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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 savings-for-retirement systems, but are concerned with 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. Phasing in a switch from the current U.S. system to a savings-for-retirement system without capital income taxes increases welfare of all current and future cohorts.

Keywords: Government debt; Tax systems; Efficient taxation; Quantitative OLG
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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.[1] One proposal is to move to a savings-for-retirement system, but critics argue that such a move will not raise welfare for all birth-year cohorts. An apparent problem 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 taxing workers' incomes in order to make lump-sum transfers to retirees, to a savings-for-retirement system without taxes on capital income is feasible and welfare improving for all birth-year cohorts. We do so even in an environment with large government debt and lump-sum taxes ruled out.

We find large social gains to the elimination of capital income taxation, because private savings opportunities are dramatically increased. The increase occurs for two reasons. First, there is the well-known reason that with this tax policy the capital-output ratio is higher. Second, there is a not so well-known, but quantitatively important, reason: The no-capital-income-tax policy results 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 there is no need to tax workers' labor income to finance lump-sum transfers to retirees. This is with demographics that result in the number of workers per retiree falling from its current value of over three to only two.

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[1] See De Nardi, Imrohoroğlu, and Sargent (1999) for an analysis.
[2] For a closed economy, the net worth of the private sector is the value of equity plus the net government debt.

An important point is that 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. Our estimate of the U.S. capital stock at reproduction cost is about 5.9 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).[3] We also include consumer durables, inventories, land, and business intangible capital, which implies an additional 3 times GNP of productive capital. Starting with a stock of 5.9 GNPs and changing the tax system appropriately increases the productive capital stock to 7.7 GNPs and significantly boosts households' net worth. Birkeland and Prescott (2007) consider policy reforms in an economy with a capital stock of 3.5 times GNP and find that a large government debt to GNP ratio is needed with a savings-for-retirement system and current demographic trends. But, given the capital stock is much larger, 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 from over three to only two.[4]

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. We consider two alternative tax systems and two alternative demographic assumptions. The first tax system is essentially the one currently in use with its high payroll and capital income tax rates and large transfers to retirees. The second one has no payroll or capital income taxes and makes

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[3] 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 consumption.

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

no retirement transfers to retirees. The first choice of demographics is one with over three workers per retiree now and in the future. The second choice has the size of the entering cohort groups stop growing. This choice is one which results in the number of workers per retiree falling to two. The growth paths are determined for both demographics, 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. For cohorts alive at the start of the transition, we find welfare gains in the range of 1 to 3 percent. For future cohorts the gains are in the range of 3 to 20 percent.

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 funded programs with individual accounts.[5] The main conclusion from this literature is that the potential long-term gains of privatizing the current system are large—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, Imrohoroğlu, 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.[6]

[5] The Feldstein (1998) volume is a nice collection of papers that consider privatization issues for 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.

[6] 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).

Conesa and Krueger (1999) and Imrohoroğlu and Kitao (2012) find that adding idiosyncratic uncertainty makes things worse since social security provides partial insurance.[7]

In order to more systematically consider alternative fiscal policy plans, Conesa and Garriga (2008) propose a particular social welfare function and, for alternative choices of generational weights, 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 the 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, that is, as long as we include all stocks of capital available for financing retirement consumption in our analysis.

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.[8] 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.

[7] See also Imrohoroğlu and Kitao (2010) and references therein for analyses of uncertain health expenditures and the impact on financing retirement consumption.
[8] Prescott (2004) also considers a reform of the U.S. Social Security system that requires a large amount of debt to finance the transition.

In Section 2 we present the model used to evaluate the alternative retirement financing systems. In Section 3 we develop the national income and product accounts and fixed asset tables. To do this we use the U.S. Department of Commerce national income and product accounts (NIPA) and fixed asset tables appropriately modified to be consistent with theory. In Section 4, we select the parameters to be consistent with the national account and fixed asset data and with demographic data. In Section 5, we report the balanced growth paths for an economy where the growth rate of new workforce entrants continues at 1 percent annually and for an economy where there is no growth in the number of new workforce entrants for both the current tax system and the proposed alternative. We also report the equilibrium paths if there is no growth in the number of workforce entrants and the welfare differences for each birth-year cohort. In Section 6, we provide a summary of the findings and some concluding remarks.

2. 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*. Years 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

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

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

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) $t = 0, 1, 2, \ldots,$ is the time period.

(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_{1T} and K_{2T} are the aggregate tangible capital stocks for the two business sectors (described below).

(v) K_{1I} and K_{2I} 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.

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

$$B_t \le \phi_{Bt} GNP_t ,$$

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:

$$G_t = \phi_{Gt} \, GNP_t \; .$$

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 $j \in \{1, 2, ..., J\}$ satisfies

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

subject to

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

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

The prime denotes the next period value of a variable and $v_{J+1} = 0$. Households with $j > J_R$ are retired and their $\ell's$ are zero. Note also, 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.

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 Y_t is

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

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}:

$$Y_{it} = K_{iTt}^{\theta_{iT}} K_{iIt}^{\theta_{iI}} (\Omega_t L_{it})^{1-\theta_{iT}-\theta_{iI}} \text{ for } i = 1, 2.$$

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

$$K_{iT,t+1} = (1-\delta_{iT}) K_{iTt} + X_{iTt} \quad \text{for } i = 1,2,$$
$$K_{iI,t+1} = (1-\delta_{iI}) K_{iIt} + X_{iIt} \quad \text{for } i = 1,2$$

where T and I denote tangible and intangible, respectively, and X is investment. Depreciation rates are 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 $X_{It} = \sum_i X_{iIt}$.

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}. Sector 1 accounting profits are

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

and distributions to its owners are

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

Sector 2 distributions to its owners are

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

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 business sector 1 profits, on distributions of sector 1 firms to their owners, on distributions of sector 2 firms to their owners, and on labor income.

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 $s' = F(s)$.

3. 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 2000–2009.[9] Here, we describe adjustments that are made to the accounts so that they better conform to the theory used to construct the model economy that we use to draw inference.

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. 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

[9] 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 (2012) we provide further details about constructing the model accounts. Some parameter estimates are based on IRS data that are only available through 2009.

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.[10] 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 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

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

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 about 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 0.135 times adjusted GNP for the period 2000–2009. Transfers, as they are categorized by the BEA, are smaller, about 0.123 times adjusted GNP over the period 2000–2009. More than half of these transfers are Social Security and Medicare, which together add up to 0.065 times adjusted GNP.

Fixed Asset Tables

The revised fixed asset tables are reported in Table 2 for the period 2000–2009. 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.[11] With these additions, the total tangible capital stock is 4.2 times our measure of adjusted GNP.

[11] See Rossi-Hansberg and Wright (2007) for introducing developers into a competitive equilibrium model with endogenous cities. Apparently, the BEA does not include land as a component of fixed assets at reproduction costs

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 2000–2009. 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.[12] Notice that the total stock in Table 2 is 5.87 times adjusted GNP, almost twice as large as the stock of reproducible assets reported in the BEA's fixed asset tables.[13]

4. Parameters

Table 3 reports the parameters used in the baseline model. These parameters imply that the model's balanced growth path is consistent with U.S. statistics.[14]

The first set of parameters govern demographics. For the baseline economy—the economy with current demographics and current policies—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.

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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.

[12] 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.

[13] 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.

[14] See McGrattan and Prescott (2012) for full details on data sources.

The preference parameters are chosen so that the model's labor input and labor share are 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 1,452 hours per year. If discretionary time per week is 100 hours, then the fraction of time at work is 0.279. Assuming logarithmic preferences, namely,

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

we set α equal to 1.297 to get the same predicted hours of work for the model. In addition, we set $\beta = 0.984$, 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 sector 1 businesses—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 (2012) we experiment with varying this parameter.

The choice of tangible capital shares $(\theta_{1T},\theta_{2T})$ and tangible depreciation rates $(\delta_{1T},\delta_{2T})$ 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 $\theta_{1T} = 0.193$ and $\theta_{2T} = 0.505$ 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 tangible and intangible capital equal. In McGrattan and Prescott (2012), 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 to 0.043 times GNP for all periods. Thus, $\phi_{Gt} = 0.043$ for all *t*. This is the average share of military expenditures in the baseline economy for the ten-year period 2000–2009. We set the maximum debt constraint parameter ϕ_{Bt} equal to the average ratio of U.S. government debt to GNP for 2000–2009. Thus, $\phi_{Bt} = 0.511$ 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 corporate income tax rate τ_1^{π} is about 40 percent for the United States when federal and state taxes are combined. 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 buy-backs.

This tax rate is about 20 percent if we include both federal and state income taxes over the past decade.

The second category of businesses is composed of those that distribute their accounting earnings to their owners and whose earnings are treated as ordinary income for tax purposes and taxed at rate τ_2^d. 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.[15] For the combined income from unincorporated business, pass-through corporations, households, and government, we use a tax rate of 40 percent.[16]

The payroll tax τ^ℓ is the rate of tax on Social Security and Medicare, adding together the rates for employers and employees, and is thus equal to 15 percent. We set the consumption tax rate τ^c equal to 27 percent, which is higher than typical estimates for the tax rate on consumption because here we are including taxes on both sales and labor earnings. Most U.S. households can on margin defer receipt of income and payment of taxes to the time retirement consumption occurs. Virtually all non-consumed income is deferred, so to a first approximation,

[15] 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.
[16] We also experiment with varying this rate in McGrattan and Prescott (2012).

the U.S. tax system is a consumption tax.[17] We chose a rate of 27 percent because, as we show later, it generates levels of transfers consistent with NIPA data.

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 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:

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

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.[18] 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 2000–2009. 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

[17] In McGrattan and Prescott (2012), we assess the quantitative impact of this choice by rerunning our policy experiments with a higher income tax rate on wage earnings and a lower consumption tax rate.
[18] 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. 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.

In Table 4, we summarize our calibration efforts by directly comparing 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.

5. Evaluation of Alternative Policies

We turn next to our policy experiments.[19] We consider two alternative policy regimes for financing retirement consumption. The first regime, which we call *current policy*, is effectively a continuation of current U.S. policy of taxing payrolls 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 the payroll tax rates over time. The second

[19] In McGrattan and Prescott (2012), we provide details of the algorithm used to compute equilibria.

policy regime, which we call *new policy*, eliminates distortionary taxes on payrolls and capital incomes and the part of transfers to retirees that are neither welfare nor local public goods.

In this section, we report the welfare consequences for the two 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.

Balanced growth comparisons

Table 5 summarizes the tax rates and transfers as we vary fiscal policies and demographics. The first column of Table 5 lists the policy parameters used in the baseline economy. (See Table 3.) Recall that this baseline parameterization is consistent with the current U.S. economy in terms of both tax and transfer policies and demographics. The current U.S. demographics has a population growth rate of 1 percent and a ratio of workers to retirees of 3.39. Under the *new demographics*, we assume that the population growth rate is zero and the ratio of workers to retirees is 2.

The second column of Table 5 lists taxes and transfers under the new policy—assuming no demographic change occurs. Notice that the income tax rates are set equal to zero and the same per capita transfers are given to retirees and to workers, that is, $\psi^r / \psi^w = 1,$ where ψ^r is the transfer to each retiree and ψ^w is the transfer to each worker. For this economy we assume that per capita transfers are equal to current per capita U.S. transfers for welfare and local public goods. The tax rate on consumption, which is 0.275, is determined residually to be the rate needed to satisfy the budget constraint of the government.[20]

The last two columns of Table 5 show the taxes and transfers for the two policy regimes assuming a demographic change does occur. Sticking with the current system necessitates an increase in payroll taxes used to finance the increased transfers to retirees. To accomplish this we need to raise the payroll tax rate from 0.15 to 0.18. The ratio of per capita transfers to the retirees relative to workers, ψ^r / ψ^w, is barely changed, but given the fact that there are many more retirees with the new demographics, the ratio of total retiree transfers to total worker transfers increases significantly. Finally, with new policies and new demographics, the only choice to consider is the tax rate on consumption, which is set equal to 0.271 in order that the government's budget balances.

Table 6 shows the balanced growth aggregate statistics for the four economies. The first column is the same as the results for the baseline economy shown in Table 4. Here, we provide additional details on sectoral incomes, intangible investments, and government transfers so that we can compare these statistics across the different economies. For the baseline model, we find that Schedule C corporations earn roughly 30 percent of the capital income and intangible investment is nearly 12 percent of GNP. Government transfers in the baseline are nearly 37 percent of GNP. Recall that this includes nondefense spending plus the usual government transfers, which is about 26 percent of GNP. Thus, the model transfers exceed NIPA nondefense spending and the usual transfers by about 11 percent of GNP. We view this as reasonable because the NIPA accounts do not include implicit taxes that arise due to the fact that marginal

[20] Recall that the ratios of defense spending and government debt to GNP are held at their baseline levels.

tax rates are much higher than average tax rates. We want to include imputations for these implicit taxes on both the revenue and expenditure sides of the government budget constraint.

The last three columns of Table 6 report the aggregate statistics as we vary demographics and policy. Several key findings emerge. First, eliminating taxes on factor incomes boosts the tangible capital stock significantly, about 84 percent in per capita terms in the case with new demographics and new policy. Because its tax treatment is completely different, the stock of intangible capital rises by less, about 39 percent, but is still significantly higher in the new regime. Since per capita GNP rises roughly 40 percent, the ratio of intangible capital to GNP stays roughly constant across balanced growth experiments. The most dramatic changes are in the category of household net worth since capital stocks are higher and tax rates are lower. Household net worth more than doubles in per capita terms with the change in policies.

There are two offsetting effects impacting total labor input when we consider new demographics and new policy; there are fewer workers but, with payroll tax rates lower, a higher per capita labor input. When both effects are included, the result is a 7 percent overall increase in the total labor input. Since consumption rises significantly, the overall effect on welfare is positive. Conditioning on the new demographics, the consumption-equivalent welfare gain of eliminating income taxes and age-dependent transfers is large, roughly 20 percent. If we stick with the current policy, we find that there is a modest welfare loss of 4 percent due to the change in demographics.

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 the new policy.[21] For the transition to the new policy, we show that it is easy to find reasonable paths for tax rates and transfers—that are nonnegative and vary smoothly over time—such that no cohorts lose during the transition. We find that it is easy because of the ample opportunities for private saving in our economy with a large total stock of capital.

For both transitions, 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 household asset holdings. To compute the transition to the current policy, we linearly phase in the higher payroll tax over five years.

To compute the transition to the new policy, we immediately set the payroll and consumption tax rates to their new levels and phase in the capital tax rates and transfers. We phase in capital tax rates to avoid a large spike in interest rates, and we phase in transfers so as to smooth out the predicted welfare gains for cohorts that are young when the transition begins and those born soon thereafter. Our choice of path for the capital tax rates is $\tau_{1t}^d = .2z_t$ and $\tau_{2t}^d = \tau_{1t}^\pi = .4z_t$, where

$$z_t = \tanh(a - 2at/t^*) + \tanh a$$

for $t = 0,1,...,t^*$ and $z_t = 0$ for $t > t^*$, with $a = 3$ and $t^* = 60$. This choice implies that tax rates decline modestly over the first 20 years and more rapidly thereafter. The rates are equal to zero by year 60.

For the transition to the new policy, the paths of transfers are found as follows. For each cohort, we find values for ψ_t^j that satisfy the household budget constraint once we substitute in allocations and prices consistent with the current policy regime and tax rates on payroll and consumption consistent with the new policy regime. This choice of transfers keeps the existing

[21] In McGrattan and Prescott (2012) we describe how we compute the transition paths using parallel computations.

cohorts at least as well off as they would be under the current policy regime. New cohorts in year 10 and later get transfers consistent with the new policy regime. Transfers for new cohorts between years 1 and 9 are a linear combination of that received in the current policy regime and that in the new policy regime. This is the sense in which the policy regarding transfers is phased in.

Figure 1 plots the welfare gains in *remaining* lifetime consumption equivalents of cohorts by age at time $t = 0$, when growth in the number of new workers falls from 1 percent per year to 0 percent per year. An important finding is all cohorts gain—this is a Pareto-improving outcome. Gains for retirees are in the range of 1 to 2 percent. Gains for current workers that can take advantage of lower taxes are in the range of 1 to 3 percent. Gains for future cohorts start at about 3 percent and rise to 20 percent, which is consistent with the balanced growth result in Table 6.

There are other policy paths that generate Pareto-improving outcomes. And they are easy to construct. If, however, we had restricted ourselves to the parameterizations typical of the literature—that are consistent with capital-output ratios much smaller than 5.9—then the task is much more difficult. In McGrattan and Prescott (2012), we demonstrate this by redoing the policy experiment for a one-sector version of our model with parameters consistent with a capital output ratio of 3, which is a typical choice of the macroeconomic theory literature. What we find is that the welfare gain of future cohorts is on the order of 9 percent rather than 20 percent, implying much less wiggle room in avoiding costly transitions for the existing cohorts.[22] In fact, when we apply the same procedure for implementing the new tax rates and transfers in transition, with the existing retirees left as well off as under the current policies, we find that the young cohorts and the initial new cohorts are strictly worse off.

[22] In addition to this alternative exercise, we do extensive sensitivity analysis and find that our quantitative results are robust to empirically plausible alternative choices of the parameters shown in Table 3.

In summary, we find that including all capital available to retirees for financing their retirement consumption 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.

6. Summary and Concluding Remarks

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 eliminating capital income taxes and relying more on saving for retirement and less on lump-sum transfers to retirees. We see this analysis as significantly advancing our understanding of alternative policies to finance retirement consumption. The broadening of the (non-human) capital stock is important as is requiring the model to be consistent with both the national accounts and the fixed asset tables.

Through discussions and insights we hope and expect that better abstractions for predicting the consequences of alternative tax and transfer policies will develop. We have costless and perfect annuitization and no bequest motive. Introducing these would increase the stock of savings. On the other hand, we do not model the rival human capital investments made over working lives, and this may also have a consequence for the stock of savings.[23]

Another point is that mandatory savings and insurance mitigates the problem of some people not saving enough for retirement and outliving their savings. Mandatory savings and insurance, which are not binding for most people, do not distort the labor-leisure and intertemporal consumption choices. They do overcome some of the problem of some people not saving for retirement and relying on others for financing their retirement consumption.

[23] Wallenius (2011) has analyzed the consequence of rival human capital production on the job for the intertemporal elasticity of substitution of labor, but did not focus on assessing the consequence for the aggregate stock of savings. See also Ueberfeldt (2010).

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TABLE 1. REVISED NATIONAL INCOME AND PRODUCT ACCOUNTS, AVERAGES RELATIVE TO ADJUSTED GNP, 2000–2009[a]

TOTAL ADJUSTED INCOME	1.000
Labor Income	.587
Compensation of employees (NIPA 1.10)	.534
70% of proprietors' income (NIPA 1.10)	.053
Capital Income	.413
Corporate profits with IVA and CCadj (NIPA 1.10)	.072
30% of proprietors' income (NIPA 1.10)	.023
Rental income of persons with CCadj (NIPA 1.10)	.016
Surplus on government enterprises (NIPA 1.10)	.000
Net interest and miscellaneous payments (NIPA 1.10)	.057
Net income, rest of world (NIPA 1.13)	.007
Taxes on production and imports[b] (NIPA 1.10)	.072
Less: Sales tax (NIPA 3.5)	.042
Imputed capital services[c] (FA 1.1)	.037
Consumption of fixed capital (NIPA 1.10)	.117
Consumer durable depreciation (FOF F.10)	.060
Statistical discrepancy (NIPA 1.10)	−.004
TOTAL ADJUSTED PRODUCT	1.000
Consumption	.743
Personal consumption expenditures (NIPA 1.1.5)	.655
Less: Consumer durables (NIPA 1.1.5)	.082
Less: Sales tax, nondurables and services	.035
Plus: Imputed capital services, durables[c] (FA 1.1)	.013
Consumer durable depreciation (FOF F.10)	.060
Government consumption, nondefense (NIPA 3.9.5)	.110
Plus: Imputed capital services, government capital[c] (FA 1.1)	.024

See footnotes at the end of the table.

TABLE 1. REVISED NATIONAL INCOME AND PRODUCT ACCOUNTS, AVERAGES RELATIVE TO ADJUSTED GNP, 2000–2009[a] (CONT.)

TOTAL ADJUSTED PRODUCT (CONT.)	
Tangible investment	.214
Gross private domestic investment[d] (NIPA 1.1.5)	.149
Schedule C corporations	.070
Other private business	.079
Consumer durables (NIPA 1.1.5)	.082
Less: Sales tax, durables	.005
Government investment, nondefense (NIPA 3.9.5)	.025
Net exports of goods and services (NIPA 1.1.5)	−.043
Net income, rest of world (NIPA 1.13)	.007
Defense spending	.043
National defense expenditures (NIPA 3.9.5)	.043

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

[a] Expressions in parentheses are the data sources and table numbers.

[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 durables 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 Schedule C 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, 2000–2009[a]

TANGIBLE CAPITAL	4.153
Fixed assets, private (FA 1.1)	2.192
Fixed assets, public (FA 1.1)	.595
Consumer durables (FA 1.1)	.305
Inventories (NIPA 5.7.5)	.134
Land (FOF B.100-B.103)	.928
INTANGIBLE CAPITAL	1.718
Plant specific (McGrattan and Prescott, 2010)	1.198
Technology capital (McGrattan and Prescott, 2010)	.519
TOTAL	5.871

Note: FA, fixed assets; FOF, flow of funds.
[a] Expressions in parentheses are the data sources and table numbers.

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)	1.297
Discount factor (β)	0.984
TECHNOLOGY PARAMETERS	
Growth rate of technology (γ)	2%
Income share, sector 1 (θ_1)	0.500
Capital shares	
Tangible capital, sector 1 (θ_{1T})	0.193
Intangible capital, sector 1 (θ_{1I})	0.189
Tangible capital, sector 2 (θ_{2T})	0.505
Intangible capital, sector 2 (θ_{2I})	0.059
Depreciation rates	
Tangible capital, sector 1 (δ_{1T})	0.051
Intangible capital, sector 1 (δ_{1I})	0.051
Tangible capital, sector 2 (δ_{2T})	0.015
Intangible capital, sector 2 (δ_{2I})	0.015

TABLE 3. PARAMETERS OF THE ECONOMY CALIBRATED TO U.S. DATA (CONT.)

POLICY PARAMETERS	
Spending and debt shares	
Defense spending (ϕ_G)	0.043
Government debt (ϕ_B)	0.511
Tax rates	
Profits, sector 1 (τ_1^{π})	0.400
Distributions, sector 1 (τ_1^{d})	0.200
Distributions, sector 2 (τ_2^{d})	0.400
Payroll (τ^{ℓ})	0.150
Consumption (τ^{c})	0.267
Transfer ratio[a] (ψ^r/ψ^w)	1.968

[a] Each retiree and worker receives transfers equal to ψ_r and ψ_w, respectively.

TABLE 4. ACCOUNTS AND FACTOR INPUTS FOR U.S. AND BASELINE MODEL, AVERAGES RELATIVE TO ADJUSTED GNP, 2000–2009

	Model	Data
TOTAL INCOME ($Y - X_I$)	1.000	1.000
Labor income (wL)	.587	.587
Capital income ($Y - wL - X_I$)	.413	.413
TOTAL PRODUCT ($C + G + X_T$)	1.000	1.000
Consumption (C)	.743	.743
Defense spending (G)	.043	.043
Tangible investment (X_T)	.214	.214
Schedule C corporations (X_{1T})	.070	.070
Other business (X_{2T})	.144	.144
LABOR INPUT (L)	.279	.279
CAPITAL STOCK, END OF PERIOD (K')	5.871	5.871
Tangible capital (K'_T)	4.153	4.153
Schedule C corporations (K'_{1T})	.892	.892
Other business (K'_{2T})	3.261	3.261
Intangible capital (K'_I)	1.718	1.718

TABLE 5. BALANCED GROWTH TAXES AND TRANSFERS, VARYING DEMOGRAPHICS AND POLICY

	Current Demographics		New Demographics	
	Current Policy	New Policy	Current Policy	New Policy
TAX RATES				
Profits, sector 1 (τ_1^{π})	.400	.000	.400	.000
Distributions, sector 1 (τ_1^{d})	.200	.000	.200	.000
Distributions, sector 2 (τ_2^{d})	.400	.000	.400	.000
Payroll (τ^{ℓ})	.150	.000	.180	.000
Consumption (τ^{c})	.267	.275	.267	.271
TRANSFER RATIO (ψ^{r}/ψ^{w})	1.968	1.000	1.946	1.000

TABLE 6. BALANCED GROWTH AGGREGATE STATISTICS,
VARYING DEMOGRAPHICS AND POLICY

	Current Demographics		New Demographics	
	Current Policy	New Policy	Current Policy	New Policy
PER CAPITA GNP	.718	1.061	.669	1.007
INCOMES RELATIVE TO GNP				
Labor income	.587	.585	.579	.578
Capital income	.413	.415	.421	.422
Schedule C corporations	.123	.125	.131	.132
Other business	.290	.290	.290	.290
PRODUCTS RELATIVE TO GNP				
Consumption	.743	.662	.782	.710
Defense spending	.043	.043	.043	.043
Tangible investment	.214	.295	.176	.247
Schedule C corporations	.070	.089	.062	.080
Other business	.144	.206	.114	.167
OTHER EXPENDITURES TO GNP				
Intangible investment	.115	.112	.099	.098
Government transfers	.369	.131	.396	.138
To retirees	.136	.030	.191	.045
To workers	.233	.101	.205	.093

TABLE 6. BALANCED GROWTH AGGREGATE STATISTICS, VARYING DEMOGRAPHICS AND POLICY (CONT.)

	Current Demographics		New Demographics	
	Current Policy	New Policy	Current Policy	New Policy
LABOR INPUT	.279	.333	.250	.299
CAPITAL STOCK TO GNP	5.871	7.463	5.899	7.686
Tangible capital	4.153	5.803	4.184	5.989
Schedule C corporations	.892	1.113	0.891	1.129
Other business	3.261	4.667	3.293	4.837
Intangible capital	1.718	1.660	1.715	1.697
HOUSEHOLD NET WORTH TO GNP	5.394	7.990	5.419	8.207
WELFARE GAIN[a]	4%	19%	0%	20%

[a] The welfare gain is the consumption equivalent gain relative to the economy with new demographics and current policy

Figure 1
Percentage Welfare Gain of New Policy by Cohort Age