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On Financing Retirement with an Aging Population*

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ABSTRACT

A problem facing the United States is financing retirement consumption as its population ages. Policy analysts increasingly advocate switching to a savings-for-retirement system that does not rely on taxing workers' incomes, but are concerned about insufficient savings opportunities with limited government debt. This concern is unwarranted. First, there is more productive capital than commonly assumed in macroeconomic modeling. Second, if the policy reform subsumes the elimination of capital income taxes, then the value of business equity increases relative to the capital stock. We show how to devise a transition path from the current U.S. system to a savings-for-retirement system that increases the welfare of all current and future cohorts, with estimates of future gains that are twice as large as those found with typically used macroeconomic models.

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1. Introduction

An important policy issue is how to finance retirement consumption in light of the falling number of workers per retiree in many countries including the United States. One proposal is to move to a savings-for-retirement system. Critics argue that such a move will not raise welfare for all birth-year cohorts because there is the shortage of good savings opportunities given the limited ability of government to honor its debt. Using a general equilibrium overlapping-generations model, we show that a move from the current U.S. retirement system—which relies heavily on payroll taxes on workers' incomes in order to make lump-sum transfers to retirees—to a savings-for-retirement system without these payroll taxes and old-age transfers is feasible and welfare improving for all birth-year cohorts, especially future cohorts who gain 15 percent in lifetime consumption equivalents. Further tax reforms eliminating capital taxes and flattening and broadening the tax system results in welfare gains that are as high as 25 percent even in an environment with large government debt and lump-sum taxes ruled out.

These welfare gains are much larger than those estimated with typically used macroeconomic models. There are two reasons for this. First, our estimate of the U.S. capital stock at reproduction cost is 5.8 times GNP, which is nearly twice as large as estimates commonly used in macroeconomic analyses. For example, Auerbach and Kotlikoff (1987) use a capital share consistent with a capital stock of 2.8 times GNP, which is the size of fixed assets reported by the Bureau of Economic Analysis (BEA).[1] Ours is larger because we include consumer durables, inventories, land, and business intangible capital, which implies an additional 3 times GNP of productive capital. Changing the tax system appropriately implies a dramatic increase in the productive capital stock, from 5.8 GNPs to 7.7 GNPs.

A second, and not so well-known, reason for larger welfare gains is that the tax reforms we consider result in a large increase in the value of private business equity because the price of businesses' productive capital is a decreasing function of tax rates on capital.[2] The increase in the market value of equity permits the financing of retirement consumption through savings, and

[1] We do not include non-rival human capital in the model's capital stock. The reason we do not include this large stock of capital is that in retirement, human capital cannot be sold and the proceeds used to finance retirement.

[2] For a closed economy, the net worth of the private sector is the value of equity plus the net government debt.

there is no need to tax workers' labor income to finance lump-sum transfers to retirees. Typical macroeconomic analyses that restrict attention to capital reported in the BEA fixed asset tables and abstract from capital tax factors that imply increasing equity values *find welfare gains half as large as our estimated gains.*

With our overlapping-generations model, we compute both balanced growth paths and equilibrium transition paths, with the initial state calibrated to the current U.S. economy. The simulated data from the model we use are consistent with the U.S. national income and product accounts and U.S. productive capital stocks. The transitions involve both changes in demographics and changes in taxes and government transfers. We model the current U.S. economy has having 3.4 workers per retiree and study the transition as that number falls to about 2. Coincident with the demographic transition is the phasing in of new policy. For the sake of comparison, we first consider transitions to a tax-transfer system that is essentially the one currently in use with its high labor and capital income tax rates and large transfers to retirees. With the population aging, we assume that taxes must rise to finance the additional old-age transfers.

We compare the results of continuing U.S. policy to three variations of a savings-for-retirement system, modifying the policy in steps so that we can highlight the role played by each factor. First, we show what happens if we eliminate payroll taxes on Medicare and Social Security along with accompanying transfers made to retirees. The payroll taxes are those imposed by the Federal Insurance Contribution Act (FICA). A second variation on the new system involves eliminating all capital taxes, that is, taxes on profits and distributions. Finally, we compute the impact of a further tax reform that flattens the income tax schedule for labor income and broadens the tax base. The growth paths are determined for all policy experiments and welfare comparisons are made. For the transition path, the measure of welfare is remaining-lifetime consumption equivalents for each birth-year cohort currently alive and each cohort joining the workforce in the future.

In order to generate transition paths with all birth-cohorts better off, we devise a tax and transfer scheme that delays the fall in transfers to retirees and allows for only modest increases—at least initially—in consumption tax rates which affect budget sets of retirees. Current retirees cannot take advantage of lower taxes on workers and changes in interest rates on their assets are of second-order importance. Workers, on the other hand, can take advantage of lower taxes on wages and, therefore, we immediately lower payroll taxes. This results in an immediate rise in labor input and GNP. To balance the government's budget during the early part of the transition, we also eliminate some *implicit transfers* for workers, which are transfers equal to the difference between what tax revenues would be if all income were taxed at the income-weighted average marginal tax rates we use in our analysis and what actual tax revenues are.[3] Total government revenue is much larger than collected tax revenue because important components of income are not taxed and because the income tax schedule is convex. Eliminating part of these transfers effectively flattens the tax schedule and broadens the tax base. In all of the experiments we consider, we retain current expenditure shares for government purchases of goods and services and transfers normally included in the national income and product accounts (NIPA) other than transfers for Medicare and Social Security.

To determine which, if any, modeling choices are crucial for our main findings, we rerun our policy experiments using various versions of the OLG framework. The only significant deviations arise when we follow the literature in restricting attention only to capital stocks reported in the BEA tables and abstracting from capital tax factors that imply increasing equity values.

In Section 2, we discuss the related literature. Section 3 presents the model used to evaluate the alternative retirement financing systems. In Section 4, we show how to modify the U.S. Department of Commerce national income and product accounts (NIPA) and fixed asset tables to be consistent with theory. In Section 5, we select the parameters to be consistent with these modified accounts. In Section 6, we report the balanced growth paths for an economy with the current tax system where the growth rate of new workforce entrants continues at 1 percent annually and for alternative economies where growth in the number of new workforce entrants falls, and we report the equilibrium paths and welfare differences for each birth-year cohort. In Section 7, we provide a summary of the findings.

[3] Following Barro and Redlick (2011), we use income-weighted average marginal income tax rates rather than average rates in order to better estimate the impact of tax reforms on macroeconomic activity.

2. Related Literature

The literature concerned with financing retirement consumption is large and growing. Papers most closely related to ours focus on shifting from the current pay-as-you-go Social Security systems to mandatory savings programs with individual accounts.[4] The main conclusion from this literature is that the long-term gains of switching to a saving-for-retirement system are positive—especially if distorting taxes on incomes can be reduced—but the welfare gains of future cohorts come at the cost of welfare losses for generations living during the transition. For example, Huang, Imrohoroglu, and Sargent (1997) study transitions following a surprise elimination of social security in which the government fully compensates all cohorts alive at the time of the policy change by issuing a large amount of government debt; although labor income taxes in the future can be lowered, they are temporarily high while the government pays off the entitlement debt and result in welfare losses for generations born just after the policy change.[5] Conesa and Krueger (1999) and Imrohoroglu and Kitao (2012) find that adding idiosyncratic uncertainty makes things worse since social security provides partial insurance.[6]

In order to more systematically consider alternative fiscal policy plans, Conesa and Garriga (2008) consider a set of social welfare functions and derive optimal policies. They are interested in designing plans that are welfare improving for transitional generations. They show it is possible but find paths for tax rates, especially tax rates on capital income, that "call into question its relevance" as an actual policy option. For example, in their baseline economy with the government choosing both labor and capital income tax rates, the optimal capital income tax rate oscillates between 60 percent and −60 percent. Here, we focus attention on smoothly declining paths for capital income tax rates and find that it is easy to construct policies that are Pareto improving for all current and future cohorts.

[4] The Feldstein (1998) volume is a nice collection of papers that consider saving-for-retirements systems in the United States, Chile, Australia, the United Kingdom, Mexico, and Argentina. Of particular relevance for our paper are the transitional studies of Feldstein and Samwick (1998) and Kotlikoff (1998), who study the United States. See also De Nardi, Imrohoroglu, and Sargent (1999) for a detailed analysis of the U.S. system.

[5] Kotlikoff, Smetters, and Walliser (1999) study transitional dynamics following a wide array of policy options and find that while "privatization offers significant long-run gain, it does so at some nontrivial short-run costs" (p. 533). See also Kotlikoff, Smetters, and Walliser (2007).

[6] Idiosyncratic uncertainty can be handled by private insurance and is therefore not an issue. See also Imrohoroglu and Kitao (2010) and references therein for analyses of uncertain health expenditures and the impact on financing retirement consumption.

Another avenue for the government is to issue a large amount of debt, which people can buy when young and sell during their retirement. The debt is used to smooth consumption over one's lifetime. In a model calibrated to U.S. data, Birkeland and Prescott (2007) find that the needed quantity of debt is about 5 times GNP—much larger than that observed in any advanced nation.[7] In this paper, we restrict the quantity of debt that the government can issue to be no greater than about 50 percent of GNP. We view this more as a political restriction than as an economic one. But, given the capital stock in our analysis is much larger than that used in Birkeland and Prescott (2007), we find that there is no need for large government debt with a savings-for-retirement system, even if the number of workers per retiree falls significantly.[8]

3. The Model Economy Used

The model economy has an overlapping-generations structure with measure n_t^1 arriving working-age households at the beginning of date t. The year since entry into the workforce is called age and is denoted by j. The measure of age j households at date t is n_t^j. The maximum possible age is J. The probability of an age $j < J$ household at date t surviving to age $j+1$ is $\sigma_t^j > 0$. The n_t^1 are parameters that define the population dynamics. We restrict attention to

$$n_{t+1}^1 = (1 + \eta_t)\, n_t^1$$

with $n_0^1 = 1$ where η_t is the growth rate of households entering the workforce.

3.1. State vector

To simplify notation, we use the recursive competitive equilibrium language. Given that the economy is non-stationary, t is included as an element of the aggregate state vector. All stocks are beginning of period stocks. The variables that define the aggregate state vector s are as follows:

(i) $t = 0, 1, 2, \dots,$ is the time period.

[7] Prescott (2004) also considers a reform of the U.S. Social Security system that requires a large amount of debt to finance the transition.

[8] The problem is not that the aging population will lead to over-accumulation of capital with a savings-for-retirement system. Absent forced savings, there cannot be an equilibrium with over-accumulation of capital if debt contracts are permitted. This was established by Thompson (1967, p. 1206). Abel et al.'s (1989) findings that over-accumulation of capital was not the case in the United States in the period they examined hold for the economies and policies we consider.

(ii) $\{a^j, n^j\}$ are the assets a^j (net worth) of an age j household and n^j the measure of age j households.

(iii) B is the government debt owned by the private sector.

(iv) K_{T1} and K_{T2} are the aggregate tangible capital stocks for the two business sectors (described below).

(v) K_{I1} and K_{I2} are the aggregate intangible capital stocks for the two business sectors.

Two business sectors are needed because different legal categories of businesses are subject to very different tax systems and, as a consequence, the market values of their equity and net debt relative to their capital stock are different. The empirical counterpart of sector 1 is Schedule C corporations, which are subject to the corporate income tax. Schedule S and other corporations that distribute all profits to owners, unincorporated businesses, and household businesses are in sector 2. Government enterprises and the government production sector are in sector 2 as well.

3.2. Prices and policy

The relevant equilibrium *price* sequences for the households are interest rates $\{i_t\}$ and wage rates $\{w_t\}$.

Policy specifies the following sequences:

(i) Tax rates $\tau = \{\tau_t^c,\ \tau_{1t}^d,\ \tau_{2t}^d,\ \tau_t^\ell,\ \tau_{1t}^\pi\}$, where c denotes consumption, d distributions from businesses to their owners, ℓ labor or actually payroll, and π profits. Note that sector 2 businesses are not subject to the corporate profit tax and must distribute all their profits to their owners.

(ii) Age-dependent lump-sum transfers to households $\{\psi_t^j\}$.

(iii) Government debt $\{B_t\}$.

(iv) Pure public good consumption $\{G_t\}$.

Constraints on the stock of government debt relative to GNP are $B_t \leq \phi_{Bt} GNP_t$, where ϕ_{Bt}

are policy-constraint parameters. The motivation for this constraint is that empirically governments have limited ability to commit to honor their sovereign debt promises. The final set of policy variables is the public goods consumptions $\{G_t\}$, which are given fractions of GNP: $G_t = \phi_{Gt} GNP_t$.

3.3. The households' problem

Savings are in the form of an annuity which makes payments to a cohort in their retirement years conditional on them being alive. All in a cohort enter symmetrically and there are no non-convexities. Consequently, all retirees of a given age at a point in time agree as to their optimal retirement distribution. Effectively the return on savings depends upon the survival probability as well as the interest rate.

Symbol ℓ denotes labor services of a household. Aggregate labor supply L is

$$L = \sum_j n_j \ell_j.$$

The value function of an individual of age $j \in \{1, 2, \ldots, J\}$ satisfies

$$v_j(a, s) = \max_{a', c, \ell \geq 0} \{u(c, \ell) + \beta \sigma_t^j v_{j+1}(a', s')\}$$

subject to

$$a' \sigma_t^j = (1 + i_t) a + \left(1 - \tau_t^{\ell}\right) w_t \ell - (1 + \tau_t^c) c + \psi_t^j$$

$$s' = F(s).$$

The prime denotes the next period value of a variable and $v_{J+1} = 0$.[9] Households with $j > J_R$ are retired and their ℓ's are zero. Note also that a component of the state is t. The equilibrium law of motion of the aggregate state variable F is taken as given by the private agents.

3.4. Technology

There is a sector that is subject to the corporate income tax and that produces intermediate good Y_{1t} and a sector that produces intermediate good Y_{2t}. The aggregate production function of the composite final good is

$$Y_t = Y_{1t}^{\theta_1} Y_{2t}^{\theta_2},$$

[9] Later, we explore the impact of two assumptions made here, namely perfect annuity markets and fixed labor productivities over the life cycle, and show that they do not impact our main quantitative results.

where the exponents are positive and sum to 1.

The aggregate sectoral production function is Cobb-Douglas with inputs of tangible capital K_{iTt}, intangible capital K_{iIt}, and labor L_{it}:

$$Y_{it} = K_{iTt}^{\theta_{iT}} K_{iIt}^{\theta_{iI}} \left(\Omega_t L_{it}\right)^{1-\theta_{iT}-\theta_{iI}}$$

for $i = 1, 2$. The labor-augmenting technical level at date t in both sectors is Ω_t, which grows at rate γ, so

$$\Omega_{t+1} = (1 + \gamma)\, \Omega_t.$$

Capital stocks depreciate at a constant rate, so

$$K_{iT,t+1} = (1 - \delta_{iT})\, K_{iTt} + X_{iTt}$$

$$K_{iI,t+1} = (1 - \delta_{iI})\, K_{iIt} + X_{iIt},$$

for $i = 1, 2$, where T and I denote tangible and intangible, respectively, and X is investment. Depreciation rates are denoted as δ and are indexed by sector and capital type. The resource balance constraint is

$$Y_t = C_t + X_{Tt} + X_{It} + G_t,$$

where $X_{Tt} = \sum_i X_{iTt}$ and $X_{It} = \sum_i X_{iIt}$.

3.5. Government budget constraints

Some notation must be set up before the law of motion for government debts can be specified. The prices of the intermediate good relative to the final good are p_{1t} and p_{2t}. Accounting profits of Schedule C corporations are given by

$$\Pi_{1t} = p_{1t} Y_{1t} - w_t L_{1t} - X_{1It} - \delta_{1T} K_{1Tt}$$

and distributions to its owners are

$$D_{1t} = (1 - \tau_{1t}^{\pi})\, \Pi_{1t} - K_{1T,t+1} + K_{1Tt}.$$

Other business distributions to its owners are

$$D_{2t} = \Pi_{2t} = p_{2t} Y_{2t} - w_t L_{2t} - X_{2It} - \delta_{2T} K_{2Tt}.$$

We can now specify the law of motion of government debt. It is

$$B_{t+1} = B_t + i_t B_t + \sum_j n_t^j \psi_t^j + G_t - \tau_t^c C_t - \tau_{1t}^\pi \Pi_{1t} - \tau_{1t}^d D_{1t} - \tau_{2t}^d D_{2t} - \tau_t^\ell w_t L_t.$$

Thus, next period's debt is this period's debt plus interest on this period's debt, plus transfers, plus public consumption, minus tax revenues. Taxes are levied on consumption, on profits of Schedule C corporations, on distributions of Schedule C corporations to their owners, on distributions of other business firms to their owners, and on labor income.

Later, when we compare model predictions to data, we use income-weighted marginal tax rates and, thus, include implicit transfers in our measure of the household transfers ψ^j. To be more concrete, consider two examples. First, if marginal tax rates exceed average rates, we assume that a household earning wage income $w\ell$ earns $(1 - \tau^{\text{marg}})w\ell$ in after-tax wages and receives implicit transfers of $(\tau^{\text{marg}} - \tau^{\text{avg}})\ w\ell$, where τ^{marg} and τ^{avg} are the marginal and average tax rates, respectively. Another example is fringe benefits. Suppose fringe benefits in the amount f are deducted from household wages. In this case, we model the after-tax wages as $(1 - \tau^\ell)w\ell$ and the implicit transfers households receive as $\tau^\ell f$, where τ^ℓ is the tax rate on labor.

3.6. Equilibrium conditions

Equilibrium conditions are

(i) Labor, capital, and goods markets clear at each point in time.

(ii) The household policy functions $\{a' = f_j(s)\}_j$ imply the aggregate law of motion $s' = F(s)$.

4. The Accounts for the Economies

We choose parameters of the model so that the balanced growth path of our baseline model is consistent with averaged values in the U.S. national accounts and fixed asset tables over the period 2000–2010.[10] Here, we describe adjustments that are made to the accounts so that they better conform to the theory used to construct the model economy.

[10] The primary sources of data are the U.S. Department of the Treasury (1918–2012), the U.S. Department of Commerce (1929–2012), the Board of Governors (1945–2012), and Bell and Miller (2005). In McGrattan and Prescott (2013) we provide further details about constructing the model accounts. Some parameter estimates are based on IRS data that are only available through 2010.

4.1. NIPA Accounts

The numbers in Table 1 are annual averages from the U.S. national income and product accounts with several adjustments made to NIPA GNP.[11] Adjusted GNP is equal to NIPA GNP after subtracting sales tax and adding imputed capital services for consumer durables and government capital. Thus, unlike NIPA, we are consistent in using business sector prices and in treating consumer durables and government capital like other investments when constructing the national income and product accounts.

We categorize income as "labor" or "capital." *Labor income* includes compensation of employees plus part of proprietors' income and comprises 59 percent of total adjusted income. *Capital income* includes all other NIPA categories of income, except the sales tax part of taxes on production and imports. The rental income of consumer durables is imputed and added to capital income. Specifically, we add consumer durables depreciation to NIPA depreciation and impute consumer durables rents less depreciation to the rental income of households. The imputed income is the product of the average after-tax real return on non-consumer durable capital and the current-cost net stock of consumer durables. Services of government capital are also imputed and added to capital income; they are estimated to be the product of the average after-tax real return on non-public capital and the current-cost net stock of government capital. We do not add depreciation of government capital since it is already included in NIPA depreciation. We use an after-tax real return of 4 percent when imputing income for both durables and government capital.

On the product side, we consolidate expenditures into three categories: consumption, tangible investment, and defense spending. *Consumption* includes private consumption of nondurables and services and the nondefense spending portion of NIPA government consumption, with adjustments made for sales tax and imputed capital services.[12] Consumption measured this way comprises 74 percent of total adjusted product. *Tangible investment* includes gross private domestic investment, consumer durables, the nondefense portion of government investment, net exports, and net foreign income, with an adjustment made for sales taxes on consumer durables. This category is 21

[11] Throughout, we are using data definitions prior to the BEA's 2013 comprehensive revision, which will not be fully completed until early 2014.

[12] We assume all sales taxes in NIPA are assessed on consumption, with pro rata shares attributed to nondurables, services, and durables.

percent of adjusted total product. To estimate the division of gross private domestic investment into investment of Schedule C corporations (which we earlier categorized as sector 1 business) and all other private business, we use balance-sheet data of corporations from the IRS and Flow of Funds. Specifically, we assume the ratio of investments is equal to the ratio of depreciable assets and, therefore, assume that that 83.5 percent of corporate investment is made by Schedule C corporations. The remainder is included with noncorporate investment. *Defense spending*—which we label G throughout—is NIPA's national defense concept and is a little over 4 percent of total adjusted product.

Here, we have included nondefense government consumption in our measure of consumption and nondefense government investment in our measure of tangible investment. Later, we assume that nondefense expenditures is part of lump-sum transfers made to households. Nondefense expenditures include expenditures on general public service, public order and safety, transportation and other economic affairs, housing and community services, health, education, and welfare and, when added up, is about 13.6 percent of adjusted GNP for the period 2000–2010. Transfers, as they are categorized by the BEA, are smaller, about 12.6 percent of adjusted GNP over the period 2000–2010. More than half of these transfers are Social Security and Medicare, which together add up to 6.6 percent of adjusted GNP. Later, when we consider policies eliminating transfers for Medicare and Social Security, we always assume that the other transfers along with nondefense government spending are not cut; added together, these categories are 19.6 percent of adjusted GNP.

4.2. Fixed Asset Tables

The revised fixed asset tables are reported in Table 2 for the period 2000–2010. The stocks of tangible capital categorized as private and public fixed assets and consumer durables are values of reproducible costs reported by the BEA in its fixed asset tables. These stocks are 3.1 times adjusted GNP. To derive an estimate of the total tangible capital stock, we add the value of inventories from the NIPA accounts and the value of land from the Flow of Funds balance sheets. We include land in the tangible capital stock because it is in large part a produced asset associated with real estate development.[13] With these additions, the total tangible capital stock is 4.1 times our measure of adjusted GNP.

To derive an estimate of the total capital available for financing retirement consumption, we add the value of intangible capital owned by private businesses as estimated by McGrattan and Prescott (2010). The stock of business intangible stock is large, averaging about 1.7 GNPs over the ten-year period 2000–2010. We do not include human capital owned by individuals in our measure of the capital stock because retired people do not rent their human capital to the business sector and cannot sell it in order to finance retirement consumption.[14] Notice that the total stock in Table 2 is 5.8 times adjusted GNP, almost twice as large as the stock of reproducible assets reported in the BEA's fixed asset tables.[15]

5. Parameters

Table 3 reports the parameters used in the baseline economy—the economy with current U.S. demographics and current U.S. policies. These parameters imply that the model's balanced growth path is consistent with U.S. statistics.[16]

The first set of parameters govern demographics. For the baseline economy, we set the growth rate of the population equal to 1 percent and the work life to 43 years. We chose these parameters because they imply that the ratio of workers to retirees is 3.39, which is equal to the ratio of full-time equivalent workers to the number of people age 65 and over. We used BEA estimates in the NIPA accounts for the number of full-time equivalent workers and Census data for population by age.

The preference parameters are chosen so that the model's labor input and labor share are

[13] See Rossi-Hansberg and Wright (2007) for introducing developers into a competitive equilibrium model with endogenous cities. The BEA does not include land as a component of fixed assets at reproduction costs because they do not have good measures of these costs. The lack of measures of the value of land at reproduction costs is why we use market values in our capital stock number.

[14] The stock of human capital is large with just that part acquired on the job at around 2 times GNP according to independent estimates of Heckman, Lochner, and Taber (1998) and Parente and Prescott (2000). Abstracting from this stock would not be appropriate when addressing some other questions.

[15] It is standard in the literature to include only fixed assets reported by the BEA. Later, we discuss how our results change if we did the same.

[16] See McGrattan and Prescott (2013) for full details on data sources.

consistent with that of the United States. Using data from the Current Population Survey (CPS), we find that total hours of work relative to the working-age population averaged 1,442 hours per year. If discretionary time per week is 100 hours, then the fraction of time at work is 0.277. Assuming logarithmic preferences, namely,

$$u(c, \ell) = \log c + \alpha \log(1 - \ell),$$

we set α equal to 1.143 to get the same predicted hours of work for the model. In addition, we set $\beta = 0.987$, so that the model's predicted division of income into labor and capital matches that of the U.S. accounts shown in Table 1.

The technology parameters in Table 3 govern technological growth, investment rates, and capital income shares across business sectors. The growth rate of labor-augmenting technology is set equal to 2 percent which is consistent with trend growth in the United States. The share parameter in the aggregate production function θ_1—which determines the relative share of income to Schedule C corporations—is set equal to 1/2. This is somewhat arbitrary because we do not have detailed NIPA data covering only Schedule C corporations. Instead, we have information on receipts and deductions from corporate tax returns and base our estimate on these data. In McGrattan and Prescott (2013) we experiment with varying this parameter.

The choice of tangible capital shares (θ_{1T}, θ_{2T}) and tangible depreciation rates (δ_{1T}, δ_{2T}) ensures that the model's investments and fixed assets line up with tangible investments and stocks reported by the BEA and Flow of Funds. As we noted earlier, we use data from the IRS on depreciable assets of Schedule C corporations to determine the relative quantities of investments and fixed assets for the model's two sectors. Doing so, we estimate tangible capital shares of $\theta_{1T} = 0.181$ and $\theta_{2T} = 0.502$ in the two sectors. The annual depreciation rates which generate investment rates consistent with U.S. data are $\delta_{1T} = 0.051$ and $\delta_{2T} = 0.015$. The high capital share and low depreciation in sector 2 follow from the fact that we have included housing and land.

The intangible capital shares and depreciation rates, θ_{1I}, θ_{2I}, δ_{1I}, δ_{2I} are not uniquely identifiable with the data we have. For the baseline model, we assume that 2/3 of the intangible capital is in Schedule C corporations and 1/3 in other businesses, and we set the depreciation rates on intangible capital equal to that of tangible capital in Schedule C corporations. In McGrattan and

Prescott (2013), we do extensive sensitivity analysis and find that the results are not sensitive to the allocation of intangible stocks across sectors, but rather to the aggregate stock of capital available for retirees to finance consumption.

The last set of parameters in Table 3 are the policy parameters. We set the level of government consumption equal to 0.044 times GNP for all periods, that is, $\phi_{Gt} = 0.044$ for all t. This is the average share of military expenditures in the baseline economy for the ten-year period 2000–2010. We set the maximum debt constraint parameter ϕ_{Bt} equal to the average ratio of U.S. government debt to GNP for 2000–2010. Thus, $\phi_{Bt} = 0.533$ for all t. When we consider changing tax and transfer policies, we hold the spending and debt shares fixed.

Tax rates are listed next in Table 3. There are two categories of businesses that are subject to different taxation. The first category are Schedule C corporations that are subject to the corporate income tax. The statutory corporate income tax rate τ_1^π is about 40 percent for the United States when federal and state taxes are combined. However, the total revenues recorded by the IRS indicates that that the effective tax rate is lower, on the order of 33 percent, which is the rate we use here.[17]

There is an additional tax on distributions τ_1^d paid by investors in these corporations, where distributions are in the form of dividends and share buy-backs. We use an estimate of 14.4 percent, which is the equal to the average marginal rate as computed by the TAXSIM model times the fraction of equity that is in taxed accounts. (See Feenberg and Coutts (1993) for details on the TAXSIM model.) The average marginal rate that we use is that for 2013 (rather than an average over 2000–2010) because we want to take into account the expiration of policies under the Jobs and Growth Tax Relief Reconciliation Act. To calculate the fraction of equity that is in taxed accounts, we use two different methods that yield close to the same estimate. First, we compute the fraction of equity in pension funds, life insurance reserves, individual retirement accounts, and nontaxable accounts of nonprofits. The estimates are based on balance sheet data with equity detail from the U.S. Flow of Funds (Table B.100.e) and data on equity holdings in retirement accounts from the Investment Company Institute (2012). These data indicate that 44 percent of equity holdings are

[17] We include a portion of property tax revenues with corporate income revenues, using assessed land values to estimate the corporate share of revenues.

in nontaxable accounts. Second, we use NIPA and IRS data to compute the fraction of corporate dividends distributed to nontaxed entities.[18] These data indicate that 45 percent are in nontaxable accounts.

For the tax rates on other business distributions (τ_2^d) and labor (τ^ℓ), we use an estimate of the income-weighted average marginal tax rate on labor-like income based on calculations of Barro and Redlick (2011) extended with the TAXSIM model. Over the period 2000–2010, this rate is estimated to be 38.2 percent when federal, state, and FICA taxes are included.[19] The non-Schedule C corporations, which is our second category of businesses, include businesses that distribute their accounting earnings to their owners and whose earnings are treated as ordinary income for tax purposes. This business category includes unincorporated businesses and pass-through corporate entities, namely, Schedule S corporations, regulated investment companies (RICs), and real estate investment trusts (REITs). We add household and government businesses to this set. The primary output of household businesses is imputed rents of real estate and consumer durables that are used by the owning household. Owner-used real estate is subject to sizable property taxes in the United States. These property taxes are treated as taxes on the returns to property used in a business. The government production sector is not explicitly taxed, although there are some implicit taxes and transfers associated with government business.[20]

The remaining policies shown in Table 3 are the tax on consumption and transfers to households, which depend on equilibrium outcomes. In the case of the consumption tax, we set the rate residually at 10 percent to balance the government's budget constraint. In the case of transfers, we pre-set the ratio of transfers to GNP, which is an equilibrium outcome. Government transfers in the baseline economy are chosen to be 37 percent of GNP. Recall that our measure of transfers includes nondefense spending plus the usual government transfers, which is about 26 percent of GNP. Thus, we are assuming that the model transfers exceed NIPA nondefense spending and the

[18] In various issues of the BEA's *Survey of Current Business* (1929–2012), BEA estimates of personal income are compared to IRS estimates of adjusted gross income, with details of nontaxed distributions to pension funds, life insurance reserves, fiduciaries, and nonprofits.

[19] The composition of the 38.2 percent is 23.1 percent for federal taxes, 4.5 percent for state and local taxes, and 10.6 percent for FICA taxes.

[20] Since the value added of government business is small, we think just aggregating it with the non-corporate taxpaying sector is reasonable as it has a negligible effect on the quantitative findings reported in this paper. Our strategy is to develop and use as simple an abstraction as possible to answer the questions we are addressing. Even with this strategy the abstraction is far from simple and to model all of the unimportant details of the tax system would greatly complicate the analysis.

usual transfers by about 11 percent of GNP. We add these *implicit transfers* to the NIPA measures because we want the model's tax rates to be approximately equal to the income-weighted average marginal income tax rates for the U.S. tax system. We also treat the deduction of fringe benefits, which are about 25 percent of total compensation, as an implicit transfer. These categories add up to roughly 11 percent of GNP.[21] If all individuals receive an equal share of transfers—with the exception of Medicare and Social Security payments that are aimed at retirees—then the split of transfers is 23.4 percent of GNP for workers and 13.6 percent of GNP for retirees.

With estimates of tax rates and capital stocks, the total value of the business sector can be determined in the model, and when added to government debt, can be compared to estimates of private net worth in the U.S. Flow of Funds. With taxes, the market value of business equity is lower than the value of business capital less net business debt. Let V_i be the market value of business sector i. In this case, the following equilibrium relations are used to predict V_i:

$$\begin{aligned} V_1 &= \left(1-\tau_1^d\right) K'_{1T} + \left(1-\tau_1^d\right)\left(1-\tau_1^\pi\right) K'_{1I} \\ V_2 &= K'_{2T} + \left(1-\tau_2^d\right) K'_{2I}. \end{aligned}$$

The factor $(1-\tau_1^d)$ in the first equation is the cost of a unit of capital in terms of the composite output good. The factor $(1-\tau_1^\pi)$ affects the second term because intangible capital investments are expensed and this reduces taxable accounting profits.[22] For sector 2, all profits except those used to finance intangible capital investment are distributed to the households who own the businesses. The total value of the business sector is $V = V_1 + V_2$, which is the value of both net private business debt and equity held directly and indirectly. Theory predicts that private net worth equals business equity V plus government debt B.

The Flow of Funds reports estimates of net worth for the private sector that averaged 4.1 times adjusted GNP in the period 2000–2010. If the model data are consistent with values for U.S. fixed assets, tax rates, and government debt, then the predicted net worth is 5.4 times GNP. This follows from application of the formulas for V_1 and V_2. There are several factors that need

[21] Estimates of the difference between marginal and average tax rates based on the TAXSIM model are on the order of 12 percent, which yields roughly 7 percent of GNP in implicit transfers. Fringe benefits, if taxed, imply roughly 4 percent of GNP in implicit transfers.

[22] We are using the fact that the purchase price for tangible capital is approximately 1 since the capital consumption allowance adjustments of the period were small, as were investment tax credits and taxes on capital equipment.

to be considered when comparing predicted and reported private net worth. First, the stock of tangible capital in Table 2 includes about 0.6 GNPs of public fixed assets that are legally owned by the government and not included in the U.S. net worth reported in the Flow of Funds. Second, about 0.2 GNPs of government debt is foreign owned and not part of U.S. net worth reported in the Flow of Funds. Third, the stock market in the period considered is low relative to theoretical predictions by a significant amount. Fourth, our baseline model has no aggregate uncertainty and as a result there is no aggregate risk premium. Fifth, to estimate private net worth, the Federal Reserve must estimate the value of unincorporated businesses which are not publicly traded; owners of these businesses have an incentive to understate the true value. Given these considerations, the discrepancy between predicted and reported net worth is not large enough to cast doubt on the appropriateness of the model used in this analysis.

Table 4 compares the model's balanced growth predictions with the U.S. national accounts (Table 1), fixed asset tables (Table 2), and the labor input. The point of the comparison is to show that the baseline model is consistent with these key U.S. aggregate statistics.

6. Evaluation of Alternative Policies

We turn next to our policy experiments.[23] We start by analyzing a policy regime which is effectively a continuation of current U.S. policy of taxing labor and capital incomes and using part of the proceeds to finance consumption of retirees. Because of the falling number of workers per retiree, a continuation of this policy entails increasing one or more tax rates over time. In the experiments reported here, we assume that the consumption tax is increased in order to finance the additional old-age transfers.[24] We compare a continuation of current U.S. policy to variations on a saving-for-retirement regime. To start, we eliminate FICA taxes and the part of transfers to retirees that are neither welfare nor local public goods. We then set all capital taxes to zero. Finally, we consider an additional tax reform, which is to eliminate implicit transfers due to marginal tax rates increasing with income and deductions for fringe benefits.

[23] In McGrattan and Prescott (2013), we provide details of the algorithm used to compute equilibria.

[24] We also tried increasing the labor tax rate but could not raise sufficient funds to finance all of the additional old-age transfers due to the significant decline in labor input.

In this section, we report the welfare consequences for these alternative policy regimes given the initial state is the one for the balanced growth path in the baseline economy of Section 4. At time $t = 0$, a demographic transition occurs and we determine the welfare consequences for each cohort alive at the time of the unexpected demographic and policy regime change and the welfare of all cohorts entering the workforce in years subsequent to the change. But first we examine the balanced growth impact of the policy and demographic changes.

6.1. Balanced growth comparisons

The upper panel of Table 5 summarizes the tax rates and transfers as we vary demographics and fiscal policies. The first column lists the policy parameters in the baseline economy with current U.S. policy and current U.S. demographics. (These are the same as in Table 4.) The current U.S. demographics has a population growth rate of 1 percent and a ratio of workers to retirees of 3.39.

The second column of Table 5 lists taxes and transfers under the current policy assuming demographic change occurs. Under the new demographics, we assume the population growth rate falls to zero and the ratio of workers to retirees is 2. Sticking with the current system necessitates an increase in the consumption tax from 10 percent to 14 percent. The share of GNP set aside for transfers to workers stays the same on a per capita basis—falling to 20.5 percent of GNP from 23.4 percent of GNP as the number of workers falls. Transfers to retirees increase as a share of GNP because a larger fraction of the population receives Medicare and Social Security transfers.

The policies associated with variations on a saving-for-retirement system with new demographics are shown in the last three columns of Table 5. In all, FICA taxes are eliminated as are the associated transfers for Medicare and Social Security. The third column shows the tax rates and transfers that would be used in the event that only these changes are implemented. Relative to a continuation of current policy, the labor tax is lower by 10.6 percentage points, which is the average marginal tax rate for FICA computed by Barro and Redlick (2011). Notice also that the transfers are only 30.3 percent of GNP, down from 36.9 percent of GNP under current U.S. policy. The difference reflects transfers for Medicare and Social Security which are eliminated in the saving-for-retirement systems.

The second variation of the saving-for-retirement system we consider eliminates taxes on profits and distributions. The corresponding taxes and transfers for this case are shown in column 4 of Table 5. Notice that the tax on consumption is much higher in this case. This is the rate needed to balance the government's budget with the taxes set to 0. The transfer to GNP ratios are the same as the case with only FICA taxes eliminated.

Finally, in column 5, we show the tax rates and transfers if implicit transfers are eliminated. Recall that implicit transfers of roughly 11 percent of GNP are added to NIPA measures to account for the fact that the model uses marginal rather than average tax rates and treats untaxed income such as fringe benefits as transfers. With implicit transfers eliminated, the income tax schedule is flattened, and marginal rates are set equal to average rates. In this case, the labor tax falls another 12 percentage points to 15.6 percent as shown in column 5. Further eliminating implicit transfers for fringe benefits implies a lower consumption tax rate, which is set residually.[25] This rate is 28 percent in the case that only old-age transfers are eliminated and falls to 23 percent if, in addition, implicit transfers are eliminated. The remaining transfers are not age-dependent and therefore, with the new demographics, two-thirds is given to workers and one-third to retirees.

Equilibrium outcomes for the different policy regimes are reported in the lower panel of Table 5. The first column is the same as the results for the baseline economy shown in Table 4. Note also that the equilibrium interest rate for this economy is 4.68 percent. The results of continuing current U.S. policy are reported in the second column of Table 5. With fewer workers the labor input falls roughly 9 percent and GNP falls roughly 6 percent. Consumption and capital shares rise, primarily because GNP falls. The welfare loss of continuing the policy is significant, roughly 4.7 percent in annual consumption.

The last three columns of Table 5 show the results for variations on the saving-for-retirement system with FICA taxes and old-age transfers eliminated. Several key findings emerge. Most notably, GNP, household net worth, and welfare are significantly higher for all three savings-for-retirement policy regimes than in the case that U.S. policy is continued. Including all three reforms, GNP is 44 percent higher than if the current policy is continued. The gains in household net worth are even greater, especially with capital taxes eliminated. Net worth is 86 percent higher if capital

[25] The ratios of defense spending and government debt to GNP are held at their baseline levels.

income taxes are cut, but not implicit transfers, and 114 percent higher if both capital taxes and implicit transfers are cut. When compared to a continuation of U.S. policy, the saving-for-retirement plans yield significant gains in welfare: 15 percent per year if FICA taxes and old-age transfers are eliminated, 18 percent if capital taxes are also eliminated, and 25 percent for the full tax reform with tax schedules flattened and the tax system broadened in addition.[26]

The huge gains in net worth are due in part to an increase in productive capital stocks and in part to the price of capital rising as capital taxes are cut. Because tangible capital is not expensed, we see a much larger rise in this stock relative to intangible capital when capital taxes are eliminated. The tangible capital stock to GNP ratio is in the range of 5.9 to 6 with capital taxes eliminated—much higher than the ratio of 4.2 found with a continuation of U.S. policy. On the other hand, the ratio of intangible capital to GNP is roughly 1.7 in the economies with and without capital taxation.

The impact of new demographics and new policy on total labor input depends on two offsetting factors: there are fewer workers but, with labor tax rates lower, greater incentives to work. If the only change is in the demographic composition, the labor input falls about 9 percent. This is the case with a continuation of U.S. policy with new demographics shown in column 2 of Table 5. If FICA taxes are eliminated, the labor input stays roughly as it was in the baseline economy. Further cuts in labor taxes that accompany the elimination of implicit transfers imply a 9 percent increase in the total labor input relative to the baseline value.

We next consider transitions from the baseline economy—with the current U.S. tax and transfer system and current demographics—to the four alternative policies with new U.S. demographics.

6.2. Welfare comparisons by cohorts

A question that arises is, What are the welfare consequences in the transition to balanced growth? Do some birth-year cohorts lose? Answering these questions requires computing the equilibrium transition paths if the U.S. stays with the current policy and, alternatively, if it switches to a

[26] Later, we rerun our experiments in a one-sector model with only tangible capital and a capital stock to GNP ratio of 3 and show that welfare gains are roughly half of what we find here for the policy comparisons.

saving-for-retirement policy.[27] For the transition to all three versions of the saving-for-retirement policy, we show how to find paths for tax rates and transfers—that are nonnegative and vary smoothly over time—such that no cohorts lose during the transition.

In all cases, we start with the initial state in the baseline economy and hold the ratios of debt to GNP and defense spending to GNP fixed over time. The initial state is summarized by the level of government debt and the distribution of household asset holdings. The initial distribution of ages is determined by the parameters of the baseline economy and, in all transitions, we assume a linear decline in the population growth rate over first forty-five years.[28] The initial population, the path of population growth rates, and survival probabilities then determine the evolution of the distribution of ages.

Table 6 summarizes key variables on the transition paths as the economy transitions from the current demographics to the new demographics. There are four future policies considered, with the eventual balanced growth paths summarized earlier. (See Table 5.) The first transition, which is a continuation of U.S. policy, is shown in Part A of Table 6. Components of the government budget constraint are shown first as a share of GNP, national account and fixed assets are shown next, again as a share of GNP, and then we have levels of several key variables in the last rows of the table.

The main policy changes are increases in transfers for the retirees and increases in consumption taxes to finance them, where the latter is residually determined to satisfy the government budget constraint. The rate of increase in transfers for Medicare and Social Security is a function of the rate of increase in the retiree population. More specifically, let r_t be the fraction of the population that is retired in year t, and let z_t be the ratio of new retirees in period t relative to new retirees on the final balanced growth path, that is, $z_t = (r_t - r_1)/(r_\infty - r_1)$, which starts at 0 and rises to 1 over time. We assume that transfers for Medicare and Social Security paid to retirees are equal to $0.066 + 0.028\ z_t$ on the transition path, where 0.028 is the additional transfers needed on the new balanced growth path. Remaining transfers are equal to 0.303 GNPs, with fraction r_t of that paid

27 In McGrattan and Prescott (2013) we describe how we compute the transition paths using parallel computations.

28 We also considered more immediate changes in the growth rate and found the results are not sensitive to this choice.

to retirees and fraction $1 - r_t$ paid to workers in year t. The consumption tax revenues required to finance these transfers rise from 7.5 percent of GNP to 10.6 percent.

The continuation of U.S. policy is our reference point when conducting welfare analysis of saving-for-retirement policies that involve the elimination of FICA taxes and transfers for Medicare and Social Security. For the sake of comparison, we present details of the transition for a continuation of current policy in Table 6A. Our goal here is to show that it is possible switch from this policy, by reducing FICA taxes and old-age transfers, in such a way that is welfare-improving for all birth-cohorts.

We do this step by step in order to provide intuition for the transition path that we report. The step-by-step construction is illustrated in Figure 1. The path marked 'Step 1' shows the welfare gains—and, for some birth cohorts, losses—of eliminating FICA taxes and old-age transfers gradually. The welfare measure that we use is remaining lifetime consumption equivalents of cohorts by age at the time of the policy change. The decline in the both the labor tax rate and the share of transfers to retirees occurs at the rate of decrease in the ratio of new workers to eventual new workers (for example, $\tau_t^\ell = .382 - .106z_t$). In other words, they are gradually lowered.

Figure 1 shows that current retirees are indifferent between this gradual elimination of FICA taxes and old-age transfers and the continuation of current U.S. policy because their benefits are not affected. Furthermore, since labor tax rates remain temporarily high at 38 percent, there is no need for consumption tax rates to rise to make up any revenue shortfall. However, current workers and some future workers face the higher tax rates on labor when they are working but receive lower transfers by the time they reach retirement. Relative to a continuation of current policy, they are worse off.

Consider next a variation on that transition path with old-age transfers gradually reduced as before and FICA taxes immediately eliminated. The welfare results for this case are shown in the line marked 'Step 2' of Figure 1. Notice that many of the cohorts with welfare losses in the first step have welfare gains when the tax rates are immediately eliminated. They can take full advantage of the lower tax rates. Notice, however, that the current retirees are worse off now. They are worse off because consumption tax rates have to rise to make up the shortfall in revenue with lost revenue from FICA taxes, and they are retired so they cannot take advantage of lower tax rates on wages.

The third step in the construction of a pareto-improving transition path involves a change that makes both current retirees and current workers better off and does so by *temporarily* cutting some implicit transfers to workers. We do this without eliminating any government spending on public goods and services and transfers other than Medicare and Social Security. Recall that transfers—when nondefense spending is included—are equal to 37 percent of GNP. Spending on Medicare and Social Security are 6.6 percent of GNP, spending on public goods and services other than Medicare and Social Security is 19.6 percent of GNP and the rest, roughly 11 percent of GNP, is implicit transfers, which account for the difference between what tax revenues would be if all income were taxed at income-weighted marginal taxes and what the IRS actually collects.

The line marked 'Step 3' in Figure 1 shows the welfare gains if we temporarily reduced workers' implicit transfers, which is equal to the fraction of the population working times 11 percent of GNP. We assume that the transfers are restored at the same rate that the population of retirees increases, that is, they rise at the same rate as z_t. What we see in this case is a large welfare gain for current retirees because the tax rate on consumption can be lowered relative to the regime with a continuation of the current U.S. taxes and transfers. In fact, if we only lowered the workers' implicit transfers in half temporarily, we would still find a Pareto improving transition. Notice that some current workers and new cohorts would rather not eliminate these transfers, but all would agree that the policy is better than continuing with current U.S. policy.

In Table 6B, we show the transition path for the case that implicit transfers are temporarily reduced by half. We also show the welfare gains by cohort for this case in Figure 2 (solid line). The data shown in Table 6 provide us with an idea of why this policy change is desirable for all cohorts. The impact of the immediate drop in labor tax rates outweighs the impact of a modest rise in consumption tax rates; there is an 8 percent rise in the labor input, a 5 percent rise in GNP and a 4 percent rise in net worth in the first decade. Multiplying the consumption share of 72.8 percent of GNP, we find aggregate consumption is equal to 76.4—which is 3 percentage points higher than the case that U.S. policy is continued. (Compare Table 6, Parts A and B.) As transfers for retirees are phased out, we see that the labor input falls back to the baseline level, while GNP and household net worth steadily rise. At the end of the transition, which is the last column of Table 6B, GNP is higher by 12 percent and net worth is higher by 23 percent, confirming what we found earlier in the balanced growth calculations.

The next major tax reform that we consider is the elimination of taxes on profits and distributions. Based on the lessons of the first reform—with just FICA taxes and old-age transfers eliminated—we choose the paths for non-capital tax rates and transfers as before and then gradually eliminate capital taxes. This choice avoids having to increase consumption tax rates early in the transition to make up for lost revenue and it avoids spikes in interest rates. The specific paths for capital tax rates that we use are of the form $\tau - \tau z_t$, where $\tau = 0.33$, 0.144, and 0.382, respectively, for the rate on Schedule C profits, the rate on Schedule C distributions, and the rate on other business distributions.

The results of this experiment are shown in Table 6, Part C and in Figure 2. Comparing these results to the case with capital tax rates held fixed, we see that the early part of the transition is by design almost the same. As a result, the welfare impact for the cohorts alive at the time of the policy change is quantitatively close. As the capital tax rates drop, we find a large increase in tangible capital. As we noted earlier, because intangible capital is expensed from profits, the stock does not rise as much as the stock of tangible capital when tax rates are lowered. In addition, wages are higher and labor input lower over the transition than they were in the case with capital tax rates fixed.

The final reform assumes that implicit transfers are permanently eliminated on the new balance growth path and tax rates on labor fall gradually from 27.6 percent to 15.6 percent (that is, $\tau_t^\ell = .276 - .12z_t$). The difference in tax rates is the estimated difference in marginal and average tax rates. In this case, the transfers on the new balanced growth path are equal to 19.6 GNPs and include only the categories of nondefense spending and transfers other than Medicare and Social Security that are usually included in NIPA measures. The results of this experiment are shown in Table 6, Part D and Figure 1.

Notice first that the tax revenues on labor are a little more than 16 percent of GNP (or, 27.6 percent of the labor share) at the start of the transition and eventually fall to about 9 percent of

GNP (or, 15.6 percent of the labor share). Revenues for the consumption tax, which are residually determined, are a little above 9 percent of GNP at the start and rise to 16 percent. In other words, this reform assumes a shift from labor taxation to consumption taxation with little change in policy at the start of the transition. The impact on welfare, shown in Figure 1, is large in terms of annual consumption for future cohorts when compared to the policy of continuing U.S. policy. Gains for future cohorts are roughly 25 percent.

In sum, we show how to construct a welfare improving path when switching from the current U.S. tax and transfer system to a saving-for-retirement system. The gains to future generations of doing so are large.

6.3. Sensitivity of the Results

How sensitive are these results to our model parameters? For variations on the model employed above—which we refer to as the *benchmark model*—we rerun our numerical experiments. We consider a number of variations on this benchmark model. We shut down annuities markets. We introduce life-cycle variation in productivities using Hansen's (1993) efficiency weights. We explore positive tax rates on capital instead of eliminating them entirely. We allow for a more flexible utility function, namely,

$$u(c,\ell) = \log c + \alpha (1-\ell)^{1-\zeta} / (1-\zeta)$$

which nests the benchmark model if we set $\zeta = 1$. Finally, we analyze a one-capital, one-sector version of the model with parameters chosen so that the total capital stock is 3 times GNP. In all versions of the model, with the exception of the one-sector version, we recalibrate parameters to match the data in NIPA and the Flow of Funds. In the one-sector version, we set the capital share equal to 0.33, the discount factor equal to 0.99, and the depreciation rate equal to 0.06.

The results for the balanced growth gains are reported in Table 7.[29] The first row of Table 7 is the benchmark economy with results matching the last line of Table 5. The second row shows the case without annuity markets. The eventual gains are higher than in the benchmark. Welfare gains with all reforms are 28 percent. The third row has the case with age-dependent productivities

[29] Analogues of Table 6 and Figure 1 are reported in McGrattan and Prescott (2013) and summarized here.

based on Hansen (1993). The eventual gains are only slightly lower than in the benchmark. With eventual profits tax rates positive, at 12 or 4 percent, we do not find an increase in welfare. Because of the finite lifetime, there is no guarantee that welfare will be highest at zero, but for our model the peak in balanced growth welfare occurs at roughly 1/2 of one percent. For the results listed under "lower labor elasticity" we chose $\zeta = 2$, which implies a Frisch elasticity that is 1/2 of that used in the benchmark. Here we see some fall in the welfare gains but they are still much larger than typical estimates.

Typical estimates are those of a one-sector model with the tangible capital stock equal to roughly 3 times GNP and no intangible capital. The welfare gains of this case are shown in the last row of Table 7. The predicted loss of continuing with current U.S. policy is about 2 percentage points higher and the predicted gains of switching to a saving-for-retirement system are roughly half of that found with benchmark parameters. With the capital stock at 3, we find much smaller welfare gains to switching to a saving-for-retirement system, even in the first experiment with only FICA taxes eliminated. The gains are 8 percent versus 15 percent in the benchmark. When capital taxes are eliminated, the gains in the one-sector model hardly rise—a difference of only 0.7 percentage points—while we find a difference close to 3 percentage points with our benchmark parameters. With all three reforms, we find a welfare gain of roughly 13 percent in the one-capital, one-sector version of the model and a 25 percent gain in our benchmark.

What about welfare, cohort by cohort, during the transitions? In all cases, we can construct Pareto-improving transitions. When we shut down annuity markets, vary life-cycle productivities, and vary the final profits tax rates, the same paths for taxes and transfers can be used as shown in Table 6. When we cut the labor elasticity in half, we need to reduce workers' implicit transfers in the early stages of transition a little more than we did with the benchmark parameters because workers are less responsive to changes in the tax rate on labor. In the one-sector model with the productive capital stock at 3, we only need to modify the phase in of taxes and transfers slightly in the case that all three reforms are instituted. But, overall, the impact on existing cohorts is relatively similar across all numerical experiments.

In summary, we find that including all capital available to retirees for financing their retirement consumption and distinguishing between different taxes on profits and distributions is quantitatively important when deciding whether to abandon tax and transfer schemes currently used in the United States in favor of a private saving scheme.

7. Summary

A looming problem in the United States and many other nations is the financing of retirement as the population ages. We find that the fall in the number of workers per retiree can be handled without major change in the retirement financing scheme. However, there are tax policy changes that dramatically increase welfare. These changes entail lowering or eliminating income taxes and relying more on saving for retirement and less on lump-sum transfers to retirees. The broadening of the (non-human) capital stock is important for our analysis as is requiring the model to be consistent with both the national accounts and the fixed asset tables. Estimates of welfare gains for switching from the current system to a saving-for-retirement system are roughly twice as large as those found with typically used macroeconomic models.

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TABLE 1. REVISED NATIONAL INCOME AND PRODUCT ACCOUNTS, AVERAGES RELATIVE TO ADJUSTED GNP, 2000–2010[a]

TOTAL ADJUSTED INCOME	1.000
Labor Income	.585
Compensation of employees	.531
Wages and salary accruals	.433
Supplements to wages and salaries	.099
70% of proprietors' income with IVA, CCadj	.053
Capital Income	.415
Corporate profits with IVA and CCadj	.073
30% of proprietors' income with IVA, CCadj	.023
Rental income of persons with CCadj	.017
Surplus on government enterprises	.000
Net interest and miscellaneous payments	.056
Net income, rest of world	.007
Taxes on production and imports[b]	.072
Less: Sales tax	.042
Consumption of fixed capital	.117
Consumer durable depreciation	.060
Imputed capital services[c]	.037
Statistical discrepancy	−.004
TOTAL ADJUSTED PRODUCT	1.000
Consumption	.743
Personal consumption expenditures	.655
Less: Consumer durable goods	.081
Less: Imputed sales tax, nondurables and services[b]	.035
Plus: Imputed capital services, durables[c]	.013
Government consumption expenditures, nondefense	.111
Plus: Imputed capital services, government capital[c]	.025
Consumer durable depreciation	.060

See footnotes at the end of the table.

Table 1. Revised National Income and Product Accounts, Averages Relative to Adjusted GNP, 2000–2010[a] (Cont.)

Tangible investment	.211
Gross private domestic investment[d]	.145
Schedule C corporations	.069
Other private business	.076
Consumer durable goods	.081
Less: Imputed sales tax, durables[b]	.005
Government gross investment, nondefense	.025
Net exports of goods and services	−.042
Net income rest of world	.007
Defense spending	.044
Government expenditures, national defense	.044
Addendum:	
NIPA GDI	.942
NIPA GDP	.938
NIPA GNP	.945
Adjustments to NIPA GNP	.055

Note: IVA, inventory valuation adjustment; CCadj, capital consumption adjustment; NIPA, national income and product accounts; FA, fixed assets; FOF, flow of funds.

[a] The source of the data are the NIPA and fixed asset tables published by the BEA prior to the 2013 comprehensive revision.

[b] This category includes business transfers and excludes subsidies.

[c] Imputed capital services are equal to 4 percent times the current-cost net stock of government fixed assets and consumer durable goods.

[d] The corporate share of gross private domestic investment is 56.5 percent. To determine the share of Schedule C corporations, we assume that the ratio of investments for these corporations and all other corporations is the same as the ratio of their depreciable assets. Based on balance sheet data from the IRS corporate tax returns, this would imply that 83.5 percent of corporate investment is made by Schedule C corporations.

Table 2. Revised Fixed Asset Tables with Stocks End of Period, Averages Relative to Adjusted GNP, 2000–2010[a]

Tangible Capital	4.117
Fixed assets, private[b]	2.193
Schedule C corporations	.674
Other private business	1.519
Fixed assets, government	.602
Consumer durables	.304
Inventories[b]	.134
Schedule C corporations	.103
Other private business	.031
Land[b]	.885
Schedule C corporations	.109
Other private business	.776
Nonfinancial corporate	.022
Nonfinancial noncorporate	.298
Households and nonprofits	.455
Intangible Capital	1.718
Total	5.835

[a] The sources of data on tangible capital stocks are the fixed asset tables published by the BEA prior to the 2013 comprehensive revision, corporate tax returns published by the IRS, and the flow of funds accounts published by the Federal Reserve. The intangible capital stocks are estimates from McGrattan and Prescott (2010).

[b] The corporate shares of private fixed assets, inventories, and land are 36.8 percent, 92.1 percent, and 15.0 percent, respectively. In the case of inventories, we assume that 13 percent of farm inventories are corporate based on the ratio of corporate farmland and buildings relative to total corporate stocks reported in Table 828 of the *U.S. Statistical Abstract,* 2012. To determine the share of Schedule C corporations, we assume that the ratio of stocks for these corporations and all other corporations is the same as the ratio of their depreciable assets. Based on balance sheet data from the IRS corporate tax returns, this would imply that 83.5 percent of corporate capital is owned by Schedule C corporations.

Table 3. Parameters of the Economy Calibrated to U.S. Data

Demographic parameters	
Growth rate of population (η)	1%
Work life in years	43
Number of workers per retiree	3.39
Preference parameters	
Disutility of leisure (α)	1.143
Discount factor (β)	0.987
Technology parameters	
Growth rate of technology (γ)	2%
Income share, Schedule C corporations (θ_1)	0.500
Capital shares	
Tangible capital, Schedule C (θ_{1T})	0.181
Intangible capital, Schedule C (θ_{1I})	0.190
Tangible capital, other business (θ_{2T})	0.502
Intangible capital, other business (θ_{2I})	0.095
Depreciation rates	
Tangible capital, Schedule C (δ_{1T})	0.051
Intangible capital, Schedule C (δ_{1I})	0.051
Tangible capital, other business (δ_{2T})	0.015
Intangible capital, other business (δ_{2I})	0.051

Table 3. Parameters of the Economy Calibrated to U.S. Data (Cont.)

Policy parameters	
Spending and debt shares	
Defense spending (ϕ_G)	0.044
Government debt (ϕ_B)	0.533
Tax rates	
Profits, Schedule C corporations (τ_1^π)	0.330
Distributions, Schedule C corporations (τ_1^d)	0.144
Distributions, other business (τ_2^d)	0.382
Labor (τ^ℓ)	0.382
Consumption (τ^c)	0.100
Transfer-GNP ratios	0.369
To workers	0.234
To retirees	0.136

Table 4. Accounts and Factor Inputs for U.S. and Baseline Model Averages Relative to Adjusted GNP, 2000–2010[a]

	Model	Data
Total Income ($Y - X_I$)	1.000	1.000
Labor Income (wL)	.585	.585
Capital Income ($Y - wL - X_I$)	.415	.415
Total Product ($C + G + X_T$)	1.000	1.000
Consumption (C)	.745	.745
Tangible investment (X_T)	.211	.211
Schedule C corporations (X_{1T})	.069	.069
Other business (X_{2T})	.142	.142
Defense spending (G)	.044	.044
Capital Stock, End of Period (K')	5.835	5.835
Tangible capital (K'_T)	4.117	4.117
Schedule C corporations (K'_{1T})	.885	.885
Other business (K'_{2T})	3.232	3.232
Intangible capital (K'_I)	1.718	1.718
Labor Input (L)	.277	.277

Table 5. Balanced Growth Aggregate Statistics

	Current U.S.	Future Policies with New Demographics: Continue U.S. Policy	Eliminate FICA Taxes and: Medicare & Social Security	Plus cut Capital Taxes	Plus cut Implicit Transfers
Policy Inputs					
Tax rates					
Profits, Sched. C	.330	.330	.330	0	0
Distributions, Sched. C	.144	.144	.144	0	0
Distributions, other	.382	.382	.382	0	0
Labor	.382	.382	.276	.276	.156
Consumption	.100	.140	.097	.280	.230
Transfers to GNP ratios	.369	.397	.303	.303	.196
To workers	.234	.205	.205	.205	.132
To retirees	.136	.192	.098	.098	.063
Equilibrium Outputs					
Consumption share	.745	.783	.765	.717	.713
Labor income share	.585	.576	.580	.576	.577
Capital Stock to GNP	5.84	5.89	6.46	7.58	7.70
Tangible capital	4.12	4.17	4.63	5.87	5.97
Schedule C corps.	.885	.889	.959	1.09	1.10
Other business	3.23	3.28	3.67	4.78	4.89
Intangible capital	1.72	1.72	1.83	1.71	1.73
GNP[a]	1.00	0.94	1.12	1.27	1.44
Labor input	1.00	0.91	1.00	0.98	1.09
Household net worth[a]	1.00	0.95	1.23	1.86	2.14
Interest rate (%)	4.68	4.46	3.93	4.48	4.38
Welfare Gain (%)	4.7	0	15.4	18.1	24.9

Table 6. Transitions from Current U.S. Policy to New Policies

A. Continuing Current U.S. Policy with New Demographics

	2011-20	2021-30	2031-40	2041-70	2071-99	∞
Shares of GNP:						
Tax revenues	.422	.422	.423	.431	.447	.454
Profits, C corps	.026	.026	.026	.027	.028	.028
Distributions, C corps	.004	.004	.004	.005	.005	.005
Distributions, Other	.094	.094	.094	.094	.094	.094
Labor	.224	.223	.223	.222	.221	.220
Consumption	.075	.075	.076	.083	.099	.106
Transfers	.369	.369	.370	.376	.390	.397
To retirees	.143	.144	.145	.156	.181	.192
To workers	.226	.226	.225	.220	.210	.205
Interest on debt	.025	.025	.025	.024	.024	.024
Labor income	.585	.584	.583	.581	.578	.576
Capital income	.415	.416	.417	.419	.422	.424
Schedule C	.121	.122	.123	.125	.128	.129
Other business	.294	.294	.294	.294	.294	.295
Consumption	.743	.746	.751	.762	.777	.783
Tangible investment	.213	.210	.206	.195	.179	.174
Intangible investment	.135	.134	.132	.127	.120	.118
Defense spending	.044	.044	.044	.044	.044	.044
Tangible capital	4.15	4.15	4.15	4.15	4.17	4.17
Schedule C	.891	.890	.889	.888	.889	.889
Other business	3.26	3.26	3.26	3.27	3.28	3.28
Intangible capital	1.73	1.73	1.72	1.72	1.72	1.72
Levels:						
Fraction working	.745	.744	.742	.727	.692	.676
Interest rate (%)	4.63	4.62	4.61	4.56	4.48	4.46
Wage rate	1.01	1.01	1.01	1.02	1.03	1.03
Labor input	0.99	0.99	0.98	0.96	0.92	0.91
GNP	1.00	1.00	0.99	0.98	0.96	0.94
Net worth	1.00	1.00	1.00	0.99	0.97	0.95

See footnotes at the end of the table.

Table 6. Transitions from Current U.S. Policy to New Policies (Cont.)

B. FICA Taxes, Medicare, and Social Security Eliminated

	2011-20	2021-30	2031-40	2041-70	2071-99	∞
Shares of GNP:						
Tax revenues	.379	.381	.380	.375	.363	.357
Profits, C corps	.025	.025	.025	.025	.026	.026
Distributions, C corps	.003	.003	.003	.004	.004	.005
Distributions, Other	.095	.094	.094	.093	.092	.092
Labor	.162	.162	.162	.161	.160	.160
Consumption	.094	.096	.096	.091	.080	.075
Transfers	.329	.329	.328	.322	.309	.303
To retirees	.143	.143	.141	.131	.109	.098
To workers	.186	.186	.187	.191	.200	.205
Interest on debt	.026	.025	.024	.023	.022	.021
Labor income	.587	.587	.586	.584	.582	.580
Capital income	.413	.413	.414	.416	.418	.420
Schedule C	.119	.119	.120	.122	.124	.125
Other business	.294	.294	.294	.294	.294	.294
Consumption	.728	.731	.734	.741	.755	.764
Tangible investment	.229	.226	.222	.215	.201	.192
Intangible investment	.140	.139	.137	.134	.129	.126
Defense spending	.044	.044	.044	.044	.044	.044
Tangible capital	4.04	4.15	4.22	4.35	4.53	4.62
Schedule C	.874	.891	.902	.921	.946	.958
Other business	3.16	3.26	3.32	3.43	3.58	3.66
Intangible capital	1.70	1.73	1.75	1.78	1.81	1.83
Levels:						
Fraction working	.745	.744	.742	.727	.692	.676
Interest rate (%)	4.86	4.68	4.55	4.34	4.07	3.94
Wage rate	0.98	1.00	1.02	1.05	1.09	1.11
Labor input	1.08	1.08	1.08	1.06	1.02	1.00
GNP	1.05	1.07	1.08	1.11	1.12	1.12
Net Worth	1.04	1.08	1.11	1.16	1.21	1.23

See footnotes at the end of the table.

Table 6. Transition from Current U.S. Policy to New Policies (Cont.)

C. FICA Taxes, Capital Taxes, Medicare, and Social Security Eliminated

	2011-20	2021-30	2031-40	2041-70	2071-99	∞
Shares of GNP:						
Tax revenues	.379	.381	.380	.376	.366	.360
Profits, C corps	.025	.024	.022	.016	.006	.000
Distributions, C corps	.003	.003	.002	.002	.001	.000
Distributions, Other	.095	.093	.089	.068	.021	.000
Labor	.162	.163	.163	.163	.160	.159
Consumption	.095	.098	.103	.127	.178	.201
Transfers	.329	.329	.328	.322	.309	.303
To retirees	.143	.143	.141	.131	.109	.098
To workers	.186	.186	.187	.191	.200	.205
Interest on debt	.026	.025	.025	.026	.025	.024
Labor income	.588	.590	.592	.592	.581	.576
Capital income	.412	.410	.408	.408	.419	.424
Schedule C	.118	.117	.115	.114	.125	.129
Other business	.294	.294	.294	.294	.294	.295
Consumption	.727	.727	.723	.705	.694	.717
Tangible investment	.230	.230	.234	.252	.262	.240
Intangible investment	.141	.144	.147	.147	.126	.118
Defense spending	.044	.044	.044	.044	.044	.044
Tangible capital	4.04	4.16	4.27	4.62	5.37	5.87
Schedule C	.875	.897	.918	.977	1.06	1.09
Other business	3.17	3.26	3.35	3.65	4.32	4.78
Intangible capital	1.71	1.75	1.80	1.89	1.82	1.71
Levels:						
Fraction working	.745	.744	.742	.727	.692	.676
Interest rate (%)	4.87	4.72	4.69	4.78	4.76	4.48
Wage rate	0.98	1.00	1.03	1.10	1.22	1.28
Labor input	1.09	1.08	1.09	1.07	1.02	0.98
GNP	1.05	1.07	1.10	1.16	1.24	1.27
Net Worth	1.04	1.09	1.14	1.33	1.69	1.86

See footnotes at the end of the table.

Table 6. Transition from Current U.S. Policy to New Policies (Cont.)

D. FICA Taxes, Capital Taxes, Medicare, Social Security, and Implicit Transfers Eliminated

	2011-20	2021-30	2031-40	2041-70	2071-99	∞
Shares of GNP:						
Tax revenues	.379	.379	.375	.347	.283	.252
Profits, C corps	.025	.024	.022	.016	.005	.000
Distributions, C corps	.003	.003	.002	.002	.001	.000
Distributions, Other	.095	.093	.089	.068	.021	.000
Labor	.162	.162	.160	.145	.107	.090
Consumption	.094	.098	.101	.117	.149	.162
Transfers	.329	.328	.323	.294	.227	.196
To retirees	.143	.142	.140	.122	.082	.063
To workers	.186	.185	.183	.172	.145	.133
Interest on debt	.026	.025	.025	.026	.025	.023
Labor income	.588	.590	.592	.594	.583	.577
Capital income	.412	.410	.408	.406	.417	.423
Schedule C	.118	.117	.115	.113	.123	.129
Other business	.294	.294	.294	.294	.294	.294
Consumption	.725	.725	.720	.698	.685	.713
Tangible investment	.231	.231	.236	.259	.273	.244
Intangible investment	.141	.145	.148	.150	.130	.119
Defense spending	.044	.044	.044	.044	.044	.044
Tangible capital	4.04	4.17	4.28	4.63	5.39	5.97
Schedule C	.875	.899	.920	.979	1.06	1.10
Other business	3.17	3.27	3.36	3.65	4.33	4.87
Intangible capital	1.71	1.76	1.81	1.89	1.82	1.73
Levels:						
Fraction working	.745	.744	.742	.727	.692	.676
Interest rate (%)	4.86	4.72	4.68	4.81	4.77	4.38
Wage rate	0.98	1.00	1.02	1.09	1.22	1.30
Labor input	1.09	1.09	1.09	1.11	1.11	1.09
GNP	1.05	1.08	1.10	1.20	1.36	1.44
Net Worth	1.04	1.09	1.15	1.38	1.84	2.14

Note: The table displays averages over subperiods. The wage rate, labor input, GNP, and net worth are relative to the U.S. current policy.

Table 7. Welfare Gains Relative to Continuation of U.S. Policy, Varying Model Parameters

		Eliminate FICA Taxes and		
	Current U.S. Policy	Medicare, Social Security	Plus cut Capital Taxes	Plus cut Implicit Transfers
Benchmark parameters	4.7	15.4	18.1	24.9
No annuity markets	5.3	15.0	20.3	27.9
Age-dependent productivities	3.6	14.4	17.5	23.5
Eventual profits tax rates:				
12 percent	4.7	15.4	17.7	24.6
4 percent	4.7	15.4	18.0	24.9
Lower labor elasticity	5.2	14.3	16.9	22.4
One-sector model	6.9	8.3	9.0	13.3

Note: Parameters in all economies except the one-sector model are recalibrated to match U.S. statistics. Parameters for the one-sector model are chosen to get a capital-output ratio of 3. See the text for more details.

Figure 1. Percentage Welfare Gains by Cohort for Eliminating FICA Taxes and Transfers for Medicare and Social Security

(Constructing a Pareto-improving policy, Step by Step)

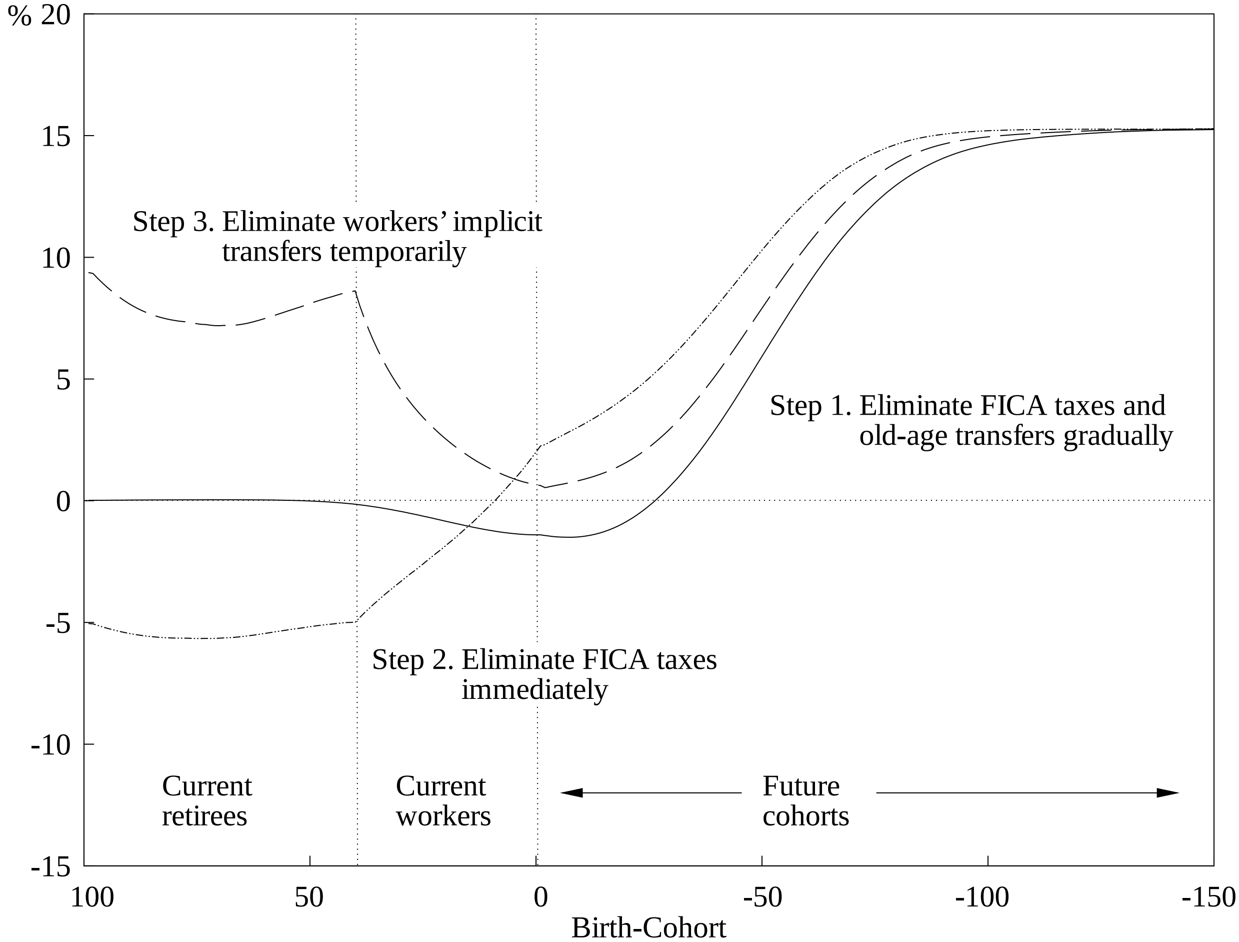

Figure 2. Percentage Welfare Gains by Cohort for Three Alternative Saving-for-Retirement Policies