Technical Paper Series
Macroeconomic Analysis and Tax Analysis Divisions
Congressional Budget Office
Washington, D.C.

PRIVATIZING SOCIAL SECURITY IN THE U.S.: COMPARING THE OPTIONS

Laurence J. Kotlikoff
Boston University
The National Bureau of Economic Research

Kent Smetters*
The Wharton School
University of Pennsylvania

Jan Walliser*
International Monetary Fund

NOVEMBER 1998

1998-4

*Kent Smetters and Jan Walliser are fom1er members of the CBO staff. This paper was written while they were employed at CBO.

Privatizing Social Security in the U.S.: Comparing the Options

Laurence I. Kotlikoff
Boston University
The National Bureau of Economic Research

* Kent Smetters
The Wharton School
University of Pennsylvania

Jan Walliser*
International Monetary Fund

November 1998

1998-4

*Kent Smetters and Jan Walliser are former CBO staffers. This paper was written while they were employed at CBO.

The views expressed herein do not necessarily represent those of the Congressional Budget Office.

Abstract

This paper considers alternative ways to privatize the U.S. Social Security system. It does so using a new rational-expectations simulation model based on the Auerbach and Kotlikoff (1987) model. The new model incorporates intra- as well as intergenerational heterogeneity and is closely calibrated to U.S. fiscal institutions. Three different dimensions of privatization are considered: the choice of the tax used to finance the transition, the degree of voluntary participation in the new retirement system, and the method of making the new system progressive.

The alternative transition taxes are the payroll tax, the income tax, and the consumption tax. In some simulations, existing workers can either remain under the old Social Security System or "opt out" from the old into the new system. And progressivity in the new retirement system is introduced either via a flat (basic) benefit or through government matching, on a progressive basis, of contributions made to workers' newly established private retirement accounts. Simulations are conducted assuming the economy is both closed :and fully open to international capital flows and that workers do and do not fully appreciate the extent of the marginal benefit-tax link provided by the current system.

The simulations deliver the following message: Privatization of the U.S. Social Security System can substantially raise the economy's living standard in the long run. But these gains come, for the most part, at the cost of welfare losses to transition generations. Importantly, the poorest members of future society have much to gain from privatization even if privatization doesn't include an explicit redistribution mechanism, such as a basic benefit or a progressive contribution match. The long-run gains from privatization take a fairly long time to materialize. This is particularly true if an income or a wage tax, as opposed to a consumption tax, is used to finance the transition. Finally, privatizations that allow initial workers to remain in the current system have particularly low transition costs and particularly favorable macroeconomic consequences.

I. INTRODUCTION

Public debate about privatizing the U.S. Social Security system has intensified in recent years. Unfortunately, this debate has been remarkably unconstrained by the lessons of economic science. Advocates of reform have tended to portray privatization as a costless panacea, whereas opponents have suggested it will hurt the elderly, particularly the elderly poor. This paper finds the truth where one might expect: in the middle. Although privatization offers significant long-run gains, it does so at some non trivial short-run costs. The precise size of the gains and the speed of their arrival depend critically on the precise manner in which privatization occurs.

This paper uses a dramatically improved version of the Auerbach and Kotlikoff (1987) perfect foresight dynamic simulation model developed in Kotlikoff, Smetters, and Walliser *(1997a,b; 1998a,b)* and Altig et. al. (1997) to compare the intra- and intergenerational distributional effects as well as the macroeconomic effects of alternative ways to privatize Social Security. We consider many options. These include the choice of the tax base used to pay off benefits accrued under Social Security; whether to force people to participate in the new system versus simply giving them the choice to opt out of Social Security; and two methods of including intra-generational redistribution: a pay-as-you-go-financed flat benefit and the progressive matching of contributions to individual accounts. We also consider several modeling assumptions, including the openness of the economy and the degree to which people correctly perceive their Social Security tax-benefit linkage.

As our results demonstrate, privatization involves important tradeoffs. Helping one generation generally involves hurting another, and speeding up the transition generally entails greater short-run sacrifice. But there is also some encouraging news. Privatization can produce a considerable increase in the long-run capital stock, real wage rate, and level of output. In addition, certain

privatizations perform particularly well in both protecting the welfare of the initial elderly and speeding up the transition. Finally, privatization appears to help the most those who are poor in the long run. This is true even in the absence of a special redistribution mechanism, such as a flat benefit, that is used to protect the poor.

Literature Review

The literature dealing with social security privatization-although growing-is still limited. The list includes Feldstein (1975), Seidman (1983), Arrau and Schmidt-Hebbel (1993), Feldstein (1995), Gustman and Steinmeier (1995), Kotlikoff (1996), Samwick (1996), Kotlikoff, Smetters and Walliser (1997), Altig and Gokhale (1997), Feldstein and Samwick (1997), Huang, Imrohoroglu, and Sargent (1997) and those presented in this volume. Some of these papers employ partial-equilibrium models while others allow for general-equilibrium effects.

Our own work on privatization has app,eared in a series of four recent papers (Kotlikoff, Smetters, and Walliser [1997*a,b*; 1998*a,b*]). Each of those papers considers a particular aspect of privatization. Kotlikoff, Smetters, and Walliser (1997 *a,b*) focused on a privatization plan in which accrued benefits are recognized and participation in the new system is mandatory. The accrued benefits are fully paid off with a specific choice of the tax base. The options include a wage base (covered earnings under the existing payroll tax base), the current progressive income tax base, and the consumption base. The purpose of those papers was to compare the distributional effects-both between and within generations-and the macroeconomic effects of using one tax base versus another. The two papers differ from one another mainly in terms of model enhancements. Our most recent two papers focused on privatization plans that might be more likely to be implemented politically.

Kotlikoff, Smetters, and Walliser (*1998a*) considered" opting out." In these simulations, people are simply given the choice of whether to stay in the existing system or to opt out. Those who opt out no longer face future payroll taxes, but they also forfeit any benefits accrued under Social Security. This setting invites adverse selection because people with the most accrued benefits-and those mostly costly for Social Security-are more likely to stay in the system. It, therefore, requires general revenue to finance: the shortfall between Social Security revenue and outlays. This experiment, therefore, changes the short-run macroeconomic and distributional performance of privatization. Kotlikoff, Smetters, and Walliser (1998*b*) reconsidered the forced participation recognition-bond approach considered in our previous two studies, but modified it to include two types of redistribution: a flat benefit and a progressive matching by the government of contributions to individual accounts. The pros and cons of each method of achieving progressivity were compared with one another and relative to our standard runs with no progressivity.

Summary

We have learned several lessons from our previous work which we summarize in this paper. This paper also provides some new comparisons of privatization options. It also tests the importance of our closed-economy assumption used in our previous work. Due to space limitations, we focus attention only on the key results and have relegated the mathematical description of the model to Appendix I which reprints Section II of Kotlikoff, Smetters, and Walliser (1998*a*). Appendix II outlines the solution methodology. The key lessons learned from our work are as follows:

o **Long-Run Macroeconomic Performance**. Alternative privatization schemes that fully eliminate unfunded liabilities and do not increase the long-run stock of explicit government debt

result the same long-run improvement in macroeconomic variables, including the capital stock, labor supply, national income, wages and interest rates. Privatizations which maintain some of Social Security's unfunded liabilities in the fonD of a pay-as-you-go-financed flat benefit result in noticeably smaller macroeconomic gains.

o **Short-Run Macroeconomic Performance.** The exact nature of the plan-including the exact experimental design (e.g., forced participation versus opting out, no progressivity versus progressivity , etc.) and the tax used to finance the transition path-are critical detemlinants of short-run macroeconomic performance. Of these elements, the choice of the transition tax used to payoff the accrued liabilities of the old system is, by far, the most important determinant of short-run macroeconomic perfonnance.

o *Choice of Tax Base.* Consumption-tax finance of the transition leads to the most rapid adjustment toward the final steady-state. Compared to other transition taxes, the consumption tax elicits the largest sacrifice from the initial retirees. It effectively levies a lump-sum tax on their accumulated assets. Since retirees are the largest spenders in life-cycle economies (they have the largest marginal propensities to consume), a consumption tax raises national saving. In a closed economy, more national saving means more domestic investment, a larger capital stock, and more output. Wage-tax finance leads to substantially smaller transitional gains. Income-tax finance, however, perfonns the worse, generally leading to a *decrease* in the capital stock, labor supply, and national income during the fIrst 25 years of the transition due to the temporary large increase in distortionary tax rates, including the marginal tax rate on capital income.

o *Choice of Experiment.* Rather interestingly, despite adverse selection problems, the opting out experiment outperfonns the other experiments in the short run holding fixed the tax base used

to finance the transition. This is because maJly people are willing to forfeit their accrued Social Security benefits under the opting out plan obviating the need to pay for these benefits during the transition. The exact method of achieving intra-generational redistribution is also important. Progressive matching of workers' contributions to their private accounts generates larger short-run gains than does using a pay-as-you-go-financed flat benefit when the transition is financed with a consumption tax, but not when financed using a wage or an income tax. This is because consumption taxation redistributes resources from high spenders (the initial elderly) to high savers (the initial young and future generations.)

o Distributional Impact for Cohorts Born in the Long Run.

o *Choice of Tax Base.* For generations born in the long run, the exact choice of the tax used to finance the transition is of no importance: our benchmark forced-participation experiments and opting out experiments lead to the same positive long-run gains for all income groups regardless of the transition tax used. The choice of the tax base used to finance a permanent flat benefit or the permanent progressive contribution matching does, of course, matter in the long run, although all runs lead to positive long-run gains for all income groups born in the final steady state. Not surprisingly, consumption-tax financing of either the flat benefit or the contribution match is worse for the very poorest two percent of lifetime income groups for both experiments relative to using an income tax base which preserves the standard deduction, exemptions, and progressive rates. But it is surprising that the consumption tax financing is not even more regressive: in fact, all agents born in the final steady State above the poorest two percent are better off with consumption-tax financing relative to income tax financing. This is mostly because the initial wealth levy associated with consumption-tax financing has a permanent effect in relaxing the government's financing constraint.

o *Choice of Experiment.* The choice between forced participation and opting out is not important for long-run utility: both lead to the same sizeable long-run increases in utility for all lifetime income groups since all income groups eventually opt out of Social Security--even the lifetime poor who get the largest replacement rate from Social Security. Not surprising, including progressive matching leads to a more progressive distribution of the long-run gains. Interestingly, the lifetime poor are actually worse off under the flat-benefit experiment than under all of the other experiments, including our benchmark forced participation and opting out approaches without any intra-generational redistribution. This is because the benefits of the pay-as-you-go flat benefit to the lifetime poor born in the final steady state are outweighed by the general-equilibrium effects (higher wages and lower interest rates) and higher rate of return to contributions that accompany the elimination of Social Security's unfunded liabilities in a closed-economy.

o Distributional Impact for Cohorts Alive in the Short Run. Positive long-run gains generally require short-run sacrifices. The intergenerational distribution of sacrifice depends on both (almost equally) the choice of tax base and the exact experimental design.

o *Choice of Tax Base.* Wage taxation financing of the transition tends to reduce welfare of the initial Social Security beneficiaries by substantially less than either consumption and income tax financing. This is because the initial beneficiaries receive little income from wages but do consume and earn interest income. Interestingly, consumption tax financing-in which the real value of Social Security benefits are fully protected in our simulations-tends to decrease the welfare of the oldest generation by less than income tax financing since these members have already consumed most of their assets. The tax base choice, however, impacts younger and older workers at the time of privatization very differently. Income tax financing tends to be more progressive than either wage

or consumption tax financing. However, the hit on existing wealth associated with consumption tax financing (which, by construction, does not change the purchasing power of Social Security benefits) is very progressive and makes consumption tax financing almost as progressive as income tax financing except for the poorest two percent. Most older workers who have accumulated lots of assets are hit hardest with a consumption tax, but younger workers with little assets are best off with consumption tax financing.

o *Choice of Experiment.* Opting out tends to do a better job than the other experiments in protecting the welfare of the initial beneficiaries for the same transitional tax base. This is because the opting out plan continues to collect some revenue from payroll taxes whereas forced participation with income tax or consumption tax financing does not. Opting out, however, leads to larger welfare losses for the initial middle-age agents across the entire income distribution: those agents tend to not opt out and, therefore, pay both the existing payroll tax along with the new transitory income or consumption tax. A modified opting-out plan with the payroll tax set at one- half of its present law value shifts much of this burden from middle-age agents to younger and future agents who benefit from the reform. In terms of accomplishing intra-generational redistribution, progressive matching leads to slightly larger welfare losses for initial generations than a pay-as-you-go-financed flat benefit. This is because progressive matching eliminates all of the unfunded liabilities which requires a relatively larger short-run sacrifice. In contrast, the flat benefit maintains almost one half of Social Security's unfunded liabilities.

Open Economy. Treating the U.S. as a small open economy almost doubles the long-run total (domestic plus international) wealth holdings of the economy and raises the long-run per-capita

factor income from domestic and foreign sources by about 16 percent. The economy also converges much more rapidly. The reason for these results the absence of the negative genera1-equilibrium effect-a declining interest rate-that limits the increase in the capital stock in the closed-economy in runs. Moreover, the open-economy simulations generate smaller welfare losses to the early transitional generations, but at the cost of smaller gains to generations born in the long-run. The smaller long-run welfare gains—although still quite large for all income groups—is primarily due to the fact that domestic wages do not rise despite the dramatic increase in the domestically-owned capital stock (i.e., the total U.S. capital stock per effective labor unit is fixed).

II. OUTLINE OF THE MODEL

The model used in this paper is a substantially enhanced version of the Auerbach-Kotlikoff (1987) life-cycle 55 overlapping-generations model (Append I). The new model incorporates intra-generational heterogeneity in addition to the inter-generational heterogeneity of its predecessor. In particular, 12 lifetime income groups with wage profiles based on micro-data estimation using the PSID are included. 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 life-time wage income, group four the third decile, and so on up to group 10.

The new model also incorporates a much more complete description of the social insurance system that exists in the United States. It includes the statutory progressive bend-point formula used by the Social Security Administration to calculate retirement benefits as a function of average wage-

indexed pre-retirement wage income. A worker's replacement rate is calculated with a sixth-order polynomial that replicates the statutory replacement rate function based on the bend-point formula to a very close approximation (Figure 1). Statutory payroll tax rates are calculated endogenously to meet the pay-as-you-go financing constraint. The model also includes a simple treatment of the Medicare and Disability Insurance programs.

The new model reflects the key features of the U.S. federal, state and local hybrid income tax system. This is important because the tax system interacts in an important way with the various options to privatize Social Security. Since the current income tax base covers only 57 percent of national income in the US, the model includes an array of tax-based reductions which allows us to use actual tax schedules. These tax-based reductions produce two kinks in the consumer's budget constraint that must be solved. The first kink is associated with the statutory non-refundable deductions in the income tax system. The second kink is associated with Social Security's payroll tax ceiling. The U.S. tax system also contains accelerated depreciation, excise taxes, consumption tax treatment of pension fringe benefits and other features that we model.

The new model moreover allows us to consider two informational assumptions about the tax-benefit linkage perceived by consumers: full perception and no perception. Figure 2 presents the net marginal payroll tax rate (the payroll tax paid minus the present value of benefits received on an additional dollar of wages) by lifetime income class and age if people perfectly perceive how benefits change a the margin with additional earnings. The net payroll tax rate simply equals the statutory rate when consumers fail to perceive any link between taxes and benefits. Modeling the case of no perceived linkage seems important to us. While everyone faces the same statutory tax rate up to the covered earnings ceiling, Figure 2 shows that the net tax rate varies significantly across lifetime

income classes and over the lifecycle within each lifetime income class. It is highly unlikely, therefore, that people know the correct net tax rate they face. Moreover, some analysts believe that people often confuse Social Security benefit rules with private pension rules. Private pension typically use a much shorter period as the basis for calculating retirement benefits. Both of these factors suggest that the payroll tax might in practice be more distorting than it need be. It is true that the US Social Security Administration will, upon request, provide individuals with an estimate of their future benefits. This information, though, does not indicate the marginal benefit associated with an extra dollar of payroll taxes—the actual information people need to calculate net tax rates.

The new model incorporates other enhancement, including endogenous bequests calibrated to micro data as well as technological progress. Values chosen for various economic variables are shown in Table 1. Altogether these models enhancements have allowed us to closely mimic the U.S. economy in the initial steady state. Given our parameter choices, the model generates a pre-tax interest rate of 9.3 percent, a net national saving rate of 5.3 percent, and a capital/national-income ratio of 2.6. Consumption accounts for 73.4 percent of national income, net investment for 5.2 percent, and government purchases of goods and services for 21.4 percent. These figures are close to their respective 1996 NIPA values. The post-tax interest rate equals 0.08 and is calculated following Auerbach (1996). Summary statistics for the initial economy are provided in Table 2.

Limitations

The model herein incorporates many complex features of the economy and fiscal institutions. However, as any model, our model also abstracts in important ways from reality and the exact numerical results should therefore be interpreted cautiously. The paper does not deal with issues

relating to aggregate and individual uncertainty. For example, the unfunded liability facing government as the insurer of last resort is not addressed; relaxing this assumptions could lead to both smaller short-run costs along with smaller long-run gains. The paper also assumes that adverse selection in the private annuities market is either unimportant numerically or is effectively dealt with via mandated annuitization. Moreover, the model does not include myopic agents with high discount rates facing borrowing constraints: whether our simulations overpredict or underpredict the saving response to privatization will depend on whether saving in the new system is mandatory.

III. 19 PRIVATIZATION EXPERIMENTS

This section provides an overview of 19 different privatization experiments ("runs") considered in this paper.

The Benchmark Experiments: Forced Participation (Runs 1-6)

Runs 1 through 6 are the benchmark experiments. In these experiments, participation in the new system is mandatory and involves three steps: a) requiring workers to contribute to private accounts; b) giving retirees and workers Social Security benefits roughly equal to only those they have accrued at the time of the reform; and c) financing these Social Security benefits for an extended—but temporary—period of time.

In our model, privatizing Social Security contributions just requires setting the model's Social Security payroll tax rate to zero; i.e. there is no need to add a formal private pension system to the model. Since the agents in our model are not liquidity constrained, forcing them to contribute to private accounts will not affect their net saving or labor supply decisions because they are free to

borrow against their mandated retirements accounts. This said, it is worth noting that in the particular economies simulated herein, only the poorest 10 percent of agents actually seek to borrow against Social Security. So were we to add a liquidity constraint (specifically, a constraint against negative net wealth), it would not materially alter our findings.

To capture the second feature of privatization, namely giving retirees and workers their full accrued Social Security benefits, we phase out Social Security benefits starting 10 years after the privatization reform occurs. The 10-year delay reflects the need to give current retirees the same benefits they would otherwise have received. In the model, Social Security benefits are received for 10 years from 45 to 55 (real age 65 to real age 75). Starting in the 11^{th} year of the reform, we phase out Social Security benefits by 2.2 percent (of the baseline benefits) per year for 45 years. This linear reduction, although still progressive, is designed to protect the approximate value of accrued liabilities for existing workers. As Feldstein (1997) notes, our general methodology in this first approach is similar to the popular "recognition bond" approach used throughout many Latin American countries—except, in our case, participation is mandatory.

We used three alternative tax bases to pay for Social Security benefits during the transition: a proportional payroll tax over Social Security's tax base, a tax on the current income tax base and a flat consumption tax. In Run 1, Social Security's existing wage tax base is used to pay off the recognition bonds. This run assumes that workers perceive the correct net payroll tax rate in the current system at each age in their lifecycles. Run 2 is the same as run 1 except workers do not perceive the correct net payroll tax rate; they instead assume they face the full statutory payroll tax rate. Runs 3 and 4 are similar except they assume the recognition bonds are paid off with the existing progressive income tax base. This is done by increasing the two components of the income

tax, the progressive wage tax and the proportional capital income tax (see Appendix I), such that the average wage tax and the average capital income tax change proportionally. Runs 5 and 6 assume that a consumption tax is used to pay off the bonds.

The transitions to a privatized system alters the income-tax base due to growth in the capital stock and labor income. Since we maintain a constant level of government purchases per effective worker in each transition, we need to adjust income-tax rates along the transition path even in those simulations in which income taxes are not used to pay the benefits accrued under Social Security. The shares of (endogenous) revenues to be made up by the income tax is determined such that the average taxes on wages and capital income change proportionally.

Opting Out (Runs 7 - 12)

A privatization plan that mandates participation in the new system may be less likely to be implemented than one that gives people the choice to simply opt out of Social Security. Indeed, most actual privatization implementations around the world have given people the choice. This was true, for example, in Chile, Argentina, and other major reforms in Latin America; only new workers were forced into the new system. In the U.K., even new workers are allowed to choose between the traditional public pension system and private accounts.

Allowing for choice generates a "fatal" adverse selection problem in a system with self-financing earmarked taxes: those agents that choose to opt out—those for whom the present value of future Social Security taxes (PVT) exceeds the present value of future benefits (PVB)—are also those for whom Social Security obtains a large amount of revenue. Increasing the payroll tax to meet existing pay-as-you-go liabilities will cause even more people to opt out; a death tax spiral will

emerge. (See Kotlikoff, Smetters and Walliser [1998a] for more details). Allowing for opting out therefore requires some financing from general revenue.

Opting out Social Security involves three steps: a) allowing workers to opt out of Social Security, thereby eliminating both the payroll tax they face as well as any claims to future Social Security benefits; b) collecting payroll taxes and paying benefits to those who do not opt out; and c) using general revenue to finance the gap between payroll taxes collected and benefits received. In runs 7 through 10, agents who stay in Social Security face the same payroll tax rate and receive the same benefits under current law. Runs 11 and 12 consider a slight twist: people who stay in Social Security now face only half of the previous payroll tax rate along with the same benefits as before. Naturally, this modification entices more people to stay with Social Security but it also puts a greater overall strain on general revenue

The necessary supplements from general revenue come from either taxing the current progressive income base or the consumption base. Runs 7 and 8 finance the gap with the income base: in run 7, people correct perceive the existing tax-benefit linkage and in run 8 people do not. Runs 9 and 10 use the consumption tax base. Run 11 considers income tax financing with full perception of the net tax rate and with the payroll tax at one half the present law value for those who remain in Social Security (benefits remain the same as before). Run 12 is similar to run 11 but uses consumption tax financing.

The solid lines in the top panel of Figure 6 shows those generations by income class who participate in the new privatized system—that is, opt out of Social Security—for the income tax finance case. (The consumption tax finance case produces similar qualitative participation rates.) In all six runs, the decision for each worker to opt out depends endogenously vis-a-vis factor prices

on whether other workers opt out, i.e., the program searches for the Nash equilibrium. Notice that all agents younger than 25 years of (real-life) age opt out as do all future agents. The participation lines therefore are not continued past transitional year 50 for resolution. The effects of adverse selection can be seen both inter-generationally and intra-generationally. Inter-generationally, many living agents, especially older people, stay with Social Security because they have accrued enough benefits and so it is not worth switching. Intra-generationally, a poor agent is less likely to opt out of Social Security than a richer agent of the same age. This reflects the progressive nature in which Social Security benefits are computed.

A Flat Benefit and Progressive Matches (Runs 13 - 18)

Instead of allowing for adverse selection, the government might instead choose to supplement a forced privatization plan with some intra-generational redistribution. As noted below, some of our privatization runs that entail no progressive elements may help the long-run lifetime poor more than the long-run lifetime rich. But additional intra-generational redistribution can be achieved. The Personal Security Account Plan of the Social Security Advisory Council includes a pay-go financed flat minimum benefit along side the new private accounts. Other plans, including that by Kotlikoff and Sachs (1997), suggest matching contributions to mandatory private saving accounts in a progressive way.

Runs 13 through 15 analyze privatization with an add-on pay-as-you-go flat benefit when a wage tax, income tax or consumption tax is used to finance both the transition and the flat benefit. To conserve space, we only report those runs that assume full perception of the tax-benefit linkage. We investigate this policy by a) providing a wage-indexed flat minimum annual benefit of $6000

in the long run and b) paying a weighted average of the old OASI and the new flat minimum benefit during the transition.

Runs 16 through 18 consider a progressive match. The government's match is calculated as a function of labor income and it falls steadily as a percentage of earnings, starting at about 5 percent for the poorest. In absolute terms, it increases from about $470 at annual earnings of $10,000 to around $840 for annual earnings of $21,000 and stays constant thereafter. On a life-time basis, the match provides a transfer to the poorest that exceeds the flat minimum benefit of the previous section by 30 percent. Workers fully incorporate the marginal subsidy associated with the progressive contribution match into their decisions. Both runs 16 and 17 finance the revenue shortfalls from tax credit by raising income taxes, and run 18 raises consumption taxes. OASI benefits are phased out as above and financed with either a payroll tax (run 16), and income tax (run 17), or a consumption tax (run 18).

Sensitivity Analysis: The Open Economy (Run 19)

Runs 1 - 18 assumes a closed-economy setting. This assumption seems like a reasonable benchmark: although the United States produces about 30 percent of the world's output, capital flows appear to be relatively immobile (Feldstein and Horioka [1980]; Gordon and Bovenberg [1996]). But for the sake of sensitivity analysis, run 19 considers the other extreme: simulating the benchmark privatization plan with wage tax financing when the U.S. is modeled as a small open economy.

IV. A COMPARISON OF THE DIFFERENT OPTIONS

The benefits and costs of privatization cannot be analyzed with a single metric. Privatization will impact both short-run and long-run macroeconomic variables and it will materially alter the distribution of resources. These multiplicity of tradeoffs are analyzed in this section. We first focus on the policy designs in a closed-economy—runs 1 - 18—before turning to the open-economy run 19.

Long-run Macroeconomic Performance

Tables 3 - 7 present the macroeconomic effects of 19 runs for selected years on the transition path. Year 150 represents the new (final) steady state. The macroeconomic effects are also plotted in the top panels in Figure 3 - 5 (for the benchmark runs), Figures 7-8 (for the opting out runs), Figures 9-10 (for the opting out runs with the new payroll tax at one-half of the present law value), Figures 11-13 (for the add-on flat benefits runs), Figures 14-16 (for the progressive match runs) and Figure 17 for the open economy run.

Capital Stock. Table 3 shows that all of the benchmark and opting out runs generate the exact same large increase in the long-run (year 150) capital stock once pay-as-you-go financing is replaced with funded private accounts. The benchmark runs, which assume full perception of the tax-benefit linkage, each lead to a 39 percent long-run increase in the capital stock. The long-run increase is the same for each of these three runs because the transition tax is only temporary and so the three experiments differ only in the transition. The long-run increase is the same for opting out runs with full perception of the tax-benefit linkage because everyone in the new steady state chooses to opt out of Social Security—even the lifetime poor. This is because the social marginal product on capital

(before corporate taxes) of 91/2 percent exceeds Social Security's internal rate of return even for the lifetime poor who receive the highest replacement rate. The benchmark runs that assume no perceived tax-benefit linkage, each lead to a 40 percent long-run increase. The slightly larger increase is due to the improvement in perception of the tax-benefit linkage that accompanies privatization. The same long-run materialize for the opting out runs without tax-benefit linkage where, again, everyone in the final steady state chooses to opt out of Social Security.

The long-run gains in the capital stock, however, are at least halved once privatization is augmented with an add-on flat benefit. Financing the transition and the flat benefit with a wage tax (run 13) produces a 19 percent increase in the capital stock, while using a income tax or consumption tax produces a 12 and 23 percent increase, respectively. The final steady states are not the same for each of the three runs because the new tax finances the flat benefit as well as the transition. Run 14 leads to a smaller increase than run 13 due to an increase in progfessivity and the increase in tax on capital income. Run 15 generates the largest long-run increase of the flat benefit experiments due to the initial wealth levy that accompanies a move to a consumption base and, relative to income-tax financing, the non-taxation of capital income. All on the add-on flat benefit experiments, however, generate a smaller increase in the capital stock relative to their benchmark and opting out counterparts for two reasons. First, the continuing unfunded liability , which amounts to about half of the current unfunded liability in Social Security system, reduces the effect of privatization on saving and capital accumulation. Second, the tax that finances the flat minimum benefit is now completely distortionary since benefits no longer change at the margin.

Achieving progressivity with a progressive match restores the large long-run gains in the capital stock to values similar to the benchmark and opting out experiments. Runs 16 and 17, which finance

the transition with a wage tax and an income tax, respectively, generate a 35 percent increase while consumption tax financing produces a 40 percent increase. The increase is identical for both wage and income tax financing because they differ only in paying off Social Security benefits: both use an income tax to finance the tax credit. All of the progressive match runs generate a larger long- run increase in the capital stock relative to the flat benefit runs due to the total elimination of pay-as-you-go financing.

Labor Supply. Table 4 shows that the long-run labor supply increases between 5Y2 and 7 percent in the long run for the benchmark and opting out runs. The 5 Y2 percent increase occurs in those runs in which the tax-benefit linkage is fully perceived under Social Security. The increase is 7 percent in those runs in which the tax-benefit linkage is not perceived, reflecting the larger distortion of Social Security's current payroll tax. The progressive match leads to a slightly smaller 4 to 4Y2 percent increase, depending on the tax base chosen to finance the tax credit. The smaller increase reflects the distortionary nature of the policy: the credit subsidizes labor for the lower lifetime income groups and taxes it at higher-the net effect of the credit itself being slightly negative. The flat benefit perfonns the worse of the policy options: labor supply increases by 21/2 percent for wage tax financing, by 1 percent for income tax financing and 3 percent for consumption tax financing. The reason for the smaller gains reflects the two factors noted above. First, the pay-as-you-go payroll tax for the flat benefit is mostly distortionary because the internal rate of return to the flat benefit is well below the marginal product of capital. Second, the tax that finances the flat minimum benefit is now completely distortionary since benefits no longer change at the margin.

Income and Factor Prices. Table 5 shows that the increase in long-run national income for each run. The increase is the largest for those runs with the largest gains in the capital stock and

labor supply. Not surprisingly, therefore, the benchmark and opting out runs generated the largest increase (between 13 and 141/2 percent), followed the progressive match runs (11 to 121/2 percent). The flat benefit runs perfonned the worse: long-run output increased between 4 and 71/2 percent, depending on the tax used to fInance the credit.

Wages increase, and the interest r ate decreases, with increases in the capital-labor ratio. This happened in all of the closed-economy runs because the capital stock increased by more than the labor supply. Table 6 shows that wages increased by about 7 percent for the benchmark, opting out, and the progressive match runs but increased by only 21/2 to 51/2 percent for the flat benefit runs. Table 7 shows that interest rates decrease by about 18 percent for the benchmark, opting out, and the progressive match runs. But the long-run decrease is only between 71/2 to 13 percent for the flat benefit runs: wage tax. financing (run 13) generates a 11 percent decline, income tax. financing (run 14) gives a 71/2 decline and consumption tax financing (run 15) creates a 13 percent decline.

Short-Run Macroeconomic Performance

Table 3 demonstrates that the speed of adjustment of the capital stock to the new steady state depends critically on two general factors: the tax. base used to finance benefits accrued under Social Security and the fonn of the privatization experiment itself. The choice of the tax. base is the most important of these two factors.

The importance of the choice of the tax. base is critical for all the experiments. Consider, for example, the benchmark runs with correctly perceived tax.-benefit linkage. Although the long-run position of the economy is the same in each of these runs, the size of the short-run economic response depends critically on the choice of the tax. base used to finance transitional Social Security

benefits. With payroll-tax. financing (run I) the capital stock is only 5 percent larger after 25 years which is only 13 percent of its ultimate increase. In the case ofincome-tax financing (run 3), the capital stock is actually 41/2 percent smaller 25 years after the transition, notwithstanding the fact that it ultimately ends up 39 percent larger. With consumption-tax financing (run 5) the transition is much faster, but it's still rather slow. After 25 years the capital stock is 13 percent larger which is only one-third of its long-run increase.

One reason why the transitions take time is that Social Security benefits are reduced gradually over a 55-year period. A second reason the transitions are slow is that the capital stock is a stock and even substantial changes in annual saving rates take quite a while to materially alter it. This feature of neoclassical economies-that policy-induced economic transitions are very slow-was one of the main messages of Auerbach and Kotlikoff (1987). The third reason the transitions are slowapplies in the case of income-tax finance. Using this tax instrument means that in the short run, there will be quite high marginal tax rates on labor supply and capital income. This gives households an incentive to substitute current leisure and consumption for future leisure and consumption. Indeed, in the case of income-tax finance, the short-term disincentive to work leads to a 5 percent decline in aggregate labor supply.

The privatization experiment itself is also important in the short run. The benchmark and opting out runs generate the quickest rates of convergence relative to the other runs-with a slight edge going to the opting out runs. Opting out with income tax financing (run 7) leads to a quicker transition path throughout the entire period relative to the benchmark run with income tax financing (run 3). With consumption tax financing (runs 5 and 9), both experiment designs virtually tie for the first quarter century before opting out pulls away with quicker convergence (see also the top panels in

Figures 3 and 5). The reason for the superior performance of the opting out plan is that it reduces Social Security wealth for young and middle-age transitional savers by more than the forced participation plan. Whereas the forced participation plan compensates young and middle-age savers in proportion to their accrued benefits, many of these same savers are willing to forfeit their Social Security wealth under the opting out plan. Overall, the flat benefit runs and progressive match runs perform relatively worse in the short run. Progressive matching with consumption tax financing (run 18), however, performs just as well as the corresponding benchmark run with consumption tax financing (run 5). But the progressive match runs perform the worse of all the runs with the other tax bases. Although the flat benefit runs underperform the benchmark and opting out runs, the flat benefit runs outperform the progressive match runs for wage and income tax financing.

Distributional Impact for Cohorts Born in the Long Run

The welfare effects of the different privatization policies are shown in Table 8 and the bottom panels of Figures 3 -5 (for the benchmark runs), Figures 7- 10 (for opting out runs), Figures 11 -13 (for the flat add-on benefit runs) and Figures 14- 16 (for the progressive match runs). The welfare effects are measured as the percentage increase in both consumption and leisure in each year of remaining life (entire life for newborns) in the pre-privatization economy needed to generate the same level of utility the agent enjoys as a result of the privatization reform (i.e., equivalent variation). The label "Year of Birth" in these tables and figures refers to birth year relative to the experiment which occurs in Year 1. So, for example, the index “-10" refers to a person born economically 10 years before the experiment and whose current economic age is 11 (real life age of 32). The index "1" refers to a person born the year of the experiment.

Notice that all households, poor and rich alike, who are born in the long run gain from privatizing Social Security. Once again, the choice of the tax base used to finance the transition path does not matter for the long run. Moreover, the benchmark and opting out runs generate the same long-run outcomes since everyone born in the long run will choose to opt out of Social Security. The gains, however, are different for the flat benefit and progressive match experiments.

For the benchmark and opting out runs, the welfare gain of those born in the long run exceeds 4 percent for each of the income classes. The gains are larger for middle income classes. Class 9, for example, enjoys an 8 percent welfare gain. The welfare gain for the top income class is 4 percent; for the bottom income class it is 6 percent. What explains these differences? The answer is that different features of the privatization policy affect income groups differently. First, we are eliminating the progressive Social Security benefit schedule. Second, we are eliminating the regressive (due to the ceiling on taxable earnings) Social Security payroll tax. Third, we are adjusting downward long-run income tax rates due to the expansion of the income-tax base associated with the long-run improvement of the economy. This reduction in income-tax rates benefits income-tax payers, a set of agents that doesn't include the very poor who pay no income taxes because of the tax exemptions and deductions. Fourth, eliminating Social Security's payroll tax has a bigger impact on households with higher earnings since they already face a higher marginal income tax rate. Since the distortion rises with the square of the tax rate, those households face a multiple of the labor supply distortion of low income households. However, those households with earnings above the payroll tax ceiling in the initial steady state (represented by class 12) benefit less from privatization since their labor supply is not affected by the payroll tax at the margin.

For the flat benefit runs, the long-run welfare gain of those born in the long run becomes less dispersed but the mean increase is now smaller. Notice that the increase in welfare is about 4 to 5 percent for each income group except the top 2 percent (class 12) whose welfare increases by only ½ to 2 percent. Although the choice of the tax base used to finance the transition path does not matter in the long run, the choice of base used to finance the flat benefit does. The income base is the best for the bottom 2 percent of the income distribution (class 1) but the income and wage base give similar results for the other income classes except the rich (who prefer the wage base). But the consumption base wins for all income groups except the bottom 2 percent. Rather interestingly, notice that for all choices of the tax bases, all income groups born in the long run are worse off under the flat benefit runs relative to either the benchmark and opting out runs. This is because the benefits of the pay-as-you-go add-on benefit to the lifetime poor born in the final steady state are outweighed by the general-equilibrium effects (higher wages and lower interest rates) and higher rate of return to contributions that accompanies the elimination of Social Security's unfunded liabilities in a closed-economy.

The runs with progressive matching combine lower dispersion in gains with a mean increase similar to the benchmark and opting out runs. But now the welfare of agents in income class 1 increases by 8 percent, compared with 6 percent in the benchmark and opting out runs. The gains for those in income class 9, however, decrease: from 8 percent to 71/2. And the gains decrease from 41/2 percent to 31/2 percent for those in income class 12. Financing the credit with a consumption tax leads to slightly smaller gains for income class 1 (71/2 percent) and slight larger gains for income class 12 (4 percent).

Distributional Impact for Cohorts Alive in the Short Run

Privatization leads to a reduction in welfare for most income groups alive at the time of privatization or born shortly thereafter. Whereas the choice of tax base used to finance the transition and the choice between benchmark and opting out is unimportant in the long run, these choices become more important in the short run. And these choices affect those alive at the time of the reform very differently.

Consider the initial elderly. First, notice that for all of the experiments, wage taxation financing of the transition tends to reduce their welfare by substantially less than either consumption and income tax financing. This is because the initial beneficiaries receive little income from wages but do consume and earn interest income. Notice that those of economic age 55 (real life 75) at the time of privatization ("Year of Birth" equal to -54) suffer less than a 0.1 percent decline in remaining lifetime utility for payroll tax financing in both the benchmark and flat benefit runs 1 and 13. The losses are slightly higher for progressive matching (run 16) since the credit itself is financed with an income tax. Second, notice that the opting out decrease the welfare of the initial elderly by less than corresponding benchmark runs when the transition is financed with either an income tax or a consumption tax. In particular, the initial decline in welfare is lower for the opting runs than the respective benchmark runs. This is because the opting out runs continue to collect some payroll taxes in the short run (since some people choose to stay with Social Security), thereby placing less pressure on the income or consumption tax base. It follows that the relatively quicker convergence associated with opting out is not incompatible with protecting the welfare of the initial elderly. Third, notice that all flat runs result in a smaller welfare loss to the initial elderly and most younger workers alive at the time of the reform than the respective progressive match runs. This is because

the larger benefits to generations born in the long run coming from progressive matching requires a larger short-run sacrifice in the form of funding previous pay-as-you-go liabilities.

Now consider middle-age workers at the time of the reform. First, notice those of economic age 26 (real life 47) born in year -25 are hurt almost equally by a wage and a consumption tax for all of the relevant experiments, although a consumption tax is slightly more painful. Using a progressive income tax is the most painful except for the lifetime poor. Older workers before retirement, however, tend to be hurt most by a consumption tax followed by an income tax and then a wage tax. Second, notice that middle-age and older workers are worse off under the opting out runs than the benchmark runs for income or consumption tax financing of the transition-just the opposite result as the initial retires. This is because these workers tend to not opt out of Social Security and, therefore, pay both the payroll tax and help finance the transition to the privatized system. Run 11 considers income tax financing with full perception of the net tax rate and with the payroll tax at one half the present law value for those who remain in Social Security (benefits remain the same as before). Run 12 uses consumption tax financing. This modification to opting out plan now makes middle-age workers better off relative to the benchmark income and consumption tax financing runs. Although fewer workers now choose to opt out of Social Security (see bottom panel in Figure 6), the total payroll revenue declines. This requires that a larger amount of revenue must be raised from younger workers (e.g., those born in year -10 through year 25) who pay little or no payroll taxes because they opt out. This modification makes them worse off. The rate of convergence of the capital stock is only little slower than straight opting out but still faster than that corresponding to forced participation.

Now consider young workers born around the time of the reform (e.g., those born in year -10 through year 25). First, as noted above, younger workers are more harmed by the modified opting out program relative to straight opting out. However, notice that the absolute welfare changes for these workers from privatization under the modified opting out program are not so different than the welfare changes for corresponding benchmark runs. This is because the modified opting out program is effective in pushing out more of the distributional pain from privatization to workers born in year 25 who positively benefit from privatization (i.e., notice their gains are positive but smaller for the modified opting out program relative to the benchmark runs). Second, except for the very rich, younger workers are actually better off with income tax financing than wage financing for most of the experiments. This is because income tax financing raises substantial revenue from middle-aged workers. But the youngest workers are best off with consumption tax financing. This is because they have little assets and, therefore, benefit from the wealth levy on the assets of older workers.

Sensitivity Analysis: The Small Open Economy

In order to create an upper bound on how much open-economy effects could matter, we consider the opposite extreme case in which the United States is treated as a small open economy in run 19 which re-examines run 1 with this model change. Factor prices-wages and interest rates-are now unaffected by privatization because capital is assumed to move costlessly across boarders. While the domestic capital stock rises by the same proportion as labor supply (Table 3), the amount of world capital stock owned by United States citizens increases by over 75 percent after privatization in the very long run compared to 39 percent assuming a closed economy. National income-now

including interest earned by United States citizens on capital located outside of the United States-increases by over 16 percent compared to 13 percent assuming a closed economy. The long-run gains to the capital stock and national income in the open-economy case are larger relative to the closed-economy setting because the return to saving-the interest rate-does not diminish as people save more. In contrast, interest rates decrease sharply in the closed economy, discouraging additional saving after privatization. United States citizens also consume much more leisure in the open economy case relative to the closed economy. Labor supply falls by four percent in the open economy case compared to an increase of five percent in the closed economy case. The increase in income affords more leisure. The long-run utility gains, although slightly smaller, are matched with smaller short-run sacrifices. In sum, the open economy assumption tends to paint a more optimistic picture for privatization.

V. CONCLUSIONS

The simulations deliver the following messages: Privatization of the U.S. Social Security System can substantially raise the economy's living standard in the long run. But these gains come, for the most part, at the cost of welfare losses to transition generations. Importantly, the poorest members of future society have the most to gain from privatization even if privatization doesn't include an explicit redistribution mechanism, such as a basic benefit or a progressive contribution match. The long-run gains from privatization take a fairly long time to materialized. This is particulary true if an income or a wage tax, as opposed to a consumption tax, is used to finance the transition. Finally, privatizations that allow initial workers to remain in the current system have particularly low transition costs and particularly favorable macroeconomic consequences.

References

Altig, David and Jagadeesh Gokhale. "Social Security Privatization: One Pipposal." *The Cato Project on Social Security Privatization,* SSP No.9, 1997.

AItig, David, Alan Auerbach, Larry Kotlikoff, Kent Smetters, Jan Walliser. "Simulating U.S. Tax Reform." NBER Working Paper No.6246, 1997.

Arrau, Patricio and Klaus Schmidt-Hebbel. "Macroeconomic and Intergenerational Welfare Effects of a Transition from Pay-as-You-Go to Fully Funded Pensions, " Policy Research Dept., Macroeconomics and Growth Division, Washington, D.C.: World Bank, Washington, D.C. 1993.

Auerbach, Alan J. and Laurence J. Kotlikoff. Dynamic Fiscal Policy, Cambridge, England: Cambridge University Press, 1987.

Auerbach, Alan J. "Tax Reform, Capital Allocation, Efficiency, and Growth, " in: Henry Aaron and William B. Gale (eds.), Economic Effects of Fundamental Tax Reform, Washington, D.C.: The Brookings Institution. 1996.

Feldstein, Martin. "Toward a Reform of Social Security." *Public Interest,* No. 40 (Summer, 1975), pages 75 -95.

_____."Would Privatizing Social Security Raise Economic Welfare?" NBER Working Paper Series, Working Paper 5281,1995.

_____."Transition to a Fully Funded Pension System: Five Economic Issues." NBER Working Paper 6149,1997.

Feldstein, Martin H. and Charles Horioka. "Domestic Savings and Capital Flows." *The Economic Journal* 90 (June 1980): 314-329.

Feldstein, Martin and Samwick, Andrew. "The Transition Path in Privatizing Social Security," forthcoming in: Martin S. Feldstein (ed.), Privatizing Social Security, University of Chicago Press, 1997.

Fullerton, Don and Diane Lim Rogers. Who Bears the Lifetime Tax Burden?, Washington, D.C.: The Brookings Institution. 1993.

Gordon, Roger H. and A. Lans Bovenbert. "Why is Capital So Immobile Internationally? Possible Explanations and Implications for Capital Income Taxation." American Economic Review 8(December 1996): 1057-1075.

Gustman, Alan and Thomas Steinmeier." Privatizing Social Security: First Round Effects of a Generic, Voluntary Privatizes U.S. Social Security System." NBER Working Paper No. 5362, 1995.

Huang, He, Selo Imrohoroglu and Thomas Sargent." Two Computational Experiments to Fund Social Security." *Macroeconomic Dynamics*, 1, 1997: 7-44.

Kotlikoff, Laurence J. "Privatizing Social Security: How It Works and Why It Matters," in: James M. Poterba (ed.), Tax Policy and the Economy, vol. 10, Cambridge, Mass.: MI,T Press, 1996.

Kotlikoff, Laurence J. and Jeffrey Sachs. "It's High Time to Privatize Social Security," *The Brookings Review*, 15, 3, 16-23.

Kotlikoff, Laurence J., Kent Smetters, and Jan Walliser. "Privatizing U.S. Social Security -A Simulation Study," forthcoming in: Klaus Schmidt Hebbel (ed.), Pension Systems: From Crisis to Reform, Washington, D.C.: The World Bank, 1997*a*.

_____. "The Economic Impact of Privatizing Social Security," Paper presented at the 1997 Kiel Week Conference, Kiel Germany, 1997*b*.

_____. "Opting Out of Social Security and Adverse Selection," NBER Working Paper 6430, 1998*a*.

_____. "Social Security: Privatization and Progressivity," *Papers and Proceedings of American Economic Review*, May 1998, 137-141.

Menchik, Paul L. and Martin David. "The Incidence of a Lifetime Consumption Tax," National Tax Journal, vol. XXXV , 1982, pp. 189-203.

Samwick, Andrew. "Discount Rate Heterogeneity and Social Security Reform." Manuscript, Dartmouth College, November, 1996.

Seidman, Laurence S. "A Phase-Down of Social Security: The Transition in a Life Cycle Growth Model." *National Tax Journal*, vol. XXXIX, 1986: 97-107.

Slemrod, Joel and Jon Bakija. Taxing Ourselves: A Citizen's Guide to the Great (Debate over Tax Reform, MIT Press: Cambridge, MA, 1996.

APPENDIX I:
OUTLINE OF THE BENCHMARK ECONOMY

This section provides an outline of the benchmark economy calibrated to the 1996 US economy. The solution technique is discussed in Appendix II. This Appendix follows Section II of KSW (1998*a*).

Demographic Structure

The model's cohorts are distinguished by their dates of birth and their lifetime labor-productivity endowment. Following Fullerton and Rogers (1993), each cohort includes 12 lifetime-earnings groups.[1] Each of these 12 groups has its own initial endowment of human capital and its own pattern of growth in this endowment over its lifetime. The lifetime-earnings groups also differ with respect to their bequest preferences. All agents live for 55 periods with certainty (corresponding to adult ages 21 through 75), each *j*-type generations is $1+n$ times larger than its predecessor. At model age 21, each *j*-type cohort gives birth to a cohort of the same type. Population growth is exogenous, and each cohort is $(1+n)^{20}$ larger than its parent cohort.

Preferences and Household Budget Constraints

Each *j*-type agent who begins her economic life at date *t* chooses perfect-foresight consumption paths (c), leisure paths (*l*), and intergenerational transfers (*b*) to maximize a time-separable utility function of the form

1. Our model has several strengths relative to Fullerton and Rogers (1993) and, at least, one weakness. The strengths include a rational-expectations solution, a social security system, a tax system with progressive marginal tax rates, an array of tax base reductions, government debt, bequests, and other features. The model herein, however, lacks the multi-sectoral detail on the production side present in the Fullerton-Rogers model. The omission of this production detail probably has little relevance for our purposes since privatization does not change the inter-sectoral distortions.

$$(1) \qquad U_t^f = \frac{1}{1-\frac{1}{\gamma}} \left[\Sigma_{s=21}^{75} \beta^{s-21} \left(c_{s,t+s-21}^{j\,1-\frac{1}{\rho}} + \alpha l_{s,t+s-21}^{j\,1-\frac{1}{\rho}} \right)^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} + \beta^{54} \mu^j b_{75,t+54}^{j\,1-\frac{1}{\gamma}} \right]$$

In (1) α is the utility weight on leisure, γ is the intertemporal elasticity of substitution in the leisure/consumption composite, and ρ is the intratemporal elasticity of substitution between consumption and leisure. The parameter μ^j is a *j*-type specific utility weight placed on bequest left to each child when the agent dies. The term $\beta = 1/(1+\delta)$ where δ is the rate of time preference, assumed to be the same for all agents.

Letting $a_{s,j}^j$ be capital holdings for type *j* agents, of age *s*, at time *t*, maximization of (1) is subject to a sequence of budget constraints given by

$$(2) \qquad \alpha_{s+1,t+1}^j = (1+r_t)\,(a_{s,t}^j + g_{s,t}^j) + w_{s,t}^j (E_{s,t}^j - l_{s,j}^j) - c_{s,t}^j - \sum_{\kappa \in \tilde{T}} T(B_{s,t}^{j,k}) - N b_{s,t}^j$$

$$l_{s,t}^j \leq E_{s,t}^J$$

where r_t is the pretax return to savings, $g_{s,t}^j$ are gifts received from parents, $E_{s,t}^j$ is the time endowment, $b_{s,t}^j$ denotes bequest made to each of the $N = (1+n)^{20}$ children, and the functions $T^k(\bullet)$ with tax base arguments $B_{s,t}^{j,k}$ determine net tax payments from income sources $k \in T = \{C,K,W,Y,P\}$. $T^C(\bullet)$, $T^W(\bullet)$, $T^Y(\bullet)$ and $T^P(\bullet)$ are consumption taxes, capital income taxes, wage taxes, income taxes, and social security payroll taxes, respectively. Social security benefits are represented in equation (2) as negative taxes with the base switching at the point of retirement from the contemporaneous payroll base to average indexed yearly earnings in the pre-retirement years. All taxes are collected at the household level and the tax system includes both a personal income tax and a business profits tax. The bases for the wage and payroll taxes are smaller than the total labor income due to the base reductions discussed below.

An individual's earnings ability is an exogenous function of her age, her type, and the level of labor-augmenting technical progress, which grows at a constant rate λ. We concentrate all skill differences by age and type in an efficiency parameter $\in_s^j$. Thus, the wage rate for an agent of type j and age s is $w_{s,t}^j = \in_s^j w_t$ where w_t is the growth-adjusted real wage at time t. $\in_s^j$ increases with age to reflect not only the accumulation of human capital, but also technical progress. To permit balanced growth for our specifications of preferences given the restriction on leisure shown in equation (2), we assume that technical progress also causes the time endowment of each successive generation to grow at rate λ.[2] Thus, if $E_{s,t}^j$ depends only on an agent's year of birth. Because E

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

grows at rate λ from one cohort to the next, there will be no underlying trend in w_t. The growth-adjusted earnings ability profiles take the form

$$(3) \quad \epsilon_s^j = e^{-a^j + a_1^j s + a_2^j s + a_3^j s^3}.$$

Values of the *a* coefficients for *j*-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, Auerbach, Kotlikoff, Smetters and Walliser (1997). 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. The estimated earnings-ability profiles, scaled to include the effects of technical progress. Given our benchmark parameterization, peak hourly wages valued in 1996 dollars are $4.00, $14.70, and $79.50 for individuals in classes 1, 6 and 12 respectively. More generally, steady-state annual labor incomes derived from the model's assumptions and the endogenous labor supply choices range from $9,000 to $130,000. These calculations do not yet include labor compensation in the forms of fringe benefits (discussed below).

Transfers are received by children, with interest, at the beginning of the period after they are made by their parents. We restrict all parental transfers to bequests, so that $b_{s,t}^j = 0$, for $s \neq 75$, and $g_{s,t}^j = 0$, for $s \neq 56$. In the steady state, therefore, $g^j = b^j$, for all *j* (where we have dropped the age subscripts for convenience). The parameters μ^j are derived endogenously for the initial steady state

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). Bequest range from $4,800 to $450,000 for the lowest and highest lifetime earnings classes, respectively.

Choices for the remaining technology, preference, and demographic parameters are summarized in Table 1. The benchmark values for δ, γ, ρ, and n are those in Auerbach and Kotlikoff (1987). The parameter α is chosen so that agents devote, on average, about 40 percent of their available time endowment (of 16 hours per day) to labor during their prime working years (real-life ages of roughly 21-55).

The Non-Social Security Government Budget Constraint

At each time t, the government collects tax revenues and issues debt (D_{t+1}) which it uses to finance government purchases of goods and services (G_t) and interest payments on the inherited stock of debt (D_t). Letting Φ^j be the fraction of j-type agents in each generation, the non-social security part of the government's budget constraint evolves according to

$$(4)\quad D_{t+1} + (1+n)^t \sum_{j=1}^{12} \Phi^j \sum_{s=21}^{75} (1+n)^{-(s-21)} \sum_{\kappa \in \{T-P\}} T^k (B_{s,t}^{j,k}) = G_t + (1+r_t) D_t.$$

The exclusion of social security taxes in equation (4) reflects the fact that social security currently uses self-financing earmarked taxes.

Government expenditures are assumed to be unproductive and generate no utility to households.[3] The values of G_t and D_t are held fixed per effective worker throughout the transition path. Any reduction in government outlays resulting from a change in the government's real interest payments is passed on to households in the form of a lower tax rate. The level of government debt, D_t, 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, G_t, to national income equals 0.239. These values corresponds very closely to the corresponding 1996 values for the combined local, state, and federal government in the United States. See Table 2.

Non-Social Security Taxes

The benchmark tax system in our initial steady state if designed to approximate the salient aspects of the 1996 U.S. (federal, state, and local) tax and transfer system. It features a hybrid tax system (incorporating wage-income, capital-income, and consumption tax elements) and payroll taxation for the Social Security and Medicare programs. To adjust for tax evasions, 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.

3. Since *G* remains fixed in all of our experiments, incorporating *G* into the utility functions is unimportant.

We approximate the hybrid current U.S. tax system by specifying a progressive wage-income tax, a flat capital-income tax, a flat state income tax, and a flat 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 1996 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 the *Statistics of Income*,[4] and 4). Earnings-ability profiles that are scaled up to incorporate pension and non-pension components of labor compensation.[5]

The model's initial economy-wide average marginal tax rate on wage income is about 21 percent, about the figure obtained from the NBER's TAXSIM model reported in Auerbach (1996). The average wage-income tax rate equals 12.1 percent. For all individuals in the highest lifetime income class (group 12), the average effective marginal tax rate on labor income is 28.6 percent. The highest realized effective marginal tax rate is 34 percent. For lifetime income class 6—whose members have peak labor earnings of about /435,000—the average tax rate and average marginal tax

4. 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 deductions of interest expense on home mortgages was included in our calculations 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.

5. 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.

rate are 10.6 and 20.0 percent, respectively. For the poorest class (group 1), the corresponding rates are zero and 5.5 percent.[6]

Capital Income Taxation

Following Auerbach (1996), we assumed 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. 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 corresponds to the amount of revenue generated by state income taxes in 1996 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

6. The average marginal rate for people with the lowest income exceeds zero due to positive shadow tax rates in peak earnings years.

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, Medicate 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 (PAI) in accordance with a progressive formula. In particular, the 1996 benefit formula has two bend points. The PIA is calculated as 90 percent of the first $436 of AIME, 32 percent of the next $2,198 of AIME, and 15 percent of AIME above $2,198. We approximate the benefit formula with a sixth-order polynomial which is applied to the dollar-scaled AIME generated by the mode. 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.

An earmarked tax applied to wage income up to a limit of $62,700—the earnings ceiling in 1996—is used to pay for OASI benefits. Define $w_{s,t}^{J} = w_{s,t}^{j}(E_{s,t}^{j} - l_{s,t}^{j})$ as the wage income earned by

the *j*-type agent who is age *s* in year *t*. Also defined $\omega_{65,t}^{-j}$ as the average indexed annual earnings for the *j*-type agent age 65 at time *t*. Labor income earned before turning age 65 is adjusted upward by the growth rate of the economy in calculating $\omega_{65,t}^{-j}$. Payroll taxes at time *t*—with retirement benefits modeled as negative taxes—equals

$$(5) \quad T^{p}(B_{s,t}^{j,k}) = \begin{cases} \tau \cdot \omega_{s,t}^{j} & ; \; s \leq 64 \; , \; \omega_{s,t}^{j} \leq \$62{,}700 \\ \tau \cdot \$62{,}700 & ; \; s \leq 64 \; , \; \omega_{s,t}^{j} > \$62{,}700 \\ -2 \cdot R(\omega_{s,t}^{-j}) \cdot \omega_{s,t}^{-j} & ; \; s > 64 \end{cases}$$

where $R(\cdot)$ is the statutory replacement rate function shown in Figure 1.

Budget balance for a self-financing pay-as-you-go social security system with earmarked taxes at time *t* requires:

$$(6) \quad \Sigma_{j=1}^{12} \Phi^{j} \; \Sigma_{s=21}^{75} (1+n)^{-(s-21)} T^{p}(B_{s,t}^{j,p}) = 0$$

The value of τ is solve for endogenously as a function of benefit rules via equation (6). The value of τ is 9.9 percent in the initial steady state, which is close to its actual value in 1996.[7]

The net marginal tax rate is a component of the consumer's first-order conditions. Let $PVT((\omega_{s,t}^{j})$ and $PVT(\omega_{s,t}^{j})$ be the present value of payroll taxes and benefits, respectively, for the *j*-type

7. The employer-employee combined payroll tax equaled 10.52 percentage points. About 1 percentage point represents a net increase to the social security trust fund.

agent age *s* at time *t*. The marginal tax rate for those below the earnings ceilings in each case considered herein is:

$$(7)\quad \theta(\omega^{j}_{s,t}) = \begin{cases} \tau\cdot\left[1 - PVB'(\omega^{j}_{s,t}) / PVT'(\omega^{j}_{s,t})\right]; & \textit{full perception linkage} \\ \tau \quad ; & \textit{no perception linkage} \end{cases}$$

where *PVB' (.)/*$\partial\omega$ and *PVT' (.)/*$\partial\omega$. The net marginal tax rates under the perception linkage are shown in Figure 2 by income class and age. These tax rates are typically relatively higher for both richer and younger agents. The higher rates for richer agents reflect the progressive manner in which social security benefits are calculated. The higher rates for younger agents reflect the compound interest effect of being required to save in a social security system whose internal rate of return i sless than after-tax rate of return to capital (reported below). Notice that the net tax rates are generally quite large and positive even for the lifetime poor because the after-tax of return to capital is higher than the internal rates of return faced by these agents. Rich agents whose labor income exceeds the payroll tax (e.g., class 12 in select years) face a zero marginal tax rate.

The HI and DI programs are modeled very simply. The HI and DI levels of lump-sum transfers are picked to generate payroll tax rates of 2.9 percent and 1.9 percent, respectively, corresponding to their 1996 statutory rates. Like the OASI tax, DI contributions apply only to wages below $62,700. The HI tax, is 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 Technology

Aggregate capital (K) and labor (L) are obtained from individual asset and labor supplies as

$$(8) \qquad K_t = (1+n)^t \sum_{j=1}^{12} \phi^j \sum_{s=21}^{75} (1+n)^{-(s-21)} a_{s,t}^j - D_t,$$

(where, recall, D_t is government debt at time t) and

$$(9) \qquad L_t = (1+n)^t \sum_{j=1}^{12} \phi \sum_{s=21}^{75} (1+n)^{-(s-21)} \in_s^j (E_{s,t}^j - l_{s,t}^j).$$

Output (net of depreciation) is produced by identical competitive firms using a neoclassical, constant-returns-to-scale production technology. The aggregate production technology is the standard Cobb-Douglas form

$$(10) \qquad Y_t = A K_t^{\theta} L_t^{1-\theta},$$

where Y_t is aggregate output (national income) and θ is capital's share in production. Denote the capital-labor ratio as κ. The time-t competitive post-tax capital rate of return equals

$$(11) \qquad r_t = \left[\theta A \kappa_t^{\theta-1} (1-\tau_t^k) + q_{t+1} - q_t \right] / q_t.$$

where $q_t = (1\text{-}z_t \tau_t^k)$ is Tobin's q at time t and z is the level of capital investment expensing.

APPENDIX II:

OUTLINE OF THE BENCHMARK ECONOMY

The model solves for the full rational-expectations dynamic (Nash) equilibrium with a Gauss-Seidel algorithm. The calculation starts with a guess for certain key variables and then iterates on those variables until a convergence criterion is met. The identifying restrictions of the model are used to compute the remaining economic variables as well as the updates for the iterations. The solution involves several steps and inner loops that solve for household-level variables before moving to an outer loop which solves for the time-paths of aggregate variables and factor prices. Since the decision to opt out by any agent will be affected by the exact time path of factor prices—which, in turn, is affected by the opting out decisions of other agents—the opting out choice is determined endogenously for each agent. The solution algorithm iterates until each agent, given the prevailing path of factor prices, prefers his/her intertemporal allocation of consumption and leisure and his/her decision whether to opt out.

The household optimization problem is subject to the constraint that leisure not exceed the endowment of time (equation (2)). For those households who would violate the constraint, the model calculates shadow wage rates at which they exactly consume their full-time endowment.

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

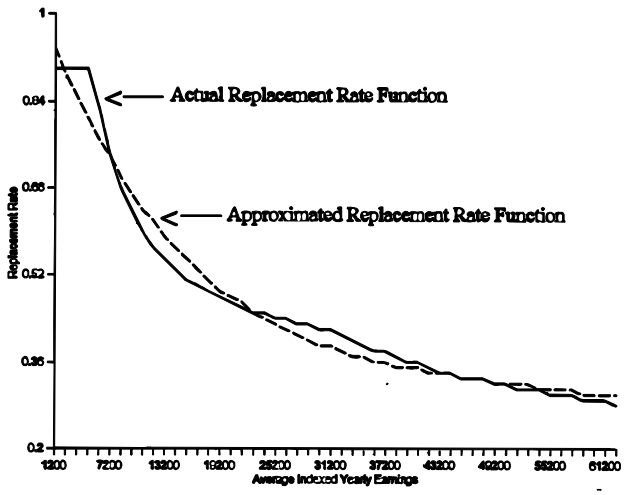
corresponding wage income above and below the kink. We then calculate a shadow marginal tax rate from the first-order conditions that puts those households exactly at the kink. This procedure generates optimal forward-looking leisure and consumption choices for all periods of life.

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 evaluate the utility on both sides of the non-convex section and put households on the side that generates highest utility.

The sequence of calculations is as follows. An initial guess is made for the time-paths of these aggregate variables as well as for the shadow wage rates, shadow tax rates, endogenous tax rates, the separate OASI / DI / HI payroll tax rates, and the Social Security and Medicate wealth 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. Household's labor supply 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 revenue-neutrality requirement. The payroll tax is also updated to preserve the pay-as-you-go financing of OASI and HI benefits.[8] The tax rate for DI benefits is also updated. The algorithm iterates until the capital stock and labor supply time-paths converge.

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

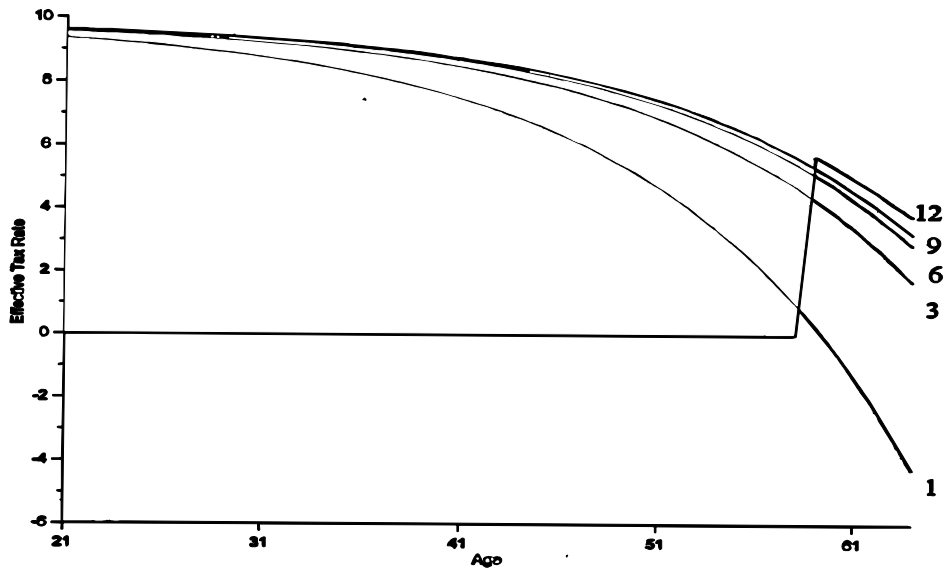
Figure 1
The US Replacement Rate as a Function of Average Indexed Yearly Earnings, $R(\cdot)$, for a Single Person Retiring in 1996: Actual and Polynomial Approximated



Notes: 1. Actual replacement rate computed using the statutory formula for a person turning age 62 in 1996. The monthly benefit equals 90 percent of first $437 of covered Average Indexed Monthly Earnings (*AIME*) plus 32 percent of the next $2,198 plus 15 percent above $2,635. *AIME* converted to Average Indexed Yearly Earnings (*AIYE*) by multiplying times 12. Replacement rates for single worker with retired spouse equals $1.5 \cdot R(\cdot)$.

2. Predicted $R(AIYE) = 0.9927 - 4.37E\text{-}05 \cdot AIYE + 1.2E\text{-}09 \cdot AIYE^2 - 1.9E\text{-}14 \cdot AIYE^3 + 1.5E\text{-}19 \cdot AIYE^4 - 6.1E\text{-}25 \cdot AIYE^5 + 9.8E\text{-}31 \cdot AIYE^6$. The regression $R^2 = 0.99$.

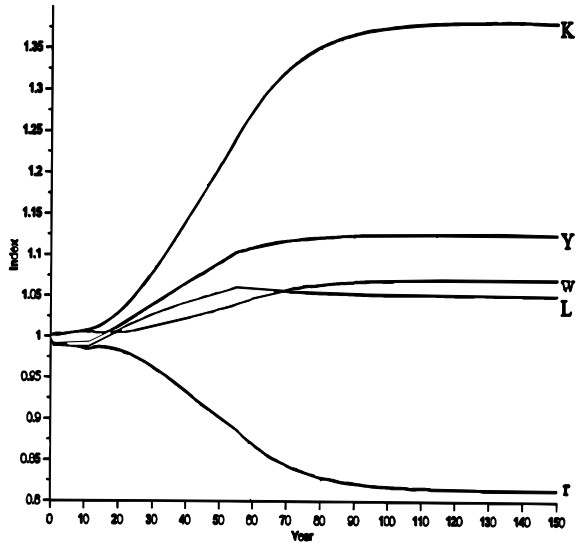
Figure 2
Effective Marginal Social Security Tax Rates by Age and Income Class



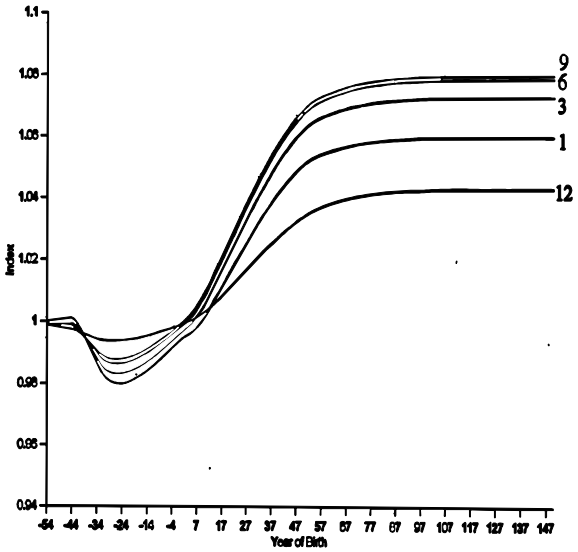
Benchmark: Recognition Bonds

Figure 3
Payroll Tax Finance of Transition with Tax-Benefit Linkage

Macro Effects



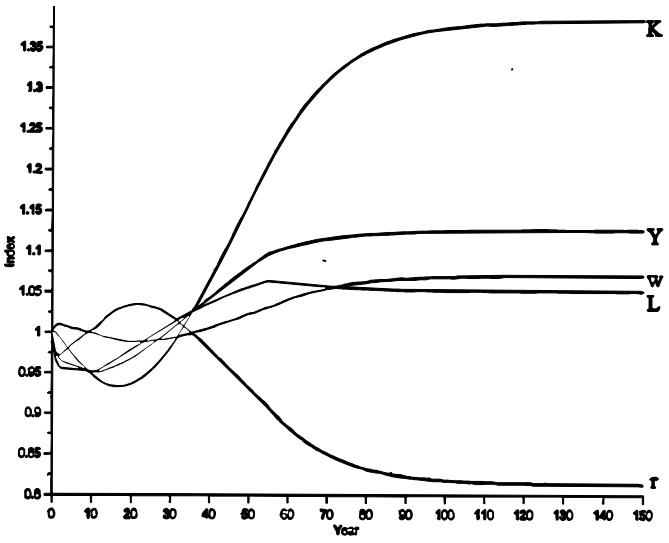
Remaining Lifetime Utility



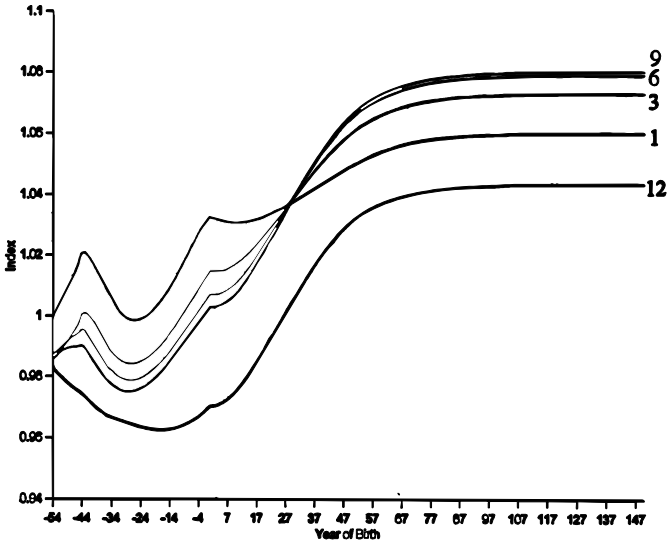
Benchmark: Recognition Bonds

Figure 4
Income Tax Finance of Transition with Tax-Benefit Linkage

Macro Effects



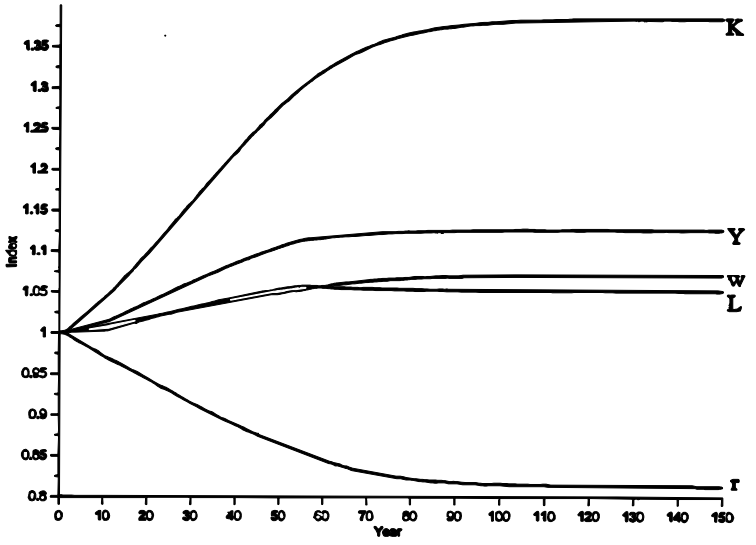
Remaining Lifetime Utility



Benchmark: Recognition Bonds

Figure 5
Consumption Tax Finance of Transition with Tax-Benefit Linkage

Macro Effects



Remaining Lifetime Utility

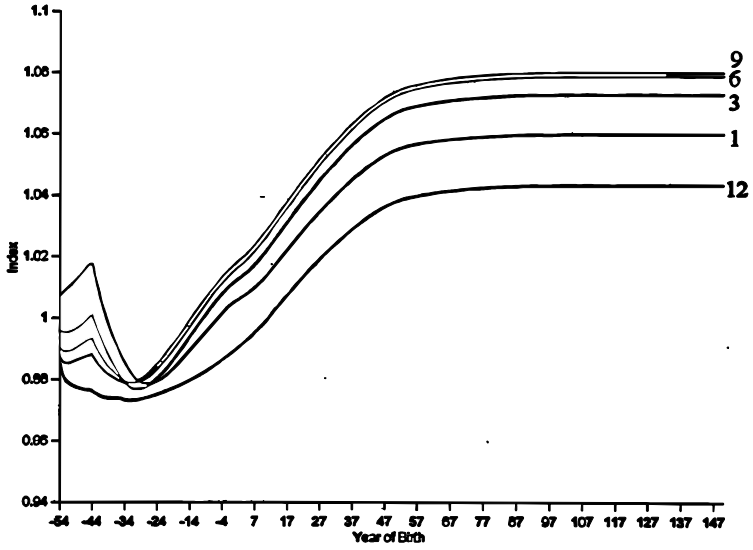
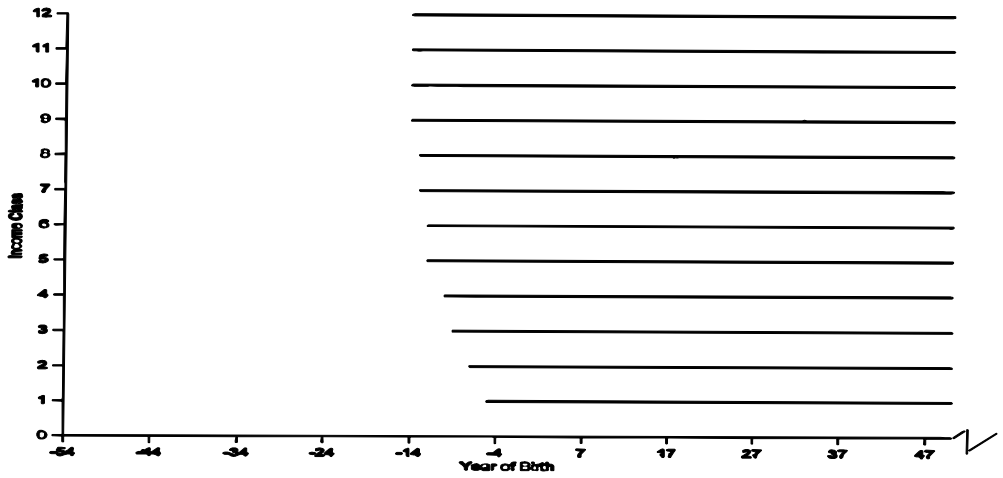
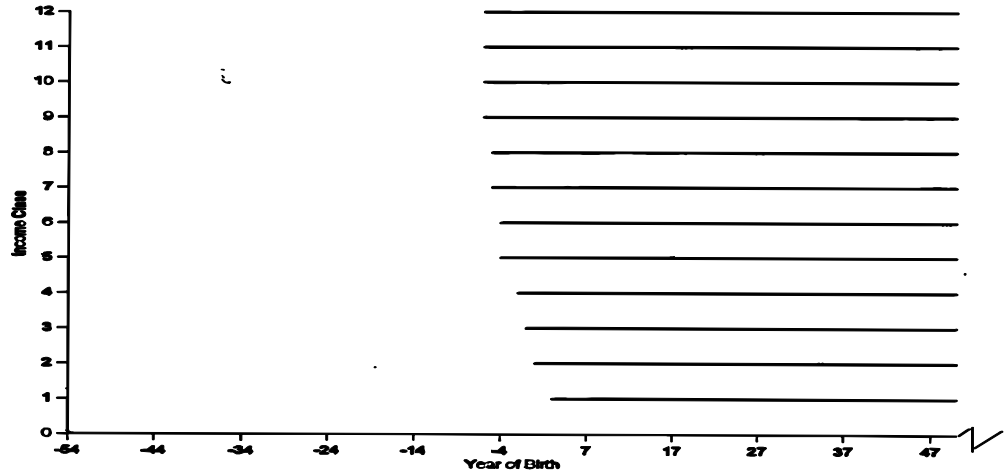


Figure 6
Who Opts Out of Social Security?

Income Tax Finance of Transition with Tax-Benefit Linkage and New Payroll Tax Equal to Present Law Value
(Solid line denotes generations that opt out)



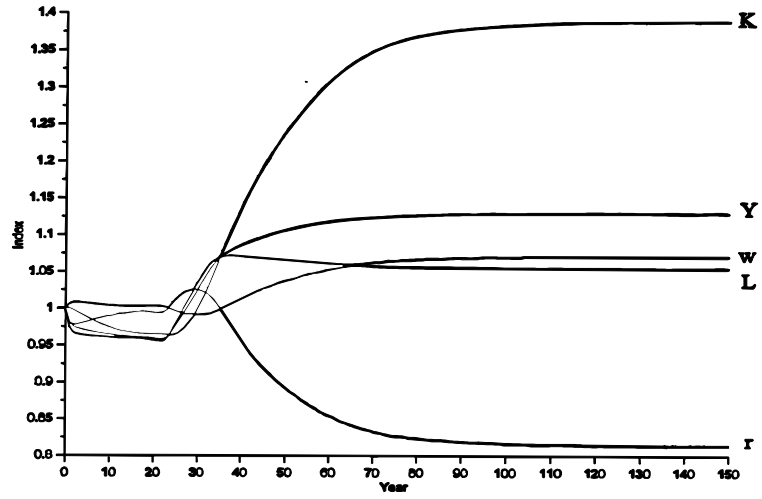
Income Tax Finance of Transition with Tax-Benefit Linkage and New Payroll Tax Equal to One-Half Present Law Value
(Solid line denotes generations that opt out)



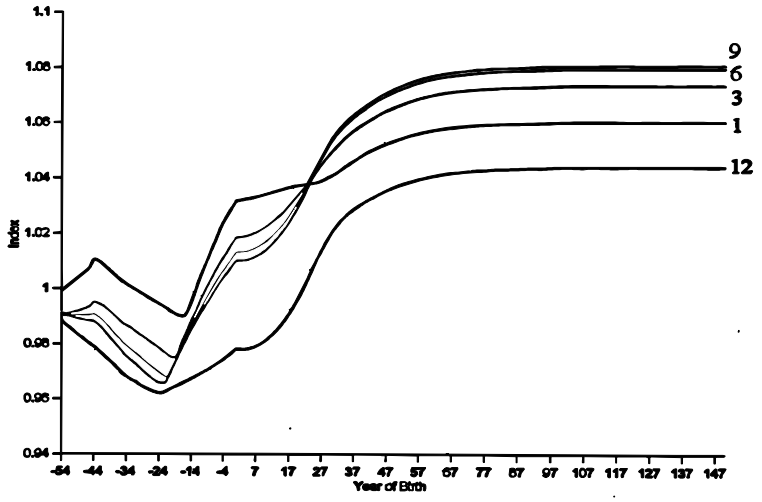
Opting Out with New Payroll Tax Equal to Present Law Value

Figure 7
Income Tax Finance of Transition with Tax-Benefit Linkage

Macro Effects



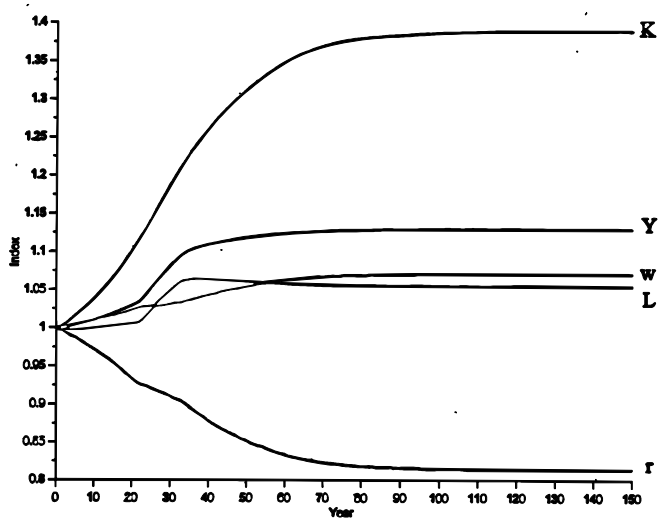
Remaining Lifetime Utility



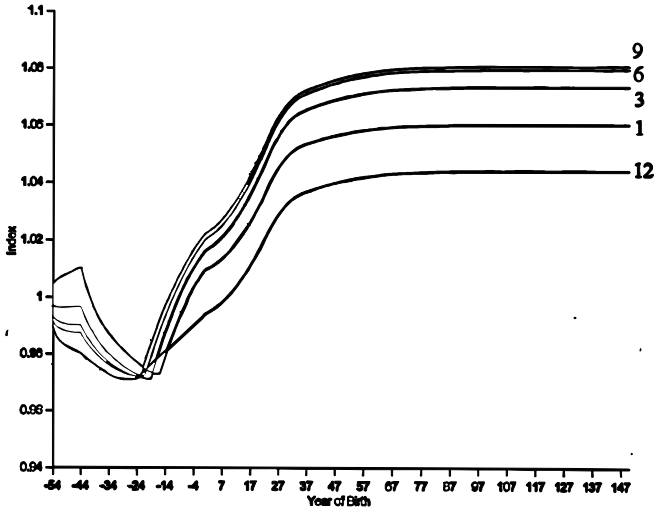
<u>Opting Out with New Payroll Tax Equal to Present Law Value</u>

Figure 8
Consumption Tax Finance of Transition with Tax-Benefit Linkage

Macro Effects



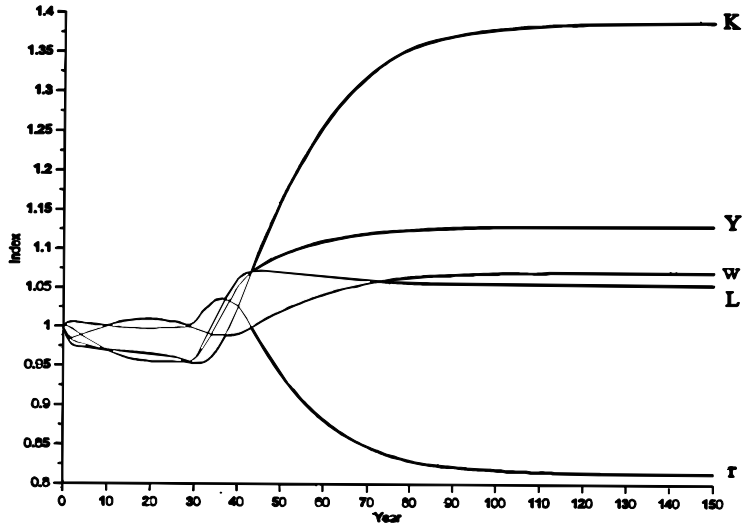
Remaining Lifetime Utility



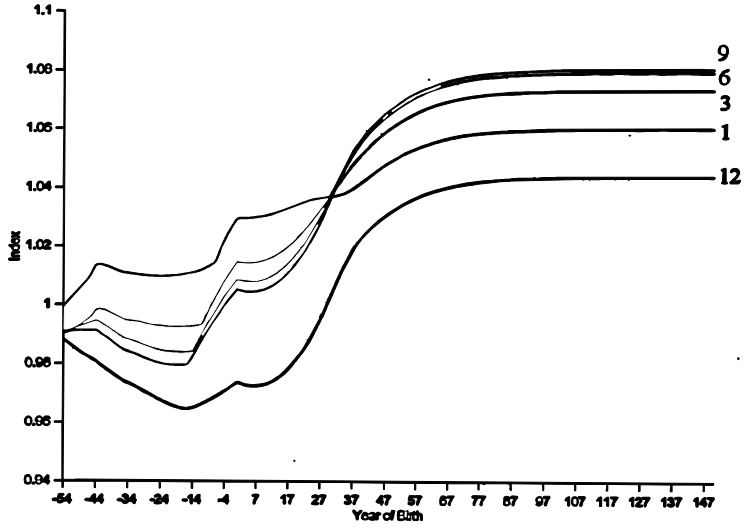
Opting Out with New Payroll Tax Equal to One-Half of Present Law Value

Figure 9
Income Tax Finance of Transition with Tax-Benefit Linkage

Macro Effects



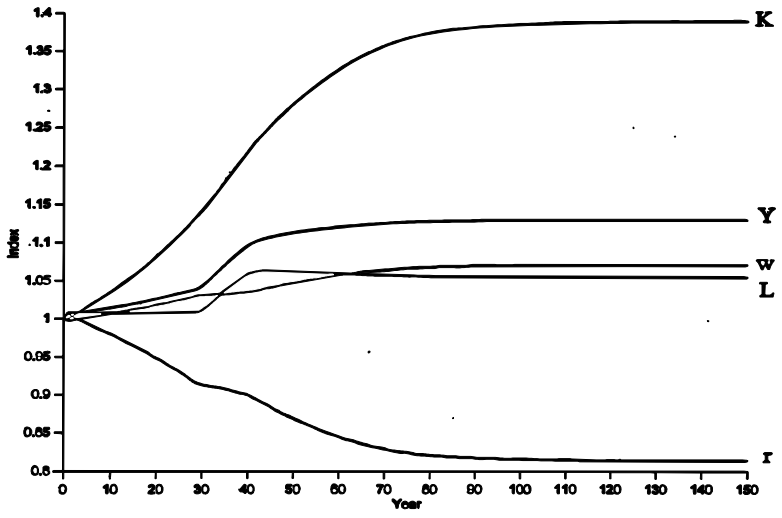
Remaining Lifetime Utility



Opting Out with New Payroll Tax Equal to One-Half of Present Law Value

Figure 10
Consumption Tax Finance of Transition with Tax-Benefit Linkage

Macro Effects



Remaining Lifetime Utility

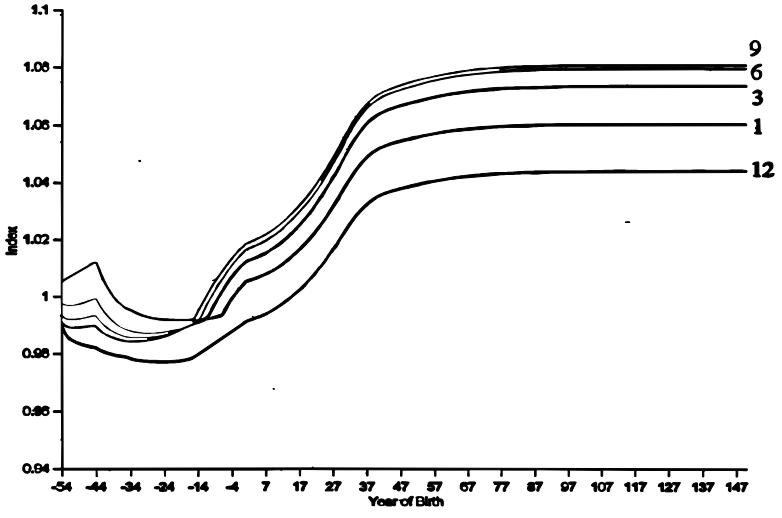
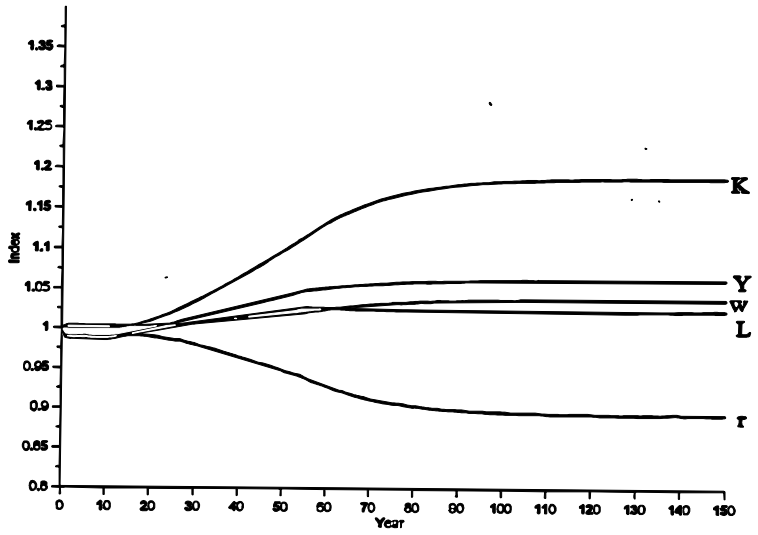


Figure 11
Flat Minimum Benefit with Payroll Tax Finance

Macro Effects



Remaining Lifetime Utility

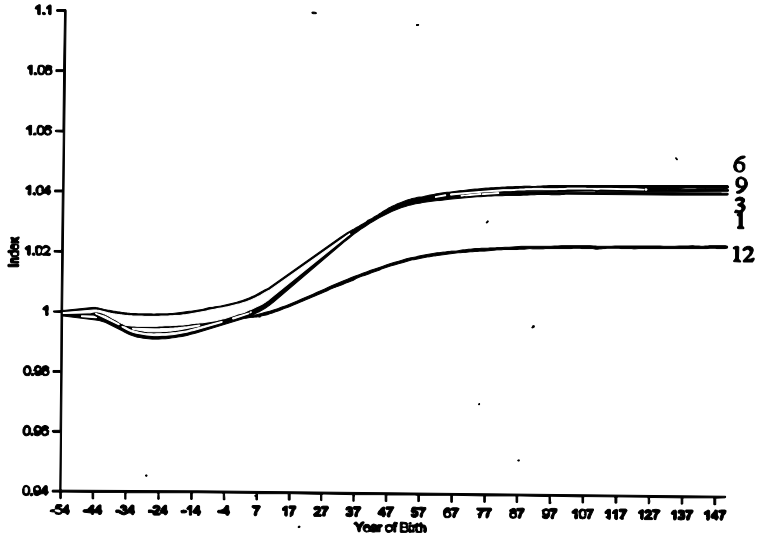
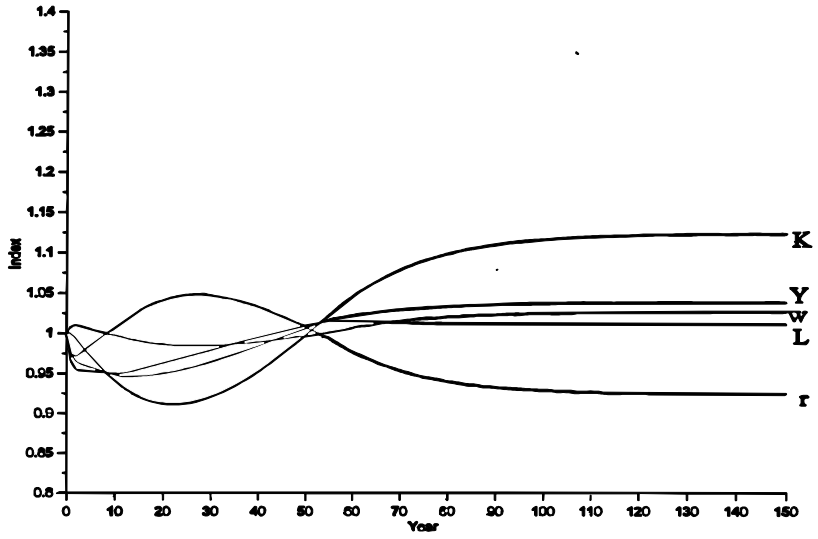


Figure 12
Flat Minimum Benefit with Income Tax Finance

Macro Effects



Remaining Lifetime Utility

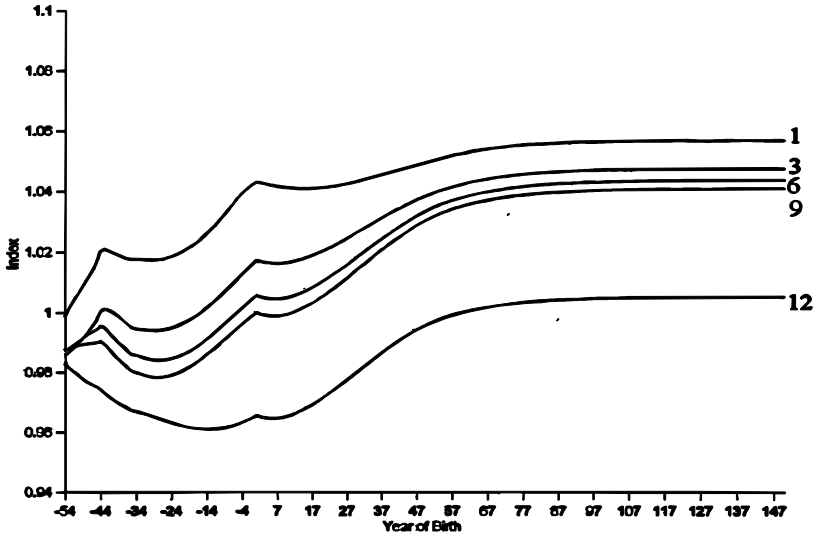
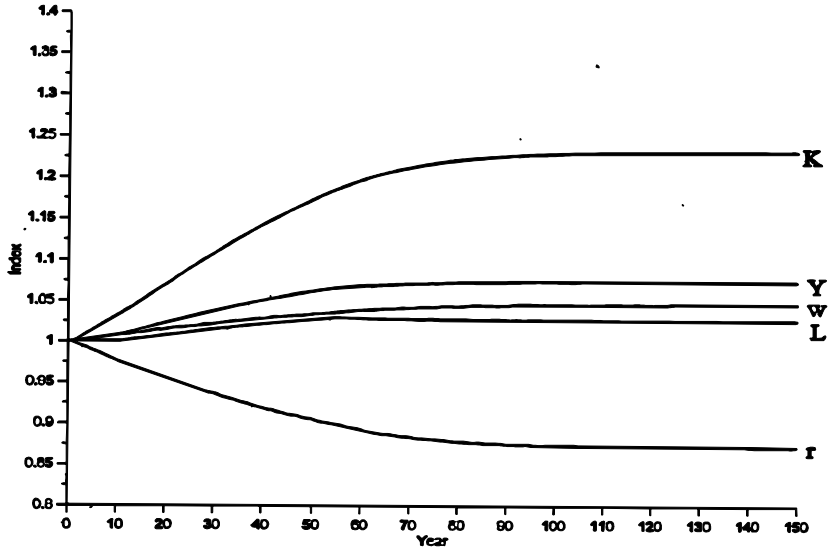


Figure 13
Flat Minimum Benefit with Consumption Tax Finance

Macro Effects



Remaining Lifetime Utility

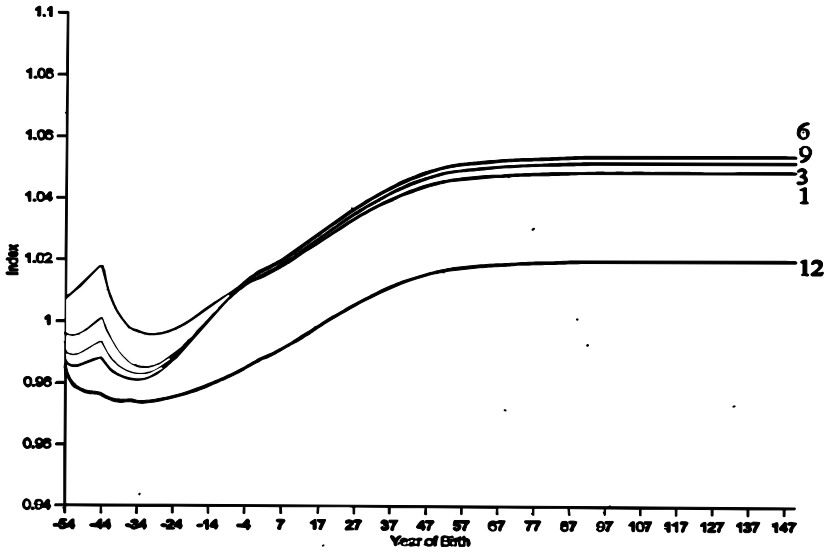
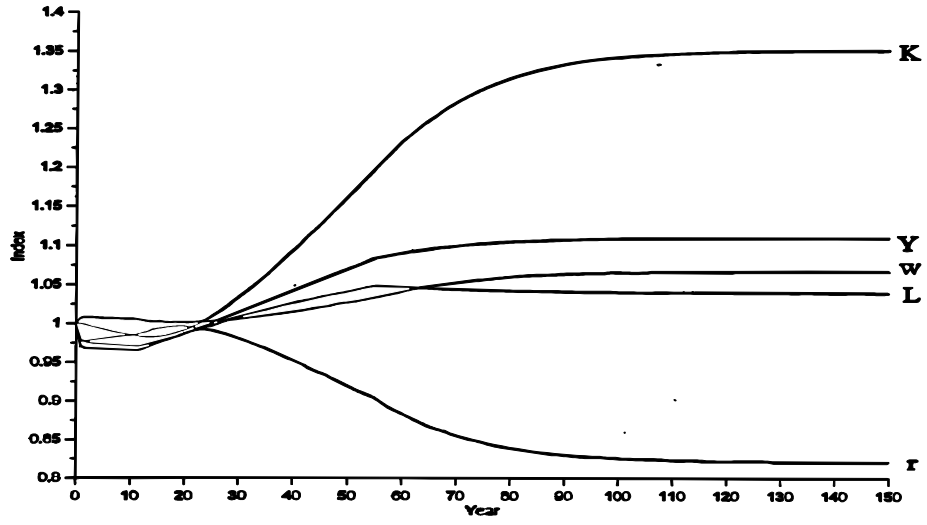


Figure 14
Progressive Match with Payroll Tax Finance

Macro Effects



Remaining Lifetime Utility

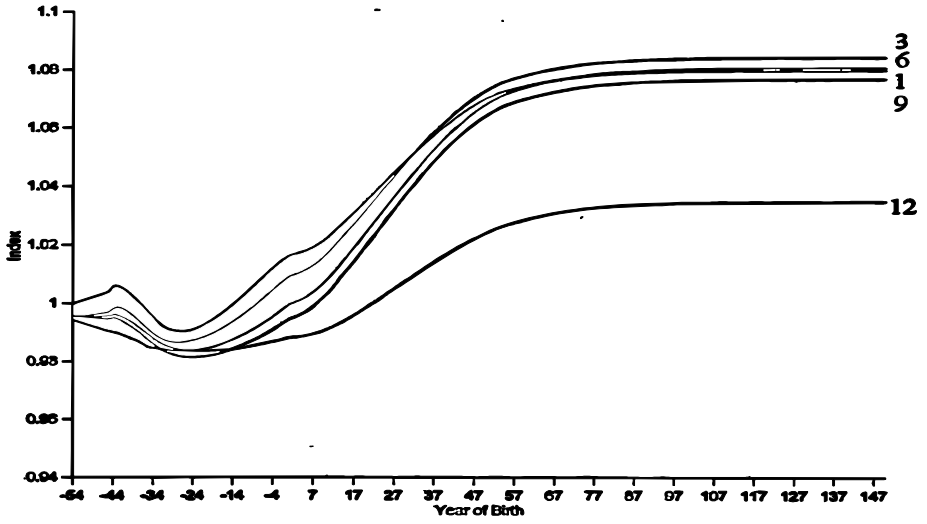
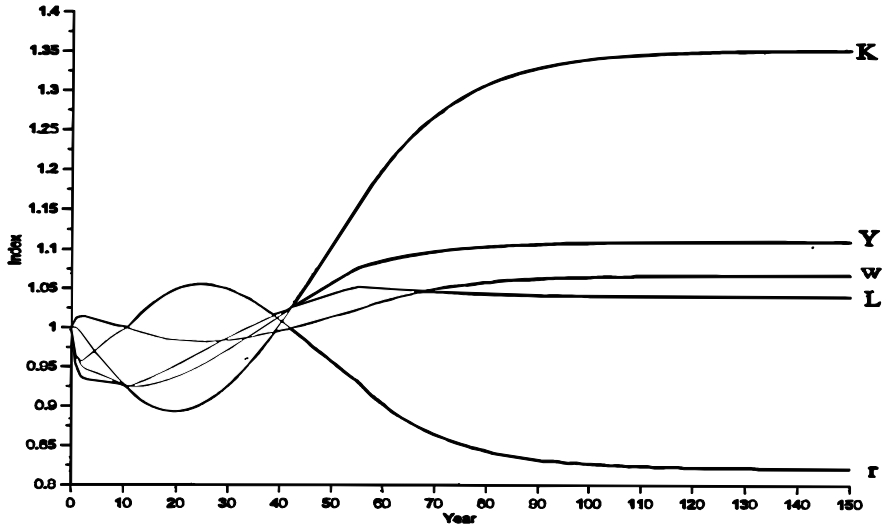


Figure 15
Progressive Match with Income Tax Finance

Macro Effects



Remaining Lifetime Utility

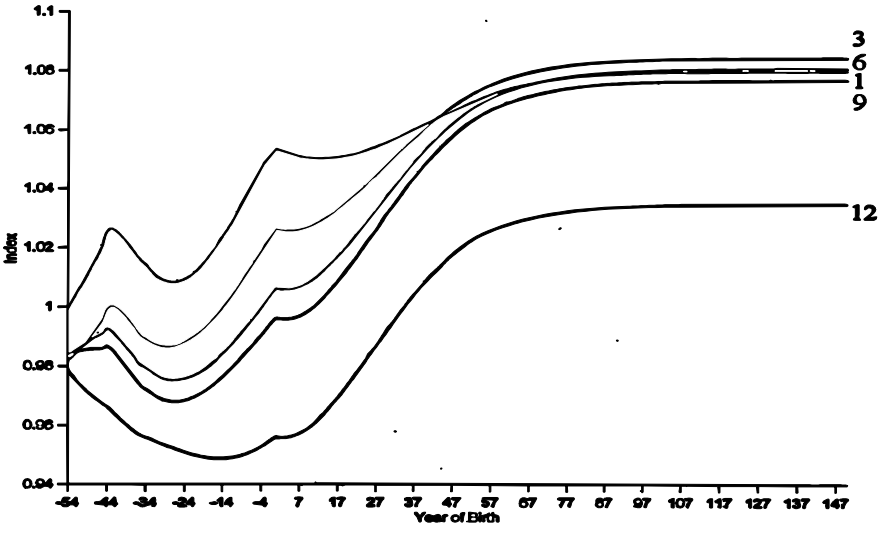
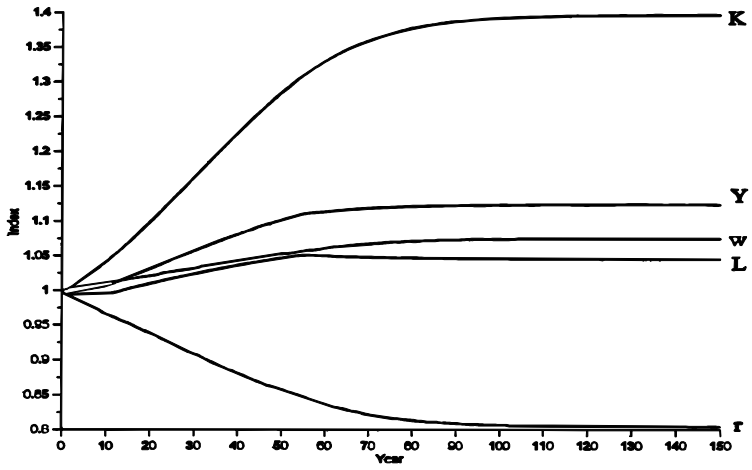


Figure 16
Progressive Match with Consumption Tax Finance

Macro Effects



Remaining Lifetime Utility

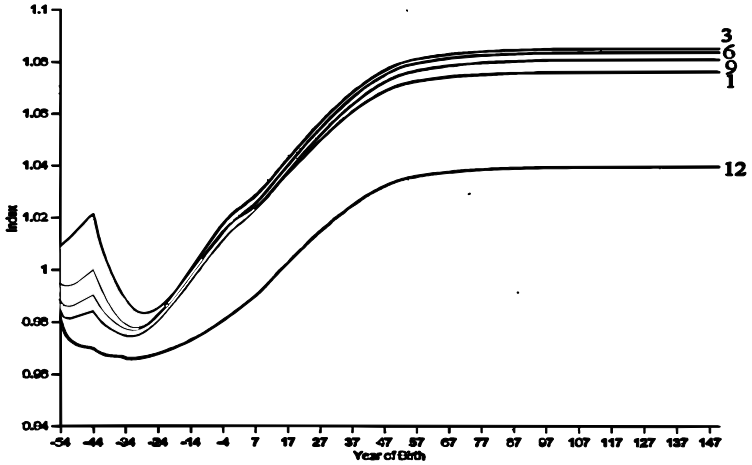
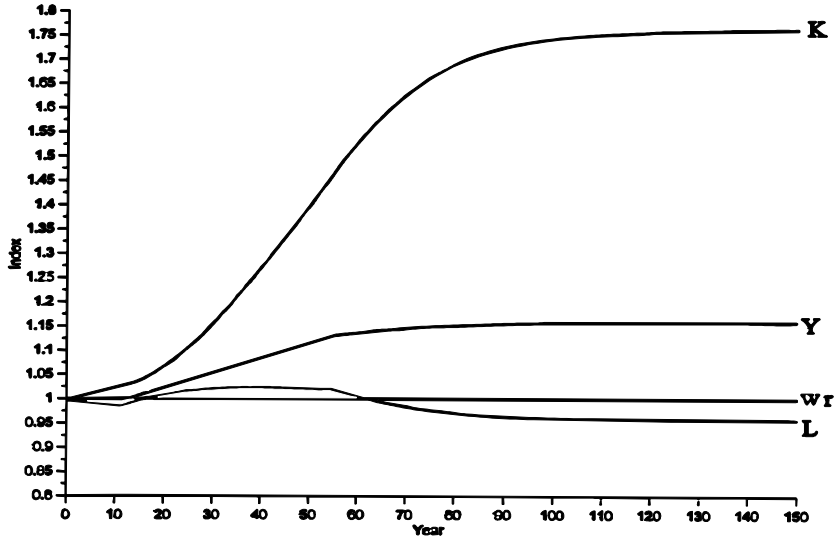


Figure 17
Open Economy with Payroll Tax Finance

Macro Effects



Remaining Lifetime Utility

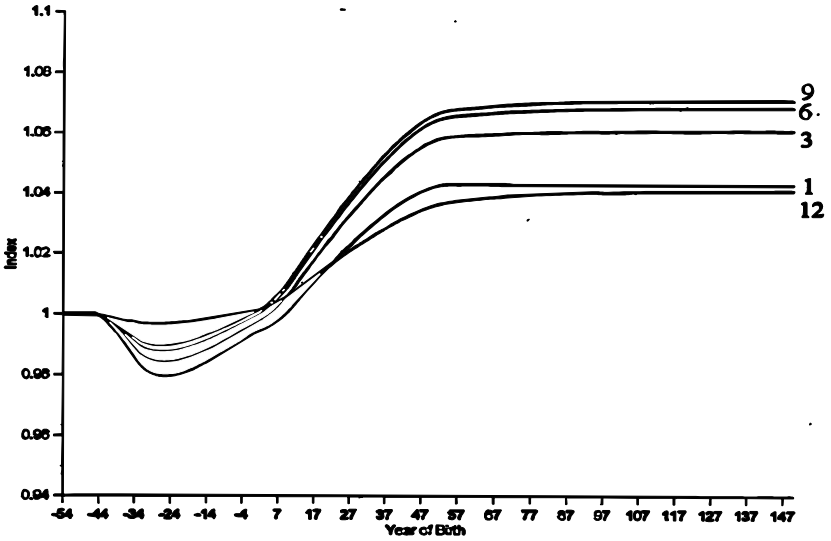


Table 1. Benchmark Parameter Definitions and Values

Symbol	Definition	Value
	PREFERENCES	
α	Utility weight on leisure	1.00
δ	Rate of time preference	0.015
γ	Intertemporal substitution elasticity	0.25
μ^j	Utility weight placed on bequests by income class	[1]
ρ	Intratemporal substitution elasticity	0.80
	HUMAN CAPITAL	
ε^j_s	Productivity of agent in income class *j* at age *s*.	[2]
	DEMOGRAPHICS	
n	Population growth	0.01
N	Number of children per adult, $(1+n)^{20}$	1.22
φ^j	Fraction of agents of income class *j*	[3]
	TECHNOLOGY	
λ	Technological change	0.01
b	Adjustment costs	0.00
θ	Net capital share	0.25
	DEBT, TAXES, DEDUCTIONS IN INITIAL STEADY STATE	
—	Debt services as fraction of National Income	0.0350
—	Disability tax rate	0.0185
—	Medicare tax rate	0.0290
—	Progressive Social Security (OAI) replacement rate	[4]
—	Social Security marginal tax-benefit linkage	0.25
—	Payroll tax ceiling	$62,700
$T^{C'}$	Proportional consumption tax	0.113
$T^{K'}$	Proportional capital income tax	0.20
$T^{W(.)}$	Kinked progressive wage tax with standard deduction	[5]
$T^{Y'}$	State proportional income tax less evasion adjustment	0.011
—	Itemized deductions proportional wage base reduction	0.0755[6]
—	Fringe benefits proportional wage base reduction	0.1129[6]
z	Expensing[7]	0.20

Footnotes:

[1] Calibrated endogenously in the initial state to match the level of bequests—as a fraction of mean national income—in Fullerton and Rogers (1993, Table 3-8), calibrated to 1996 dollars.

[2] See Appendix for estimation procedure

[3] φ^1=0.02, φ^2=0.08, φ^i=0.10 ($3 \leq i \leq 10$), φ^{11}=0.08, φ^{12}=0.02

[4] The statutory progressive endpoint formula for 1996, scaled up by a factor of 2 to account for the fact that other non-DI benefits (mainly espousal and survivors benefits) account for 50% of all benefits paid (see 1996 OASDI Trustee Report, Table II.C7).

[5] The 1996 statutory tax function for a single individual with a deduction equal to $9661 ($4,000 standard deduction, $2,550 personal exemption and $2,550-*N* exemption for dependents).

[6] Total proportional base reduction above the standard deduction therefore equals 0.18845.

[7] Deductions for new investment above economic depreciation and adjustment costs.

Table 2. Key Endogenous Equilibrium Values for the Initial Steady State and the Corresponding Empirical Values

Model		Empirical Estimate and Calculation	
Concept	Value	Estimate	Calculations (using NIPA unless indicated)
COMPOSITION OF NATIONAL INCOME (PERCENT)			
Personal Consumption	0.734	0.720	Personal consumption expenditures - housing services
Net Saving Rate	0.053	0.056	(National saving - capital consumption allowance)/NI
Government Consumption	0.212	0.212	Consumption expenditures + gross investment for federal (defense and non defense) and state and local - consumption of fixed capital
TAX RATES AND GOVERNMENT REVENUE			
Avg. Marginal Wage Tax[1]	0.214	0.217	Auerbach (1996) based on the NBER TAXSIM model.
Government Revenue	0.239	0.239	Total receipts - contributions for social insurance - property taxes (state and local)
Social Security (OAI) Tax[2]	0.100	0.100	1996 tax rate is 10.52 which includes trust fund contributions equal to about 0.5 to 0.7.
CAPITAL-OUTPUT RATIO AND BEFORE-TAX INTEREST RATE			
Capital-Income Ratio	2.564	2.660	1993 current-cost net stock of fixed reproducible wealth in the SCF - gov't owned fixed capital / 1993 NI
Before-Tax Rate of Return[3]	0.097	0.093	The average from 1960-94 of the sum of interest, dividends, retained earnings and all corporate taxes to the replacement value of capital stock (Rippe, 1995).

Footnotes:
[1] Does not include the payroll tax.
[2] The combined OASDI_HI payroll tax therefore equals 0.147 which is close to the actual value of 0.153 and exactly equal to the correct value for the payroll tax after subtracting 0.006 for contribution to the trust fund.
[3] The social marginal rate of return (i.e., before corporate taxes).

Table 3

Percentage Change in Capital Stock Relative to Steady State

Run	Experiment	Finance of Social Security Benefits	Tax-Benefit Linkage	New Social Security Tax Rate	Year of Transition 5	10	25	150
1	---	W	Yes	n/a	0.0	0.1	5.2	39.0
2	---	W	No	n/a	0.5	1.1	6.1	39.8
3	---	Y	Yes	n/a	-2.4	-5.0	-4.6	39.0
4	---	Y	No	n/a	-2.2	-4.3	-3.5	39.8
5	---	C	Yes	n/a	1.8	4.1	12.8	39.0
6	---	C	No	n/a	2.1	4.7	13.6	39.8
7	Opting Out	Y	Yes	PL	-1.2	-2.5	-3.4	39.0
8	Opting Out	Y	No	PL	-1.4	-3.1	-4.0	39.8
9	Opting Out	C	Yes	PL	1.5	3.8	14.2	39.0
10	Opting Out	C	No	PL	1.4	3.4	14.1	39.8
11	Opting Out	Y	Yes	PL / 2	-1.4	-3.0	-4.5	39.0
12	Opting Out	C	Yes	PL / 2	1.5	3.5	11.0	39.0
13	Flat Benefit	W	Yes	n/a	0.0	0.0	2.0	19.0
14	Flat Benefit	Y	Yes	n/a	-2.8	-5.7	-8.7	12.4
15	Flat Benefit	C	yes	n/a	1.4	3.2	8.9	23.2
16	Prog. Match	W	Yes	n/a	-0.7	-1.4	0.9	35.4
17	Prog. March	Y	Yes	n/a	-3.4	-7.1	-9.7	35.4
18	Prog. Match	C	Yes	n/a	1.8	4.1	13.0	39.8
19	Open Econ.	W	Yes	n/a	-0.8	-1.3	1.5	-4.3

C: Consumption Tax
n/a: non-applicable. For forced privatization, payroll tax is endogenous for payroll tax financing and zero for income tax and consumption tax financing.
PL: Present Law payroll tax rate
PL / 2: Present Law payroll tax rate divided by 2
W: Payroll Tax
Y: Income Tax

Table 4

Percentage Change in Capital Stock Relative to Steady State

Run	Experiment	Finance of Social Security Benefits	Tax-Benefit Linkage	New Social Security Tax Rate	Year of Transition 5	10	25	150
1	---	W	Yes	n/a	-1.1	-1.1	1.8	5.5
2	---	W	No	n/a	0.3	0.4	3.2	7.0
3	---	Y	Yes	n/a	-4.5	-4.7	0.0	5.5
4	---	Y	No	n/a	-2.9	-3.1	1.1	7.0
5	---	C	Yes	n/a	0.3	0.4	2.4	5.5
6	---	C	No	n/a	1.8	1.9	3.9	7.0
7	Opting Out	Y	Yes	PL	-3.6	-3.9	-2.1	5.5
8	Opting Out	Y	No	PL	-3.8	-4.0	-0.6	7.0
9	Opting Out	C	Yes	PL	-0.2	0.0	2.4	5.5
10	Opting Out	C	No	PL	-0.2	0.3	3.9	7.0
11	Opting Out	Y	Yes	PL / 2	-2.6	-3.0	-3.8	5.5
12	Opting Out	C	Yes	PL / 2	0.8	0.8	0.9	5.5
13	Flat Benefit	W	Yes	n/a	-1.3	-1.4	0.2	2.3
14	Flat Benefit	Y	Yes	n/a	-4.7	-4.9	-2.9	1.2
15	Flat Benefit	C	yes	n/a	0.0	0.1	1.1	2.7
16	Prog. Match	W	Yes	n/a	-3.2	-3.3	-0.2	4.0
17	Prog. March	Y	Yes	n/a	-6.7	-7.3	-3.0	4.0
18	Prog. Match	C	Yes	n/a	-0.5	-0.4	1.7	4.5
19	Open Econ.	W	Yes	n/a	-0.8	-1.3	1.5	-4.3

C: Consumption Tax
n/a: non-applicable. For forced privatization, payroll tax is endogenous for payroll tax financing and zero for income tax and consumption tax financing.
PL: Present Law payroll tax rate
PL / 2: Present Law payroll tax rate divided by 2
W: Payroll Tax
Y: Income Tax

Table 5

Percentage Change in Income Relative to Steady State

Run	Experiment	Finance of Social Security Benefits	Tax-Benefit Linkage	New Social Security Tax Rate	Year of Transition 5	10	25	150
1	---	W	Yes	n/a	-0.8	-0.7	2.6	13.0
2	---	W	No	n/a	0.4	0.6	3.9	14.4
3	---	Y	Yes	n/a	-4.0	-4.8	-1.5	13.0
4	---	Y	No	n/a	-2.7	-3.4	0.0	14.4
5	---	C	Yes	n/a	0.6	1.3	4.9	13.0
6	---	C	No	n/a	1.9	2.6	6.3	14.4
7	Opting Out	Y	Yes	PL	-3.0	-3.5	-2.4	13.0
8	Opting Out	Y	No	PL	-3.2	-3.8	-1.4	14.4
9	Opting Out	C	Yes	PL	0.2	1.0	5.2	13.0
10	Opting Out	C	No	PL	0.2	1.1	6.4	14.4
11	Opting Out	Y	Yes	PL / 2	-2.3	-3.0	-4.0	13.0
12	Opting Out	C	Yes	PL / 2	1.0	1.5	3.3	13.0
13	Flat Benefit	W	Yes	n/a	-1.0	-1.1	0.6	6.2
14	Flat Benefit	Y	Yes	n/a	-4.2	-5.1	-4.4	3.9
15	Flat Benefit	C	yes	n/a	0.4	-.8	3.0	7.5
16	Prog. Match	W	Yes	n/a	-2.6	-2.9	0.1	11.1
17	Prog. March	Y	Yes	n/a	-5.9	-7.2	-4.7	11.1
18	Prog. Match	C	Yes	n/a	0.0	0.7	4.4	12.4
19	Open Econ.	W	Yes	n/a	0.0	-0.4	3.8	16.0

C: Consumption Tax
n/a: non-applicable. For forced privatization, payroll tax is endogenous for payroll tax financing and zero for income tax and consumption tax financing.
PL: Present Law payroll tax rate
PL / 2: Present Law payroll tax rate divided by 2
W: Payroll Tax
Y: Income Tax

Table 6

Percentage Change in Wages Relative to Steady State

Run	Experiment	Finance of Social Security Benefits	Tax-Benefit Linkage	New Social Security Tax Rate	Year of Transition 5	10	25	150
1	---	W	Yes	n/a	0.4	0.5	0.8	7.1
2	---	W	No	n/a	0.1	0.2	0.7	6.9
3	---	Y	Yes	n/a	0.5	0.0	-1.0	7.1
4	---	Y	No	n/a	0.2	-0.3	-1.2	6.9
5	---	C	Yes	n/a	0.4	0.9	2.4	7.1
6	---	C	No	n/a	0.1	0.6	2.3	6.9
7	Opting Out	Y	Yes	PL	0.6	0.3	-0.3	7.1
8	Opting Out	Y	No	PL	0.6	0.2	-0.9	6.9
9	Opting Out	C	Yes	PL	0.4	0.9	2.8	7.1
10	Opting Out	C	No	PL	0.4	0.8	2.4	6.9
11	Opting Out	Y	Yes	PL / 2	0.3	0.0	-0.2	7.1
12	Opting Out	C	Yes	PL / 2	0.2	0.7	2.4	7.1
13	Flat Benefit	W	Yes	n/a	0.3	0.4	0.5	3.9
14	Flat Benefit	Y	Yes	n/a	0.5	-0.2	-1.5	2.7
15	Flat Benefit	C	yes	n/a	0.3	0.8	1.9	4.7
16	Prog. Match	W	Yes	n/a	0.6	0.5	0.3	6.8
17	Prog. March	Y	Yes	n/a	0.9	0.1	-1.8	6.8
18	Prog. Match	C	Yes	n/a	0.6	1.1	2.7	7.5
19	Open Econ.	W	Yes	n/a	0.0	0.0	0.0	0.0

C: Consumption Tax
n/a: non-applicable. For forced privatization, payroll tax is endogenous for payroll tax financing and zero for income tax and consumption tax financing.
PL: Present Law payroll tax rate
PL / 2: Present Law payroll tax rate divided by 2
W: Payroll Tax
Y: Income Tax

Table 7

Percentage Change in Interest Rates Relative to Steady State

Run	Experiment	Finance of Social Security Benefits	Tax-Benefit Linkage	New Social Security Tax Rate	Year of Transition 5	10	25	150
1	---	W	Yes	n/a	-1.0	-1.4	-2.5	-18.6
2	---	W	No	n/a	-0.1	-0.7	-2.0	-18.2
3	---	Y	Yes	n/a	-1.5	0.0	3.2	-18.6
4	---	Y	No	n/a	-0.6	0.9	3.6	-18.2
5	---	C	Yes	n/a	-1.1	-2.7	-6.9	-18.6
6	---	C	No	n/a	-0.2	-2.0	-6.5	-18.2
7	Opting Out	Y	Yes	PL	-1.8	-1.0	1.1	-18.6
8	Opting Out	Y	No	PL	-1.9	-0.7	2.7	-18.2
9	Opting Out	C	Yes	PL	-1.2	-2.7	-7.8	-18.6
10	Opting Out	C	No	PL	-1.1	-2.3	-6.8	-18.2
11	Opting Out	Y	Yes	PL / 2	-0.9	0.0	0.5	-18.6
12	Opting Out	C	Yes	PL / 2	-0.5	-1.9	-6.8	-18.6
13	Flat Benefit	W	Yes	n/a	-0.9	-1.0	-1.4	-10.8
14	Flat Benefit	Y	Yes	n/a	-1.4	0.6	4.7	-7.6
15	Flat Benefit	C	yes	n/a	-1.0	-2.2	-5.4	-12.8
16	Prog. Match	W	Yes	n/a	-1.9	-1.5	-0.8	-17.9
17	Prog. March	Y	Yes	n/a	-2.6	-0.2	5.4	-17.9
18	Prog. Match	C	Yes	n/a	-1.7	-3.4	-7.6	-19.6
19	Open Econ.	W	Yes	n/a	0.0	0.0	0.0	0.0

C: Consumption Tax
n/a: non-applicable. For forced privatization, payroll tax is endogenous for payroll tax financing and zero for income tax and consumption tax financing.
PL: Present Law payroll tax rate
PL / 2: Present Law payroll tax rate divided by 2
W: Payroll Tax
Y: Income Tax

Table 8
Percentage Change in Remaining Lifetime Utility for Selected Income Classes

		Year of Birth						
Run	**Class**	-54	-25	-10	1	10	25	150
1	1	0.0	-2.0	-1.3	-0.6	0.1	2.2	6.0
	3	-0.1	-1.7	-1.1	-0.4	0.5	3.0	7.4
	6	-0.1	-1.4	-0.8	-0.2	0.8	3.3	8.0
	9	-0.1	-1.2	-0.7	-0.1	0.9	3.5	8.1
	12	-0.1	-0.6	-0.4	-0.1	0.3	1.5	4.4
2	1	-0.2	-1.8	-1.1	-0.5	0.2	2.3	6.0
	3	-0.1	-1.4	-0.7	-0.2	0.7	3.2	7.4
	6	0.0	-1.1	-0.4	0.1	1.1	3.6	8.0
	9	0.0	-0.9	-0.3	0.2	1.2	3.7	8.1
	12	0.0	-0.3	-0.1	0.1	0.5	1.8	4.4
3	1	-0.1	-0.2	1.6	3.2	3.1	3.5	6.0
	3	-1.4	-1.6	0.0	1.4	1.7	3.3	7.4
	6	-1.3	-2.1	-0.7	0.7	1.1	3.2	8.0
	9	-1.2	-2.4	-1.0	0.3	0.8	3.1	8.1
	12	-1.7	-3.6	-3.6	-3.0	-2.5	-0.2	4.4
4	1	-0.1	0.0	1.9	3.3	3.1	3.6	6.0
	3	-1.3	-1.2	0.4	1.7	1.9	3.5	7.4
	6	-1.1	-1.8	-0.2	1.0	1.4	3.5	8.0
	9	-1.1	-2.1	-0.5	0.6	1.1	3.4	8.1
	12	-1.6	-3.2	-3.2	-2.7	-2.1	0.1	4.4
5	1	0.7	-2.1	-0.6	0.5	1.3	3.2	6.0
	3	-0.4	-2.0	0.0	1.2	2.1	4.2	7.4
	6	-0.9	-1.7	0.3	1.6	2.6	4.8	8.0
	9	-1.2	-1.6	0.5	1.7	2.7	4.9	8.1
	12	-1.5	-2.5	-1.8	-1.0	-0.1	1.7	4.4

Table 8 Cont.

Run	Class	-54	-25	-10	1	10	25	150
6	1	0.7	-2.0	-0.3	0.6	1.4	3.4	6.0
	3	-0.3	-1.8	0.4	1.4	2.3	4.4	7.4
	6	-0.8	-1.4	0.8	1.8	2.8	5.0	8.0
	9	-1.1	-1.3	1.0	2.0	3.0	5.1	8.1
	12	-1.3	-2-2	-2.4	-0.8	0.1	1.9	4.4
7	1	-0.1	-0.5	0.7	3.2	3.4	3.8	6.0
	3	-0.9	-2.1	-0.2	1.8	2.2	4.2	7.4
	6	-0.9	-2.9	-0.5	1.3	1.7	4.3	8.0
	9	-0.9	-3.3	-0.7	1.0	1.4	4.2	8.1
	12	-1.1	-3.8	-3.0	-2.2	-1.9	0.9	4.4
8	1	-0.1	-0.6	0.8	3.2	3.4	3.8	6.1
	3	-1.0	-2.1	-0.1	1.9	2.2	4.3	7.5
	6	-0.9	-3.0	-0.4	1.4	1.7	4.4	8.2
	9	-0.9	-3.4	-0.6	1.1	1.5	4.4	8.3
	12	-1.2	-3.7	-2.9	-2.1	-1.8	1.0	4.6
9	1	0.5	-2.2	-1.0	0.9	1.6	4.2	6.0
	3	-0.3	-2.7	-0.2	1.6	2.4	5.2	7.4
	6	-0.6	-2.8	0.3	2.0	2.9	5.8	8.0
	9	-0.8	-2.8	0.5	2.2	3.1	5.9	8.1
	12	-1.0	-2.9	-1.6	-0.6	0.1	2.5	4.4
10	1	0.5	-2.3	-0.9	1.0	1.6	4.2	6.1
	3	-0.3	-2.7	-0.1	1.7	2.5	5.4	7.5
	6	-0.6	-2.7	0.4	2.1	3.0	6.0	8.2
	9	-1.5	-2.7	1.1	2.7	3.7	6.3	8.3
	12	-1.0	-2.7	-1.4	-0.5	0.3	2.7	4.6

Table 8 Cont.

Run	Class	-54	-25	-10	1	10	25	150
11	1	-0.1	1.0	1.2	2.9	3.0	3.6	6.0
	3	-0.9	-0.7	-0.4	1.5	1.5	2.9	7.4
	6	-0.9	-1.5	-0.8	0.9	0.9	2.6	8.0
	9	-0.9	-1.9	-1.0	0.6	0.6	2.4	8.1
	12	-1-1	-3.2	-3.3	-2.6	-2.7	-0.9	4.4
12	1	0.5	-0.8	-0.8	0.5	1.0	2.8	6.0
	3	-0.2	-1.3	-0.5	1.2	1.8	3.8	7.4
	6	-0.6	-1.4	0.1	1.7	2.2	4.3	8.0
	9	-0.8	-1.4	0.3	1.8	2.4	4.4	8.1
	12	-1.0	-2.3	-1.7	-0.9	-0.4	1.3	4.4
13	1	0.0	-0.1	0.0	0.3	0.8	1.9	4.0
	3	-0.1	-0.7	-0.4	-0.1	0.4	1.7	4.2
	6	-0.1	-0.8	-0.5	-0.2	0.3	1.7	4.3
	9	-0.1	-0.9	-0.6	-0.2	0.3	1.6	4.3
	12	-0.1	-0.5	-0.4	-0.2	0.0	0.6	2.3
14	1	-0.1	1.8	3.1	4.3	4.1	4.2	5.7
	3	-1.4	-0.5	0.6	1.7	1.7	2.3	4.8
	6	-1.3	-1.6	-0.5	0.6	0.5	1.4	4.4
	9	-1.2	-2.1	-1.0	0.0	-0.1	1.0	4.1
	12	-1.7	-3.6	-3.9	-3.4	-3.5	-3.4	0.5
15	1	0.7	-0.3	0.8	1.4	2.0	3.2	4.9
	3	-0.4	-1.2	0.6	1.5	2.1	3.4	5.2
	6	-0.9	-1.3	0.6	1.6	2.2	3.5	5.4
	9	-1.2	-1.3	0.6	1.6	2.2	3.5	5.4
	12	-1.5	-2.5	-1.9	-1.2	-0.7	0.5	2.0

Table 8 Cont.

Run	Class	-54	-25	-10	1	10	25	150
16	1	0.0	-1.0	0.4	1.6	2.2	4.2	8.0
	3	-0.5	-1.3	-0.2	0.9	1.6	4.0	8.4
	6	-0.4	-1.6	-1.0	0.0	0.9	3.3	8.1
	9	-0.4	-1.8	-1.4	-0.6	0.3	2.9	7.7
	12	-0.5	-1.7	-1.5	-1.2	-0.9	0.3	3.5
17	1	-0.2	0.9	3.2	5.3	5.0	5.3	8.0
	3	-1.8	-1.3	0.7	2.6	2.7	4.2	8.4
	6	-1.6	-2.4	-1.0	0.7	0.9	2.9	8.1
	9	-1.6	-3.2	-1.8	-0.4	-0.1	2.2	7.7
	12	-2.1	-4.9	-5.0	-4.3	-4.1	-1.7	3.5
18	1	0.9	-1.6	0.5	1.9	2.8	4.7	7.6
	3	-0.5	-1.8	0.7	2.3	3.2	5.4	8.5
	6	-1.1	-1.9	0.4	1.9	3.1	5.1	8.4
	9	-1.5	-2.0	0.2	1.7	2.7	4.9	8.1
	12	-1.8	-3.2	-2.4	-1.6	-0.7	1.2	4.0
19	1	0.0	-2.0	-1.2	-0.6	0.1	2.0	4.3
	3	0.0	-1.6	-0.9	-0.3	0.6	3.0	6.1
	6	0.0	-1.2	-0.6	0.0	0.9	3.4	6.8
	9	0.0	-1.0	-0.5	0.0	1.1	3.6	7.1
	12	0.0	-0.3	-0.1	0.1	0.6	1.9	4.1