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ABSTRACT

Notwithstanding the rosy short-term fiscal scenarios being advanced in Washington, the demographic transition presents the United States with a very serious fiscal crisis. In 30 years there will be twice the number of elderly, but only 15 percent more workers to help pay Social Security and Medicare benefits. A realistic reading of the government demographic projections suggests a two-thirds increase in payroll tax rates over the next three to five decades. However, these forecasts ignore macroeconomic feedback effects. In particular, they ignore the possibility that the nation will have more capital per worker as the number of elderly wealth-holders rises relative to the number of young workers.

More capital per worker would mean higher worker productivity, higher real wages, and the lower return to capital that worries Wall Street. It would also mean a bigger payroll tax base and a smaller rise in tax rates. On the other hand, a higher payroll tax will leave workers with less after-tax income out of which to save and, therefore, fewer retirement assets than would otherwise be the case. Thus capital deepening is not a foregone conclusion.

This study develops a dynamic general equilibrium life-cycle simulation model to study these conflicting forces. The model is the first of its kind to admit realistic patterns of fertility and lifespan extension. It also features heterogeneity, within as well as across generations, and, thus, can be used to study both intra- and intergenerational equity.

Unfortunately, our baseline demographic simulation, which assumes the continuation of current social security policy, shows deteriorating macroeconomic conditions that will exacerbate, rather than mitigate, our fiscal problems. Real wages per effective unit of labor fall 4 percent over the next 30 years and 10 percent over the century. For Wall Street, this bad news about real wages is good news about the real return on capital, which rises 100 basis points by 2030 and 300 basis points by 2100.

The model's gradual capital shallowing reflects the concomitant major rise in tax rates. In 2030, payroll tax rates and average income-tax rates applied to wages are 77 and 9 percent higher, respectively, than in 2000. Together, these tax hikes raise the average total tax on labor income tax by 44 percent. These tax increases and the decline in the wage per unit of human capital will deprive the next generation of much of its natural economic endowment. Taking technology-driven productivity growth into account, workers' 2030 after-tax real wages will be only 12 percent higher, compared with 35 percent higher if tax rates and the real wage per unit of human capital were fixed.

Is there a painless way out of our demographic dilemma? The answer is no. Any policy, including replacing the existing Social Security system with a privatized system of compulsory saving, will have losers as well as winners. But the simulations presented here demonstrate that Social Security's privatization, if conducted responsibly, entails moderate pain for current generations, but major gain for future generations, particularly those with very low incomes.

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I. Introduction

Growing old is no fun. And it is not something people like to talk about. But America is starting to grey, and the older it gets the worse will be its economic as well as physical health. While many are looking for an economic fountain of youth in Silicon Valley, it is important to have a realistic picture of how our economy will fare when the entire country becomes as old as today's Florida. On that day, which is 30 years off, all 77 million baby boomers will be retired, leaving twice the number of elderly relying on only 15 percent more workers for financial support. This support will be delivered primarily through the Social Security and Medicare programs, which will start paying benefits to baby boomers in just seven and ten years, respectively.

The fact that the country is aging is not new. It has been forecast by demographers for decades and discussed for years in the annual *Trustees Reports* of the Social Security Administration and Medicare. But, for whatever reason, the government has done relatively little to confront Social Security's and Medicare's long-term fiscal problems. Indeed, the trustees of Social Security and Medicare admit to being roughly one fifth short of the resources needed to pay benefits over the next 75 years.

This funding assessment is offered in the most recent OASDI and HI Trustees Reports and is based on so-called "intermediate" economic and demographic assumptions. However, the intermediacy of these assumptions, particularly with respect to longevity, has been strongly questioned by Social Security's own 1999 Technical Panel. The Panel also raised concerns about truncating the projection horizon at 75 years, pointing out the huge cash flow deficits lying in wait in 2076 and beyond.

What happens to the projections if one extends the projection horizon and adopts the Technical Panel's longevity assumptions? The answer is not pleasant. The OASDHI (Social Security plus Medicare) present-value funding shortfall doubles from one to two fifths.¹ As discussed in Gokhale and Kotlikoff (2000), eliminating this funding gap without cutting current or future benefits requires an immediate and permanent 10 percentage point increase in the 15.3 percent FICA payroll tax.

Given the high level of current U.S. tax rates, moving from a 15 percent to a 25 percent payroll tax rate would dramatically raise the lifetime tax burdens and labor supply disincentives of current and future generations. As it is, today's newborns are projected to pay about one quarter of their lifetime earnings to the government in taxes net of transfers.² A 10 percentage-point payroll tax hike would raise this lifetime net tax rate to more than one third. It would also substantially raise the marginal tax brackets of America's workers, most of whom are currently paying close to 50 cents of every dollar earned to federal and state governments.³ Since the economic costs of tax distortions rise with the square of the tax rate, putting workers into 60 percent rather than 50 percent effective marginal net tax brackets raises the tax system's excess burden from distorting labor supply by 44 percent.

In contemplating the immediate need for a 25 percent payroll tax rate, one should bear in mind that delay in implementing the tax increase will necessitate even larger tax increases in the future. Given the

¹See The 1999 Technical Panel on Assumptions and Methods (1999).

² See Gokhale, Page, Potter, and Sturrock (2000).

³ This total effective marginal tax rate includes a) marginal federal income taxes, marginal state income taxes, marginal payroll taxes, marginal sales taxes, and marginal excise taxes plus b) marginal reductions in earnings-tested transfer payments, including earned income tax benefits, welfare benefits, food stamps, housing assistance, and itemized tax deductions.

current political climate, the chances of a major payroll tax hike in this decade are remote. So a likely scenario entails a doubling of the payroll tax rate between 2010 and 2030.

But is the situation really this bad? After all, these putative payroll tax hikes are calculated in partial equilibrium, i.e., they ignore general equilibrium feedbacks on wages and interest rates that may arise as part of the demographic transition. In particular, the aging of society could lead to capital deepening and higher real wages as the number of retirees with capital rises relative to the number of workers supplying labor. This is the scenario that many on Wall Street predict and fear, because it spells lower real returns to capital.

Higher real wages would raise the wage base and, thereby, limit the increase in payroll tax rates. This potential silver lining in a set of otherwise dark clouds was explored by Auerbach, Hagemann, Kotlikoff, and Nicoletti (1989) in an early simulation study of demographic change. But they also pointed out that capital deepening is not inevitable in an aging society because the associated payroll tax hikes will reduce the amount of their earnings available for workers to save and leave them accumulating less capital to finance their retirements. This study revisits this issue using a new dynamic simulation model, which we denote the KSW Model. The model builds on the Auerbach-Kotlikoff model, but has five critical features not included in Auerbach, et. al. (1989). These are 1) a much more realistic treatment of fertility, 2) cohort-specific longevity, 3) multiple earnings groups within each cohort⁴, 4) the ability to simulate the model from non steady-state initial conditions, and 5) a more careful calibration of the model to U.S. fiscal conditions and institutions. Several of these points deserve amplification. To begin, the KSW model permits

⁴This feature was introduced in Altig, Auerbach, Kotlikoff, Smetters, and Walliser (2001).

households to give birth at different ages, rather than immediately upon reaching adulthood. It circumvents the discrete nature of whole births and the family-specific tracking that they would require by assuming that households give birth to fractions of children. This assumption dramatically improves the model's ability to replicate the initial population age distribution and to track changes in that distribution through time. Another advantage of modeling the right distribution of age gaps between parents and children involves bequests and inheritance. Since each cohort of parents has children of different ages, bequests made by decedents are inherited by different age groups, rather than concentrated into the hands of a single age group.

Second, a significant share of the nation's projected aging is due, not to past fertility patterns, but to lifespan extension. According to the Social Security actuaries, today's 65 year-old Americans can expect to live to age 82; in contrast those 65 in 2050 will expect to live to age 84. Incorporating this growth in life expectancy turns out to be important for producing a realistic simulation of the U.S. demographic transition.

A third key element of the new model is its ability to begin simulations with arbitrary initial demographic and economic conditions. The model developed in Auerbach, et. al. (1989) didn't include this feature. Consequently, the authors were forced to assume the economy was in a steady state in its initial position. Since the U.S. has been experiencing tremendous demographic changes over this century, it is very difficult to approximate our actual age distribution with one that would arise in a situation of ever constant fertility and mortality rates. The prevailing U.S. age-wealth distribution is also the result of historic demographic and economic circumstances that cannot easily be represented as steady-state outcomes.

To summarize, by starting with the actual U.S. fiscal, economic, and demographic realities, the

KSW model generates a much more realistic time-path of economic outcomes. Our first goal in this study is understanding how the economy will fare over time given the demographic change and assuming ongoing pay-as-you-go financing of our social insurance programs. Our second objective is understanding the sensitivity of these outcomes to longevity increases and changes in retirement behavior. Our third aim is to determine whether alternative methods of privatizing Social Security would a) materially improve the long-run economy and the well being of our descendants and b) do so at major or minor costs to those now alive.

The paper delivers nine punch lines: First, general equilibrium effects will not insulate our economy from major payroll tax hikes assuming a continuation of pay-as-you-go finance of Social Security and Medicare. On the contrary, general equilibrium responses will have make the medium-term situation somewhat worse and the long-term situation significantly worse; our base-line transition features capital shallowing, rather than deepening, over the course of the century, leaving the real wage per unit of effective labor 4 percent lower in 2030 and 10 percent lower in 2100 than it is today.⁵

This bad news for the economy is good news for Wall Street because it portends a 100 basis-point rise in the real return to capital for the next three decades and an additional 200 basis point rise thereafter. But it's bad news for the Social Security and Medicare systems whose combined OASDHI payroll tax rate rises in the model by 77 percent over the next three decades and by 93 percent between now and

⁵ This finding differs from that of Bohn (1998) who states that "...a defined benefit social security system dampens the macroeconomic effects of demographic change without realistically overturning them." Bohn reaches his conclusion using a very simple two-period model. The difference in findings may reflect the limitation of a two-period model or some other factor of which we aren't aware.

2100.⁶ The model's predicted 2030 OASDHI cost rate is 24.3 percent of salary, which is somewhat higher than the Social Security Administration's (SSA) predicted cost rate of 22.0 percent. For 2075, the model's and SSA's respective projected cost rates are very close – 26.4 percent and 26.2 percent.

Second, if Social Security's Technical Panel is correct, and lifespans rise more rapidly than the Social Security Trustees predict, the combined cost rate will reach 24.9 percent in 2030 and 29.1 percent in 2100. Adding fuel to this fire is the fact that paying for the government's spending on goods and services and debt service will require higher average income tax rates between now and 2030 as well, indeed 9 percent higher according to our model. Together, these increases in the taxation of labor income will raise average effective tax rates on labor supply by two fifths by 2030.⁷

Third, increases in the age at which workers retire, which we model as endogenous responses to an assumed exogenous increase in old age productivity, will not save the day. Although both labor supply and labor income rise, the shorter retirement period leads to less life-cycle wealth accumulation. Consequently, there is a concomitant decline in the capital-labor ratio that serves to lower the real wage. So the wage base, on which payroll taxes are assessed, expands because of the delay in retirement, but shrinks because of the decline in the real wage. Consequently, the net impact of delayed retirement on the simulated rise in the payroll tax rate turns out to be trivial.

Fourth, a higher rate of technological progress can improve the situation, but not fundamentally alter

⁶ Note that we calibrate our model's payroll tax rate to the system's cost rate, which is currently 13.2 percent; i.e., we do not include in the payroll tax revenues being used to accumulate a surplus for the Social Security Trust Fund. Instead, we calibrate the model's general wage tax based on the federal government's unified budget surplus, which includes the surplus. We also calibrate the model's initial level of debt based on the federal government's unified outstanding debt net of financial assets.

⁷This refers to the average, as opposed to marginal, tax rate on labor supply averaged over all workers.

the nature of the demographic transition. Fifth, cutting Social Security benefits by enough to prevent increases in the program's payroll tax rate prevents the deleterious macroeconomic effects that would otherwise accompany the nation's aging. Sixth, under current policy, workers' after-tax real wages will be only 12 percent higher in 2030 than they are today. While better than nothing, this is a far cry from the 35 percent after-tax real wage increase they would enjoy were payroll tax rates to remain fixed and the aging process permitted to contribute to capital deepening.

Seventh, the interaction of aging with old age transfer programs aside, the demographic transition is likely to generate less capital deepening than is commonly believed. The reasons here are twofold. First, while the country will age very dramatically when one compares the number of future old to the number of future young, it will age by considerably less when one measures the old and young in terms of their lifetime labor productivities. Recall, that it is their past labor productivity that primarily determines how much wealth the elderly have and it is their current labor productivity that determines how much labor the young have to supply. Second, the recent increase in asset valuations suggests that the U.S. ratio of assets to labor earning may be higher now than it would be were policy and the demographic structure to remain constant. I.e., aging aside, we may be embarked on a transition path that involves working off temporarily high levels of capital per workers.

Eight, replacing Social Security with a compulsory private saving system represents a way to keep the next generation from facing much higher payroll tax rates. But this "cure" is not painless since paying off the unfunded liabilities of the existing system entails a real sacrifice. Still, our simulations demonstrate that the economic losses to current generations would be modest compared to the major gains they would provide to future generations. The simulations also show that the choice of transition finance -- the choice

of how to pay off the unfunded liabilities -- makes a big difference to the economy's short- and medium-term performance and to the intra- and intergenerational distributions of welfare.

Finally, as a long-run proposition, privatizing Social Security is a highly progressive policy. The welfare gains enjoyed by the poorest future members of society are 21 percent, compared with only 5 percent for the richest future members. Welfare gains refer here to the percentage increase in consumption and leisure that an agent would need, under baseline policy, to experience every year through the end of her life to generate the same utility as the policy generates.

The paper proceeds in Section II with a literature review. Section III presents our model, paying particular attention to how we incorporate fertility and lifespan extension. This section also reviews our calibration and solution method. Section IV presents our baseline simulations plus four variants – one that entertains the Technical Panel's projection of lifespan extension, one with later retirement by the elderly, one with twice the projected rate of technical program, and one with three times the projected rate of technical progress.

Section IV also considers different ways to limit Social Security payroll tax hikes while maintaining the pay-as-you-go structure of the system. The first is to eliminate the ceiling on taxable OASI payroll. The second is to raise over the next 25 years Social Security's normal age of retirement to age 70. This increase is three years more than the normal retirement age is slated to rise over this period, both in the law and in our baseline model. A third option is to gradually cut Social Security benefits in half by 2030. Three final options involve privatizing Social Security in its entirety. The three schemes differ with respect to the method of financing the accrued benefit obligations of the old system. The welfare implications of the various reforms are discussed in Section V. Section VI concludes the paper with a summary and

caveats about our findings and methodology.

II. Literature Review

The natural marker for any review of the economics of social security is Feldstein's (1974) seminal article contending that the program dramatically lowers national saving. Feldstein's paper spawned an enormous number of theoretical, empirical, and simulation studies. The simulation studies are of interest here. Their defining characteristic is the assumption of life-cycle microeconomic saving and labor supply decisions. These microeconomic behaviors are aggregated to determine macroeconomic outcomes. Early contributions here include Kotlikoff (1979), Auerbach and Kotlikoff (1983), and Seidman (1983). These papers confirmed Feldstein's theoretical prediction that unfunded social security systems significantly reduce nations' long-run capital intensivities and living standards. Kotlikoff (1979) and Auerbach and Kotlikoff (1983) examined how introducing "pay-as-you-go" social security would worsen an economy's economic position through time, notwithstanding induced changes in retirement behavior. Seidman, in contrast, appears to be the first to study the economic gains from entirely eliminating unfunded social security.

More recent contributions to the simulation literature include Auerbach and Kotlikoff (1987), Auerbach, Hagemann, Nicolette, and Kotlikoff (1989), Hubbard and Judd (1987), Hansson and Stuart (1989), Arrau and Schmidt-Hebbel (1993), Kotlikoff (1996), Samwick (1996), Hubbard, Skinner, and Zeldes (1994a, 1994b, 1995), Kotlikoff, Smetters and Walliser (1997, 1998a, 1998b, 1999a, 1999b, and 2001), Huang, Anrohorolu, and Sargent (1997), and Imrohoroglu, Imrohoroglu, and Joines (1995, 1999), Knudsen, et.al, (1999), Fougere and Merette (1998, 1999), Scheider (1997), Raffelhüschen (1989, 1993), Cooley and Soares (1999a, 1999b), Huggett and Ventura (1998), Nardi, Anrohorolu, and

Sargent (1999), and Galasso (1999). These studies have included a range of additional important factors, including demographics, land, earnings uncertainty, liquidity constraints, and majority voting on the system's continued existence. They have also examined the different ways a transition to a privatized social security system could be financed.

Our own past work has explored social security's privatization, but in a model with no demographic change and, indeed, no children. The principal finding of this research, and one that is reinforced here, is that the method chosen to finance social security's privatization can make a major difference to macro- as well as microeconomic outcomes over the short and medium runs. Our prior research also explored policies that would enhance the progressivity of social security's privatization and that would permit workers alive at the time of the reform a free choice with respect to joining a privatized system.

III. The KSW Model

This section describes the KSW Model as well as its calibration and solution methods. It draws, in part, on Altig, Auerbach, Kotlikoff, Smetters, and Walliser (2001) and Kotlikoff, Smetters, and Walliser (2001).

Preferences, Demographics, and Bequests

The model features twelve lifetime earnings classes in each cohort. An agent in income class m maximizes the following utility function:

$$(1) \quad U^m = V(c_p^m, l_p^m) + H(c_k^m, l_k^m) + Z(b^m)$$

The function $V(,)$ records the household's utility from the lifetime consumption vector, c_p , and lifetime leisure vector, l_p , of the parent. The function $H(,)$ records the household's utility from the corresponding consumption and leisure vectors of young children. And the function $Z()$ measures the household's utility from leaving bequests of b^m per child at the end of life. By assumption, agents reside with their parents until age 20 and form their own households afterwards. So the elements of the vector c_k end at age 20.

To deal with the fact that household heads between the ages of 20 and 45 give "birth" to fractions of children, we define the function $kw(i,j)$, where j is the parent's age, ranging from 21 to 75, and i is the child's age, ranging from 1 to 20. The $kw(,)$ function represents the share of children age i that have parents who are age j . For example, if $kw(7,35)=0.05$, 5 percent of seven year-olds have parents who are age 35.

$$(2) \quad kw(i,j) = 0 \quad \text{if} \quad (j-i) < 20$$

$$(3) \quad kw(i,j) = 0 \quad \text{if} \quad j > 45 \wedge (j-i) > 20$$

Equations (2) and (3) condition the function kw . Equation (2) requires that children must be at least 20 years younger than their parents. Equation (3) stipulates that agents older than 45 years do not have any more children. For cohorts under the age of 30, it also holds that

$$(4) \quad \sum_{j=21}^d kw(i,j) = 1$$

because all of the parents of that cohort are still alive. In (4), d stands for the prevailing maximum age of life. However, for older cohorts summing over j will generally result in a value of less than 1 because some parents have already died.

The utility functions for parental consumption and leisure and child consumption and leisure are

specified as follows:

$$(5) \quad V(\cdot) = \frac{1}{1 - \frac{1}{\gamma}} \sum_{j=21}^d \left(\frac{1}{1+\delta} \right)^{j-21} \left[c_{pj,m}^{1-\frac{1}{p}} + \alpha l_{pj,m}^{1-\frac{1}{p}} \right]^{\frac{1-\frac{1}{\gamma}}{\frac{1}{p}}}$$

and

$$(6) \quad H(\cdot) = \frac{1}{1 - \frac{1}{\gamma}} \sum_{j=21}^d \left(\frac{1}{1+\delta} \right)^{j-21} \sum_{i=1}^{20} \phi_i kv(i,j) \frac{P(i)}{P(j)} \left[c_{ki,m}^{1-\frac{1}{p}} + \alpha l_{ki,m}^{1-\frac{1}{p}} \right]^{\frac{1-\frac{1}{\gamma}}{\frac{1}{p}}}$$

where N_i stands for the adult-equivalency scale of age- i children and $P(i)$ is the size of cohort aged i . The cohort size is scaled by the parent's cohort size to arrive at the number of children per parent. The utility of children living with their parents is the summation of the welfare levels of all the children living in a parent's household at each age of the parent.

The utility for bequests is defined as follows:

$$(7) \quad Z(\cdot) = \left(\frac{1}{1+\delta} \right)^{d-21} \sum_{d=21}^d kv(i,d) \frac{P(i)}{P(d)} \underbrace{\mu^m}_{\mu^m} \underbrace{b^m}_{b^m}^{1-\frac{1}{\gamma}},$$

where b^m is defined as the bequest per child and μ is a bequest preference parameter. Equation (7) says that the parent receives utility from the bequests received by all her children. The number of her children is calculated by adding up all the children that were ever born to the cohort that is dying (the cohort that is currently age d) and then dividing by the size of the dying cohort.

Utility maximization by a 21 year-old born in year t is subject to the budget constraint given in (8).

In this constraint, we do not subscript variables by the year of birth of the cohort or the current time period in order to limit notational complexity.

$$\begin{aligned}
(8) \quad & \sum_{j=21}^d w_{j,m} (E - l_{p,j,m}) - c_{p,j,m} - T_{j,m} \mathbf{N}_{j-1}^{j-21} \frac{1}{1+r_{t+s-1}} \\
& - \sum_{j=21}^d \sum_{i=1}^{20} \left(kw(i,j) \frac{P(i)}{P(j)} c_{k,j,m} \right) \mathbf{N}_{j-1}^{j-21} \frac{1}{1+r_{t+s-1}} \\
& + \sum_{j=21}^d kw(j,d) b^m \mathbf{N}_{j-1}^{j-21} \frac{1}{1+r_{j-1}} \\
& = b_d^m \sum_{j=21}^d kw(i,d) \frac{P(i)}{P(d)} \mathbf{N}_{j-1}^{j-21} \frac{1}{1+r_{j-1}}
\end{aligned}$$

The first element of the budget constraint is the discounted present value of the household's labor income net of a) the amounts consumed by parents and b) the net taxes, of all kinds, paid by parents. Total time endowment is E . The term $T_{j,m}$ references the amount of net taxes paid at age j by income class m . These net taxes are not exogenous, but rather functions of the levels of the relevant bases of the tax and transfer systems that are operative.

The second line of the budget constraint captures the discounted present value of children's consumption. At each age j of the household, there are children of several ages in the household and the budget constraint sums over these children's consumption, giving appropriate weights to each cohort and scaling the consumption by cohort size. The budget constraint assumes that children do not work ($l_k = E$).⁸

The third line is the discounted present value of bequests an average member of cohort j receives

⁸ The model generates this outcome endogenously because we set children's wages to zero.

over his or her life span. In each year, total bequests of the deceased cohort are distributed among cohorts who are 20 to 45 years younger (those with positive k_w). Each cohort aged j receives a share of these bequests equal to its share of all the children of the members of the dying cohort. This is done on a class by class basis, so children with, for example, parents in the seventh highest earning class inherit only from parents who are in that earnings class.

The right-hand-side of the equation uses the fact that the total value of inheritances received in a given year equals the total value of bequests left in that year. The level of bequests made by a decedent in a given year is calculated by multiplying the inheritance per capita received by children in that year by the total number of the decedent's children and then dividing by the number of decedents.

Letting a_j^m stand for capital holdings of type m agents who are age j , a household's assets prior to its last year of life, when it makes its bequest, evolve according to equation (9), where we again ignore time subscripts to ease notation.

$$(9) \quad a_{j+1}^m = (1+r) (a_j^m + I_j^m) + w_j^m (E - l_j^m) - c_j^m - \sum_{i \in \mathbf{T}} T^i(A_j^m).$$

In (9), r is the pretax return to savings, I_j^m are inheritances received from parents at age j , E is the time endowment, and the functions $T^i(\cdot)$ with tax base arguments $A_{j,t}^{m,i}$ determine net tax payments from income sources $i \in \mathbf{T} = \{C, K, W, Y, S\}$, where $T^C(\cdot)$, $T^K(\cdot)$, $T^W(\cdot)$, $T^Y(\cdot)$ and $T^S(\cdot)$ are the respective tax bases for consumption, capital income, labor income, total income, and net social insurance taxes. Social insurance net taxes incorporate OASDI payroll taxes net of the benefits of the OASI, DI, and HI programs. The tax system also features a personal income tax and a business profits tax. As discussed below, the base for OASDI payroll taxation is limited by the ceiling on taxable earnings.

Technical Change

Given the nature of our model, including its non-Cobb-Douglas preferences and leisure constraints, the standard assumption of labor-augmenting technological change, which entails multiplying the labor input entering the production function by a factor that grows at a constant rate through time, is not compatible with balanced growth; i.e., with such a formulation of technological change, the economy would never achieve a steady state even were demographics stable. Our solution method requires that the economy achieve balanced growth in the long run.⁹ To achieve that end, but still incorporate technical change, we assume a different type of labor-augmenting technical change. Specifically, we assume that technical progress causes the time endowment of each successive generation to grow at rate \mathcal{G} .¹⁰

More precisely, if E_t^m is the endowment of cohort members of type m born at time t , then $E_t^m = (1 + \mathcal{G})E_{t-1}^m$, for all t and m . The endowment E_{t-1}^m depends only on an agent's year of birth. Because E grows at rate \mathcal{G} from one cohort to the next, there is no underlying time trend imparted to the wage per unit of human capital, w_t . This fact notwithstanding, agents born later in time will, other things equal, have higher lifetime incomes. The reason is that they will have more time to allocate to both work and leisure. So their lifetime earnings will be higher than their forefathers and foremothers, even if they spend the same share of their time working and earn the same wage per unit time.

Note that our treatment of technological change is isomorphic to simply positing that each cohort's population size is \mathcal{G} percent larger than that of its immediate predecessor. Stated differently, assuming that

⁹ This provides us with a terminal condition that we use in solving for the transition path.

¹⁰ See Auerbach, et al. (1989) for a more complete discussion of this strategy for dealing with balanced growth.

each agent has more time available to spend on leisure or working is equivalent to assuming that each agent has a fixed amount of time, but that there are more agents in the economy.

Human Capital

We capture all age- and type-specific skill differences in a single efficiency parameter g_j^m . Thus, the wage rate for an agent of type m and age j is $w_{j,m,t} = g_j^m w_t$, where w_t is the economy-wide real wage per unit of human capital at time t . The growth-adjusted earnings ability profiles take the form

$$(10) \quad \epsilon_j^m = e^{a_0^m + a_1^m j + a_2^m j^2 + a_3^m j^3} (1 + \lambda)^j h_j$$

Values of the a coefficients for m -type groups 1 through 12—in ascending order of lifetime income—are based on regressions fitted to the University of Michigan's Panel Study of Income Dynamics and are taken from Altig, et. al. (2001). Groups 1 and 12 comprise the bottom and top 2 percent of lifetime wage income earners, and groups 2 and 11 the remaining 8 percent of the top and bottom deciles. All other groups constitute 10 percent of the population. For example, group 3 is the second decile of lifetime-wage income, group four the third decile, and so on up to group 10.

In estimating these coefficients from the PSID's longitudinal data on wage rates, we abstracted from secular growth in real wages. Such secular growth, which is driven in large part by technological change, is, however, an important determinant of the growth over one's life cycle in real wages. Hence, we explicitly add this growth in our longitudinal real wage profile through the final multiplicative term involving δ . By assuming that growth in the lifetime time endowment and the technology component of growth in real wages over the life cycle both equal δ , we replicate two key features of traditional labor-augmenting technical change. First, in steady state, real lifetime earnings grow at the rate of technical change, and

second, the longitudinal age-wage profile is steepened by this same rate of technical change.

The final factor determining real wage growth in equation (10) -- h_j -- is an old-age productivity factor. In our base-case simulation, this factor equals 1 through age 62 and .2 thereafter. This factor is included to model workers reaching a physical limit in their ability to work. Without its inclusion, our model would generate more old-age labor supply than is realistic. A useful byproduct of including this factor is that we can use it to consider whether delays in retirement could materially improve the U.S. fiscal picture. Specifically, in Section V we show how our base-case transition is altered if h_j equals 1 through age 65 and .2 thereafter.

Given our benchmark parameter values, peak hourly wages valued in 2000 dollars are \$4.00, \$14.70, and \$79.50 for individuals in classes 1, 6, and 12, respectively. Steady-state annual labor incomes derived from the model's assumptions and the endogenous labor supply choices range from \$9,000 to \$130,000.¹¹

Bequests

Bequests are received by children at the beginning of the period. The parameters β^j are for each earnings class j are calibrated such that the ratio of the bequest to economy-wide mean income corresponds to the ratio originally estimated by Menchik and David (1982) and updated by Fullerton and Rogers (1993). Bequests range from \$20,000 to \$450,000 for earnings group eight through group twelve, respectively.

¹¹These calculations do not include labor compensation in the form of fringe benefits.

Parameter Values¹²

The value for the time preference rate, ρ , is .02. The intratemporal and intertemporal substitution elasticities, D and ζ , are set to .4 and .25, respectively. The parameter λ is chosen so that agents devote, on average, about 40 percent of their available time endowment (16 hours per day) to labor during their prime working years (ages 21-55). We assume a 1 percent value for δ , the rate of technological change. Hence, each successive cohort is endowed with 1 percent more time than its immediate predecessor.

What is the relationship between our utility function parameter values and those typically estimated in the labor supply literature? Papers in this literature contain a variety of different labor supply elasticity concepts. Perhaps most useful from our perspective is that of the “ δ -constant” or Frisch elasticity of labor supply (e.g., Thomas MaCurdy 1981), which measures the variation in labor supply along an optimal path holding the marginal utility of income constant.¹³

For our time-separable utility function, a δ -constant change in the after-tax wage, w_t , affects only consumption and leisure at date t . Thus, given the optimal path for these variables (Auerbach and Kotlikoff 1987, p. 31, expressions 3.11 and 3.12), date- t leisure may be shown to satisfy:

$$(11) \quad l_t = \left(\frac{w_t}{\alpha} \right)^{-\rho} (1 + \alpha^\rho w_t^{1-\rho})^{\frac{\rho-\gamma}{1-\rho}} x(\lambda)$$

where $x(\delta)$ does not depend on w_t . Using (A1), we derive the following expression for the δ -constant elasticity of labor supply, L_t , with respect to w_t :

¹² Parts of this section draw heavily from the appendix to Altig, et. al. (2001).

¹³ Our use of the variable δ here follows the notation found in the relevant literature, and should not be confused with its use in the body of the paper, to represent the rate of technological progress.

$$(12) \quad \eta = \left(\frac{l}{L}\right)(\gamma \zeta + \rho(1 - \zeta))$$

where

$$(13) \quad \zeta = \frac{\alpha^p v_t^{1-p}}{1 + \alpha^p v_t^{1-p}}$$

Note that ζ corresponds to leisure’s “share” in the within-period utility function. Since we calibrate the model for different values of D and γ (so that this share is roughly .6 (and the consumption/labor share is .4), the value of O from (A2) is roughly $1.5(.6 + .4D)$. Our values of $D=.4$ and $\gamma=.25$, this gives a value of $O=.465$. This elasticity is reasonable, given the range of values estimated in the literature, some of which are surveyed in Browning, Hansen and Heckman (1998).¹⁴ Estimates for men are in some cases higher, but typically somewhat lower, while estimates for women are generally at least as high, and in some cases much higher.

The Non-Social Security Government Budget Constraint

At each point in time, the government collects tax revenues and issues debt, which it uses to finance government purchases of goods and services (G_t) and interest payments on the existing stock of debt. Government expenditures are assumed to be unproductive and generate no utility to households.¹⁵ The per capita values of government purchases and government debt are held fixed throughout the

¹⁴Other recent papers in the literature include Blundell, Meghir and Neves (1993), Mulligan (1998), and Ziliak and Kniesner (1999).

¹⁵ Since G remains fixed in all of our experiments, incorporating G into the utility function is unimportant.

transition path. To do so, specific tax rates are made endogenous. The initial level of government debt in 2000 was chosen such that the associated real interest payments equal about 3.5 percent of national income in the initial steady state. The statutory tax schedules, described below, generate a level of revenue above debt service such that the benchmark steady-state ratio of government purchases to national income equals 0.239. These values correspond very closely to the corresponding 2000 values for the combined local, state, and federal government in the United States.

Non-Social Security Taxes

The benchmark tax system in our initial steady state is designed to approximate the salient aspects of the 2000 U.S. federal, state, and local tax and transfer system. It features separate wage and capital income taxes, a consumption tax, and a payroll tax. To adjust for tax evasion, we reduce income taxes by 2.6 percentage points. This adjustment is consistent with the degree of tax evasion reported in Slemrod and Bakija (1996). In the various alternative tax structure experiments we assume that evasion reduces the post-reform tax base (income net of deductions and exemptions) by the same percentage as before the reform. Thus, the level of tax evasion falls when the tax base shrinks. We approximate the hybrid U.S. tax system by specifying a progressive wage-income tax, a flat-rate capital-income tax, a flat-rate state income tax, and a flat-rate consumption tax.

Wage Income Taxation

The wage-income tax structure has four elements: 1) a progressive marginal rate structure derived from a quadratic approximation to the 2000 federal statutory tax rates for individuals, 2) a standard deduction of \$4000 and exemptions of \$5660 (which assumes 1.2 children per agent, consistent with the

model's population growth assumption), 3) itemized deductions — applied only when they exceed the amount of the standard deduction — that are a positive linear function of income estimated from data reported in *Statistics of Income*,¹⁶ and 4) earnings-ability profiles, discussed above, that are scaled to incorporate pension and non-pension components of labor compensation.¹⁷

In the first year of the transition, the effective marginal tax rate on labor income at age 45 for those in the highest earnings group (12) is 24.2 percent and the average tax rate is 13.8 percent. The corresponding tax rates for age-45 members of group 6 are 18.1 and 10.9 percent. For group 1 members, the tax rates are 16.5 and 1.1 percent. Note that for those in group 1, their marginal tax rate includes the value of the shadow tax rate needed to induce them to voluntarily and optimally choose labor supply at the kink point on their budget constraint that is caused by the standard deduction and exemptions. These simulated tax rates are close to the empirical estimates, as discussed in Altig, et al, (2001).

Capital Income Taxation

Following Auerbach (1996), we assume that income from residential capital and non-residential capital are taxed at flat rates of 6 percent and 26 percent, respectively. Given the roughly equal amounts of these two forms of capital, the effective federal marginal tax rate on total capital income is 16 percent.

¹⁶ The data used in this estimation was taken from all taxable returns in tax year 1993. The function was obtained by regressing deductions exclusive of mortgage interest expense on the midpoints of reported income ranges. (The deduction of interest expense on home mortgages was included in our calculation of the capital-income tax rate, as we will subsequently describe.) The regression yielded a coefficient of 0.0755 with an R^2 equal to 0.99.

¹⁷ Benefits as a function of adjusted gross income were kindly provided by Jane Gravelle of the Congressional Research Service and Judy Xanthopoulos of the Joint Committee on Taxation, respectively. Based on this information we regressed total benefits on AGI. The regression yielded a coefficient of 0.11295 with an R^2 equal to 0.99. In defining the wage-tax base, we therefore exempt roughly 11 percent of labor compensation from the base calculations.

However, this rate applies only to new capital. Existing capital faces a higher tax rate which, given depreciation schedules, is estimated to be 20 percent. We model this gap by assuming that all capital income faces a 20 percent tax, but that 20 percent of new capital may be expensed, thereby generating a 16 percent effective rate on new capital.

State Income Taxation

In addition to the federal taxation, both capital and wage income are subject to a proportional state income tax of 3.7 percent. This value equals total state income-tax revenue in 2000 divided by national income.

Consumption Taxation

Consumption taxes in the initial steady state reflect two elements of the existing tax structure. First we impose an 8.8 percent tax on consumption expenditures consistent with values reported in the National Income and Product Accounts on indirect business and excise revenues. However, because contributions to both defined benefit and defined contribution pension plans receive consumption tax treatment, we levy an additional 2.5 percent tax on household consumption goods expenditures to account for the indirect taxation of labor compensation in the form of pension benefits (Auerbach 1996). This 2.5 percent tax replaces the wage tax that otherwise would apply to labor compensation in the form of fringe benefits.

Social Security, Medicare, and Disability

The model has a social insurance system that incorporates social security Old-Age and Survivors Insurance (OASI), Social Security Disability Insurance (DI), and public health insurance taking the form of Medicare (HI). OASI benefits are calculated according to the progressive statutory bend-point formula. U.S. Social Security benefits are based on a measure of average indexed monthly earnings (AIME) over a 35-year work history. The AIME is converted into a primary insurance amount (PIA) in accordance with a progressive formula. In particular, the 2000 benefit formula has two bend points. The PIA is calculated as 90 percent of the first \$437 of AIME, 32 percent of the next \$2,198 of AIME, and 15 percent of AIME above \$2,198. In the model, we wage-index past covered earnings based on the growth in the economy-wide real wage per unit of human capital.

We approximate the benefit formula with a sixth-order polynomial which is applied to the dollar-scaled AIME generated by the model. This polynomial approximation is very accurate with a $R^2 = 0.99$ (Figure 1). We achieve replacement values between 25 and 75 percent for the lifetime richest and lifetime poorest, respectively. Since approximately 50 percent of Social Security benefits are paid to survivors and spouses, we multiply benefits by a factor of two. In ignoring spousal benefits and the fact that the rich live longer than the poor, we may be overstating the programs degree of progressivity.

Our model has separate OASI, DI, and HI taxes. The values of the OASI tax rate are determined endogenously to finance benefits on a pay-as-you-go basis. The net OASI marginal tax rate enters agents' first-order conditions in determining their supplies of labor. These effective marginal net payroll taxes differ across agents. For example, low income agents receive a better return on their OASI contributions due to the progressivity of the system's benefit formula. This reduces the size of their effective net tax rate. And high earning agents face a zero net marginal OASI as well as DI tax since their marginal labor income

is not subject to OASDI taxation. Our simulations assume full perception of marginal OASI net taxes, i.e., they assume that agents correctly foresee how their OASI payroll tax payments relate to their OASI future benefits.

The HI and DI programs are modeled very simply. The HI and DI levels of lump-sum transfers are chosen to generate payroll tax rates of 2.9 percent and 1.9 percent, respectively, corresponding to their 2000 statutory rates. Like the OASI taxes, DI contributions apply only to wages below \$62,700. The HI tax, in contrast, is not subject to an earnings ceiling. Lump-sum HI and DI benefits are provided on an equal basis to agents above and below age 65, respectively.

Aggregation and Production

The aggregate supply of capital at a point in time is obtained from summing over individual asset holdings and subtracting the contemporaneous value of government debt. The aggregate supply of human capital at a point in time is calculated by summing together the effective labor supplies of all agents. Any particular agent's labor supply is simply given by the product of a) the difference between her time endowment and her leisure and b) her human capital efficiency coefficient specified in equation (10). Output (net of depreciation) is produced by identical competitive firms using a standard Cobb-Douglas production function, with a capital coefficient equal to .25.

Initial Demographic and Economic Conditions, Lifespan Extension, and Population Growth

Our kidweight function is assumed to remain fixed through time. Its values were obtained from Social Security Administration estimates for 2000. The same data source provides past and projected

totals of cohort births, which we use to fill in our cohort population functions. The Social Security population projections extend through 2075, after which we assume that the birth rate stabilizes. We also used Social Security life expectancy data to calibrate the model's initial maximum age of life and changes in this age through time. The particular data we used here are Social Security's uni-sex life expectancies conditional on reaching age 65. Life expectancy equals 82 for the year 2000 and increases to 83 by 2010, 84 by 2030, and 85 by 2060.

Table 1 compares our model's predicted population totals as well as population shares with those forecast by the Social Security Administration. Our population totals line up quite well over the next 30 years, but understate projected population growth thereafter. In 2030, the model predicts there will be 22.8 percent more Americans alive than are now living. The comparable Social Security figure is 22.6 percent.

The model also does a very good job tracking population shares. In 2075, the model predicts that 23 percent of the population will be 65 and older – the same share predicted by Social Security. In that year the model's and Social Security's predicted shares of those under age 20 differ by only 1 percentage point. While the model's long-run age distribution is quite similar to that of Social Security's, its medium terms distribution is somewhat different. In particular, the model predicts that the elderly will be a somewhat higher share of the population than Social Security believes will be the case. Finally, note that the U.S. population is predicted by both Social Security and our model to get old and stay old. Thus, unless policy is changed, the economic implications of America's aging will be here to stay.

Our model also requires an initial level and distribution of assets by age and earnings class. To obtain these initial conditions, we calculated average net worth by age of household head in the 1998

Survey of Consumer Finances. For each earnings class at a given age we set initial assets equal to the average for its age group multiplied by the ratio of the earnings class' wage at age 40 to that of earnings class 6's wage at age 40. Thus we determine relative initial assets by earnings class based on a rough measure of relative lifetime earnings capacity. Given this preliminary allocation of net worth by age and earnings class, we scale up or down each agent's assets by the same factor until the model produces a realistic year-2000 national saving rate.

Solving the Model

The model uses a Gauss-Seidel algorithm to solve for the perfect foresight general equilibrium transition path of the economy. The calculation starts with a guess for the time-paths of the aggregate supplies of capital and labor then iterates on those variables until a convergence criterion is met. In each iteration, the time-paths of aggregate factor supplies are assumed to equal their corresponding factor demands and are thus used to determine the time-paths of factor prices. These factor price time-paths are, in turn, used in conjunction with time-paths of tax rates and certain shadow prices to determine the household sector's supplies, over time, of labor and capital. In each iteration, the new household factor supply time-paths are averaged with the time-paths initially guessed for that iteration and the resulting average is used as the guess for the next iteration. In addition to this "outerloop" iteration, the model has "innerloop" iterations that ensure that, given the iteration's assumed time-paths of factor prices, households are properly maximizing lifetime utility subject to their lifetime budget constraints.

Household optimization includes the constraint that leisure not exceed the endowment of time. For those households who would violate the constraint, the model calculates shadow wage rates at which they

supply exactly zero labor. The household's budget constraint is kinked due to the tax deductions applied against wage income. A household with wage income below the deduction level faces marginal and average tax rates equal to zero. A household with wage income above the deduction level faces positive marginal and average tax rates. Due to the discontinuity of the marginal tax rates, it may be optimal for some households to locate exactly at the kink.

Our algorithm deals with this problem as follows. We identify households that choose to locate at the kink by evaluating their leisure choice and corresponding wage income above and below the kink. We then calculate a shadow marginal tax rate from the first-order conditions that puts those households exactly at the kink. This procedure generates optimal forward-looking leisure and consumption choices for all periods of life.

The payroll tax ceiling introduces additional complexity by creating a non-convexity in the budget constraint. For those above the payroll tax ceiling, the marginal tax rate on labor falls to zero. We model this non convexity by assuming that earnings groups 8 through 12 face no marginal payroll tax on their labor supply, but rather simply an inframarginal payroll tax equal to the payroll tax rate times the payroll tax ceiling. For earnings groups 1 through 7, we assume that payroll taxes are assessed on all their earnings.

The sequence of calculations follows: An initial guess is made for the time-paths of aggregate factor supplies as well as for the shadow wage rates, shadow tax rates, endogenous federal wage-income or consumption tax rates, OASI, DI, and HI payroll tax rates, and the Social Security and Medicare benefit levels. The corresponding factor prices are calculated along with the forward-looking consumption, asset and leisure choices for all income classes in each current and future cohort. Shadow wages and shadow taxes are calculated to ensure that the time endowment and the tax constraints discussed above are

satisfied. Households' labor supplies and assets are then aggregated by both age and lifetime income class at each period in time. This aggregation generates a new guess for the time-paths of the capital stock and labor supply. The tax rate, which is endogenous for the particular simulation, is updated to meet the relevant revenue requirement. OASI, HI, and DI payroll tax rates are also updated to preserve the pay-as-you-go financing of these benefits.¹⁸ The new supplies of capital and labor generated by the household sector of our model are weighted, on an annual basis, with the initial guess of these supplies to form a new guess of the time path of these variables. The algorithm then iterates until the capital stock and labor supply time-paths converge. In the algorithm, we give the economy 275 years to converge to its final steady state.

Checking the Solution and Uniqueness

Although the model is highly stylized, there are enough interacting and complex elements for a reader to wonder if one can really check the solution. Indeed, we can and do check that the transition path to which our program converges is indeed an equilibrium. We do this by verifying that a) supply for labor, capital, and output equal their respective demands in each year, b) all agents in each cohort satisfy their intertemporal budget constraints, c) the constraint that leisure not exceed the endowment of time is never violated, and d) the government satisfies its intertemporal budget constraints.¹⁹ A related question is whether the “box” we’ve created is black or whether we can see through it and provide the intuition for the results. We believe the results are easily explained and that differences across simulations are exactly

¹⁸ Note that the Social Security replacement rate and absolute level of Medicare benefits are exogenous.

¹⁹ Given Walras' Law, some of these checks are redundant.

what one would expect.

One might also wonder whether the transition paths we generate are unique. Although we have no formal proof of uniqueness, Laitner (1984) has proved uniqueness in a linearized version of the original Auerbach-Kotlikoff model for the same utility- and production-function parameter values entertained here. Another indicator of uniqueness is that we arrive at the same long-run steady state from any arbitrary initial conditions provided the policy chosen is held fixed. In addition, small perturbations in initial conditions generate transition paths that are very close to those without the perturbations. Were there multiple equilibria, one would expect that small differences in initial conditions could lead to substantial differences in how the economy progresses through time. Finally, we had no problem getting the model to converge for the simulations we report, which would be unlikely were there multiple paths on which the economy could embark.²⁰

IV. Findings

This section first presents our base-case transition and explores its sensitivity to longevity, retirement behavior, and the rate of technical change. We then consider two reforms of the existing pay-as-you-go OASI program that would limit increases in the OASI tax rate. These are an additional 3-year increase in the normal retirement age and a gradual 50 percent cut in benefits. Social Security's normal retirement age is already scheduled to rise from 65 to 67 between now and 2025. In simulating the increase in the

²⁰ After many, but not all possible attempts at applying different dampening factors, we were unable to get a simulation to converge in which the ceiling on taxable payroll is eliminated. Apparently, placing high income households into much higher marginal tax brackets renders the model very hard to solve, suggesting that there may be an economic barrier to conducting certain policies.

normal retirement age we simply modify the base case to phase in the higher age over the same time period. In simulating the benefit cut, we assume it occurs gradually over the next 30 years, with benefits for each year's new set of retirees declining an additional one thirtieth of 50 percent. Our remaining three policy simulations all fully privatize the OASI system, but differ with respect to the method of financing benefits accrued under the old system. The three methods of transition finance are a proportional consumption tax, a proportional wage tax (with no ceiling on taxable earnings), and an increase in the model's income tax.

The Base-Case Demographic Transition

The first panel in Table 2 shows how key macroeconomic variables evolve in our base-case transition in which Social Security and Medicare tax rates are adjusted through time to finance the benefits of those programs on a strictly pay-as-you-go basis. The economy's year-2000 national saving rate is 4.6 percent, its pre-tax return to capital is 7.5 percent, and its OASDHI tax rate is 13.7 percent. The saving rate is within close range of the current U.S. national saving rate. The pre-tax return to saving also seems reasonable. And, the model's combined OASDHI tax rate is with .6 percentage points of the current combined cost rate of those three social insurance programs. Another important initial condition, not shown in the table, is the economy's capital-output ratio. This value is 3.3, which is at the lower range of recent estimates of this variable based on market valuations of assets.

Turn now to the economy's evolution through time. Although the economy is aging, total effective labor supply continues to increase. Indeed, in 2030, labor supply is 58.7 percent larger than its initial value. This growth is due primarily to our assumed labor-augmenting technical change that raises successive cohorts' time endowments by 1 percent. Absent this technical change, the economy's 2030 labor supply

would exceed its 2000 supply by only 24 percent.

The rapid aging of the population and the growth of labor income affect capital accumulation. According to the model, the nation's capital stock and output in 2030 are 36.6 percent and 52.9 percent greater than their respective 2000 values. Since labor supply growth over the next three decades exceeds growth in the capital stock, the capital-output ratio falls over this period, and, indeed, continues to fall over the remainder of the century. In 2030, the real wage is 3.7 percent lower than in 2000; in 2100, it's 9.8 percent lower. Over the next three decades, the real return to capital rises by almost 100 basis points and then increases by another 200 basis points over the rest of the century.

The good news then is that output growth will continue, provided technical change continues apace. The bad news is that the economy won't grow as rapidly as it might, that there is capital shallowing rather than capital deepening, that the real wage (the wage per unit of human capital) falls, and that the OASDHI payroll tax rate rises dramatically.

Whither the Asset Glut?

The main reason the retirement of the baby boomers doesn't generate the advertised capital glut, with its supposed major rise in real wages and major decline in the real return to capital, is the presence of the Social Security and Medicare programs. As the next to the last column in Table 2 shows, the baseline transition features a remarkable increase in the OASDHI payroll tax rate -- from 13.7 percent in 2000 to 24.3 percent in 2030.²¹ Most of this tax increase occurs between 2010 and 2030. As the

²¹Recall that our model's 13.2 percent value for the tax rate in 2000 is lower than the actual 15.3 percent OASDHI tax rate because we incorporate payroll taxes in excess of benefit costs as part of general revenue finance.

payroll tax rises, it reduces significantly the amount of asset accumulation that occurs in these two decades, and this reduction in asset accumulation prevents the capital stock from rising relative to the work force. Between 2030 and 2100, the OASDHI tax rate rises to 26.5 percent. Hence, the payroll tax not only rises dramatically. It also stays very high for the rest of the century.

Are these tax rate increases plausible? They are, indeed. The last column in Table 2 shows the Social Security Administration's (SSA's) own cost rate projections. SSA projects a 68 percent increase in cost rates between 2000 and 2030, compared with 77 percent in our model. In 2075, the model's and SSA's projected cost rates are almost identical.

A second factor preventing capital deepening is the increase over time in the rate of general revenue taxation. As previously mentioned, we model the federal income tax by a) taxing capital income at an effective rate of 20 percent, which we hold fixed through time, and b) taxing labor income on a progressive basis. Specifically, the marginal tax rate is zero for wage earnings below the level of minimum taxable earnings, which we calibrate based on existing deductions and exemptions, and a linear function of wage earnings for earnings above this minimum. Along the economy's baseline transition path, we adjust the intercept of this marginal tax rate function. This adjustment affects both the average and marginal rates of taxation of wage earner. In year 2000, the average (across all wage earners) value of the average labor income tax rate is 11.3 percent. The average marginal tax rate in that year is 28.9 percent. Both of these rates rise somewhat over the following three decades. In 2030, the average value of the average general wage tax rate is 12.3 percent, while the average marginal rate is 38.2 percent.

The fact that workers have less disposable income out of which to save as well as much less incentive to work is evidenced in their asset accumulation. If one ignores the expansion of workers' time

endowments through technical change and compares a middle-class (group 5) 40 year-old in 2030 with a 40 year-old in 2000, one finds the 40 year-old in 2030 holding 25.7 percent fewer assets.

A third point is that when the population is measured in terms of lifetime labor productivity, the nation's impending aging is much less significant. Table 3 compares the evolution of population shares measured in bodies with shares measured in units of lifetime labor productivity. Under the former measure, the share of the elderly in 2000 is 12 percent; under the later measure, it's 9 percent. In 2030, the elderly represent 22 percent of the population, but only 16 percent of the population adjusted for lifetime productivity. Thus, correcting for labor productivity, the population is substantially younger now and will be substantially younger in the future.²²

A final possible reason that capital deepening does not arise is that the country is not starting its aging process from a steady state with a stable ratio of capital per effective unit of labor. If, because of historic reasons, including past fiscal policy and recent increases in asset valuations, the capital-labor ratio is unusually high, the country may, in part, be embarked on a transition path to a lower capital-labor ratio.

Living Standard Implications

As mentioned, payroll taxes in 2030 are 77 percent higher than in 2000, and average income tax rates are 9 percent higher. Together, these tax hikes raise the average total tax on labor income tax by 42 percent. These tax increases will deprive the next generation of workers of much of their natural economic

²² Recall that in our model, a higher rate of technical change has the same implications as a higher rate of population growth. And faster population growth translates into a younger society.

inheritance. Taking technology-driven productivity growth into account, 40 year-old workers' 2030 after-tax real labor earnings will be only 12 percent higher because of the tax increases, compared with 35 percent higher were tax rates fixed

Alternative Life Expectancies

Although the Social Security Administration projects substantial growth in longevity, this growth falls short of that forecast by demographers Ronald Lee and Lawrence Carter in their most recent update of the Lee and Carter's (1992) calculations. Indeed, the Social Security Administration's projection assumes it will take Americans over four decades to start living as long as the Japanese now live. The more optimistic Lee-Carter projection was adopted by the 1999 Technical Panel of the Social Security Advisory Board, but largely ignored by the Social Security trustees. It foresees 65 year-old Americans in 2050 living to age 86 – three years longer than the Social Security trustees predict.

The second panel of Table 2 shows the results of replacing our model's Social Security-based longevity projection with that of Lee and Carter. The major differences between the base-case and the Lee-Carter simulation involves the OASDHI tax rate. In 2030, the Lee-Carter tax rate is .6 percentage points higher than in the base case. By 2100 it is 2.6 percentage points higher. The need to save for a longer retirement stimulates some additional capital accumulation as well as more labor supply. In the long-run, the economy's capital-labor ratio and the real wage are essentially unchanged.

Delayed Retirement

Table 2's next panel considers whether getting retirees to go back to work would materially

improve the situation. Specifically, it displays the results of assuming that workers remain fully productive through age 65 rather than through age 62. Unfortunately, the results suggest that delayed retirement is no panacea with respect to our social security problems. The 2030 OASDHI tax rate is essentially unchanged. Aggregate labor supply is not much affected by the increase in retirement because young and middle-aged agents spend some of their higher future earnings on more leisure. For example, in 2030, 40 year-olds in group 6 supply .6 percent less labor than in the base case.

Delayed retirement also leads workers to reduce their retirement saving. This means less capital accumulation, which, in turn, spells a fall in the capital-labor ratio and a drop in the real wage. In 2030, the real wage is 4.2 percent lower than its initial value, compared with 3.7 percent lower in the base case. This decline in the real wage undoes the decline in the OASDHI tax rate associated with the expansion of the economy's labor supply from delayed retirement.

Can Higher Rates of Technical Change Save the Day?

The next two panels of Table 2 reproduce the baseline transition, but assume, respectively, 2 and 3 percent annual growth rates of technical progress rather than the 1 percent rate assumed in the base-case. These higher rates of growth in the size of the effective work force limit the rise in payroll tax rates through time. In 2030, the OASDHI tax rate is 24.3 percent in the base case, but 21.7 percent with 2 percent technical progress and 19.2 percent with 3 percent technical progress. In 2100 the base-case OASDHI tax rate is 26.5 percent; the corresponding tax rates assuming 2 and 3 percent technical progress are 19.7 and 14.7. Recall that higher rates of technical progress are, in our model, effectively equivalent to higher rates of population growth. Hence, one would expect higher rates of technical progress to effectively

reduce the country's aging and materially limit the rise in the OASDHI tax rate. But even assuming an historically very high 3 percent rate of technical progress, the OASDHI tax rate still rises by one third between now and 2030.

Higher rates of technical progress have only minor implications for capital intensity. The capital shallowing exhibited in the base case occurs here as well, meaning that the real wage per unit of effective labor also declines. With a 2 percent rate of technical change, the long-run wage is 9.1 percent lower than its initial value; with a 3 percent rate of technical change, it's 8.7 percent lower. For point of reference, the long-run real wage decline in the base case is 9.8 percent. Other things equal, one would expect higher rates of technical change of the type we entertain to lower the real wage relative to the base case since it entails more rapid growth of the effective labor force. However, in limiting the increase over time in the payroll tax rate, more capital accumulation occurs, which limits the decline in the real wage.

Gradually Cutting OASI Benefits By 50 Percent

The next set of results consider a gradual, 50 percent cut in OASI benefits. This reduction leaves the OASDHI tax rates in 2030 and 2100 only 2.0 and 3.5 percentage points above the 2000 level. Limiting the growth in payroll tax rates limits the process of capital shallowing. Indeed, in 2030, the capital-labor ratio is the same as in 2000. Thereafter, the supply of capital does grow more slowly than labor supply, but the long-run wage per effective unit of labor supply ends up only 2.5 percent lower, compared with 9.8 percent lower in the base case. What's interesting, though, is that the long-run wage falls at all. Our prior was that we'd see a major increase in capital per unit of labor and the real wage were the payroll tax rate to remain fixed. Upon reflection, the explanation appears to be that because of technical change,

the effective (measured in productivity units) population doesn't age as much and that the economy's initial capital-labor ratio may be high relative to what would arise in the long-run.

Raising Social Security's Retirement Age

Directly cutting OASI benefits by 50 percent, even were it done slowly, would raise enormous political objections. In contrast, raising the system's age of normal retirement by three years more than is currently slated to occur might be politically palatable. For comparison with the previous results, note that a three-year increase in the normal retirement age constitutes a roughly 17 percent benefit cut. The next panel in Table 2 shows the results of such a policy. While the OASDHI tax hike is mitigated, the effect is small. By 2030, the tax rate is 19.2 percent. At the end of the century, it's 20.9 percent. The message here is that even a very major increase in the OASI retirement age would not suffice to prevent major increases in the rate of payroll taxation.

Privatizing Social Security

Our next three simulations contemplate an even more dramatic change to the OASI program, namely its complete elimination *at the margin* by paying out only those benefits accrued under the current system. To be precise, the three simulations pay the OASI benefits of initial retirees in full and linearly phase out OASI benefits for new retirees over a 45-year period starting in 2000. In addition to providing current retirees their full accrued benefits and existing workers with what amounts to roughly their accrued benefits, each privatization eliminates the OASI tax rate and finances transitional OASI benefits with a new tax.

Consider first using a specially dedicated consumption tax for transition finance. The required tax rate is initially 10.1 percent. It rises as the baby boomers retire to a value of 13.6 percent in 2020 and then gradually declines. After 2062, the added tax is zero. The combined OASDHI payroll tax is reduced immediately by 9 percentage points. It then grows by 3.4 percentage points over time as the demographics raise cost rates for the DI and HI programs.

The long-run economic gains from privatizing social security are substantial. Compared with the base case, the real wage is 15.1 percent higher in 2100. These gains arrive, however, slowly. By 2030, the real wage is only 5.3 percent larger than it would have been in the absence of privatization. This relatively slow adjustment to Social Security's privatization is not surprising given the enormous overhang of accrued OASI benefits that need to be paid.

The major rise in the real wage reflects significant capital deepening. By 2030, the capital stock is 22.5 percent larger than in the base case. By 2100, it's 77.6 percent larger. Long-run labor supply, in contrast, is somewhat smaller than in the base case. However, the stimulus to capital formation is, by itself, enough to generate more output. Indeed, output at the end of the century is 11.1 percent larger thanks to privatization.

While the consumption-tax transition is slow, it is more rapid than either the wage- or income-tax financed transitions. Both of the later two transitions leave the economy in the same long-run position, but neither generates any capital deepening over the next thirty years. Indeed, in both cases there is capital shallowing at least through 2030 and aggregate output in that year is essentially the same as in the base case.

The explanation here is twofold. First, the consumption tax places more of its tax burden on the

initial elderly, who, because they are close to the ends of their lives, have higher propensities to consume than do the initial middle-aged or the young. In placing a bigger share of the burden of paying off OASI on old spenders and lowering the fiscal burdens on young savers, the economy consumes less and saves more. Stated differently, with wage- and income-tax transition finance, the young and middle-aged are left with less disposable income that they can save for old age. The second reason is that the consumption tax represents, in part, a lump-sum tax on the economy's initial wealth. Because lump-sum taxes are non-distortionary, the consumption tax provides workers with better overall incentives to work and save.

V. Welfare Effects of Alternative Reforms

Tables 4 through 8 show the welfare effects of the five policy reforms discussed above. The welfare changes are measured as the equal percentage increase (decrease) in consumption and leisure needed by an agent in each year of her remaining life in the base-case transition to achieve the same level of utility as under the policy. The tables consider agents in five earnings classes born in different years, where the year of birth is measured relative to 2000.

Welfare Effects of Cutting Social Security Benefits or Raising the Normal Retirement Age

Table 4 displays the welfare effects from the gradual, 50 percent reduction in OASI benefits. This policy is fairly benign when it comes to the very oldest initial members of society, whose benefits are largely unchanged. But it visits some rather large welfare losses on initial middle-aged and low-income agents who are close to retirement and experience most or all of the benefit cut. The largest of the table's reported losses is the 7.0 percent loss of agents in class 1 who are initially age 60. In contrast, their highest-earning

contemporaries, those in group 12, have a much smaller welfare change -- only .935 percent. This is expected given the comparatively small stake that high-income agents have in the U.S. Social Security system and the progressivity of the system's benefit formula.

While cutting OASI benefits in half is highly regressive in the short run, it's also highly progressive in the long run. Take those born 80 years after the policy begins. The poor in this cohort experience an 11.0 percent welfare gain, while the rich experience only a 2.8 percent gain. This long-run progressivity of reducing or eliminating pay-as-you-go Social Security is a feature of our other policy simulations as well.

What explains these long-run results? There are three offsetting factors at play. First, in cutting OASI benefits, we are cutting the benefits of a system that provides benefits on a progressive basis. This would suggest a regressive long-run outcome. But in cutting benefits we are also precluding major increases in the highly regressive Social Security payroll tax. Stated differently, maintaining the pay-as-you-go nature of Social Security is highly regressive given that it will visit major tax hikes on low- and middle-income workers, but not on high-income workers, given the ceiling on the payroll tax. The third factor involves the long-run increases in real wages arising under the different policies. High- as well as middle- and low-income agents experience the same percentage real wage increase, but since we are dealing here with large tax and wage changes there is a significant interaction between the two; i.e., for those paying a larger share of their lifetime earnings in payroll taxes, the real wage increase coupled with the substantial long-run tax cut spells a larger percentage increase in lifetime after-tax earnings.

Table 5 shows the welfare effects from raising Social Security's normal retirement age by 5 rather than 3 years by 2025. As expected, the pattern of welfare changes is similar to that in Table 3 because this policy represents an indirect way of phasing in a major benefit cut. But because benefits are cut by a

smaller percentage, the losses to the losers and gains to the winners are smaller than in the previous case.

Welfare Effects of Privatizing Social Security

Tables 6 through 8 present welfare changes arising from the complete privatization of the OASI program assuming consumption-, wage-, and income-tax finance of transition benefits. Note the remarkably large welfare gains privatization generates for low- and middle-income agents in the long run. Class 3, for example, experiences close to a 21 percent gain. For Class 12, there is also a sizable, 5.2 percent long-run gain. Why are these long-run gains so large? First, privatizing the OASI system prevents the doubling over the course of the century of what is already a very high tax. Second, it eliminates this very high tax. And third, it leads to substantial capital deepening. Indeed, rather than declining by 10 percent, the real wage ends up rising by 5 percent. Compared with the base case, this long-run 15 percent increase in real wages and the roughly 20 percentage point decline in the payroll tax rate is strong medicine for what would otherwise be a rather ailing economy.

Since all three privatizations generate the same long-run welfare levels, their welfare differences involve the treatment of initial generations. Wage-tax transition finance entails essentially no welfare changes for the initial elderly and very small welfare changes for those about to retire at the time of the reform. In contrast, initial young workers fare much worse with wage-tax finance than with either consumption-tax or income-tax finance. The reason is that under wage-tax finance, the initial elderly aren't asked to contribute very much to pay off the benefit liabilities of the old system. Take, for example, initial 30 year-olds in class 3. Their welfare loss is 1.82 percent under wage-tax finance, whereas under consumption-tax and income-tax finance, their losses are just 1.12 percent and 1.07, respectively. In

delaying the transition, wage-tax finance also reduces the welfare gains that would otherwise be enjoyed by generations born a short time after the reform. Class 6 members born five years after the reform begins experience a 4.78 percent welfare gain with wage-tax finance, but 8.48 percent and 7.22 percent gains under consumption- and income-tax finance.

A comparison of Tables 6 and 8 indicates the somewhat surprising fact that income-tax finance hurts the initial elderly more than does consumption-tax finance. There are three reasons. First, OASDHI benefits are indexed by the model to the price level, so the consumption tax used to finance the privatization transition triggers a benefit adjustment that insulates the real purchasing power of the elderly's benefits. In contrast, this automatic tax protection isn't triggered by increases in the income tax. Second, one can, and our agents do, partly avoid the consumption tax by making bequests. This option isn't available with income taxation; i.e., agents pay the same income tax regardless of how they spend their money. Third, given our modeling of investment incentives as partial expensing of new capital goods, increases in the capital-income tax rate, which occurs under income-tax finance, generates a capital loss with respect to the value of existing capital. The initial elderly are primary owners of existing capital and are hit by this capital loss regardless of their expenditure choice with respect to consumption and bequests.

Finally, note that none of the privatization simulations generate the quite large welfare losses observed in Tables 4 and 5, in which benefits are cut in half or greatly reduced via an increase in the age of normal retirement. In Tables 6 through 8, none of the welfare losses exceed 3 percent. These sacrifices seem modest compared to the very large welfare gains accruing to low- and middle-income households in the long run.

VI. Summary and Conclusion

Our simulation model does a remarkably good job in tracking the nation's aging. And, while it abstracts from many features of economic reality, it seems to be a reasonable tool for studying the general equilibrium feedback effects of the demographic transition. Although many commentators have suggested that these feedbacks would ameliorate our social insurance financing problems, the model says otherwise. Over the next three decades, the model's dramatic 77 percent run-up in the payroll tax dissipates what would otherwise be a natural process of capital deepening. Indeed, labor will grow more rapidly than capital throughout this century leaving 2100 real wages per unit of effective labor about 10 percent lower than their current value. Although technical change will prevent the next generation of workers from experiencing absolute declines in their living standards, the payroll tax hikes will expropriate much of what would otherwise be a very healthy rise in their levels of welfare.

Maintaining the existing system, but preventing payroll taxes from dramatically rising would require cutting Social Security benefits in half or tripling the increase in Social Security's normal age of retirement that is now underway. Given this gloomy prognosis, does privatization offer a solution? The answer is yes, with a big "but." The yes refers to the fact that in privatizing retirement saving and eliminating the OASI payroll tax, workers will be given a much desired tax break. But the taxes needed to pay off the accrued liabilities of the old system will impose burdens of their own. Generations alive at the time of the reform would be hurt, with the identity of the worst hit depending on the choice of the transition tax. The sacrifices that would be extracted from initially living generations aren't trivial, yet they appear modest compared to the tremendous gain privatizing Social Security in the manner described here would provide the next generation.

Is there a silver lining in the social insurance clouds that this paper misses? There could be. Our model treats technical change as exogenous and our base case assumes the 1 percent annual rate of this change will remain the same through time. Clearly, there is no way of knowing precisely how fast technology will progress. If it does advance much more rapidly, our children will be able to bear their higher OASDHI tax burdens much more easily. But the possibility of slower technical progress also exists, and this possibility may deserve more weight if, as some believe, technical progress is due to entrepreneurial effort, which may be sensitive to after-tax incentives.

Our model can also be questioned because of its stylized nature. It abstracts from uncertainty, international trade, monetary policy, borrowing constraints, and a number of other aspects of economic reality. Whether the inclusion of those factors would materially alter our conclusions is a question for future research. But our own sense is that it would not. Our nation's pending demographic change is so severe that any reasonable modeling of the economy will generate a fiscal dilemma of the first order.

If demographics are going to dictate our economic future, the sooner we realize it the better. This paper's findings help in that respect. They show that macroeconomic feedback effects will not save the day, and that nothing short of major cuts in Social Security and Medicare or the wholesale privatization of Social Security will prevent a long-run doubling of U.S. payroll tax rates.

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Table 1**Comparing the Model's and Social Security's Population Projections**

Year	Social Security Population Projections				The Model's Population			
	Total Population Index (100 in 2000)	Population Shares			Total Population Index (100 in 2000)	Population Shares		
		0-19	20 - 64	65 +		0-19	20 - 64	65 +
2000	100.0	0.29	0.59	0.12	100.0	0.29	0.59	0.12
2005	104.1	0.28	0.60	0.12	104.6	0.27	0.60	0.13
2010	108.1	0.27	0.60	0.13	108.6	0.26	0.59	0.15
2020	116.0	0.25	0.58	0.16	116.0	0.25	0.57	0.18
2030	122.6	0.25	0.56	0.20	122.8	0.24	0.54	0.22
2050	131.2	0.24	0.56	0.21	124.2	0.23	0.53	0.23
2075	140.3	0.23	0.54	0.23	125.8	0.24	0.53	0.23

Table 2 Simulation Results

	Year	National Income	Capital Stock	Effective Labor Supply	National Saving Rate	Before- Tax Wage	Interest Rate	OASDHI Cost Rates	
								Model ²	SSA
Base Case	2000	1.000	1.000	1.000	.046	1.000	.075	.137	.131
	2005	1.091	1.064	1.101	.044	.992	.077	.145	.136
	2010	1.191	1.137	1.209	.047	.985	.079	.158	.147
	2020	1.361	1.271	1.393	.030	.977	.081	.197	.183
	2030	1.529	1.366	1.587	.011	.963	.084	.243	.220
	2050	1.889	1.500	2.039	.015	.926	.095	.257	.237
	2075	2.479	1.845	2.736	.023	.906	.101	.264	.262
	2100	3.303	2.421	3.663	.027	.902	.103	.265	na
Lee-Carter Life Expectancies	2000	1.000	1.000	1.000	.051	1.000	.076	.136	.131
	2005	1.091	1.066	1.100	.048	.992	.077	.145	.136
	2010	1.194	1.147	1.210	.053	.987	.079	.157	.147
	2020	1.368	1.294	1.393	.032	.982	.080	.203	.183
	2030	1.541	1.403	1.590	.014	.969	.083	.249	.220
	2050	1.918	1.548	2.060	.026	.931	.094	.265	.237
	2075	2.529	1.926	2.770	.021	.913	.099	.291	.262
	2100	3.358	2.480	3.715	.026	.904	.102	.291	na

Table 2 Simulation Results

	Year	National Income	Capital Stock	Effective Labor Supply	National Saving Rate	Before- Tax Wage	Interest Rate	OASDHI Cost Rates	
								Model ²	SSA
Three-Year Later Retirement	2000	1.000	1.000	1.000	.041	1.000	.076	.137	.131
	2005	1.096	1.057	1.109	.042	.988	.079	.145	.136
	2010	1.197	1.129	1.220	.045	.981	.080	.157	.147
	2020	1.371	1.256	1.411	.029	.971	.083	.196	.183
	2030	1.539	1.353	1.607	.011	.958	.086	.241	.220
	2050	1.903	1.485	2.067	.015	.921	.097	.255	.237
	2075	2.500	1.832	2.772	.023	.902	.103	.262	.262
	2100	3.330	2.408	3.711	.026	.898	.105	.263	na
2% Rate of Technical Progress	2000	1.000	1.000	1.000	.051	1.000	.087	.140	.131
	2005	1.102	1.083	1.108	.047	.994	.088	.147	.136
	2010	1.221	1.174	1.236	.049	.987	.090	.157	.147
	2020	1.461	1.350	1.500	.035	.974	.094	.188	.183
	2030	1.753	1.509	1.843	.022	.951	.101	.217	.220
	2050	2.578	1.960	2.824	.038	.913	.114	.198	.237
	2075	4.362	3.266	4.804	.046	.908	.116	.197	.262
	2100	7.453	5.593	8.202	.047	.909	.115	.197	na

Table 2 Simulation Results

	Year	National Income	Capital Stock	Effective Labor Supply	National Saving Rate	Before- Tax Wage	Interest Rate	OASDHI Cost Rates	
								Model ²	SSA
3% Rate of Technical Progress	2000	1.000	1.000	1.000	.060	1.000	.100	.144	.131
	2005	1.115	1.115	1.115	.054	1.000	.100	.149	.136
	2010	1.257	1.237	1.264	.054	.994	.10	.158	.147
	2020	1.583	1.479	1.619	.040	.978	.107	.180	.183
	2030	2.033	1.731	2.145	.032	.948	.117	.192	.220
	2050	3.552	2.672	3.906	.053	.909	.132	.152	.237
	2075	7.692	5.820	8.442	.060	.911	.132	.147	.262
	2100	16.783	12.786	18.376	.061	.913	.131	.147	na
50% Cut in Benefits	2000	1.000	1.000	1.000	.065	1.000	.076	.136	.131
	2005	1.096	1.094	1.096	.062	.999	.076	.135	.136
	2010	1.200	1.198	1.201	.063	.999	.076	.138	.147
	2020	1.387	1.403	1.382	.048	1.004	.075	.148	.183
	2030	1.578	1.578	1.578	.029	1.000	.076	.156	.220
	2050	1.967	1.886	1.995	.027	.986	.079	.167	.237
	2075	2.602	2.423	2.665	.033	.976	.082	.171	.262
	2100	3.472	3.218	3.561	.035	.975	.082	.171	na

Table 2 Simulation Results

	Year	National Income	Capital Stock	Effective Labor Supply	National Saving Rate	Before- Tax Wage	Interest Rate	OASDHI Cost Rates	
								Model ²	SSA
Raise Social Security's Retirement Age by 5 rather than 2 Years	2000	1.000	1.000	1.000	.059	1.000	.076	.136	.131
	2005	1.094	1.084	1.097	.055	.997	.076	.137	.136
	2010	1.196	1.177	1.203	.057	.995	.077	.141	.147
	2020	1.381	1.356	1.389	.042	.994	.077	.156	.183
	2030	1.557	1.500	1.577	.020	.987	.079	.192	.220
	2050	1.934	1.721	2.011	.021	.962	.085	.204	.237
	2075	2.551	2.166	2.694	.028	.947	.089	.209	.262
	2100	3.401	2.861	3.603	.031	.944	.090	.209	na
Consumption-Tax Finance	2000	1.000	1.000	1.000	.063	1.000	.076	.047	.131
	2005	1.096	1.093	1.098	.062	.999	.076	.051	.136
	2010	1.201	1.199	1.202	.066	.999	.076	.056	.147
	2020	1.396	1.434	1.383	.059	1.009	.074	.068	.183
	2030	1.598	1.674	1.574	.046	1.016	.072	.081	.220
	2050	2.056	2.230	2.001	.051	1.027	.070	.081	.237
	2075	2.753	3.145	2.633	.048	1.045	.066	.081	.262
	2100	3.684	4.299	3.499	.046	1.053	.065	.081	na

Table 2 Simulation Results

	Year	National Income	Capital Stock	Effective Labor Supply	National Saving Rate	Before- Tax Wage	Interest Rate	OASDHI Cost Rates	
								Model ²	SSA
Wage-Tax Finance	2000	1.000	1.000	1.000	.052	1.000	.074	.044	.131
	2005	1.094	1.070	1.102	.054	.993	.076	.048	.136
	2010	1.198	1.162	1.211	.062	.990	.076	.052	.147
	2020	1.350	1.309	1.364	.035	.991	.076	.064	.183
	2030	1.548	1.451	1.582	.027	.979	.079	.077	.220
	2050	2.044	1.894	2.096	.053	.975	.080	.080	.237
	2075	2.808	2.977	2.753	.057	1.020	.070	.081	.262
	2100	3.774	4.243	3.630	.048	1.040	.066	.081	na
Income-Tax Finance	2000	1.000	1.000	1.000	.052	1.000	.076	.043	.131
	2005	1.083	1.067	1.088	.045	.995	.077	.047	.136
	2010	1.184	1.145	1.197	.051	.989	.079	.051	.147
	2020	1.368	1.318	1.386	.046	.988	.079	.061	.183
	2030	1.564	1.506	1.584	.038	.988	.079	.074	.220
	2050	2.021	2.037	2.016	.056	1.003	.076	.079	.237
	2075	2.731	3.060	2.629	.053	1.039	.068	.081	.262
	2100	3.664	4.271	3.482	.047	1.052	.065	.081	na

Table 3

**The Projected Aging of the U.S. Population
Measured in Bodies and Units of Lifetime Labor Productivity**

Year	Population Shares Measured in Bodies			Population Shares Measured in Units of Lifetime Labor Productivity		
	0-19	20 - 64	65 +	0-19	20 - 64	65 +
2000	0.29	0.59	0.12	0.36	0.55	0.09
2005	0.27	0.60	0.13	0.35	0.56	0.09
2010	0.26	0.59	0.15	0.34	0.56	0.10
2020	0.25	0.57	0.18	0.32	0.55	0.13
2030	0.24	0.54	0.22	0.32	0.52	0.16
2050	0.23	0.53	0.23	0.31	0.52	0.16
2075	0.24	0.53	0.23	0.31	0.52	0.16

Table 4**Welfare Effects of 50 Percent Cut in Benefits**

(base-case percentage change in lifetime consumption and leisure needed to achieve policy-induced utility level)

Generation's Year of Birth Relative to Policy Start Year	Class 1	Class 3	Class 6	Class 9	Class 12
-81	.020	.024	.025	.025	.018
-70	-3.701	-3.269	-2.585	-2.115	-.735
-60	-7.049	-5.870	-4.599	-3.555	-.935
-50	-5.180	-4.424	-3.288	-2.587	-.787
-40	-3.136	-2.281	-1.748	-1.474	-.640
-30	-.467	-.294	-.246	-.310	-.419
-20	1.871	1.722	1.494	1.244	.142
5	8.468	8.088	7.176	6.258	1.583
30	10.320	10.450	9.483	8.296	2.383
55	10.795	11.142	10.221	9.085	2.735
80	10.959	11.369	10.450	9.300	2.823

Table 5
Welfare Effects of 5-Year Rather than 2-Year Increase in Social Security Normal Retirement Age
 (base-case percentage change in lifetime consumption and leisure needed to achieve policy-induced utility level)

Generation's Year of Birth Relative to Policy Start Year	Class 1	Class 3	Class 6	Class 9	Class 12
-81	.012	.015	.015	.015	.011
-70	-3.088	-2.732	-2.292	-1.871	-.639
-60	-6.179	-5.115	-3.985	-3.064	-.776
-50	-4.423	-3.272	-2.417	-1.894	-.558
-40	-1.631	-1.190	-.917	-.795	-.376
-30	.148	.146	.100	.002	-.224
-20	1.612	1.446	1.241	1.040	.149
5	5.317	5.110	4.556	3.991	1.013
30	6.219	6.321	5.778	5.135	1.459
55	6.473	6.784	6.283	5.626	1.673
80	6.561	6.915	6.420	5.756	1.725

Table 6**Welfare Effects of Privatization with Consumption-Tax Transition Finance**

(base-case percentage change in lifetime consumption and leisure needed to achieve policy-induced utility level)

Generation's Year of Birth Relative to Policy Start Year	Class 1	Class 3	Class 6	Class 9	Class 12
-81	-121	-337	-493	-563	-622
-70	-574	-820	-978	-1.025	-1.271
-60	-1.502	-1.899	-1.972	-1.923	-1.507
-50	-2.858	-2.836	-2.598	-2.452	-1.605
-40	-2.935	-2.569	-2.294	-2.193	-1.813
-30	-1.641	-1.301	-1.177	-1.220	-1.810
-20	.876	1.254	1.258	1.109	-1.125
5	9.407	9.409	8.480	7.424	.941
30	17.982	17.853	16.019	14.022	3.994
55	20.172	20.340	18.353	16.113	4.994
80	20.692	20.941	18.921	16.620	5.221

Table 7**Welfare Effects of Privatization with Wage-Tax Finance**

(base-case percentage change in lifetime consumption and leisure needed to achieve policy-induced utility level)

Generation's Year of Birth Relative to Policy Start Year	Class 1	Class 3	Class 6	Class 9	Class 12
-81	-.041	-.050	-.053	-.052	-.038
-70	-.150	-.194	-.214	-.217	-.214
-60	-.272	-.469	-.513	-.507	-.263
-50	-.551	-1.263	-1.349	-1.240	-.277
-40	-.797	-1.812	-1.945	-1.822	-.888
-30	.217	-1.421	-1.822	-1.863	-1.700
-20	2.506	-.207	-1.121	1.458	-3.037
5	9.194	6.365	4.782	3.741	-1.568
30	16.399	15.836	14.082	12.280	3.004
55	19.589	19.748	17.828	15.656	4.754
80	20.551	20.799	18.794	16.511	5.165

Table 8**Welfare Effects of Privatization with Income-Tax Finance**

(base-case percentage change in lifetime consumption and leisure needed to achieve policy-induced utility level)

Generation's Year of Birth Relative to Policy Start Year	Class 1	Class 3	Class 6	Class 9	Class 12
-81	-.914	-1.116	-1.180	-1.161	-.848
-70	-.747	-.986	-1.109	-1.138	-1.189
-60	-1.059	-1.471	-1.595	-1.588	-1.260
-50	-2.333	-2.311	-2.153	-2.056	-1.358
-40	-2.652	-2.195	-1.941	-1.873	-1.627
-30	-1.845	-1.259	-1.069	-1.105	-1.763
-20	-.046	.828	1.023	.950	-1.245
5	7.396	7.850	7.220	6.366	.335
30	16.820	16.772	15.083	13.221	3.569
55	19.879	20.004	18.092	15.886	4.857
80	20.621	20.870	18.857	16.565	5.193