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Prospects for Social Security Reform

Edited by Olivia S. Mitchell, Robert J. Myers, and Howard Young

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Frontispiece: Special Treasury securities, stored in a federal government filing cabinet in West Virginia, represent $700 billion in Social Security Trust Fund assets. Photo: Jeff Baughan.

Chapter 7

Stochastic Simulation of Economic Growth Effects of Social Security Reform

Martin R. Holmer

Proposals for trust fund equity investment and individually-managed investment accounts under social security raise questions about the national saving and economic growth effects of these reforms, as well as some of their risk implications. But current models are not structured in a way that permits quantitative analysis of these policy-induced growth and risk effects. This chapter describes a new model that seeks to overcome the limitations of previous models. We begin by describing this new policy simulation model and then present preliminary simulation results of the economic growth effects of current law policy. We also evaluate two "generic" social security reforms: one that increases taxes to maintain current benefits (the rising-tax reform), and a second that substitutes individual accounts for current defined benefits and increases taxes only temporarily to fund transition costs (the two-tier reform). Each of these policy regimes is explored using three different simulation modes. The first simulation mode assumes that demographic and economic assumptions are deterministic and that economic growth is exogenous, as in the Trustees Report (1996) projections. The second simulation mode posits deterministic assumptions, but makes growth endogenous by activating the embedded economic growth model and its links to the broader policy simulation model. Finally, the third simulation mode adds stochastic assumptions to endogenous economic growth in order to characterize economic and demographic (but not political) risks.

Modeling Social Security Reforms

Our social security policy simulation model incorporates dynamic interactions between the population (represented with age-gender cells rather

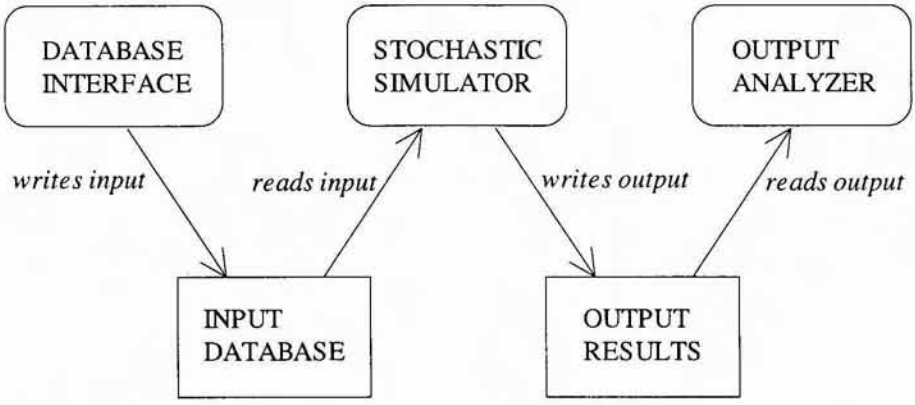

Figure 1. Modular architecture of the model. This architecture allows specialization among component programs and provides a development path to a client/server architecture that permits distributed processing of simulation runs among networked computers. Source: Holmer (1997b: 5).

than with a sample of individuals), the economy (represented in aggregate terms), and social security programs.[1] The model can analyze the implications of adding individual defined-contribution accounts to social security's existing defined-benefit OASI and DI programs, or adopting alternative asset allocation policies for the defined-benefit trust funds. It can also simulate a wide range of benefit and tax policy reforms that leave unchanged the defined-benefit structure of social security. In addition, a neoclassical economic growth model has been embedded in the broader policy simulation model so that a reform that changes national savings rates will generate a different growth path with altered earnings and asset returns. Monte Carlo methods are also used to estimate certain types of risk caused by uncertainty in social security's future demographic and economic environment, including asset returns.[2]

The model's stochastic simulation logic is encapsulated in a single computer program that reads input assumption parameters from a relational database, conducts the long-term simulation calculations for the specified policy regime under the specified demographic and economic assumptions, and writes output results to a set of text files that enable easy visualization of results or other post-simulation calculation using spreadsheets or statistical packages. The relationship between the stochastic simulator program and the other elements of the overall simulation system are shown in Figure 1. The annual recursive simulation logic of the stochastic simulator is represented in Figure 2.

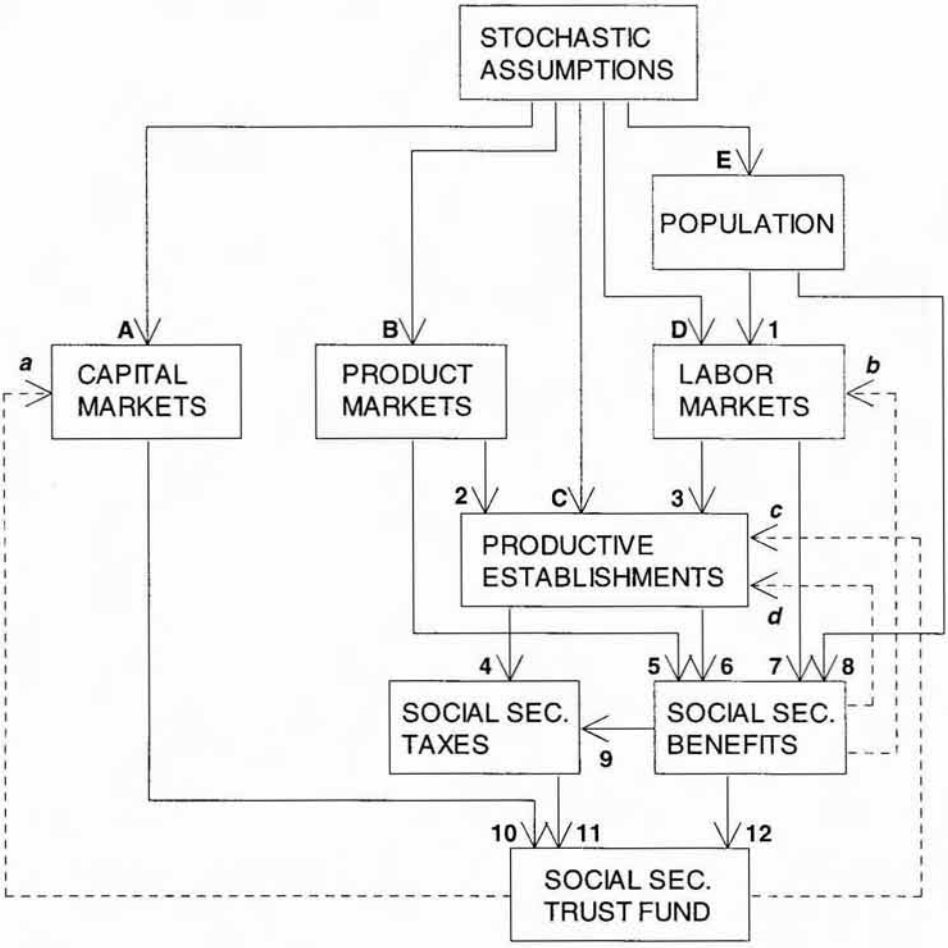

Figure 2. Modular structure of the stochastic simulator. Individual modules are represented as boxes, selected recursive linkages are marked with numbers, and lagged feedback links are marked with lowercase letters. The individual account module, which is not shown in this figure, is at the same level as the trust fund module, has the same recursive and lagged feedback links as the three social security modules. The key stochastic assumption variables include A (interest rate, corporate bond return, and equity return), B (inflation), C (productivity growth, wage-share growth, hours-worked growth), D (female and male labor force participation, unemployment), E (fertility, immigration, mortality decline, disability incidence, disability recovery). Source: Holmer (1997b: 10).

Endogenous Economic Growth

The growth model embedded in the policy simulation model is a neoclassical economic production model that assumes an exogenous rate of technological change. The logical structure of the economic growth model is specified in several equations.[3] The Cobb-Douglas production function with labor-augmenting technological change is

$$Y = A^{1-\alpha} K^{\alpha} L^{1-\alpha} = K^{\alpha} (AL)^{1-\alpha}$$

where A denotes the level of efficiency of labor input denoted by L, K denotes capital input, Y denotes real GDP, and α denotes the elasticity of real GDP with respect to capital.[4]

It is assumed that the rate of growth of physical labor input and of the level of labor efficiency (that is, the rate of labor-augmenting technological change) are exogenous to the growth model. In the broader social security policy simulation model (within which the growth model is embedded), the rate of labor input growth is determined by the population and labor market modules, whose logic is similar to that of the model used for Trustees Report projections. These modules produce growth rates in L that are exogenous to the embedded growth model, but vary in value from year to year and across stochastic scenarios. In this simplified presentation, these two exogenous rates are assumed constant. The growth path of L is specified by

$$\dot{L}/L = n$$

where n denotes the exogenous rate of growth in physical labor input and the dot notation represents a time derivative. The growth path of A is specified by

$$\dot{A}/A = g$$

where g denotes the exogenous rate of growth in labor efficiency. The assumption module of the broader policy simulation model produces values of g that may vary from year to year and across stochastic scenarios.

The growth path of K depends on the rate of capital depreciation (denoted by δ) and the rate of gross domestic capital investment as follows:

$$\dot{K} = I - K\delta$$

where I denotes gross domestic investment. To make the growth path of K endogenous to the economic growth model, the relationship between GDP and saving, and between saving and investment, must be specified. In the broader policy simulation model, the national saving rate (expressed as a fraction of GDP) is determined jointly by assumptions about private saving and government saving (surplus) in the social security program and in all

other programs. Changes in social security program or individual account finances (measured from the starting simulation year) cause changes in the initial simulation year's national saving rate. And changes in the national saving rate (measured from the starting simulation year), in turn, generate changes in net foreign investment and the gross domestic investment rate (expressed as a fraction of GDP).

These saving and investment links produce a yearly value of s that is exogenous to the embedded growth model, whose investment equation is as follows

$$I = sY$$

where the gross domestic investment rate is denoted by s.

Combining equations 4 and 5 produces

$$K = sY - K\delta$$

which completes the growth path equations for the three variables in the production function specified in equation 1. The saving-investment links from the broader policy simulation model to the embedded economic growth model are discussed in more detail below along with the link from the growth model to the broader model's asset returns.

The economic growth model's constant parameters are assumed to have the following values: the capital share parameter α in the Cobb-Douglas production function is assumed to be 0.41, based on Christenson, Cummings, and Jorgenson (1980) and Dougherty (1991) as summarized by Barro and Sala-i-Martin (1995). The rate of capital depreciation δ is assumed to be 0.04, based on the average value for the 72 countries included in the Penn World Tables (Summers and Heston 1991, as reported by Binder and Pesaran 1996). The starting simulation year's gross domestic investment rate s_0 is assumed to be 0.165, based on the value used in the Brookings model (Aaron, Bosworth, and Burtless 1989). The rate in subsequent simulation years is determined by changes in social security program or individual account finances and the parameter values assumed for the saving-investment input link described below. The starting simulation year's capital-output ratio (K/Y) is assumed to be 3.11, which is the value that, under the nonstochastic Trustees Report (1996) intermediate-cost assumptions and deactivated saving-investment and asset-return links, generates an estimate of 2070 GDP equal to that of the Trustees Report intermediate-cost projection.

These baseline growth model parameter assumptions produce two steady-state results that correspond closely to the stylized facts of economic growth. First, using these baseline parameter assumptions and deactivating the saving-investment and asset-return links, the steady-state marginal product of capital implies, assuming marginal productivity pricing, a pre-tax, net-of-depreciation, real rate of return on capital equal to 9.3 percent, which

corresponds to the recent U.S. empirical estimate referred to by Feldstein and Samwick (1996). And second, the annual rate of convergence to the steady state implied by the simulation is about 0.031, which is quite close to the 2 to 3 percent range suggested by recent empirical studies summarized by Barro and Sala-i-Martin (1995).

Endogenous Growth Links

The broader social security policy model and the embedded economic growth model are connected via growth model input links and growth model feedback links. The discussion above described the input links for the employment growth rate and the productivity growth rate. The input link between social security program and individual account finances and the rates of saving and investment is discussed here. Also discussed are the feedback links between the growth model and taxable earnings, and between the growth model and asset returns.

First, we describe the growth model *input link between program finances and saving and investment*. Changes in old-age and survivors insurance (OASI) and disability insurance (DI) program finances cause changes in the OASI program surplus and DI program surplus (measured from the starting simulation year and expressed as a fraction of GDP). The change in program surplus is assumed to have both direct and indirect effects on the national saving rate. The direct effect represents the national income and product accounting effect by which the change in program surplus translates directly into a change in the national saving rate (measured from the starting simulation year and expressed as a fraction of GDP). The indirect effects represent behavioral offsets to the direct accounting effect. These indirect effects are characterized by three parameters. The first is the OASI program surplus federal surplus offset rate, which expresses the assumed change in the non-OASDI federal surplus as a fraction of the change in the OASI program surplus. This offset parameter would be greater than zero if it were assumed that the federal political process would "spend" some of any increase in the program surplus. The second parameter is the corresponding federal surplus offset rate for DI program surplus changes. The third indirect saving effect parameter is the federal surplus national saving offset rate. This offset rate represents the assumption about how saving behavior in the business, household, and state and local government sectors will change in response to a change in the federal government's budget surplus. A value of zero assumes there is no change in saving, while a value of one assumes that changes in the expectations of other sectors cause saving changes that completely offset the direct effect of a change in the federal surplus on the national saving rate. The baseline values of these three parameters are 0.0 (no within-budget offsets for OASI), 0.0 (no within-budget offsets for DI) and 0.5 (consistent with Congressional Budget Office 1996), respectively.

Changes in individual account finances are also assumed to have both direct and indirect effects on the national saving rate. The direct saving effect is caused by the fact that a net surplus for all individual accounts—that is, total account contributions plus total account investment earnings minus total account withdrawals and annuity payments—contributes directly to national saving in the national income and product accounts. A change in the account surplus rate, therefore, causes a change in the national saving rate that is the same percent of GDP. A change in the account surplus rate also has two different sets of indirect saving effects caused by changes in saving behavior and tax revenue: one set associated with changes in the total amount of account contributions and investment income, and another set associated with changes in the total amount of account benefits (that is, account withdrawals and annuity payments).

Consider the first set of indirect account saving effects. A change in the total amount of required account contributions is assumed to be offset to a certain degree by a reduction in saving by other sectors of the economy. If individual accounts were mandatory, it is plausible that any increase in contributions to those accounts would lead to smaller contributions to other voluntary defined-contribution pension plans or to other household retirement savings, not only because the mandatory accounts reduced the need for other retirement savings, but also because household disposable income would be lower. In addition, because the account contributions and investment income are tax-free, governments experience an increase in lost tax revenue, which reduces their budget surpluses and the national saving rate. But the reduction in other retirement saving, to the extent that it was in tax-favored pension plans, causes a decrease in lost tax revenue.

Now consider the second set of indirect account saving effects. A change in the total amount of account benefits is also assumed to affect government tax revenues (because benefits are taxable income) and hence their budget surpluses and the national saving rate.

The total national saving effect of a change in individual account finances is the sum of this direct effect and these several indirect effects. The baseline values of the four account saving offset parameters are all drawn from a recent quantitative study of the effects of introducing large individual accounts by Howe and Jackson (1996: 23–24) and are as follows: the account contribution saving offset rate is 0.3, the (combined federal and state) income tax rate is 0.19 on account contributions and investment income, the fraction of saving offsets that occur in tax-exempt retirement saving programs is 0.5, and the (combined federal and state) income tax rate is 0.127 on account withdrawals and annuity payments.

Now that all the saving relationships associated with the input link between retirement program finances and domestic investment have been described, it remains to document the nature of the relationship between a

change in the national saving rate (measured from the starting simulation year and expressed as a fraction of GDP) and a change in the gross domestic investment rate (measured and expressed in the same way). The Bureau of Economic Analysis (1996) reports that net foreign investment was about −5.3 percent of national saving during 1992. So, when the saving-investment input link is activated in the model, the starting simulation year's national saving rate is assumed to be about 0.1566, so that the domestic investment rate is 0.165 of GDP. A change of x in the national saving rate is assumed to induce a change in the domestic investment rate of $0.6x$ and a change in net foreign investment of $0.4x$, following Congressional Budget Office (1996).

Next, the growth model *feedback link to taxable earnings* is discussed. When the embedded economic growth model is activated, it determines endogenously the time path of real GDP. The establishment module of the broader social security policy simulation model contains logic that translates this level of real output into taxable earnings, a key variable for social security policy analysis. This same translation logic is used even when the growth model is deactivated and the model is operating with the Trustees Report model's logic of exogenous economic growth. So, faster (slower) growth in real output translates directly into faster (slower) growth in taxable earnings and all related social security benefits and taxes.

And finally, we describe the *feedback link to asset returns*. As the economic growth model's capital-output ratio (denoted by v and equal to K/Y) changes, the marginal productivity of capital net of depreciation (denoted by r) will change according to the equation $r = \alpha / v - \delta$. Assuming the capital markets are reasonably competitive, marginal productivity pricing implies that changes in r should induce changes in the social security policy simulation model's three asset returns. The change in r (measured from the starting simulation year) is used to induce changes in the real Treasury yield, the corporate bond spread, and the real rate of return on equities, that are proportional to the ratio of the real return and r in the starting simulation year.[5]

Growth Effects of Alternative Social Security Policies

Model estimates are presented for the economic growth effects of three social security policy regimes: (1) current law benefit and tax policy (current-law policy); (2) a defined-benefit-oriented reform that maintains current law benefits and increases future payroll taxes to achieve pay-as-you-go financing balance (the rising-tax reform); and (3) a defined-contribution-oriented reform that introduces large mandatory individual accounts, reduces defined benefits gradually, and leaves the payroll tax unchanged for 40 years to fund the reform's transition costs, and then reduces payroll taxes so that combined with the 5 percent account contribution they are at the

current-law level (the two-tier reform). It should be clear that these reforms are different in specifics from those analyzed by the Advisory Council on Social Security (1997), though not dissimilar in spirit.

Estimates are produced for all three of these policy regimes using three different simulation modes: (1) the deterministic-assumption and exogenous-growth mode (abbreviated Deterministic/Exog-Growth in the tables), which is the mode used in the Trustees Report model; (2) the deterministic-assumption and endogenous-growth mode (abbreviated Deterministic/Endog-Growth in the tables), which activates the embedded economic growth model and its input and feedback links to the broader social security policy simulation model; and (3) the stochastic-assumption and endogenous-growth mode (abbreviated Stochastic/Endog-Growth in the tables), which activates the growth model and uses Monte Carlo methods to generate 1,000 stochastic scenarios that represent uncertainty in the future value of demographic and economic assumption variables as well as asset returns.

The policy simulation model's 13 major demographic and economic assumption variables are assumed to have means equal to the intermediate-cost assumptions in the Trustees Report (1996), except for the mortality decline rate. The annual rate of decline in mortality rates is assumed to have a higher mean value equal to the new Census Bureau mid-range estimate (Holmer 1997a) and similar to that recommended by the Technical Panel (1997). The equity return variable is assumed to have a mean of 10.3 percent, equal to its historical average from the late 1920s through the early 1990s.

In the deterministic-assumption mode, these 13 assumption variables and the equity return variable have a standard deviation of zero. In the stochastic-assumption mode, 10 of these 13 assumption variables are assumed to have a constant ultimate value that is drawn from a normal distribution with a mean equal to that described above and a standard deviation equal to one-fourth of the difference between the high-cost and low-cost assumption in the Trustees Report (1996). The distributions of the long-run (or ultimate) value of these 10 variables are assumed to be uncorrelated. The three other variables—the unemployment rate, inflation rate, and nominal interest rate—are assumed to fluctuate around means equal to the intermediate-cost assumptions in the Trustees Report (1996), with deviations from the long-run mean being generated by a second-order vector autoregressive process that has been estimated with historical data from the late 1920s through the early 1990s. The errors terms of these three deviation processes were found in the statistical estimation to be contemporaneously correlated. The stochastic equation for the equity return variable exhibits no autocorrelation and the standard error of the natural logarithm of the equity return is about 19 percent (Holmer 1996: 30–39).

Seven different simulation estimates appear in the tables below. The first

three are average OASI cost rates and actuarial deficits (summarizing the experience over the 75-year period ending in 2070). Average cost rates are presented for both the combined defined-benefit (DB) and defined-contribution (DC) elements of OASI, if the latter exists in a policy regime, and for just the defined-benefit element of OASI. The third average estimate is the defined-benefit actuarial deficit (the negative of the summarized actuarial surplus presented in the Trustees Report). The remaining four simulation estimates are for the year 2070. The actuarial deficit (the difference between that year's cost rate and income rate) for the defined-benefit elements of OASI is expressed as a percent of taxable payroll, as are all the cost rate and actuarial deficit estimates. The remaining three estimates describe the state of the economy in 2070: real per-capita GDP (expressed in thousands of 1992 dollars), the Treasury interest rate, and the equity rate of return.

Current Law Policy

Current law policy generates in the long run a financial imbalance in the OASI program. Using all Trustees Report (1996) intermediate-cost assumptions and the deterministic-assumption/exogenous-growth simulation mode, the model produces an estimate of 1.84 percent of taxable payroll for the average actuarial deficit, which is close to the 1.85 estimate reported in the Trustees Report (1996).

OASI program finance and economic effects estimates for current-law policy in each of the three simulation modes appear in Table 1. Here, the average actuarial deficit in the deterministic-assumption/exogenous-growth simulation mode is 2.41 percent of taxable payroll, which is higher than the 1.84 percent estimate discussed above because the assumed rate of mortality decline is higher, and hence the length of retirement is longer, than assumed in the Trustees Report (1996) intermediate-cost projection. The large difference between these two estimates illustrates the critical significance of future demographic trends for the financial condition of the OASI program as it is currently designed.

When the embedded growth model and its links to the broader policy simulation model are activated, the average actuarial deficit falls (from 2.41 to 2.27) despite lower payroll tax revenue caused by lower GDP (from 49.51 to 47.87 in 2070), which is induced by the OASI deficits. The fall in the actuarial deficit is caused, in part, by the even larger decline in future initial benefit awards, which is induced by the lower level of earnings that goes along with the lower per-capita GDP. Also contributing to the fall in the actuarial deficit is the rise in the nominal interest rate (from 6.30 to 6.61 in 2070), which is caused by the growth model feedback link to asset returns. The higher interest rates produce smaller present values in the actuarial deficit calculation.

TABLE 1. Estimated OASI Program Finance and Economic Growth Effects of Current-Law Policy.

	Simulation Mode		
Simulation Estimate	*Deterministic/ Exog-Growth*	*Deterministic/ Endog-Growth*	*Stochastic/ Endog-Growth*
Average DB+DC Cost Rate (% taxable payroll)	13.87	13.74	14.45 (1.09)
Average DB Cost Rate (% taxable payroll)	13.87	13.74	14.45 (1.09)
Average DB Actuarial Deficit (% taxable payroll)	2.41	2.27	2.95 (1.05)
2070 DB Actuarial Deficit (% taxable payroll)	5.82	5.82	6.96 (2.92)
2070 Real Per-Capita GDP (thousands of 1992 dollars)	49.51	47.87	47.53 (5.07)
2070 Treasury Interest Rate (%)	6.30	6.61	6.72 (2.41)
2070 Equity Rate of Return (%)	10.30	10.82	11.20 (21.8)

Source: Author's calculations.
Note: See text for detailed descriptions of the current-law policy regime, the three simulation modes, and the seven estimates. Means and standard deviations of estimates are calculated using 1,000 simulation scenarios. Standard deviations are omitted in the two deterministic-assumption modes (because they are zero) and are shown in parentheses in the stochastic-assumption mode. Average estimates are for the 75 years ending in 2070.

Recognizing the effects of social security finances on the path of economic growth produces an estimate of 2070 real per capita GDP that is about 3.3 percent lower than if these effects are ignored in the exogenous-growth simulation mode. As discussed in the conclusion, this difference would be much larger if the rate of national saving were allowed to influence the rate of technological change as in many contemporary endogenous-technological-change growth models, but even a 3 percent difference is socially and politically significant.

The main conclusion from the stochastic-assumption/endogenous-growth results in Table 1 is that the future financial condition of the OASI program is highly uncertain. The mean value (over the 1,000 stochastic scenarios) of the average actuarial deficit over the 75 years ending in 2070 is 2.95 percent of taxable payroll, and the standard deviation of those 1,000 values is 1.05 percent of taxable payroll. This implies that the average actuarial deficit estimate is above 4.00 percent of taxable payroll in about 17 percent of the scenarios (and below 1.90 in as many scenarios). This mean of 2.95 percent is significantly higher than the deterministic-assumption estimate of 2.27 percent because the standard error of the 2.95 mean is only 0.03 percent (1.05 divided by the square root of 1,000). This higher mean

TABLE 2. Estimated OASI Program Finance and Economic Growth Effects of the Rising-Tax Reform.

	Simulation Mode		
Simulation Estimate	*Deterministic/ Exog-Growth*	*Deterministic/ Endog-Growth*	*Stochastic/ Endog-Growth*
Average DB+DC Cost Rate (% taxable payroll)	13.87	13.75	14.46 (1.10)
Average DB Cost Rate (% taxable payroll)	13.87	13.75	14.46 (1.10)
Average DB Actuarial Deficit (% taxable payroll)	0.03	0.00	0.68 (0.97)
2070 DB Actuarial Deficit (% taxable payroll)	0.02	−0.06	1.07 (2.90)
2070 Real Per-Capita GDP (thousands of 1992 dollars)	49.51	48.73	48.39 (5.17)
2070 Treasury Interest Rate (%)	6.30	6.44	6.56 (2.41)
2070 Equity Rate of Return (%)	10.30	10.54	10.92 (21.8)

Source: Author's calculations.
Note: See text for detailed descriptions of the rising-tax policy regime, the three simulation modes, and the seven estimates. Means and standard deviations of estimates are calculated using 1,000 simulation scenarios. Standard deviations are omitted in the two deterministic-assumption modes (because they are zero) and are shown in parentheses in the stochastic-assumption mode. Average estimates are for the 75 years ending in 2070.

value arises from the nonlinear effect on the average actuarial deficit of the interactions of the stochastic assumption variables.

Rising-Tax Reform

The rising-tax policy regime maintains current-law OASI benefit policy and gradually increases the OASI payroll tax to maintain pay-as-you-go financing of the program. The OASI payroll tax rate remains at 10.6 percent through 2024, rises to 13.7 during 2025–2029, moves to 14.6 for the two decades between 2030 and 2049, rises to 16.0 for 2050–2059, and then remains at 16.4 percent beginning in 2060. The long-term rise from 10.6 to 16.4 represents a tax increase of nearly 55 percent. OASI program finance and economic effects estimates for the rising-tax reform in each of the three simulation modes appear in Table 2.

The rising-tax reform's payroll tax increases have been designed so that, in the deterministic-assumption/exogenous-growth simulation mode, the model produces a near zero estimate for both the average actuarial deficit (0.03) and the actuarial deficit in 2070 (0.02). There is little change in either the program finance or economic measures for 2070 because this reform

brings the OASI program into long-run financial balance, and hence produces relatively small declines in national saving rates relative to present rates that benefit from the large current surpluses in the OASI program. Even though this rising-tax reform leaves the program in long-run financial balance, the resulting decline in national saving rates does cause a decline in real per-capita output over the next 75 years, and a rise in both interest rates and equity returns over the same period. These movements are much smaller in magnitude than those caused by current-law policy shown in Table 1.

Two-Tier Reform

The two-tier policy regime introduces a 5 percent contribution personal retirement account in 1998. Individuals are assumed to invest their account balance using a life-cycle asset-allocation strategy that calls for investing completely in equities when young and for the equity fraction to decline gradually to 23 percent beyond age 60, with the bond fraction rising. Individuals are also assumed at retirement to convert all of their account balance into an inflation-indexed annuity, which is priced assuming a 5 percent loading factor, a continuation of recent mortality decline rates, and the use of a real rate of interest calculated with an expected rate of inflation that is a moving average of recent inflation rates (Holmer 1996).

Also, as part of the two-tier reform, the defined-benefit OAI program (payroll-tax financed OASI benefits first received by those aged 60 or more) is gradually scaled back. The benefits are scheduled to decline gradually from 1999 to 2040, when initial OAI benefits would be reduced 70 percent below current-law levels. The OASI payroll tax, which is currently scheduled to be 10.6 percent during the next century, would decline, but not gradually like the benefits. The combination of the 5 percent account contribution rate and the reduced OASI payroll tax rate would be 10.6 percent beginning in 2040. But during the first four decades of the next century, the 10.6 payroll tax rate would remain in place to finance the cost of transition from pay-as-you-go financing to more fully-funded financing. In other words, the mandatory five percent account contribution would be in addition to current payroll taxes until 2040. So, during these four decades the combined tax/contribution rate would be 15.6 percent, and then after 2040 the combined rate would fall back to 10.6 percent. This simple scheme for paying the defined-contribution-oriented reform's transition cost means that those cohorts working during the first four decades of the next century will bear the cost of the transition.

OASI program finance and economic effects estimates for the two-tier reform in each of the three simulation modes appear in Table 3. This two-tier reform has been designed so that, in the deterministic-assumption/exogenous-growth simulation mode, the model produces a near zero estimate for the OASI actuarial deficit in 2070 (−0.18), which produces a

TABLE 3. Estimated OASI Program Finance and Economic Growth Effects of the Two-Tier Reform.

	Simulation Mode		
Simulation Estimate	*Deterministic/ Exog-Growth*	*Deterministic/ Endog-Growth*	*Stochastic/ Endog-Growth*
Average DB+DC Cost Rate (% taxable payroll)	13.52	13.33	13.87 (0.74)
Average DB Cost Rate (% taxable payroll)	8.95	8.77	9.27 (0.73)
Average DB Actuarial Deficit (% taxable payroll)	−0.69	−0.71	−0.24 (0.59)
2070 DB Actuarial Deficit (% taxable payroll)	−0.18	−0.18	0.22 (0.95)
2070 Real Per-Capita GDP (thousands of 1992 dollars)	49.51	52.03	51.57 (5.56)
2070 Treasury Interest Rate (%)	6.30	5.87	6.00 (2.40)
2070 Equity Rate of Return (%)	10.30	9.56	9.99 (21.8)

Source: Author's calculations.
Note: See text for detailed descriptions of the two-tier policy regime, the three simulation modes, and the seven estimates. Means and standard deviations of estimates are calculated using 1,000 simulation scenarios. Standard deviations are omitted in the two deterministic-assumption modes (because they are zero) and are shown in parentheses in the stochastic-assumption mode. Average estimates are for the 75 years ending in 2070.

modest long-run financial surplus (average actuarial deficit of −0.69). When the embedded growth model and its links to the broader policy simulation model are activated, the average and 2070 actuarial deficits change very little because of the offsetting deficit effects of higher payroll taxes and lower interest rates, both of which are caused by the higher level of per-capita output (up from 49.51 to 52.03 in 2070). The growth effects cause nominal Treasury interest rates in 2070 to be lower by 43 basis points, with the equity rate of return dropping by 74 basis points.

Recognizing the effects of social security finances on the path of economic growth produces an estimate of 2070 real per-capita GDP that is about 5.1 percent higher than if these effects are ignored in the exogenous-growth simulation mode. This two-tier reform produces a deterministic-assumption/endogenous-growth estimate for real per-capita GDP in 2070 of 52.03 (thousands of 1992 dollars), which is 6.8 percent above the estimate for the rising-tax reform and 8.7 percent above the estimate for current-law policy. As mentioned above, these differences would be much larger if the rate of national saving were allowed to influence the rate of technological change, as in many contemporary endogenous-technological-change growth models.

Estimates for the stochastic-assumption simulation mode indicate that the two-tier reform reduces significantly the uncertainty in the future financial condition of the OASI trust fund. The standard deviation of the 2070 actuarial deficit is less than one-third the corresponding standard deviation under current-law policy. Of course, much of this reduction is accomplished by the reform's shift from exclusive reliance on defined benefits to a heavy reliance on defined-contribution benefits. Future analysis of the variability of birth cohort replacement rates and money's worth measures will determine the overall effect of this risk transfer from the trust-funds (that is, payroll taxpayers) to beneficiaries.

Conclusion

Social security reforms that increase national saving rates can have a significant impact on the rate of economic growth, according to our simulations. The resulting higher standard of living is desirable in its own right, and also would enable society to finance future retirement income more easily.

It would seem desirable for official Social Security Administration estimates to incorporate such economic growth effects for at least two reasons. First, the magnitude of program finances relative to the size of the economy means that the program's growth effects are not insignificant. Also, official estimates already incorporate other feedback effects that are arguably smaller than the economic growth effects analyzed here. For example, the Trustees Report (1996) describes the assumed changes in the age pattern of initial benefit receipt as the normal retirement age and the delayed retirement credit rise under current-law policy. There is little rationale for including only some of social security's important behavioral effects in official estimates.

The current-law policy results presented here suggest that estimates of the program's unfunded liability (see the chapter by Steven Goss in this volume, for example) may be somewhat overstated. The overestimate is caused by the fact that most such analyses ignore the negative growth effect caused by projected social security deficits, and therefore, ignore the lower payroll taxes and the eventually lower benefit levels associated with lower national output and earnings.

The simulation results reported here are derived from an economic growth model that ignores "learning-by-doing" effects. Empirical evidence (Barro and Sala-i-Martin 1995) suggests this causes higher national saving and domestic investment rates to raise the rate of labor-augmenting productivity growth (as well as increase the capital intensity of production as in the current neoclassical growth model). Adding "learning-by-doing" effects to the growth model will increase substantially the magnitude of the long-term economic growth effects of reforms that increase the national saving rate. Recognizing endogenous productivity growth would lead to bigger declines

in long-term growth under current-law policy and larger increases in future output under the two-tier reform considered here.

In addition, future research with the model will investigate the sensitivity of these economic growth results to changes in a number of behavioral parameters that are already incorporated in the model. Also, the nonpolitical risk implications of these reforms will be estimated using policy performance measures (such as replacement rates and money's worth payback ratios) for several different birth cohorts.

Notes

1. In this sense it is similar to the model used by the Social Security Administration's Office of the Actuary to produce Trustees Report projections and reform estimates.

2. The original social security policy simulation model was developed for the 1994–96 Advisory Council on Social Security. The need to gain experience with a stochastic model that uses Monte Carlo methods of representing uncertainty was recognized by the Council's Technical Panel on Assumptions and Methods (1997). In addition to its recommendation on this matter, the Panel supported development of stochastic demographic modules. The Advisory Council also supported development of stochastic economic modules (including econometric estimation of a VAR(2) model for generating cyclical paths for three macroeconomic assumption variables: nominal interest rate, inflation rate, and unemployment rate) and program modules that enabled the model to analyze the risk implications of trust fund equity investment policies (1997). Subsequently, the Employee Benefit Research Institute has supported ongoing model enhancements and analysis. Structural defined-benefit calculation modules were added to the model as well as birth cohort experience analysis capabilities, a number of new cohort policy performance measures (such as replacement rates and money's worth returns), and an individual defined-contribution account module that allows specification of alternative lifecycle investment strategies and account balance annuitization/withdrawal options (Holmer 1996). We have also added an embedded economic growth model and linked that growth model to the broader social security policy simulation model (Holmer 1997b, c).

3. A continuous-time, differential-equation version of the growth model is presented here to simplify presentation. The implemented model is a discrete-time, difference-equation model that is logically equivalent to the one presented here.

4. This representation of technological change differs from that used in the Brookings model of social security (Aaron, Bosworth, and Burtless 1989) and in the Congressional Budget Office long-term macroeconomic model (1996). Both utilize a Cobb-Douglas production function with factor-neutral technological change. Such a factor-neutral formulation cannot generate steady-state growth behavior in the long run because it does not assume labor-augmenting technological change (Barro and Sala-i-Martin 1995). This makes a factor-neutral formulation fundamentally inconsistent with the model used in the Trustees Report for projections of current-law policy.

5. This asset return adjustment method, which is similar to that used in the Brookings model by Aaron, Bosworth, and Burtless (1989), generates changes in asset returns that are somewhat less than the change in the marginal productivity of capital net of depreciation (r). This approach differs from the feedback method

used by Congressional Budget Office (1996), in which real interest rates were assumed to rise in step with the real return on capital.

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