasticity of Labor Supply

Panel A: Annuitized Value of the Change in Households' Net Transfers (As a percentage of GDP per household)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-1.6	-5.6	0.0	-0.4	-1.4
41-64	-2.0	-4.2	-1.3	-2.2	-2.4
21-40	-2.3	-2.4	-2.7	-3.3	-2.6
0-20	-2.4	-2.1	-2.8	-3.1	-2.5
Unborn	-2.5	-2.2	-2.8	-3.1	-2.5

Panel B: Consumption-Equivalence Measure of Households' Welfare (Percentage change in consumption equivalence)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-5.0	-14.6	-0.1	-0.3	-3.1
41-64	-4.2	-6.9	-1.6	-1.5	-3.1
21-40	-4.4	-3.0	-3.1	-2.9	-3.1
0-20	-4.4	-1.8	-3.8	-4.0	-3.1
Unborn	-4.4	-1.6	-4.1	-4.7	-3.1

Notes: Panel A shows the annuitized value of the change in net transfers that a household (with an average size of 2.6 people) experiences relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—expressed as a percentage of GDP per household. In 2014, GDP per household was roughly \$141,000.

Panel B shows how a household's well-being would change relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—measured as a percentage decrease in the household's lifetime consumption.

For households headed by someone age 21 or older, the policy changes are evaluated at the time of their implementation. For people under age 21 or not yet born, the policy changes are evaluated at the time they turn 21. The Unborn category represents generations that are born into an economy that has fully adjusted to the policy changes (in other words, that has reached steady state).

The five stylized policy changes are described in Sections 5.4 and 5.5 of the text.

GDP = gross domestic product; OASDI/HI = Old-Age, Survivors, Disability, and Hospital Insurance.

A.3 Risk Aversion of 2.0

Table 8: Changes in Net Transfers and Welfare Under Various Policies With a Lower Risk Aversion

Panel A: Annuitized Value of the Change in Households' Net Transfers (As a percentage of GDP per household)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-1.6	-5.8	0.0	-0.3	-1.4
41-64	-2.0	-4.4	-1.3	-2.2	-2.5
21-40	-2.3	-2.5	-2.7	-3.3	-2.6
0-20	-2.5	-2.2	-2.8	-3.1	-2.5
Unborn	-2.5	-2.2	-2.8	-3.0	-2.5

Panel B: Consumption-Equivalence Measure of Households' Welfare (Percentage change in consumption equivalence)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-4.6	-14.8	-0.1	-0.4	-3.1
41-64	-3.8	-7.0	-1.6	-1.7	-3.1
21-40	-4.0	-3.3	-3.1	-3.1	-3.1
0-20	-4.1	-2.2	-3.6	-4.0	-3.1
Unborn	-4.1	-2.1	-3.8	-4.5	-3.1

Notes: Panel A shows the annuitized value of the change in net transfers that a household (with an average size of 2.6 people) experiences relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—expressed as a percentage of GDP per household. In 2014, GDP per household was roughly \$141,000.

Panel B shows how a household's well-being would change relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—measured as a percentage decrease in the household's lifetime consumption.

For households headed by someone age 21 or older, the policy changes are evaluated at the time of their implementation. For people under age 21 or not yet born, the policy changes are evaluated at the time they turn 21. The Unborn category represents generations that are born into an economy that has fully adjusted to the policy changes (in other words, that has reached steady state).

The five stylized policy changes are described in Sections 5.4 and 5.5 of the text.

GDP = gross domestic product; OASDI/HI = Old-Age, Survivors, Disability, and Hospital Insurance.

A.4 Small Open Economy

Table 9: Changes in Net Transfers and Welfare Under Various Policies With a Small Open Economy

Panel A: Annuitized Value of the Change in Households' Net Transfers (As a percentage of GDP per household)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-1.6	-5.6	0.0	-0.4	-1.6
41-64	-2.0	-4.7	-1.1	-2.0	-2.6
21-40	-2.3	-2.8	-2.4	-2.6	-2.6
0-20	-2.4	-2.4	-2.5	-2.4	-2.4
Unborn	-2.5	-2.4	-2.6	-2.5	-2.4

Panel B: Consumption-Equivalence Measure of Households' Welfare (Percentage change in consumption equivalence)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-3.9	-11.8	-0.1	-0.6	-3.0
41-64	-3.2	-6.2	-1.5	-2.1	-3.0
21-40	-3.4	-3.3	-2.9	-3.2	-3.0
0-20	-3.6	-2.4	-3.4	-3.8	-3.0
Unborn	-3.6	-2.0	-3.8	-4.7	-3.0

Notes: Panel A shows the annuitized value of the change in net transfers that a household (with an average size of 2.6 people) experiences relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—expressed as a percentage of GDP per household. In 2014, GDP per household was roughly \$141,000.

Panel B shows how a household's well-being would change relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—measured as a percentage decrease in the household's lifetime consumption.

For households headed by someone age 21 or older, the policy changes are evaluated at the time of their implementation. For people under age 21 or not yet born, the policy changes are evaluated at the time they turn 21. The Unborn category represents generations that are born into an economy that has fully adjusted to the policy changes (in other words, that has reached steady state).

The five stylized policy changes are described in Sections 5.4 and 5.5 of the text.

GDP = gross domestic product; OASDI/HI = Old-Age, Survivors, Disability, and Hospital Insurance.

A.5 Policy Changes Announced 15 Years Ahead

Table 10: Changes in Net Transfers and Welfare Under Various Policies With the Policies Preannounced by 15 Years

Panel A: Annuitized Value of the Change in Households' Net Transfers (As a percentage of GDP per household)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-0.1	-0.4	0.0	0.0	-0.1
41-64	-1.2	-3.4	-0.2	-0.9	-1.4
21-40	-2.0	-2.8	-2.0	-3.1	-2.5
0-20	-2.9	-2.6	-3.7	-4.5	-3.2
Unborn	-3.3	-2.6	-4.2	-5.1	-3.4

Panel B: Consumption-Equivalence Measure of Households' Welfare (Percentage change in consumption equivalence)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-1.6	-3.7	-0.1	-0.1	-0.9
41-64	-3.0	-6.4	-0.4	-0.5	-2.0
21-40	-3.1	-2.9	-1.6	-1.5	-2.3
0-20	-4.7	-1.4	-3.7	-3.5	-3.3
Unborn	-6.0	-1.5	-6.0	-7.1	-4.1

Notes: Panel A shows the annuitized value of the change in net transfers that a household (with an average size of 2.6 people) experiences relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—expressed as a percentage of GDP per household. In 2014, GDP per household was roughly \$141,000.

Panel B shows how a household's well-being would change relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—measured as a percentage decrease in the household's lifetime consumption.

For households headed by someone age 21 or older, the policy changes are evaluated at the time of their implementation. For people under age 21 or not yet born, the policy changes are evaluated at the time they turn 21. The Unborn category represents generations that are born into an economy that has fully adjusted to the policy changes (in other words, that has reached steady state).

The five stylized policy changes are described in Sections 5.4 and 5.5 of the text.

GDP = gross domestic product; OASDI/HI = Old-Age, Survivors, Disability, and Hospital Insurance.

B Change in the Net Present Value of Net Transfers in the Benchmark Calibration

In Panel A of Table 5 on page 35, we show the costs to different households of policies that close the fiscal gap, as measured by the change in the net present value (NPV) of net transfers to each age cohort, expressed in terms of an annuity stream (a fixed amount of money that a household would lose every year until the end of its life). That measure illustrates the size of the annual financial burden to households of implementing a policy (with that burden measured beginning at the date of implementation).

Table 11 shows the estimated change in the NPV of net transfers, but not expressed in terms of an annuity stream, which illustrates how much members of a cohort contribute to closing the fiscal gap in terms of total net present value. This measure is generally larger for younger people than for older people because they are affected by a policy change for a greater number of years.

Table 11: Net Present Value of the Change in Households' Net Transfers Under Various Policies (As a percentage of GDP per household)

Age of Head of Household	Benefit Cuts		Tax Increases		
	Transfers	OASDI/HI	Payroll	Income	Consumption
65 and Older	-12.2	-43.5	-0.7	-4.7	-12.5
41-64	-47.0	-74.8	-30.4	-47.0	-39.0
21-40	-66.1	-60.2	-71.0	-83.8	-59.7
0-20	-68.9	-57.7	-78.6	-85.3	-67.8
Unborn	-68.9	-58.7	-78.5	-84.2	-68.2

Notes: The table shows the net present value of the change in net transfers that a household (with an average size of 2.6 people) experiences relative to the benchmark economy—in which, by assumption, fiscal policy is sustainable and the debt-to-GDP ratio is constant in the long run—expressed as a fraction of GDP per household. In 2014, GDP per household was roughly \$141,000.

For households headed by someone age 21 or older, the policy changes are evaluated upon implementation. For people under age 21 or not yet born, the policy changes are evaluated at the time they turn 21. The Unborn category represents generations that are born into an economy that has fully adjusted to the policy changes (in other words, that has reached steady state).

The five stylized policy changes are described in Sections 5.4 and 5.5 of the text.

GDP = gross domestic product; OASDI/HI = Old-Age, Survivors, Disability, and Hospital Insurance.

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