ORS Working Paper Series

Number 56

Simulating the Long-Run Aggregate Economic and Intergenerational Redistributive Effects of Social Security Policy

Dean R. Leimer *

Division of Economic Research

August 1992

Social Security Administration
Office of Research and Statistics

* Suite 211, 4301 Connecticut Ave., N.W., Washington, D.C. 20008

The author is indebted to Stephen Goss and Eugene Yang of the Office of the Actuary, Social Security Administration, for making available data underlying the annual Trustees' Report projections; to Henry Ezell for assistance in preparing the data base underlying the simulation model reported in this paper; and to Benjamin Bridges, Jr., Selig Lesnoy, and David Pattison for helpful comments.

I. Introduction

Changes in the age structure of the U.S. population over the next 75 years are projected to have important effects on the financial status of the Social Security program,[1] as the ratio of retired to working age populations increases dramatically.[2] The aging of the population also will have important effects on economic growth. For example, workers tend to become more productive over their working lives as they gain experience and training. Workers also tend to save more as they approach retirement age. As the labor force ages, these factors should tend to increase the rates of growth in aggregate productivity, saving, and output.

Such effects should be considered when projecting the long-run financial status of the Social Security program, which depends critically on the rate of economic growth. Social Security policy may itself have important effects on economic growth by changing economic behavior. For example, certain Social Security policies may induce workers to save more or less for retirement than they would have in the absence of the program. Such indirect effects on economic growth also should be considered in projecting the long-run financial status of the program as well as in assessing the intergenerational equity implications of Social Security policy.

This paper reports on the status of a long-run simulation model of the U.S. economy and its interrelationships with the Social Security program that was designed with these considerations in mind. The model, hereafter referred to as the LRM, was developed

---

[1]Only the Old-Age and Survivors Insurance (OASI) portion of the program is modeled in this paper, and references to the "Social Security" program refer only to this portion, unless otherwise noted.

[2]For example, see Board of Trustees [1992]. The annual report to Congress by the Board of Trustees of the Old-Age and Survivors Insurance and Disability Insurance (OASDI) trust funds is referred to in this paper as the annual Trustees' Report.

specifically to analyze the potential equity and efficiency effects of alternative Social Security policies in a long-run context. The LRM projects demographic and economic variables of interest, including population, labor supply, earnings, private consumption and transfers, OASI taxes and transfers, other government[3] taxes and transfers, wages, prices, and rates of return to various asset types. Where appropriate, the variables are disaggregated by age, allowing the LRM to identify the differential treatment of successive generations under alternative policies. Section II of this paper provides an overview of the LRM, including some of its weaknesses. Section III compares a baseline simulation of the LRM with the intermediate projection of the annual Trustees' report for a recent year. Section IV illustrates the application of the LRM to an analysis of Social Security policy; the illustration chosen contrasts the simulation of a stylized privatization plan with the baseline simulation presented in Section III. The final section presents some summary observations.

II. Simulation Model

Analysis of the effects of Social Security policy over the lifetimes of present and future generations obviously requires very long projection horizons. In keeping with this long-run focus, the LRM is relatively simple in concept, with the greatest detail given to those relationships that affect or are potentially affected by Social Security or that are especially sensitive to demographic change. The LRM differs from other long-run economic simulation models primarily in its detailed treatment of Social Security taxes and transfers and their

---

[3]The term "other government" is used in this paper to refer to all government entities (including federal, state, and local) other than the OASI program.

potential feedback effects on the economy.[4] In addition to these feedback effects, the LRM differs from the projections underlying the annual Trustees' Report in that the time paths of some key economic variables in the LRM, such as output, wage growth, and interest rates, are determined endogenously rather than assumed exogenously; these differences are illustrated in Section III below.

The projections underlying the annual Trustees' Report contain much detail concerning various rates and relationships between demographic and OASI program variables. The LRM takes advantage of this detail, where possible and appropriate, by incorporating selected rates and relationships from the Trustees' Report projections into the LRM as exogenous assumptions; for the most part, the rates and relationships selected are limited to those that are not central to or likely to be affected by the policy alternatives being considered. Points at which the LRM borrows from the Trustees' Report projections are noted in the discussion below.[5]

The LRM includes five main sectors, corresponding to the simulation of demographic changes; the production and distribution of output; Social Security taxes and transfers; other government taxes, transfers, and consumption; and private consumption, transfers, saving, and investment. Where possible, the economic variables in the LRM are defined for consistency with the corresponding National Income and Product Account (NIPA) concepts. Although the LRM has a long-run focus, it starts up from real world NIPA and OASI program values in the

---

[4]For examples of other long-run economic simulation models applied to the analysis of social insurance issues, see Denton, Spencer, and Feaver [1979], Aaron, Bosworth, and Burtless [1989], and Anderson et al. [1990].

[5]Simulation variables that are identified in this paper as exogenous projections taken from the Trustees' Report are generally not presented in the Report itself but rather are data projections underlying the Report that have been provided to us by the Office of the Actuary of the Social Security Administration.

simulation base year before converging, after a relatively short transition period, to a long-run economic growth path determined by the growth in factor supplies. At present, the simulation base year is 1984, but historical data are used to provide aggregate controls for most of the simulation variables over the subsequent historical period.[6] As such, the base year is used primarily to establish the initial age and sex distributions of disaggregated simulation variables. OASI program data are used to establish the initial age and sex distributions for all Social Security variables. For internal consistency, a single data file, the 1982-83 Consumer Expenditure Survey, was used to estimate the private consumption function and to establish the initial distributions of the disaggregated economic variables, including earnings, private consumption, fungible assets, and other government transfers.

In the simulations, all variables are effectively determined as nominal values and then deflated to their constant dollar equivalents.[7] Discrete analysis is employed, with each simulation period defined as a calendar year. Stock variables are defined as of the beginning

---

[6]This approach is necessitated by a lag in the availability of some OASI program variables, which forces the base year of the model to typically lag behind the year of the most recently available Trustees' Report projections and NIPA data by two or three years. At present, the LRM incorporates the intermediate (II-B) projections of the 1987 Trustees' Report, with the corresponding base year of 1984. We are currently updating the LRM to incorporate the 1991 Trustees' Report projections with a base year of 1989, but this is a considerable effort that is not yet complete. As noted below, the LRM does not generally use nominal variable values from the Trustees' Report projections, but rather uses various rates and projected relationships between selected nominal values. Because these rates and relationships frequently undergo little change between successive Trustees' Reports, updating the LRM to the most recent Trustees' Report is often not crucial for many applications. In any event, such updates do not change the structure of the LRM as reported in this paper.

[7]The LRM projects separate price series for capital and consumption goods, but the simulations presented in this paper assume that, by 1992, both series converge to the 4% inflation rate assumed in the Trustees' Report projections for recent years. (See Board of Trustees [1992].) For simplicity, the equations presented in this paper are described as relationships between real variables, even though the LRM does not directly compute them as such.

of each period, and flows are conceptualized as occurring at an instant in time at the end of each period. The model is solved recursively in each simulation year—the values required on the right hand side of each equation are provided either by a previous calculation or by an exogenous projection or start-up value. This recursive order is indicated by the order in which each LRM equation is introduced and discussed below. Although each sector of the LRM is described in some detail, the purpose of this report is to give a simplified overview of the LRM—most of the actual implementation detail is omitted for the sake of brevity and readability. For ease of reference, the Appendix repeats the LRM equations in a summary listing and provides a notation key to the functions, parameters, and variables appearing in the equations.

Demographic Sector

The LRM incorporates a relatively simple demographic sector that determines the population by sex and age in each simulation year, given exogenous projections of mortality rates, fertility rates, and net immigration; at present, these exogenous projections are derived from the annual Trustees' Report. Two distinct populations are maintained in the LRM; these populations are referred to in this paper as the Social Security area population and the NIPA population.[8] In recent years, the Social Security area population exceeded the NIPA population by about 2.8 percent. The Social Security area population is appropriate for use in conjunction with the various OASI variables in the LRM; the NIPA population is appropriate for use in conjunction with the various economic variables in the LRM that correspond to NIPA concepts.

---

[8]In concept, the Social Security area population refers to the population covered by the OASDI program; besides residents of the fifty States and the District of Columbia, this population includes civilian residents of Puerto Rico, the Virgin Islands, Guam, and American Samoa; Federal civilian employees and Armed Forces and their dependents overseas; crew members of merchant vessels; other citizens overseas; and an adjustment for net census undercount. The NIPA population refers to the population the United States including Armed Forces overseas.

Given an initial Social Security area population by sex and age at the start of the simulation, the LRM calculates the corresponding population, excluding newborns, at the beginning of each subsequent simulation period by subtracting deaths from the previous year's population and adding net immigrants; i.e.,

$$(1)\quad N^{S}_{s,a,t} = N^{S}_{s,a-1,t-1}\,(1 - m_{s,a-1,t-1}) + M_{s,a-1,t-1} \quad ,$$

where the s, a, and t subscripts respectively represent sex, age, and the current simulation period, $N^{S}_{s,a-1,t-1}$ denotes the corresponding sex- and age-specific Social Security area population in the previous period, $m_{s,a-1,t-1}$ the corresponding mortality rates, and $M_{s,a-1,t-1}$ the corresponding net immigration. The population of newborns at the beginning of each simulation period is determined by applying age-specific fertility rates to the female population of child-bearing age, with births allocated by sex in fixed proportions that are assumed to be constant over time; i.e.,

$$(2)\quad N^{S}_{s,0,t} = \sigma_s \sum_{a} f_{a-1,t-1}\, N^{S}_{2,a-1,t-1} \quad ,$$

where σ_s denotes the sex-specific birth shares and $f_{a-1,t-1}$ denotes the age-specific fertility rates applicable to the previous period.

The relative sex and age distributions of the Social Security area population and the NIPA population are assumed to be identical, with the aggregate populations maintaining the same proportional relationship over time. Specifically,

$$(3)\quad N^{N}_{s,a,t} = \phi\, N^{S}_{s,a,t} \quad ,$$

where $N^{N}_{s,a,t}$ denotes the NIPA population, disaggregated by sex and age, in the current period, and ϕ represents the ratio between the NIPA and Social Security area populations, assumed constant over time after the last available historical year.

Subsequent simulation equations also require information on the number of NIPA population decedents during each current simulation year. The number of NIPA decedents by sex and age can be derived as

$$(4)\quad N^D_{s,a,t} = m_{s,a,t}\, N^N_{s,a,t} \quad ,$$

under the assumption that mortality rates are identical for both the Social Security area and NIPA populations. Aggregating across sex, the corresponding age-specific populations are given by

$$(5)\quad N^N_{a,t} = \sum_s N^N_{s,a,t} \quad \text{and}$$

$$(6)\quad N^D_{a,t} = \sum_s N^D_{s,a,t} \quad .$$

Production/Distribution Sector

This sector implements a relatively simple, neoclassical description of the growth and distribution of output. There are two continuously substitutable inputs, effective labor and capital services, and one output, which can be used for either consumption or capital formation. The distribution equations for both factors are based on a marginal productivity approach.

Employment by sex and age in each simulation year is derived as

$$(7)\quad E_{s,a,t} = N^N_{s,a,t}\, p_{s,a,t}\, (1 - u_{s,a,t}) \quad ,$$

where $p_{s,a,t}$ denotes the sex- and age-specific labor force participation rate, and $u_{s,a,t}$ denotes the corresponding unemployment rate. At present, the participation and unemployment rates are exogenous projections from the annual Trustees' Report. Based on these employment projections, an index of aggregate effective labor input is derived as

$$(8)\quad L_t = \sum_s \sum_a E_{s,a,t}\, \pi_{s,a} \quad ,$$

where $\pi_{s,a}$ denotes relative productivity weights differentiated by sex and age. These productivity weights are derived from cross-section earnings data[9] and are assumed to be constant over time.

Reliance on exogenous labor supply projections is one of the more important deficiencies of the LRM in its present form, at least from a conceptual point of view. This forces the introduction of *ad hoc* assumptions concerning likely or bounding labor supply responses when simulating policies where such responses may be important. As a practical matter, however, most studies have found that labor supply is highly inelastic, reducing the severity of this deficiency.[10]

The present version of the LRM incorporates a simple Cobb-Douglas production function, although other forms could be incorporated; specifically,

$$(9)\quad O_t^g = z_t\, L_t^{\alpha}\, K_t^{1-\alpha} \quad ,$$

where O_t^g denotes gross output, K_t denotes the capital stock, α denotes labor's share of gross output,[11] and z_t is a scale variable incorporating the assumption of a constant rate of Hicks-neutral technical progress.[12] Capital services are assumed proportional to the size of the capital

---

[9]The productivity weights are based on data for average earnings per worker, by sex and age, from the 1982-83 Consumer Expenditure Survey.

[10]See Burtless [1986] for a recent survey of labor supply response studies.

[11]Labor's share is assumed to be constant over time after the last available historical year and is derived as the share of output distributed to labor under the assumption that the share of proprietors' income attributable to labor is the same as labor's share of output in the remainder of the economy.

[12]Equation (9) corresponds to a gross domestic product concept; i.e., O_t^g conceptually corresponds to the goods and services produced by labor input (L_t) and capital (K_t) located in the United States.

stock at the beginning of the period. A constant rate of depreciation (δ) is also assumed, so that net output is given by

$$(10)\quad O_t^n = O_t^g - \delta K_t \ .$$

Both production factors are assumed to be paid their marginal products. Labor compensation per worker, by sex and age, is given by

$$(11)\quad h_{s,a,t} = \pi_{s,a} \left[\frac{\alpha O_t^g}{L_t} \right] \ .$$

Total labor compensation for all NIPA workers of a given age is consequently given by

$$(12)\quad H_{a,t} = \sum_s h_{s,a,t} \, E_{s,a,t} \ .$$

Current average OASI taxable wages are assumed to be proportional to current average labor compensation; specifically,

$$(13)\quad e_{s,a,t} = x_t^e \, h_{s,a,t} \ ,$$

where x_t^e is the current factor of proportionality, assumed constant across sex and age in each period. This factor of proportionality is specified exogenously and is derived in part by assuming that the ratio between OASI taxable earnings per worker in Social Security covered employment and earnings per worker in the economy will remain constant over time after the last available historical year and in part from Trustees' Report projections of labor income as a proportion of compensation.

Marginal productivity conditions are also assumed to determine the rate of return to capital. Specifically, the profit rate net of depreciation is defined as

$$(14)\quad r_t = \left[\frac{(1-\alpha) O_t^g}{K_t} \right] - \delta \ .$$

The LRM also projects the rates of return to a number of other asset types, each of which is assumed to be functionally tied to the rate of return to capital. Although the implementation details are somewhat more complicated than described here, these rates of return are essentially determined by assuming a constant proportional relationship between the *ex ante* expectations for the real after-tax net profit rate and the relevant real after-tax interest rate.[13] Two of the interest rates simulated in this fashion are the interest rate on other government debt and the interest rate earned by OASI trust fund assets.[14] A composite rate of return across all assets held by domestic consumers is also computed, based on the average portfolio.[15] These relationships are represented by the equations

(15) $r_t^D = r^D(r_t, \tau_t^K, \tau_t^L)$,

---

[13]Basing the relationship on *ex ante* expectations requires that the LRM incorporate assumptions about expected inflation rates in consumer and capital goods. Inflation expectations in the base year are input parameters that are chosen close to actual experience. After the base year, an adaptive expectations process is assumed so that inflation expectations adjust in response to simulated inflation experience.

[14]For most simulations, the portfolio of the OASI trust fund is assumed to consist exclusively of Federal government securities. The rate of return to this portfolio will generally differ from that for other government securities held privately because of differences in term structure and differences between the rates applicable to Federal government securities compared to all other government securities. For flexibility in simulating various policy options, the LRM also has the ability to allow the OASI trust fund to hold capital assets or to become negative. For simulation periods in which the trust fund holds capital, a composite rate of return across both the capital and Federal government security holdings of the OASI trust fund is computed. If allowed to go negative, the OASI trust fund is assumed to pay interest at the other government bond rate r_t^D.

[15]The portfolio mix may change over time but is assumed to be identical across all domestic consumers at any given point in time. The LRM actually distinguishes three specific asset types held directly or indirectly by domestic consumers and simulates a separate rate of return for each asset type using the general approach described in the text. These three asset types are the domestic capital stock, domestic government debt, and net foreign assets held by domestic consumers. Although simulated by the LRM, these asset types and the U.S. assets held by foreigners are not denoted separately in the text or Appendix equations to simplify the exposition.

$$(16)\quad r_t^F = r^F(r_t, \tau_t^K, \tau_t^L) \quad , \quad \text{and}$$

$$(17)\quad r_t^W = r^W(r_t, \tau_t^K, \tau_t^L) \quad ,$$

where r_t^D, r_t^F, and r_t^W respectively denote the government bond rate, the rate of return to OASI trust fund assets, and the composite rate of return across all assets held by domestic consumers; r^D, r^F, and r^W denote the corresponding functional relationships, described above, that are generally dependent on the net profit rate (r_t), the effective tax rate on net profits (τ_t^K), and the effective tax rate on personal compensation[16] (τ_t^L). As discussed below, both of these tax rates are assumed to be proportional for simplicity. The time pattern of both tax rates is specified exogenously; endogenous adjustments to the personal compensation tax rate are also effected under certain fiscal policy simulations, as described below.

Social Security Sector

This sector simulates the level and age distribution of net OASI transfers and the status of the OASI trust fund. In each simulation period, new Social Security retirees are derived from the corresponding Social Security area population by applying eligibility and retiring rates. The surviving population of previous retirees is calculated by subtracting decedents from the prior year population of retirees. Specifically, the number of retirees by sex, age, and age at retirement in the current period is given by

$$(18)\quad \begin{aligned} R_{s,a,j,t} &= n_{s,j,t}\, i_{s,a,t}\, N_{s,a,t}^S && \text{for } a=j \ , \quad \text{and} \\ &= R_{s,a-1,j,t-1}\,(1-m_{s,a-1,t-1}) && \text{for } a>j \ , \end{aligned}$$

[16]The term "personal compensation" is used in this paper to refer to the total labor compensation and asset income net of taxes on corporate profits that is received directly or indirectly (as to stockholders through retained earnings, e.g.) by U.S. consumers. For simplicity, this personal compensation measure is assumed to be the effective tax base for all other government taxes other than corporate profits taxes and taxes on Social Security benefits.

where the j subscript denotes age at retirement, $i_{s,a,t}$ denotes the proportion of the Social Security area population of sex s and age a in the current period who have achieved fully-insured status for OASI retirement benefits, and $n_{s,j,t}$ denotes the proportion of the fully-insured population of sex s and age j who retire during the current period.[17] The eligibility and retiring rates are exogenous, derived from Trustees' Report projections.

Individual OASI benefit payments to the two categories of retirees are derived as

$$(19)\quad b_{s,a,j,t} = b(a, s, t, e_{s,0,t-a}, \dots, e_{s,a-1,t-1}) \quad \text{for } a = j \text{ , and}$$
$$\qquad = g_t \, \mu_{s,a} \, b_{s,a-1,j,t-1} \qquad \text{for } a > j \text{ ,}$$

where the first line represents the determination of individual retirement benefit awards for new retirees under present Social Security law. The present law benefit award computation function, b, depends on age at retirement, sex, year of retirement, and the lifetime OASI taxable earnings of the retiree. Alternative benefit award computation functions can be substituted to simulate certain other benefit structures.[18]

The second line of equation (19) determines individual benefit payments for previously retired workers. Each retiree's benefit in the previous period is adjusted by a general benefit adjustment factor (g_t) applicable to all retirees and by a sex- and age-specific adjustment factor

[17]For simplicity, the LRM assumes that, once workers accept OASI retirement benefits, they remain as retirement beneficiaries until death.

[18]The LRM effectively assumes that the distribution of benefit awards about the mean for each sex and age category remains constant over time in relative terms, such that the average benefit award for each category can be calculated from the average earnings history for that category. Some alternative benefit structures, such as "price-indexed" structures that index prior earnings and the "bend points" in the benefit formula by prices rather than wages, clearly violate this assumption and therefore cannot be simulated by the LRM in its present form.

($\mu_{s,a}$) that reflects the effect of benefit recomputations.[19] The general benefit adjustment factor is typically determined endogenously in the simulations under the particular benefit structure being simulated; under the present benefit structure, for example, g_t represents the effect of the annual automatic adjustment for inflation. The sex- and age-specific benefit adjustment factor $\mu_{s,a}$ is assumed constant over time and is derived from longitudinal data on average benefits in current payment status by age and sex for recent retirement cohorts; the sex- and age-specific adjustment factor is assumed to be zero for workers after the age at which the retirement earnings test no longer applies.

Aggregate retirement benefits by age in each simulation period can now be derived as

$$(20) \quad B_{a,t} = \sum_{s} \sum_{j} R_{s,a,j,t} \, b_{s,a,j,t} \quad .$$

Auxiliary benefits to dependents and survivors of retirement beneficiaries are determined as functions of total retirement benefits in each year. Specifically, aggregate auxiliary benefits by age are determined as

$$(21) \quad A_{a,t} = d_{a,t} \sum_{a} B_{a,t} \quad ,$$

where the $d_{a,t}$ ratios are determined exogenously by the Trustees' Report projected ratio of aggregate auxiliary benefits to aggregate retirement benefits and by the assumptions that (1) average auxiliary benefits at each age remain constant over time relative to average auxiliary benefits at each other age and (2) the proportion of persons at each age receiving auxiliary benefits remains constant over time. The latter two assumptions determine the age distribution of total auxiliary benefits each period.

---

[19]Such benefit recomputations may reflect the effects of additional earnings after retirement on the benefit award or changes over the retirement period in the proportion of benefits withheld due to the earnings test.

Proceeds from the other government income taxation of Social Security benefits by age is determined as

$$(22) \quad Q_{a,t} = \tau_t^Q \, (B_{a,t} + A_{a,t}) \quad ,$$

where the effective tax rate τ_t^Q is exogenously determined by the Trustees' Report projection of the ratio of benefit taxation proceeds to total OASI benefits. This approach assumes that the effective benefit taxation rate is identical across age groups at any given point in time.

The liability by age from the tax on Social Security covered earnings is modeled as

$$(23) \quad T_{a,t}^S = \tau_t^S H_{a,t} \quad ,$$

where the effective tax rate τ_t^S is a weighted average of the OASI tax rates on employers, employees, and the self-employed, with the weights representing the proportions of labor compensation of each type that are effectively subject to the tax. These weights are exogenously determined by the Trustees' Report projections of the proportion of each type of labor compensation covered by Social Security and the proportion of covered compensation of each type that is taxable.[20] The OASI tax rates scheduled under present law can be modified exogenously or endogenously, depending on the alternative policy under consideration.

Net OASI transfers by age are calculated simply as retirement and auxiliary benefits less taxes on benefits and earnings; specifically,

$$(24) \quad J_{a,t} = B_{a,t} + A_{a,t} - Q_{a,t} - T_{a,t}^S \quad .$$

---

[20]The proportion of aggregate output distributed as self-employment income is also determined exogenously in the LRM from Trustees' Report projections. The LRM implicitly assumes that the proportion of compensation that is taxable in any given period is constant across ages.

Aggregating across all ages gives aggregate net transfers for the OASI program in each simulation period;[21] i.e.,

$$(25)\quad J_t = \sum_a J_{a,t} \quad .$$

Subtracting this aggregate net transfer from the interest earnings on OASI trust fund assets yields the net surplus for the fund in the current period; i.e.,

$$(26)\quad S_t^S = r_t^F F_t - J_t \quad ,$$

where F_t denotes OASI trust fund assets as of the beginning of the period. Trust fund assets as of the beginning of the succeeding period are then given by

$$(27)\quad F_{t+1} = F_t + S_t^S \quad .$$

Other Government Sector

Given the focus of the LRM on Social Security policy issues, the taxes, transfers, and consumption[22] of the other government sector are modeled relatively simply. As indicated

[21]Although not depicted in the equations, the LRM assumes that the ratio of total OASI expenditures to total OASI benefits remains constant after the last available historical year. Other expenditures besides benefits include net administrative expenses and transfers to the Railroad Retirement program, which together averaged about two percent of total expenditures over the period 1985-90. Also not depicted in the equations is the relationship between 1) total OASI receipts excluding trust fund interest earnings and 2) total OASI tax revenues from earnings and benefit taxation. In addition to interest earnings and tax receipts, the OASI trust fund also receives relatively small net transfers from the general fund of the U.S. Treasury; these net transfers averaged well less than one percent of total receipts over the period 1985-90. For simplicity, the LRM assumes that these net transfers fall to zero after a short transition period.

[22]The term "government consumption" is used in this paper to refer to all purchases of goods and services by the other government account. Some components of such expenditures, of course, are more appropriately interpreted as investment expenditures, but are not treated as such in the LRM because of data limitations. An analogous situation arises in the case of private consumption expenditures, which include substantial components that are more appropriately interpreted as investment, either in durable goods or human capital.

above, only two other government tax rates are assumed. These tax rates, τ_t^L and τ_t^K, are specified exogenously and, for simplicity, are assumed to apply proportionally to personal compensation and net profits, respectively. In most simulations, endogenous adjustments to the personal compensation tax rate are also effected by the specification of particular fiscal policy rules applying to either the other government or total government deficit; for example, tax adjustments may be effected to maintain the specified deficit within some absolute range or within some proportional range relative to gross output. This allows the effects of Social Security policy changes to be examined in the context of alternative fiscal policy rules, which typically are crucial to both the aggregate economic and intergenerational redistributive effects of Social Security policy.

Because both the personal compensation and net profit tax rates are assumed to be proportional, both are constant across age groups. As such, a composite asset income tax rate, τ_t^W, can be computed for the average portfolio mix, which is also assumed to be identical across all age groups; this asset income tax rate is computed as a weighted average of the personal compensation tax rate τ_t^L and the profit tax rate τ_t^K under the assumption that the personal compensation tax rate applies to asset income net of profits taxes. Aggregate other government taxes by age can then be computed as

$$(28) \quad T_{a,t}^O = \tau_t^L H_{a,t} + \tau_t^W r_t^W W_{a,t} \quad ,$$

where $W_{a,t}$ denotes aggregate fungible assets by age held by domestic consumers.[23] Aggregate other government tax revenues across all ages are given by

$$(29)\quad T_t^O = \sum_a T_{a,t}^O \quad .$$

Aggregate other government transfers are determined as a share of gross output; i.e.,

$$(30)\quad G_t = x_t^G O_t^g \quad ,$$

where the time path of the proportionality factor x_t^G is exogenously specified. Aggregate other government transfers are distributed among NIPA population age groups each period under the assumptions that (1) age-specific transfer program participation rates remain constant over time and (2) the relative profile of average transfers per participant across ages also remains constant over time.[24] Under these assumptions, the relative age profile of other government transfers per capita, θ_a,[25] is constant over time, and aggregate other government transfers by age can be derived as

$$(31)\quad G_{a,t} = G_t \left[\frac{\theta_a N_{a,t}^N}{\sum_a \theta_a N_{a,t}^N} \right] \quad .$$

---

[23]In this formulation, the capital held by corporations, the profits on that capital, and the taxes on those profits are indirectly allocated by age among shareholders. The initial age allocation of the aggregate capital stock and other government debt holdings of domestic consumers in the base year is based on the age distribution of assets as reported in the 1982-83 Consumer Expenditure Survey, under the assumption that the mix of these assets in individual portfolios is constant across ages. Profit taxes are also assessed in the LRM on the profits earned on U.S. capital owned by foreigners, but these taxes are not depicted in the equations for simplicity.

[24]That is, the ratios of the transfer per participant for any given age to the transfer per participant for each other age remain constant over time.

[25]This profile is derived from the 1982-83 Consumer Expenditure Survey.

Total other government consumption expenditures are also determined as a share of gross output; specifically,

$$(32) \quad C_t^O = x_t^C O_t^g \quad ,$$

where the time path of the proportionality factor x_t^C is exogenously specified.[26] The net other government surplus can then be calculated as tax receipts less transfer program, consumption, and interest expenditures; i.e.,

$$(33) \quad S_t^O = T_t^O - G_t - C_t^O - r_t^D D_t \quad ,$$

where D_t denotes the other government debt as of the beginning of the period. Other government debt as of the beginning of the next period is then given by

$$(34) \quad D_{t+1} = D_t - S_t^O \quad .$$

Consumption/Investment Sector

This sector determines private transfers, private consumption, saving, and net investment. A life cycle model of consumption behavior is used to determine private consumption in the LRM. Consumers of each age are assumed to form perceptions of prospective consumption wealth, based on expected future flows of labor compensation net of other government tax liability, Social Security benefits less taxes, other government transfers, and private transfer receipts.

The perception assumptions used by the LRM to form these components of prospective wealth are identical to those described in equations (3.2)-(3.16) of Leimer and Richardson [1989], although the computation is simplified in the LRM because consumption behavior in

---

[26]In the simulations reported in this paper, the other government transfer share x_t^G and the government consumption share x_t^C are assumed to remain constant after attaining their respective values in the last available historical year.

each period is disaggregated only by age. The general sense of the prospective wealth perception assumptions is that consumers of each age in each simulation year project that the current cross-section relative average age profiles of the various prospective income and tax flows will persist into the relevant future, with the absolute flows at each age growing over time at the expected rate of growth in per capita real output. Under certain policy simulations, these expectations may be altered by announced changes in future other government or Social Security taxes and transfers. The expected per capita growth rate is determined in the simulations by an adaptive expectations process, with the initial expectation chosen on the basis of historical experience.[27]

With the exception of private transfer receipts, the simulated current age-specific compensation, tax, and transfer flows underlying these perception assumptions have already been described. In the LRM, all private transfers across ages are assumed to take the form of bequests. Decedents are assumed to die at year-end following the instant when all consumption is assumed to occur, so that bequests, along with accumulated interest, are effectively distributed to heirs prior to the consumption instant at the end of the following year; i.e,

$$(35) \quad X^R_{a,t} = X^R(r^W_t,\ X^G_{a,t-1}) \quad ,$$

---

[27]The LRM can also simulate a number of other perception assumptions, one of which is a "correct foresight" assumption. Under this perception assumption, the LRM iterates over the simulation period until close correspondence is achieved between the prospective net income flows perceived by simulation consumers at each age in each simulation year and the net income flows that are subsequently simulated. This perception assumption provides an interesting benchmark, by identifying the prospective wealth and associated consumption behavior in the case where consumers are assumed to correctly perceive the prospective net income flows underlying their prospective wealth perceptions. This case differs from a "perfect foresight" assumption in that consumers are still assumed to discount their perceived prospective net income flows for uncertainty, rather than using a riskless discount rate, since they are only assumed to perceive their prospective net income flows correctly, not with perfect certainty.

where $X^R_{a,t}$ denotes the inheritances received by age in the current period, defined as a function of the bequests given by decedents of each age at the end of the preceding year ($X^G_{a,t-1}$). The function X^R linking bequests and inheritances utilizes an empirical distribution of age differences between parents and children under the assumption that this distribution remains constant over time.[28]

Although the LRM allows different discount rates to be applied to the different component flows underlying prospective wealth, the simulations reported in this paper apply the same discount rate to all components.[29] An identical process is used to adjust the prospective wealth discount rates over simulation periods in response to simulated changes in the profit rate and tax rates as is used to adjust the government bond rate and the rate of return to OASI trust fund assets, as described in the discussion of equations (15) and (16) above.

Under these assumptions, aggregate prospective wealth for persons of each age can be represented as

$$(36)\quad P_{a,t} = W^H_{a,t} + W^S_{a,t} + W^G_{a,t} + W^X_{a,t} \quad ,$$

where $W^H_{a,t}$ denotes prospective human wealth derived from expected labor compensation net of the other government tax liability on that compensation, $W^S_{a,t}$ denotes prospective Social Security benefit wealth, net of Social Security earnings and benefit taxation liability, $W^G_{a,t}$ denotes

---

[28]This distribution is derived from the 1982-83 Consumer Expenditure Survey. For simplicity, this distribution of age differences is assumed to be independent of the age and sex of the parent.

[29]A rate close to the historical composite rate of return across all assets (r_t^W) was chosen for the initial prospective wealth discount rate in the simulations presented in this paper. Choosing a prospective wealth discount rate close to the composite rate of return has the advantage of allowing a closer correspondence between the *ex ante* and *ex post* evaluations of each cohort's consumption wealth; i.e., consumers' *ex ante* evaluations of their consumption wealth turn out to be more realistic, because the *ex ante* discount rate is closer to the rate of return actually realized *ex post*.

prospective other government transfers wealth, and $W^X_{a,t}$ denotes prospective private transfers receipts wealth.

The parameters of the actual consumption function implemented in the LRM were estimated under these assumptions using the 1982-83 Consumer Expenditure Survey. The general approach used to estimate the consumption function is described in Leimer and Richardson [1989].[30] The general form of the consumption function can be described as

$$(37) \quad C_{a,t} = \gamma_a \, (W_{a,t} + P_{a,t}) \quad ,$$

where $C_{a,t}$ denotes aggregate consumption by age, γ_a denotes the age-specific consumption-wealth ratios estimated in the consumption function regressions, and $W_{a,t}$ denotes fungible consumer assets by age.

[30]The main differences between the specification estimated for the LRM and the specification described in equations (4.4)-(4.6) of Leimer and Richardson [1989] are that, in the LRM specification, the parameter λ in equation (4.5) (measuring the substitutability of prospective wealth in general for fungible assets) is assumed equal to one, based on the results for equation (1) of Table 1 in that paper, and the intergenerational offset parameters δ_a, f_a, and t_G in equations (4.5)-(4.6) are assumed equal to zero, given the assumption of pure life cycle behavior in the LRM. In keeping with the pure life cycle behavior assumption, the parameter ψ in equations (4.5)-(4.6) is reinterpreted as a proportional measure of the imperfect substitutability of government-based prospective wealth for other forms of prospective wealth (or for fungible assets). This parameter is omitted from equation (36) above, because ψ was estimated on its upper bound of one in the consumption function employed in the simulations reported in this paper; i.e., social security and other government wealth are treated as perfect substitutes for other forms of prospective wealth or for fungible assets in these simulations. With these qualifications and the assumption of a higher discount rate, as noted in the preceding footnote, the consumption function specification in the LRM is identical to equation (1) of Table 1 in Leimer and Richardson [1989]. In part because the range of estimates for analogous substitutability parameters reported in other studies is extraordinarily large, ranging from zero and even negative substitutability to unitary and even larger substitutability, the validity of the life cycle model of consumption and the substitutability of social security wealth for fungible assets remain sources of controversy. Although the LRM can simulate only life cycle consumption behavior as presently structured, alternative values can be specified for the substitutability parameter ψ as well as for the prospective wealth discount rates to test the sensitivity of simulation results to these consumption function parameter specifications.

The LRM uses a concept of disposable private income analogous to its concept of fungible assets held directly or indirectly by consumers. Specifically,

$$(38) \quad Y_{a,t} = r_t^W W_{a,t} + H_{a,t} + J_{a,t} + G_{a,t} + X_{a,t}^R - T_{a,t}^O \quad ,$$

where net corporate profits are allocated by age among shareholders; i.e., disposable private income available for consumption, saving, and bequests consists of asset income, labor compensation, net OASI transfers, other government transfers, and private transfers receipts, less other government tax liability.

As indicated above, decedents are assumed to die at year-end following the instant when all consumption is assumed to occur. Consequently, aggregate bequests by decedents of each age are given by

$$(39) \quad X_{a,t}^G = \left(W_{a,t} + Y_{a,t} - C_{a,t}\right) \left[\frac{N_{a,t}^D}{N_{a,t}^N}\right] \quad .$$

Similarly, aggregate private saving at each age is given by

$$(40) \quad S_{a,t}^P = Y_{a,t} - C_{a,t} - X_{a,t}^G \quad .$$

Aggregating across all ages gives total private saving in each simulation year; i.e.,

$$(41) \quad S_t^P = \sum_a S_{a,t}^P \quad .$$

Total private saving at each age is used to update the aggregate fungible assets held by each age for use in the subsequent simulation period; i.e.,

$$(42) \quad W_{a+1,t+1} = W_{a,t} + S_{a,t}^P \quad .$$

Net foreign investment in the LRM is assumed to be a function of gross output; specifically,

$$(43) \quad I_t^F = x_t^F O_t^g \quad ,$$

where the time path of the proportionality factor x_t^F is specified exogenously.[31] The equality between saving and investment, then, determines net private domestic investment as

$$(44) \quad I_t = S_t^P + S_t^O + S_t^S - I_t^F \quad .$$

Finally, net private domestic investment is used to increment the capital stock available for production in the subsequent period; i.e.,

$$(45) \quad K_{t+1} = K_t + I_t \quad .$$

III. Baseline Simulation

This section describes the results of a LRM simulation in which the input parameters were adjusted to achieve as high a degree of correspondence as possible to the Trustees' Report projections.[32] This exercise illustrates some similarities and differences between the two projection processes and provides a baseline scenario for contrast to other LRM scenarios incorporating alternative Social Security policies.

The first comparison is between LRM and Trustees' Report projections of the Social Security area population, as summarized in Figure 1.[33] As noted in the preceding section, the

---

[31]In the simulations presented in this paper, the net foreign investment factor x_t^F is assumed to fall to zero by the year 2000. The lack of a more sophisticated foreign sector to simulate international capital flows is another important deficiency of the LRM in its present form. The simulations presented in this paper can be interpreted as consistent with the assumption that the economic forces affecting capital/output ratios in the rest of the world are similar to those at work in the U.S., so that changing differentials in returns to capital among countries do not arise and induce changes in international capital flows, at least after the assumed initial transition period.

[32]The LRM projections presented in this section are contrasted to the intermediate (II-B) projections of the 1987 Trustees' Report, since selected rates and relationships derived from the projections underlying that Report are incorporated into the present LRM data base, as noted above. The last available historical year used in the simulations reported in this paper is 1988.

[33]The figures appear at the end of the main text.

LRM utilizes Trustees' Report projections of mortality rates, fertility rates, and net immigration. The LRM demographic projection process differs from the Trustees' Report projection process in other respects, however, including the determination of male/female birth shares, the treatment of newborn mortality, and the timing of demographic events.[34] Because of these differences, the Social Security area population projections differ slightly between the two processes, and an across-the-board reduction of about one percent (not one percentage point) in the Trustees' Report fertility rates was adopted in the LRM baseline projection to achieve greater conformity with the Trustees' Report aggregate population projection. The age structure of the population is quite similar between the LRM and Trustees' Report projections, as illustrated in Figure 2; this figure shows the aged (ages 65+ to ages 20-64) and total (ages 0-19 and 65+ to ages 20-64) population dependency ratios under the two projections.

A key determinant of the financial status of the OASI program is the rate of growth in its payroll tax base. In addition to demographic and labor force participation changes, key determinants of payroll tax base changes are productivity growth and changes in the linkage between labor compensation and taxable earnings. As indicated in the previous section, the linkage between labor compensation and taxable earnings in the LRM is largely determined by exogenous relationships between those variables derived from the Trustees' Report projections. Productivity growth in the LRM is determined by changes in effective labor input, the capital/labor ratio, and technical progress. Effective labor input and the capital/labor ratio are endogenously determined in the LRM, but the rate of technical progress is exogenously specified as an input parameter.

---

[34]Wade [1989] provides some detail on the process used to develop the population projections for the Trustees' Report.

Given the other exogenous assumptions discussed above, the input parameter specifying the rate of technical progress was adjusted to achieve close correspondence between the 75-year OASI actuarial balance measure reported in the annual Trustees' Report and the corresponding measure simulated by the LRM.[35] Under this assumption, the LRM generates a geometric mean annual growth rate in real average covered earnings of 1.5 percent between 1995 and 2060, while the Trustees' Report assumes a 1.6 percent growth rate over that period. Despite the similarity between these long run averages, Figure 3 illustrates the much greater variability in the annual real wage growth rates simulated endogenously by the LRM, compared to those assumed exogenously in the Trustees' Report projections. In the LRM simulations, wages respond directly to simulated changes in productivity, whether due to technical change, changes in the demographic structure of the work force, or changes in the capital/labor ratio.

The rate of return to the other government securities held by the OASI trust fund is also determined endogenously in the LRM. Figure 4 contrasts the OASI trust fund interest rate assumed in the Trustees' Report with the rate simulated in the baseline LRM run. Also shown in Figure 4 is the real rate of return to capital (net of depreciation, gross of taxes) simulated in the baseline LRM run; under LRM assumptions, changes in this rate after an initial transition period result solely from changes in the capital/output ratio. As indicated in the previous section, the simulated linkage between the rate of return to capital and the OASI trust fund

[35]The 75-year OASI balance measure reported in the 1987 Trustees' Report for alternative II-B was -0.43 percent of taxable payroll. This is the average of the difference between the OASI income and cost rates over the 75-year projection period, where the income and cost rates are expressed as percentages of taxable payroll. The corresponding measure for the LRM simulation was -0.42 percent when the annual rate of Hicks-neutral technical progress was assumed equal to 1.0 percent. Closer correspondence could be achieved by further refinement of the technical progress parameter, but the -0.42 result was considered sufficiently close for the present purpose.

interest rate is more complex. Nevertheless, changes in the OASI trust fund interest rate tend to follow those in the rate of return to capital, although the relationship is somewhat obscured in Figure 4 by the difference in scale between the two simulated rates. The initial sharp decline in the simulated OASI trust fund interest rate from recent historical values is the result of an arbitrary assumption that forces the real rate to 2 percent by the year 2000 in both the Trustees' Report and the LRM baseline projections; this assumption was imposed on the LRM simulation so that the OASI interest rate in the LRM and Trustees' Report projections would proceed from initially similar values.

Other published Trustees' Report projections that can be compared directly to LRM projections consist primarily of OASI program variables. Figures 5-7 illustrate the generally close correspondence between the two projections in the number of retired worker beneficiaries, OASI expenditures as a percentage of taxable payroll, and the OASI trust fund as a percentage of annual expenditures. Although close, the LRM projections of retirees and expenditures are initially below and subsequently above the Trustees' Report projections, with the result that the OASI trust fund first increases and subsequently declines more rapidly than under the Trustees' Report projections. As in the Trustees' Report projections, the baseline LRM scenario projects that the trust fund will become negative between 2055 and 2060. Because the LRM baseline projection period extends to 2150 to facilitate the cohort comparisons presented below, a combined employer-employee OASI tax increase of 3.43 percentage points was imposed in 2062 under the baseline scenario.[36] This increase is sufficient to generate a projected OASI trust fund balance slightly larger than zero in the terminal simulation year of 2150, balancing the initial value of the trust fund plus revenues against expenditures over the entire simulation period

[36]After this increase, the OASI combined employer-employee tax rate was 14.41 percent.

in a present value sense. As shown in Figure 8, this simulated tax increase is also sufficient to bring current OASI tax receipts and expenditures net of general revenue reimbursements[37] into rough equality at the end of the LRM baseline simulation period.

As indicated in the previous section, the time paths of the economic and program variables simulated by the LRM depend critically on the saving behavior of the government and private sectors. This dependence is illustrated in Figure 9, which depicts the simulated endogenous saving behavior of the various sectors of the LRM.

As shown in Figure 9, dissaving by the other government sector is maintained within a relatively narrow range as a percentage of gross output, under the fiscal policy rule assumed in the baseline simulation. The fiscal policy rule imposed on the baseline simulation is designed to maintain the other government deficit within approximately 2.5 to 3.0 percent of gross output. Whenever the other government deficit falls outside this range, a personal compensation tax increase or decrease, as appropriate, is instituted in the following period sufficient to bring the deficit back within this range. The application of this rule in the baseline simulation resulted in a series of small tax increases between 2010 and 2030, with the cumulative effect being an increase of 3.2 percent (not percentage points) in the tax rate; these tax increases were followed by a series of small tax reductions between 2045 and 2070, leaving personal compensation tax rates 0.5 percent (not percentage points) higher between 2070 and 2150 than their level during the simulation period up to 2010.

[37]These general revenue reimbursements consist almost entirely of receipts from the taxation of OASI benefits. As noted in the preceding discussion, the relatively small component of these reimbursements other than benefit taxation revenues is assumed to fall to zero after a short transition period.

As indicated in Figure 9, projected saving by the OASI trust fund is initially positive and increasing, reflecting the scheduled buildup of the trust fund in anticipation of the retirement of the baby boom cohorts.[38] As the baby boom cohorts begin to move into retirement, however, the OASI trust fund begins to save less and eventually incurs a deficit. As indicated in Figure 7, the OASI deficits eventually draw the trust fund below zero, until the tax increase assumed in the baseline simulation takes effect in 2062. This tax increase rapidly brings the OASI program back into a modest surplus and deficit pattern until the end of the simulation period, as illustrated in both Figures 8 and 9.

The private saving time path depicted in Figure 9 reflects the effects of a number of influences, including consumer responses to OASI and other government tax changes and the interaction of demographic changes with life cycle saving patterns. The initial rise and subsequent decline in the private saving rate largely reflects the interaction of demographic change and life cycle saving patterns; during this period, the baby boom first moves through middle age and approaches retirement, causing aggregate private saving rates to rise because of the increased individual saving rates typical for that period of the life cycle. The effect is reversed as the baby boom moves into retirement, however, forcing the aggregate saving rate downward. The series of other government tax increases between 2010 and 2030 reinforces the downward trend in the private saving rate, as life cycle consumers, although consuming less in response, suffer an even greater reduction in disposable income. The downward trend in the private saving rate is reversed around 2035, as other government tax rates stabilize and the aging

[38]The buildup of the OASI trust fund was not explicitly mandated by the Congress in anticipation of the retirement of the baby boom cohorts, but rather is an effect of the tax increases and benefit reductions incorporated in the 1983 amendments; these amendments were designed to address the actuarial imbalance projected under the program at that time. That imbalance was due in large measure, however, to the impending retirement of the baby boom cohorts.

of the population slows, even reversing for a brief time during the 2035-45 period. The series of other government tax reductions between 2045 and 2070 reinforces the increase in the private saving rate, until the sharp increase in OASI payroll taxes is instituted in 2062; this tax increase causes a similarly sharp reduction in the private saving rate that offsets the increase in OASI trust fund saving. After this point the private saving rate stabilizes, reflecting increased stability in the population age structure and the absence of additional tax rate changes.

These saving rate changes, of course, result in corresponding changes in the capital stock. Along with the effects of demographic change on productivity, these changes in the capital stock have direct effects on the growth of output over time. The rate of growth in per capita output can be decomposed into a number of component factors. Given the assumption of Cobb-Douglas production technology with a constant rate of Hicks-neutral technical progress, output per capita can be expressed as

$$(46) \quad o_t = z_o\,(1+\lambda_z)^t\, k_t\, q_t\, v_t \ , \quad \text{where}$$

$$(47) \quad o_t = \frac{O_t^g}{N_t}\ , \quad k_t = \left[\frac{K_t}{L_t}\right]^{1-\alpha}\ , \quad q_t = \frac{L_t}{E_t}\ , \quad \text{and} \quad v_t = \frac{E_t}{N_t}\ .$$

The λ_z parameter denotes the assumed rate of technical progress; the k_t index, a measure of capital deepening, reflects changes in the capital/effective labor ratio as it affects output per capita; q_t denotes the effective labor/employment ratio, a measure of labor quality; and v_t, the productive population ratio, denotes the ratio of the employed population to the total population.

The annual growth rate in output per capita, then, can be derived as

$$(48) \quad \left[\frac{o_t - o_{t-1}}{o_{t-1}}\right] = (1+\lambda_z)\left[\frac{k_t}{k_{t-1}}\right]\left[\frac{q_t}{q_{t-1}}\right]\left[\frac{v_t}{v_{t-1}}\right] - 1$$

$$= (1+\lambda_z)\,(1+\lambda_k)\,(1+\lambda_q)\,(1+\lambda_v) - 1\ , \quad \text{where}$$

$$(49)\quad \lambda_k = \left[\frac{k_t - k_{t-1}}{k_{t-1}}\right], \quad \lambda_q = \left[\frac{q_t - q_{t-1}}{q_{t-1}}\right], \quad \text{and} \quad \lambda_v = \left[\frac{v_t - v_{t-1}}{v_{t-1}}\right] .$$

The rate of growth in per capita output can therefore be approximated by the expression

$$(50)\quad \left[\frac{o_t - o_{t-1}}{o_{t-1}}\right] \approx \lambda_z + \lambda_k + \lambda_q + \lambda_v \quad \text{for} \quad |\lambda_z|,\ |\lambda_k|,\ |\lambda_q|,\ |\lambda_v| \ll 1 ,$$

where all the multiplicative terms involving the λ_z, λ_k, λ_q, and λ_v growth rates in the expansion of equation (48) have been dropped, under the assumption that these terms will have negligible values as the products of relatively small growth rates.[39]

The contribution of each of these components to the annual rate of growth in output per capita is illustrated in Figure 10. Over the 1990-2150 period, per capita real output grows at a geometric mean rate of 1.56 percent. Of this, a constant 1.00 percent is attributable to technical progress, reflecting the value assumed for the corresponding input parameter, as discussed above. The remaining 0.56 percentage points of mean per capita economic growth over this period are endogenously determined; on average, changes in the productive proportion of the population retarded per capita economic growth over this period by a geometric mean -0.07 percentage points, while changes in labor quality contributed a modest geometric mean 0.01 percentage points and capital deepening a more substantial geometric mean 0.61 percentage points. As shown in Figure 10, a considerable degree of year-to-year variability underlies the average contributions of these endogenous components.

The contribution of changes in the proportion of the population engaged in the production of output is at first positive, as the baby boom cohorts move into age ranges characterized by high labor force participation rates. This effect declines rapidly, however, and begins to retard

[39]The continuous time analog to equation (50) holds exactly at any given instant.

the growth in output per capita by 2005, as the baby boom cohorts mature and begin to reduce their labor force participation as retirement approaches. This negative effect on the growth in per capita output continues to expand as the baby boom cohorts move into retirement, but begins to reverse itself by about 2020, as the flow of baby boom cohorts into retirement begins to abate and the older baby boom cohorts begin to die in increasing numbers. These forces continue to result in a reduction in the negative effect of the productive population component of per capita economic growth until the stabilizing age structure of the population keeps the effect of this component close to zero after the middle of the next century.

The changing age structure of the work force over the baseline simulation period has a similar, but less pronounced, effect on the labor quality component of per capita economic growth. Initially, the movement of the baby boom cohorts into more productive ages of the life cycle contributes to the growth in output per capita. As the baby boom cohorts move into retirement, however, this effect begins to retard the growth in per capita output. The growth in the labor quality component first becomes negative in 2004, but a stronger decline begins in 2016. As with changes in the productive population ratio, this effect later abates as the flow of baby boom cohorts into retirement diminishes and as mortality claims increasing numbers of baby boom cohort members. After about mid-century, changes in labor quality have very little effect on per capita economic growth as the age structure of the work force stabilizes.

Aside from technical progress, capital deepening provides the greatest impetus to per capita economic growth over the baseline simulation period, as illustrated in Figure 10. After an initial transition period, the capital/effective labor ratio increases over the remainder of the simulation period, contributing to economic growth. As with the other endogenous components of per capita economic growth, the impact of capital deepening is dependent on changes in the population age structure. The effect of capital deepening grows initially, as OASI trust fund saving and the increased saving of the baby boom cohorts in anticipation of retirement cause increases in the capital stock to outpace increases in effective labor input. The effect continues, although less intensively, as the baby boom cohorts begin to move into retirement and leave a relatively smaller work force to benefit from the increased capital stock. The intensity of the effect diminishes rapidly during the baby boom retirement period, however, reflecting the decline in private saving rates and the OASI trust fund. The contribution of capital deepening rebounds somewhat in later periods, as the effects of the baby boom retirement period diminish and the population age structure stabilizes.

IV. Application

This section uses the LRM to illustrate the aggregate economic and intergenerational redistributive effects of a stylized plan to privatize the OASI program.[40] The privatization plan considered here effects privatization gradually, by imposing a pre-announced reduction in OASI benefit awards of 5 percent (not percentage points) per year, beginning in the year 2000; once beneficiaries are on the rolls, their real benefit levels are maintained by annual inflation adjustments. The reductions in total benefit costs under this plan are reflected in commensurate decreases in OASI payroll taxes. As such, the size of the program gradually diminishes over time, so that tax receipts fall to less than 1 percent of taxable payroll by the year 2065.

The award reduction plan is assumed to be announced in 1995, at which point individuals are free to respond in any way they deem appropriate; i.e., the plan does not invoke a

[40]The discussion in this section is partially summarized from Leimer [1991], which analyses an additional stylized privatization plan and provides more detail on the rationale and effects of privatization plans in general.

mandatory alternative private saving scheme, and individuals are assumed to enjoy full freedom of choice regarding their retirement saving responses.[41] The award reduction simulation adopts the same fiscal policy rule adopted in the LRM baseline simulation described in the previous section; this rule ensures that the award reduction plan results in an increase in private saving and that this increased saving is not canceled by offsetting changes in the other government (non-OASI) deficit.[42]

The effect of the award reduction plan on the aggregate capital stock is illustrated in Figure 11, which shows the simulated stock under the award reduction scenario relative to the baseline "present law" scenario. These changes in the capital stock have corresponding effects on aggregate output, and the plot of aggregate output under the award reduction plan relative to that under the present law baseline simulation has virtually the same shape as that depicted for the relative capital stock in Figure 11. The capital stock and output begin to increase immediately under the award reduction scenario, as OASI taxpayers perceive a reduction in their net OASI wealth upon the announcement of the plan. This loss in net OASI wealth is translated into a reduction in lifetime consumption for those cohorts. The corresponding increase in saving results in a larger capital stock.

---

[41]In this sense, this plan might not be considered by some to be a privatization plan, since workers are not forced to adopt a private alternative. Such a requirement is not necessary in these simulations, however, since the nature of the consumption function ensures that workers will save on their own both in anticipation of retirement and to satisfy the bequest motive.

[42]Both the baseline and award reduction simulations adjust other government taxes over time in an effort to maintain the other government deficit within a relatively narrow range (2.5-3.0 percent) as a proportion of gross output. Technically, the absolute size of the other government deficit should be equal across the baseline and award reduction scenarios to ensure that the full increase in private saving is carried over into national saving. Maintaining the other government deficit as a proportion of output seems more realistic, however, and suffices in this example to generate increases in national saving.

When actually put into effect in the year 2000, the reduction in awards and commensurate reductions in payroll taxes of the award reduction plan cut into the buildup of the OASI trust fund projected under the present law scenario. This reduction in saving by the trust fund under the award reduction plan relative to the present law scenario offsets the increase in private saving and causes the relative capital stock curve in Figure 11 to begin to decline shortly after the plan is put into effect. The reduction in trust fund saving gradually diminishes after about 2010 and is reversed after about 2040, when the trust fund is projected to begin running deficits under the present law scenario; relative to the present law scenario, then, the trust fund contributes to increased saving under the award reduction plan during the period from about 2040 to 2060. The local trough in the relative capital stock curve occurs much earlier than 2040, as continuing increases in private saving begin to outweigh the declining effect of lower trust fund saving under the award reduction plan.

The effect of the award reduction plan on the net lifetime transfers received by different cohorts under the OASI program is depicted in Figure 12.[43] For purposes of illustration, the after-tax government bond rate is used to discount simulated OASI benefits net of payroll and

[43]Figure 12 depicts the present values of the simulated aggregate net lifetime transfers received by each cohort, divided by the number of "initial cohort members". For cohorts born before the start of the simulation (1984), an initial cohort member refers to a member of the original birth cohort who is still alive at the start of the simulation. For cohorts born after the start of the simulation, an initial cohort member refers to any member of the original birth cohort.

benefit taxes for each cohort back to the beginning of the simulation period.[44] The net lifetime wealth curves for both simulations increase across the earliest cohorts, because the present values are only computed over partial lifetimes for cohorts already alive at the start of the simulation. For this discussion, the main point of Figure 12 is the lower net lifetime wealth received under the award reduction plan by cohorts born after about 1905. The reduction in net lifetime wealth remains relatively small (less than five percent) through about the 1930 birth cohort, but then begins to increase rapidly. By this measure, then, all cohorts born after about 1905 would favor the present law plan over the award reduction plan.

The award reduction plan affects more than the lifetime OASI taxes and benefits experienced by each cohort, of course. The reductions in lifetime OASI wealth experienced by most cohorts when the plan is announced and put into effect also causes a reduction in their total lifetime wealth, and therefore in their lifetime consumption under the assumption of life cycle consumption behavior incorporated into the LRM.[45] If not offset by increases in government dissaving, the corresponding increase in aggregate saving benefits subsequent cohorts by increasing the capital stock, which, in turn, increases productivity and output.

---

[44]As described in the baseline simulation discussion above, an initial sharp decline is imposed on the OASI trust fund interest rate for consistency with the Trustees' Report projections. A similar decline is imposed on the government bond rate in these simulations before the rate is allowed to respond to changes in the profit rate and tax rates after the year 2000, as described in equation (15). As a consequence, the real after-tax government bond rate is close to zero (varying between .11 and .14 percent) for the bulk of these simulations, resulting in the large present values depicted in Figure 12. Whether or not such low rates are appropriate for estimating the absolute size of the net lifetime transfers received under Social Security is a source of controversy. The focus of Figure 12, however, is on the relationship between the two simulations, rather than on the absolute sizes of the estimated present values.

[45]Changes in lifetime OASI wealth might not result in changes in lifetime consumption under alternative models of consumption behavior. Under the intergenerational model, for example, changes in lifetime OASI wealth may be offset by corresponding changes in private transfers so that no intergenerational redistributive or aggregate economic effects arise.

The net effect of the award reduction plan on the simulated lifetime utility of individual cohorts is illustrated in Figure 13, which depicts the difference in the expected lifetime utility of each cohort under the award reduction scenario relative to the present law scenario. The utility function used to evaluate the lifetime consumption and bequests of each cohort under these simulations is consistent with the consumption function incorporated into the simulation model;[46] the parameters of the utility function were estimated empirically in conjunction with the estimation of the consumption function parameters.

For each cohort member, the utility function is assumed to be of the form

$$(51)\quad U_t = \sum_{i=B}^{D} S_{B,i}\,(1+\rho)^{B-i}\,\ln c_i + \beta \sum_{i=B}^{D} d_{B,i}\,\ln b_i \ ,$$

where U_t is the expected lifetime utility for a member of the birth cohort born in year t; B is the first simulation age for this cohort (age 0 or age in the simulation start year if born prior to that year); D is the last simulation age for each cohort (assumed to be age 100 in these simulations); $S_{B,i}$ is the probability of surviving from age B to age i for members of this cohort; ρ is the time preference rate, assumed constant over the life cycle; c_i is consumption per surviving member of this cohort at age i; β is the relative bequest preference parameter, assumed constant across all ages; $d_{B,i}$ is the probability for this cohort of dying at age i, given survival to age B; and b_i is the bequest per member of this cohort who dies at age i.

[46]The general form of the consumption function incorporated into the LRM can be derived from the utility function defined in equation (51) if the b_i variables are interpreted as intended bequests and treated as choice variables in the utility maximization problem. As actually implemented and depicted in Figure 13, however, the b_i are measured as the terminal assets of decedents, rather than as their intended bequests. This is not a serious problem in the present context, because the lifetime utility comparisons are only intended to be suggestive.

The evaluation of simulation outcomes in Figure 13 makes use of simulated *ex post* values for the mortality, consumption, and bequest experience of each cohort. Consumption at each age is defined to include not only private consumption expenditures, but also government consumption expenditures that have been allocated by age in each simulation year on the basis of relative other government tax payments.[47] The utility calculations for the earliest cohorts (born from 1884 to 1983) cover only that part of their lifetimes that was actually simulated (1984 until death).

As illustrated in Figure 13, the award reduction plan reduces the lifetime utility of the cohorts participating in the OASI program at the time that the plan is instituted. Lifetime utility for these cohorts declines because of the reduction in the amount of wealth available for their lifetime consumption, as discussed above. The baby boom cohorts born around 1945-60 are affected most adversely. These cohorts are aged 40-55, some 10 to 25 years from Social Security retirement, when the award reduction plan is instituted. Although the cohorts just about to retire when the plan is instituted have the most to lose in terms of net OASI wealth holdings, these cohorts also have a shorter period of time over which the award reductions can take effect. Somewhat younger cohorts, then, will suffer bigger losses in lifetime utility under the award reduction plan than will the cohorts just about to retire when the plan takes effect. Still younger cohorts, however, suffer smaller losses because they benefit more fully from the increases in the capital stock and because they have less accumulated net OASI wealth at stake.

To give a feel for the relative importance of the lifetime consumption differences implicit in Figure 13, the lifetime utility measures for each cohort under the baseline present law

---

[47]This allocation of other government consumption expenditures is consistent with the benefit principle of taxation; i.e., cohorts are assumed to derive benefits from public consumption in proportion to their tax payments.

scenario and the award reduction scenario were converted to the corresponding constant real lifetime consumption streams that would generate the same lifetime utilities, assuming that the cohort makes zero bequests. That is, the lifetime utility measure U_t calculated for each cohort, the survival probabilities $S_{B,i}$ for that cohort, and the time preference rate ρ were used to solve for the equivalent constant lifetime consumption stream c_t in the equation

$$(52) \quad U_t = \ln c_t \sum_{i=B}^{D} S_{B,i} \, (1+\rho)^{B-i} \quad .$$

Relative to the present law scenario, the resultant constant lifetime consumption stream for the award reduction plan ranged from a reduction of 4.6 percent for the 1951 cohort to an increase of 3.1 percent for the 2099 cohort. These results suggest that the award reduction plan has the potential for important effects on the lifetime consumption and utility of affected cohorts.

This example illustrates the potential differences between narrow and broad measures of the intergenerational redistributive effects of Social Security policy. The narrow OASI net lifetime wealth increment measure, which reflects only the balance between Social Security taxes and benefits, suggests that no cohort is better off, and most are worse off, under the award reduction plan than under present law. In contrast, a broader measure reflecting differences in the lifetime consumption and bequests experienced by each cohort suggests that later cohorts benefit under the award reduction plan as a result of the reduced lifetime consumption imposed on earlier cohorts. The desirability of such a policy, of course, depends on judgments comparing the welfare gains of the later cohorts with the welfare losses of the earlier cohorts.

V. Concluding Remarks

Anticipated changes in the age structure of the U.S. population between now and the middle of the next century will have important effects on the economy, as well as on the financial status of the Social Security program. Increased private saving rates and labor productivity are likely to contribute to economic growth during the period prior to the retirement of the baby boom cohorts. As the baby boom cohorts move into retirement, however, reverse demographic shifts will tend to retard economic growth, although capital deepening will provide an offsetting influence. Since these factors will influence the level and timing of Social Security tax revenues and benefit expenditures, they should be considered when projecting the financial status of the program.

It is also likely that Social Security policy affects private economic behavior to some extent, through such mechanisms as the private consumption and saving decision. Besides affecting the level of aggregate economic activity, then, Social Security policy is also likely to affect the economic well-being of successive generations of workers and beneficiaries in ways that cannot be identified by simply looking at the balance between taxes and benefits for each cohort. It is important that these broader effects be considered when evaluating the impact of Social Security policy.

The long-run simulation model described in this paper was designed with these considerations in mind. By disaggregating key relationships and devoting special attention to relationships that are sensitive to demographic change or that affect or are potentially affected by Social Security taxes and benefits, the model can not only simulate the impact of Social Security policy on the lifetime taxes and benefits of affected workers, but can also simulate the broader impact of policy on economic well-being at both the aggregate and cohort levels.

Figure 1

Social Security Area Population:
Trustees' Report (solid) and LRM (dashed) Projections, by Year

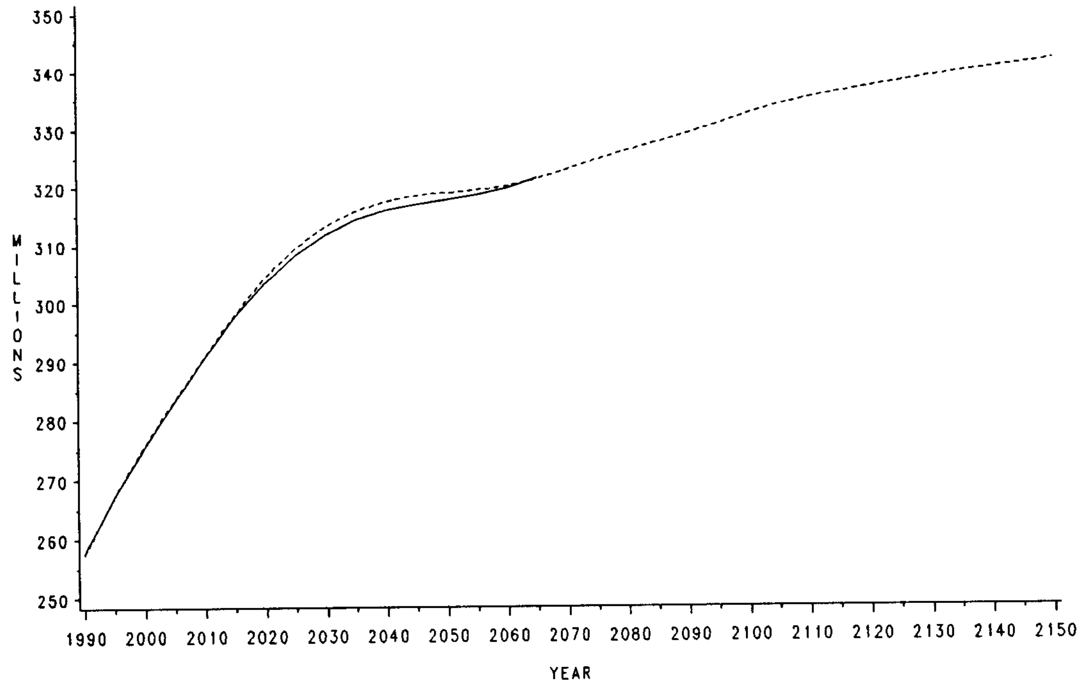


Figure 2

Aged and Total Dependency Ratios:
Trustees' Report (solid) and LRM (dashed) Projections, by Year

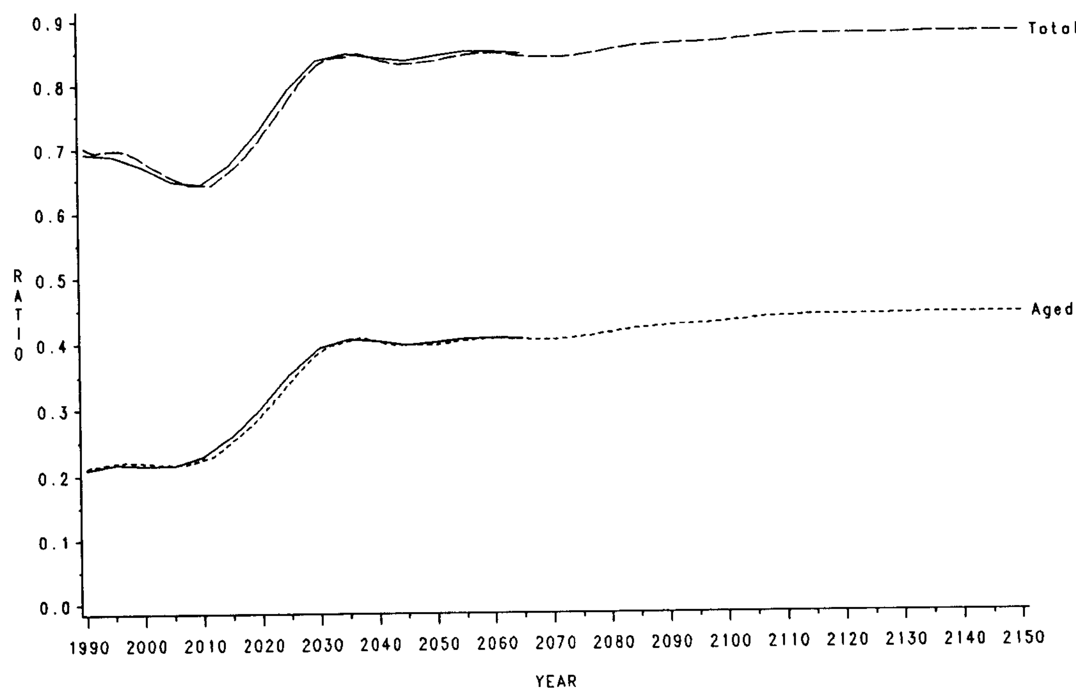


Figure 3

Growth Rate in Real Wages:
Trustees' Report (solid) and LRM (dashed) Projections, by Year

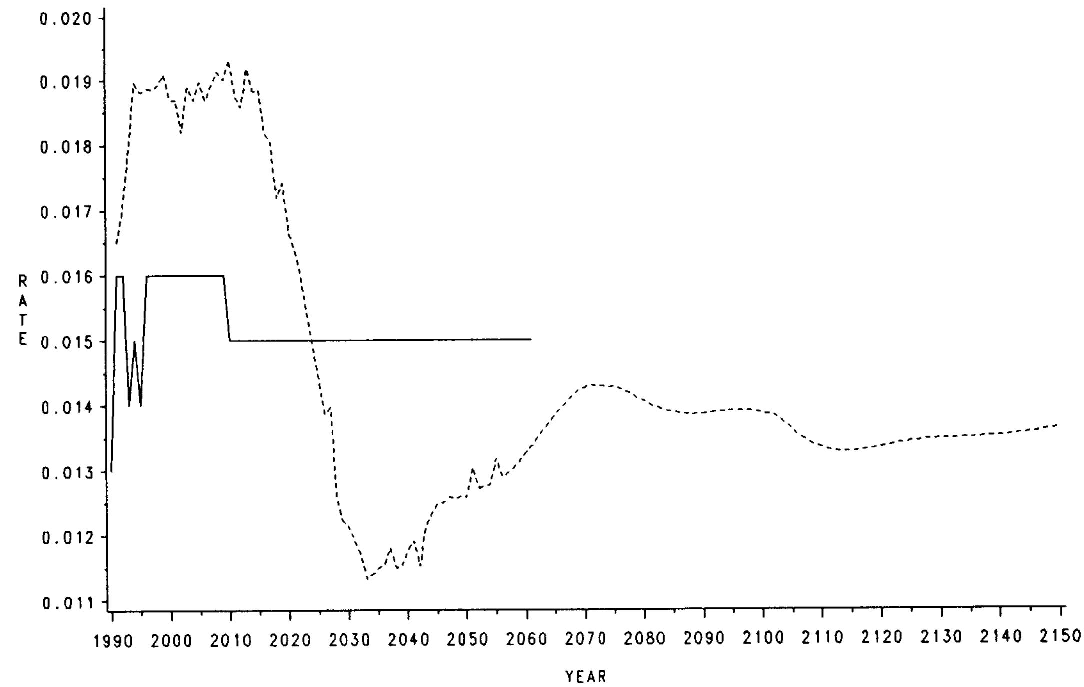


Figure 4

Real Profit Rate (PR) and Real Rate of Return to OASI Trust Fund Assets (TFR):
Trustees' Report (solid) and LRM (dashed) Projections, by Year

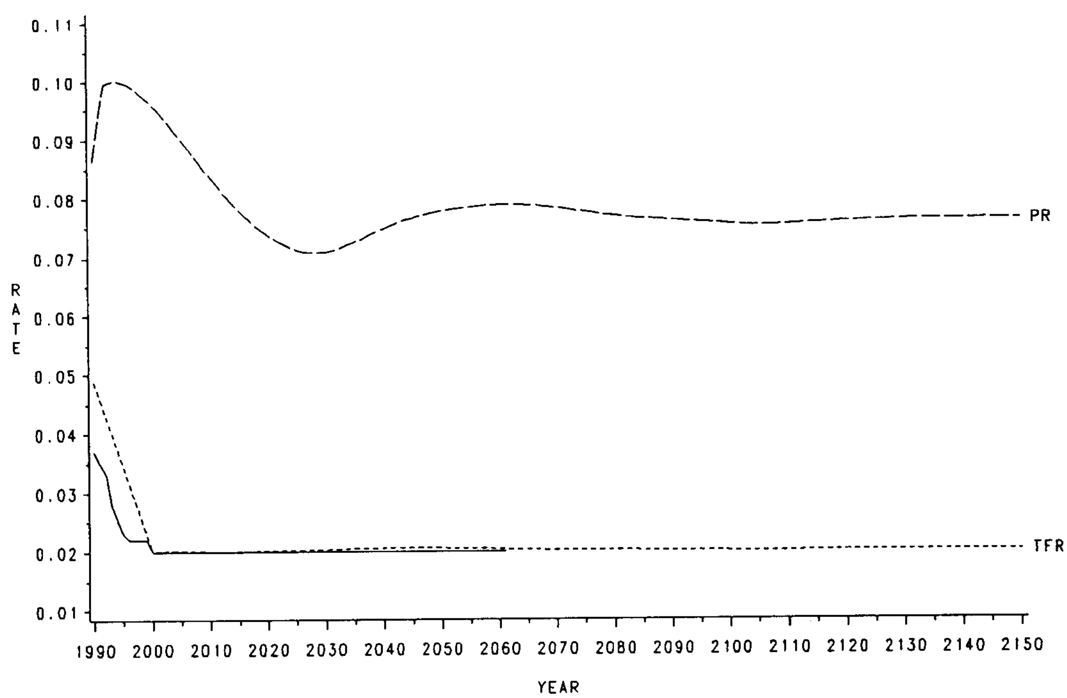


Figure 5

Retired Worker Beneficiaries:
Trustees' Report (solid) and LRM (dashed) Projections, by Year

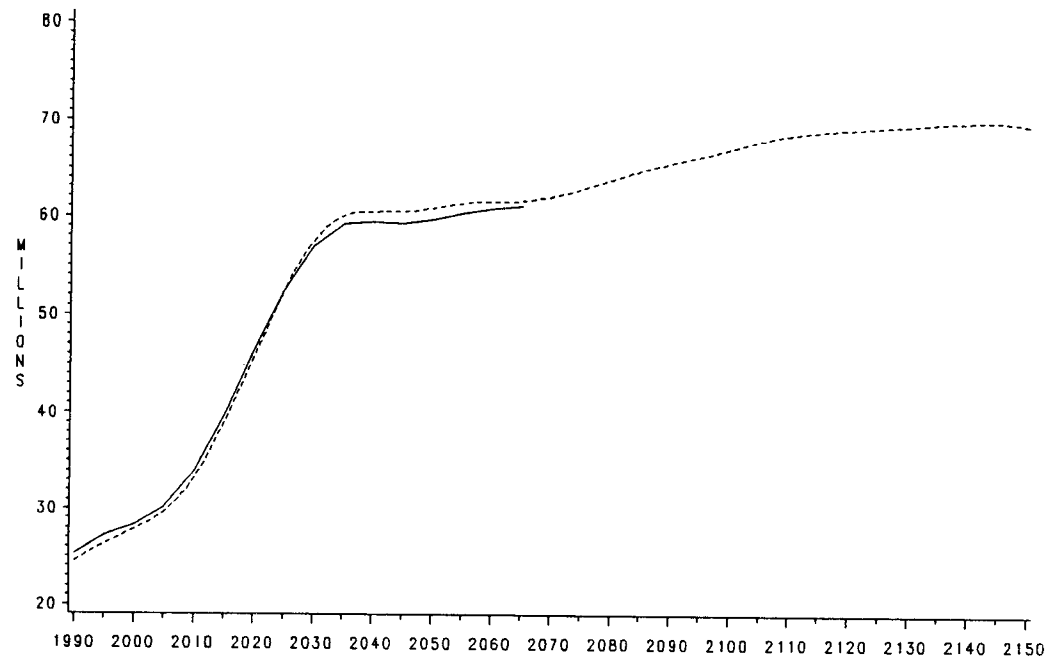


Figure 6

OASI Expenditures as a Percent of Taxable Payroll:
Trustees' Report (solid) and LRM (dashed) Projections, by Year

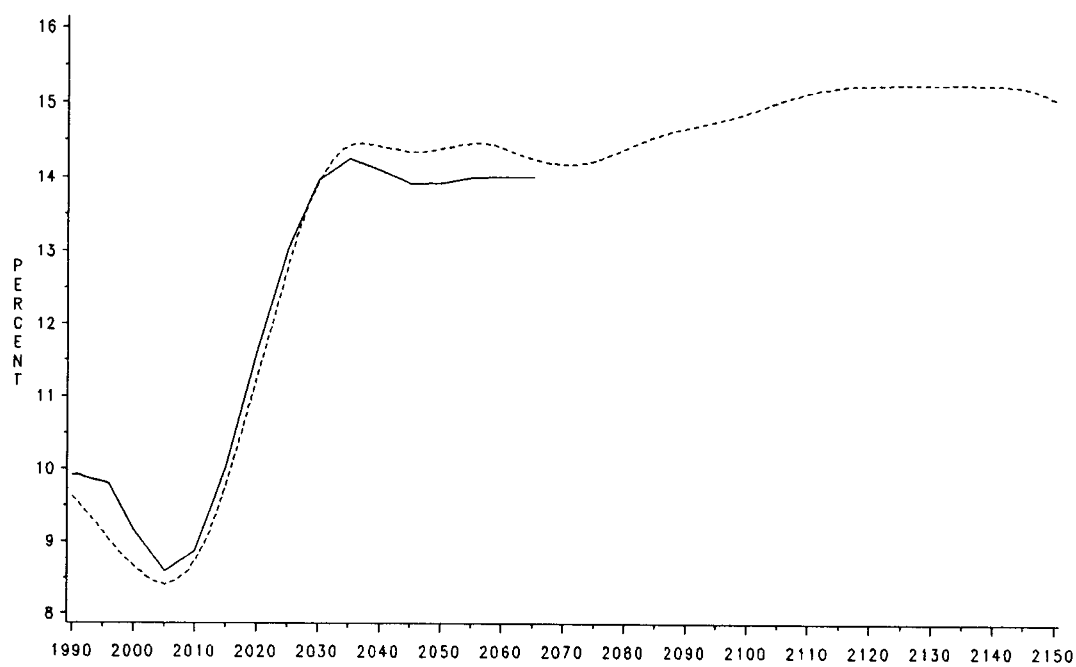


Figure 7

OASI Trust Fund as a Percent of Expenditures:
Trustees' Report (solid) and LRM (dashed) Projections, by Year

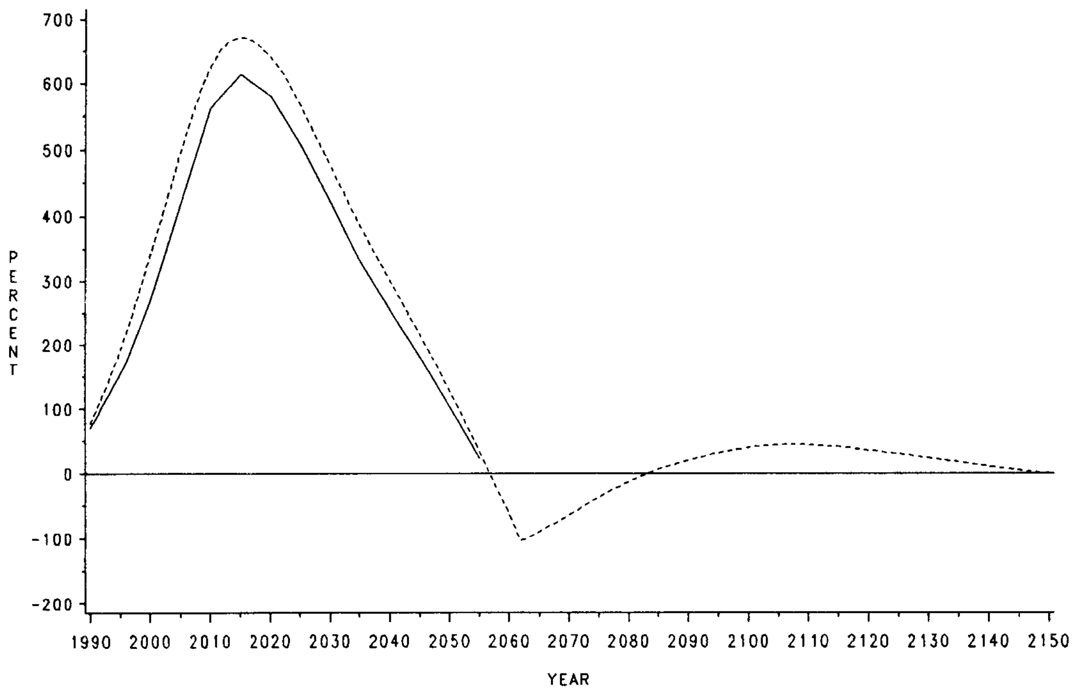


Figure 8

OASI Expenditures Net of General Revenue Reimbursements (Exp) and
OASI Tax Receipts (Tax), as a Percent of Taxable Payroll:

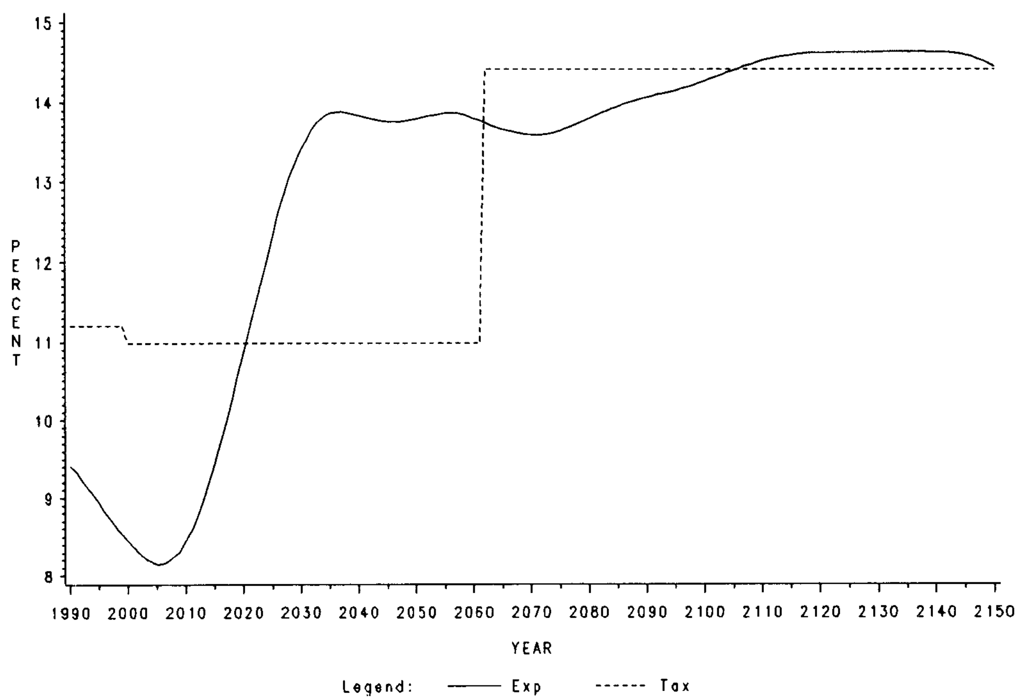


Figure 9

Saving Rates:
Private Saving (PS), OASI Surplus (OASI), Other Government Surplus (OGS), and
Total Saving (S), as a Percent of Gross Output

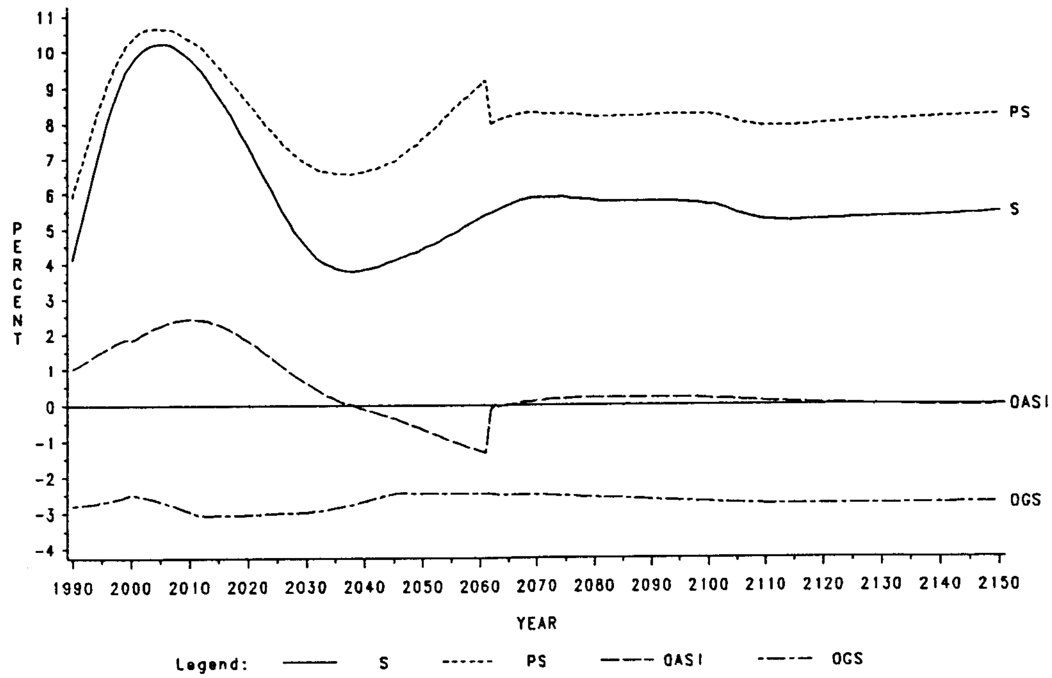


Figure 10

Components of Economic Growth:
Growth Rates in Output per Capita (OPC), Technical Progress (TP),
Productive Population (PP), Labor Quality (LQ), and Capital Deepening (CD)

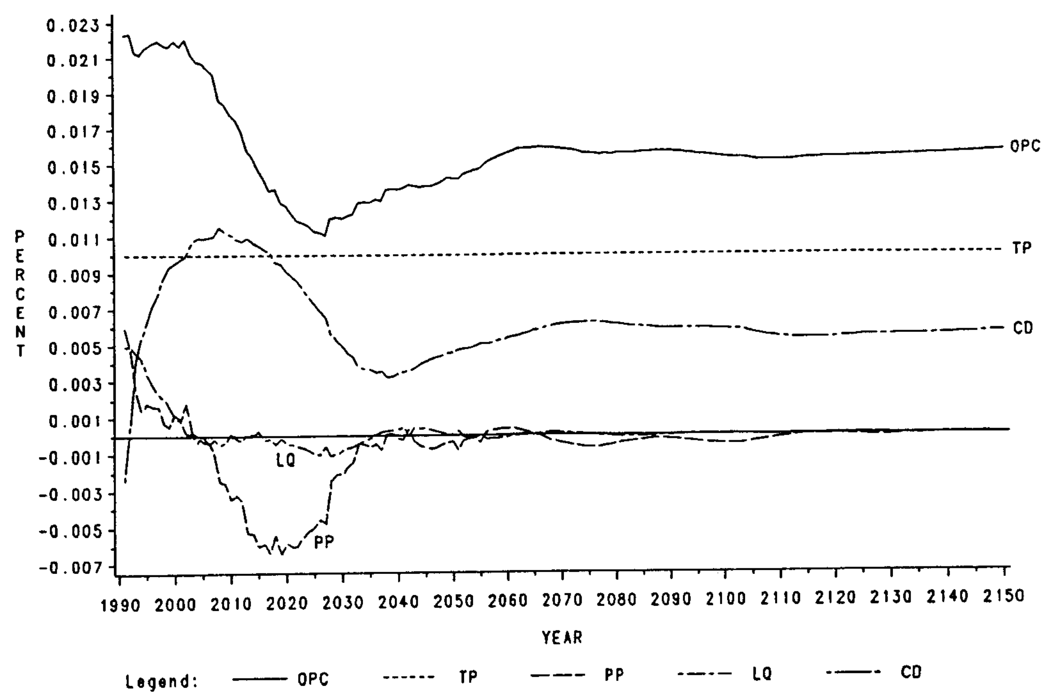
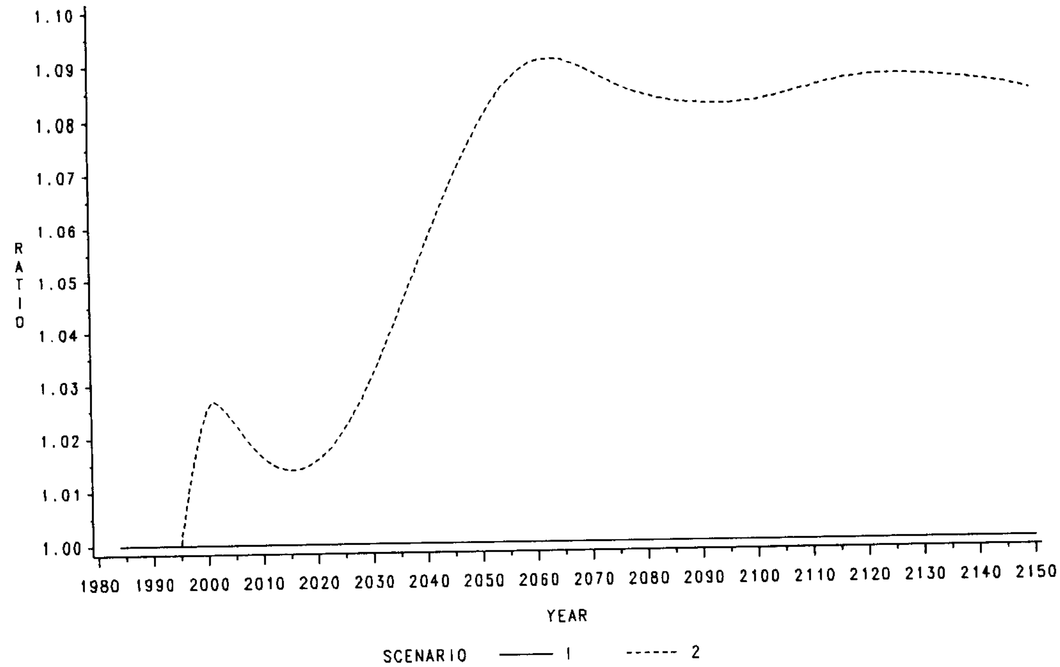


Figure 11

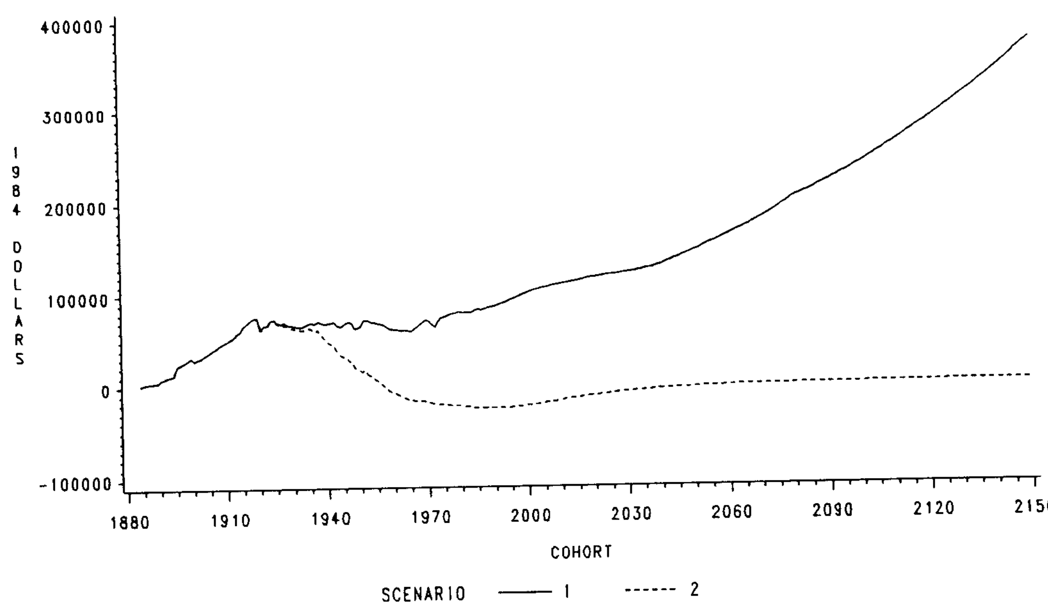
Relative U.S. Capital Stock, by Scenario and Year



Scenario 1: Present Law Scenario 2: Award Reduction

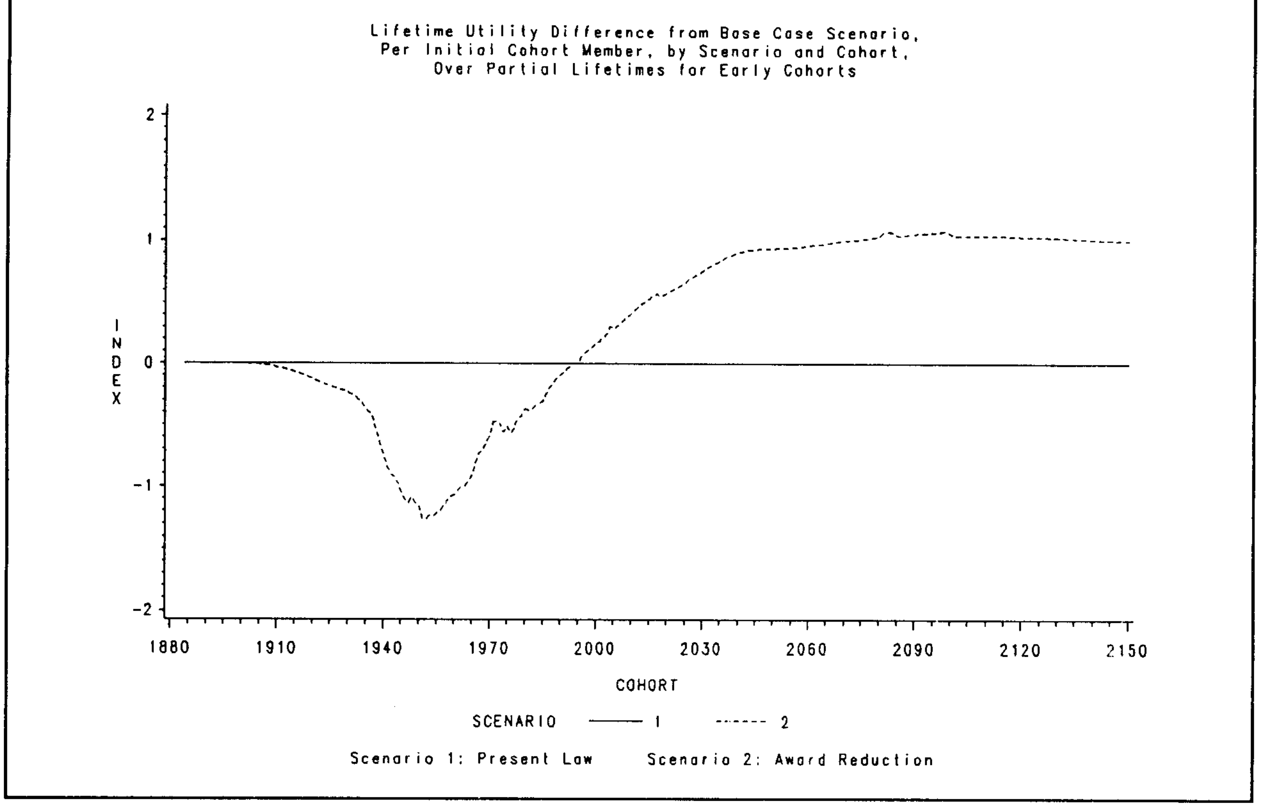
Figure 12

OASI Net Lifetime Wealth Increment
Per Initial Cohort Member, by Scenario and Cohort,
Over Partial Lifetimes for Early Cohorts,
Evaluated as of the Initial Year
at the After-Tax Government Bond Rate



Scenario 1: Present Law Scenario 2: Award Reduction

Figure 13


Lifetime Utility Difference from Base Case Scenario,
Per Initial Cohort Member, by Scenario and Cohort,
Over Partial Lifetimes for Early Cohorts
INDEX
2
1
0
-1
-2
1880
1910
1940
1970
2000
2030
2060
2090
2120
2150
COHORT
SCENARIO
1
2
Scenario 1: Present Law
Scenario 2: Award Reduction

References

Aaron, Henry J., Barry P. Bosworth, and Gary Burtless, *Can America Afford to Grow Old?*, Washington, D.C.: The Brookings Institution, 1989.

Anderson, Joseph M., Dale W. Jorgenson, John F. Moeller, and Daniel T. Sleznick, *The National Institute on Aging Macroeconomic-Demographic Model of Health Care and Consumer Expenditures*, NIH Publication No. 90-2986, U.S. Department of Health and Human Services, National Institutes of Health, 1990.

Board of Trustees, Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds, *1992 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and the Federal Disability Insurance Trust Funds*, Communication to the 102nd U.S. Congress, 2nd Session, 1992, House Document 102-279.

Burtless, Gary, "The Work Response to a Guaranteed Income: A Survey of Experimental Evidence," in Alicia H. Munnell, ed., *Lessons from the Income Maintenance Experiments*, Boston: Federal Reserve Bank of Boston, 1986, 22-52.

Denton, Frank T., Byron G. Spencer, and Christine H. Feaver, "OASI and the U.S. Economy: A Model and Some Long-Run Projections," in U.S. Congress, Joint Economic Committee, *Special Study on Economic Change*, Volume 8, *Social Security and Pensions: Programs of Equity and Security*, 96th U.S. Congress, 2nd Session, December 4, 1980, 1-37.

Leimer, Dean R. and David H. Richardson, "Social Security, Uncertainty Adjustments, and the Consumption Decision," ORS Working Paper No. 40, Office of Research and Statistics, Social Security Administration, November 1989 (abbreviated version forthcoming in *Economica*).

Leimer, Dean R., "The Pareto Optimality of Existing Pay-As-You-Go Social Security Programs," ORS Working Paper No. 47, Office of Research and Statistics, Social Security Administration, June 1991.

Wade, Alice, *Social Security Area Population Projections 1989*, Actuarial Study No. 105, Office of the Actuary, Social Security Administration, June 1989.

Consumption/Investment Sector

(35) $X^R_{a,t} = X^R(r^W_t,\ X^G_{a,t-1})$

(36) $P_{a,t} = W^H_{a,t} + W^S_{a,t} + W^G_{a,t} + W^X_{a,t}$

(37) $C_{a,t} = \gamma_a\ (W_{a,t} + P_{a,t})$

(38) $Y_{a,t} = r^W_t W_{a,t} + H_{a,t} + J_{a,t} + G_{a,t} + X^R_{a,t} - T^O_{a,t}$

(39) $X^G_{a,t} = \left(W_{a,t} + Y_{a,t} - C_{a,t}\right) \left[\dfrac{N^D_{a,t}}{N^N_{a,t}}\right]$

(40) $S^P_{a,t} = Y_{a,t} - C_{a,t} - X^G_{a,t}$

(41) $S^P_t = \sum_a S^P_{a,t}$

(42) $W_{a+1,t+1} = W_{a,t} + S^P_{a,t}$

(43) $I^F_t = x^F_t\, O^g_t$

(44) $I_t = S^P_t + S^O_t + S^S_t - I^F_t$

(45) $K_{t+1} = K_t + I_t$

Long-Run Model Overview Notation Key:

Functions:

b : benefit award computation function
r^D : government bond interest rate function
r^F : OASI trust fund interest rate function
r^W : composite assets rate of return function
X^R : private transfers received function

Time-independent parameters:

α : labor's share of output
γ_a : ratio of private consumption to private consumption wealth, by age
δ : depreciation rate of capital
θ_a : relative profile of other government transfers per capita, by age
$\mu_{s,a}$: benefit recomputation adjustment factor, by sex and age
$\pi_{s,a}$: relative productivity of workers, by sex and age
σ_s : share of births, by sex
ϕ : ratio of NIPA population to Social Security area population

Time-specific variables:

a : subscript denoting age in years
$A_{a,t}$: OASI auxiliary benefits, disaggregated by age
$b_{s,a,j,t}$: individual OASI retirement benefit, by sex, age, and age at retirement
$B_{a,t}$: OASI retirement benefits, disaggregated by age
$C_{a,t}$: private consumption, disaggregated by age
C_t^O : government consumption
$d_{a,t}$: ratio of auxiliary benefits to total retirement benefits, disaggregated by age (exogenous)
D_t : other government debt
$e_{s,a,t}$: individual OASI taxable earnings (per covered worker), by sex and age
$E_{s,a,t}$: employment, disaggregated by sex and age
$f_{a,t}$: fertility rate, by age (exogenous)
F_t : OASI trust fund assets
g_t : general benefit adjustment factor
G_t : other government transfers
$G_{a,t}$: other government transfers, disaggregated by age
$h_{s,a,t}$: individual labor compensation (per worker), by sex and age
$H_{a,t}$: labor compensation, disaggregated by age
$i_{s,a,t}$: proportion of the *t-a* cohort to achieve fully-insured status, by sex and age (exogenous)
I_t : net private domestic investment
I_t^F : net foreign investment

j : subscript denoting age at retirement
J_t : net OASI transfers
$J_{a,t}$: net OASI transfers, disaggregated by age
K_t : capital stock
L_t : effective labor input
$m_{s,a,t}$: mortality rate, by sex and age (exogenous)
$M_{s,a,t}$: net immigration, disaggregated by sex and age (exogenous)
$n_{s,j,t}$: proportion of the fully-insured population retiring at age j, by sex (exogenous)
$N^D_{a,t}$: number of NIPA population decedents, disaggregated by age
$N^D_{s,a,t}$: number of NIPA population decedents, disaggregated by sex and age
$N^N_{a,t}$: NIPA population, disaggregated by age
$N^N_{s,a,t}$: NIPA population, disaggregated by sex and age
$N^S_{s,a,t}$: Social Security area population, disaggregated by sex and age
O^g_t : gross output
O^n_t : net output
$p_{s,a,t}$: labor force participation rate, by sex and age (exogenous)
$P_{a,t}$: prospective private consumption wealth, disaggregated by age
$Q_{a,t}$: OASI benefit taxation payments, disaggregated by age
r_t : profit rate, net of depreciation
r^D_t : rate of return on other government bonds
r^F_t : rate of return to OASI trust fund assets
r^W_t : composite rate of return on fungible consumer assets
$R_{s,a,j,t}$: number of retirees, by sex, age, and age at retirement
s : subscript denoting sex ($1 \Rightarrow$ male, $2 \Rightarrow$ female)
S^O_t : other government surplus
S^P_t : net private saving
$S^P_{a,t}$: net private saving, disaggregated by age
S^S_t : trust fund surplus
τ^K_t : effective tax rate on net profits (exogenous)
τ^L_t : effective tax rate on personal compensation (exogenous/endogenous)
τ^Q_t : effective benefit taxation rate on OASI benefits (exogenous)
τ^S_t : ratio of OASI tax payments to labor compensation (exogenous)
τ^W_t : effective composite tax rate on consumer asset income
t : subscript denoting time period
T^O_t : other government taxes
$T^O_{a,t}$: other government taxes, disaggregated by age
$T^S_{a,t}$: OASI tax payments, disaggregated by age
$u_{s,a,t}$: unemployment rate, by sex and age (exogenous)
$W_{a,t}$: fungible consumer assets, disaggregated by age
$W^G_{a,t}$: prospective other government transfers wealth, disaggregated by age

$W_{a,t}^{H}$: prospective human wealth, net of other government tax liability, disaggregated by age
$W_{a,t}^{S}$: prospective social security benefit wealth, net of social security earnings and benefit taxes, disaggregated by age
$W_{a,t}^{X}$: prospective private transfers receipts wealth, disaggregated by age
x_t^C : ratio of other government consumption to gross output (exogenous)
x_t^e : ratio of average OASI taxable earnings to average labor compensation (exogenous)
x_t^F : ratio of net foreign investment to gross output (exogenous)
x_t^G : ratio of other government transfers to gross output (exogenous)
$X_{a,t}^{G}$: private transfers (bequests) given, disaggregated by age of decedent
$X_{a,t}^{R}$: private transfers (inheritances) received, disaggregated by age of heir
$Y_{a,t}$: disposable private income, disaggregated by age
z_t : technical progress index (exogenous)

ORS Working Paper Series

Division of Economic Research

Recent Working Papers and Staff Reports

Number	Date	Title and Author
35	January 1988	Shifts in the Aged-Nonaged Income Relationship, 1979-85 by Daniel B. Radner
36	January 1988	The Wealth of the Aged and Nonaged, 1984 by Daniel B. Radner
39	September 1989	Reflections on the Income Estimates from the Initial Panel of the Survey of Income and Program Participation (SIPP) by Denton R. Vaughan
40	November 1989	Social Security, Uncertainty Adjustments, and the Consumption Decision by Dean R. Leimer and David H. Richardson
41	January 1990	A Review of the Net Revenue Estimates in Robbins and Robbins, "Paying People Not to Work" by David Pattison
42	March 1990	Alternative Estimates of Economic Well-Being by Age Using Data on Wealth and Income by Daniel B. Radner
45	July 1990	Economic Retirement Studies: An Annotated Bibliography by Michael V. Leonesio
46	July 1990	Simulating Aggregate and Distributional Effects of Various Plans for Modifying the Retirement Earnings Test by David Pattison, Benjamin Bridges, Jr., Michael V. Leonesio, and Bernard Wixon
47	June 1991	The Pareto Optimality of Existing Pay-As-You-Go Social Security Programs by Dean R. Leimer
48	June 1991	On the Existence of Pareto-Superior Reversals of Dynamically Inefficient Social Security Programs by Dean R. Leimer

Recent Working Papers and Staff Reports – Continued

Number	Date	Title and Author
49	July 1991	A Mathematical Demonstration of the Pareto Optimality of Pay-As-You-Go Social Security Programs in a Closed Economy by Dean R. Leimer
50	July 1991	Would Monetary Policy Be Effective if the OASDI Trust Funds Held Most Treasury Debt? by Willem Thorbecke and Tarik Alami
51	September 1991	Changes in the Incomes of Age Groups, 1984-1989 by Daniel B. Radner
52	September 1991	The Demand for Older Workers: The Neglected Side of a Labor Market by John W. Straka
53	December 1991	Social Security and Older Workers by Michael V. Leonesio
54	December 1991	Two Papers on a New SIPP-Based Microsimulation Model of SSI and OASDI by Denton R. Vaughan and Bernard Wixon
55	April 1992	An Assessment of the Economic Status of the Aged by Daniel B. Radner
56	August 1992	Simulating the Long-Run Aggregate Economic and Intergenerational Redistributive Effects of Social Security Policy by Dean R. Leimer