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ABSTRACT

Demographic changes, such as those anticipated in most OECD countries, have many economics effects that impinge on a country's fiscal viability. Evaluation of the effects of associated changes in capital-labor ratios and the welfare and behavior of different generations requires the use of a dynamic general equilibrium model.

The 75 generations - 250 year demographic simulation model, presented in Auerbach and Kotlikoff (1987, Chapter 11), has been modified to incorporate bequest behavior, technological change, the possibility that the economy is open to international trade, and government consumption expenditures that depend on the age composition of the population.

The model has been further adapted to study the effects of impending demographic changes in Japan, the Federal Republic of Germany, Sweden and the United States. The simulation results indicate that these changes will have a major impact on rates of national saving, real wage rate and current accounts. One of this paper's fundamental lessons is that allowing for general equilibrium adjustments reduces the adverse welfare effects of increasing dependency ratios. Nevertheless, the welfare costs, and particularly their distributions across cohorts, pose serious challenges for policy makers in some cases.

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I. Introduction

Demographic changes, such as those anticipated in most OECD countries, have many economic effects that impinge on a country's fiscal viability. For instance, a higher ratio of old (who have saved) to middle aged (who work) is likely to increase a country's capital intensity, raising real wages and the potential for workers to finance government programs. Also, the presence of fewer children per family may reduce child-related spending needs. Of perhaps greatest importance, changes in tax rates and pension attributes are likely to influence household behavior. For example, any anticipated reductions in the generosity of government pension schemes should increase the saving of those currently at work, who would then provide more personal resources for their retirement years.

The impact of a change in the capital-labor ratio and in household behavior can only be measured using a general equilibrium model of the economy, one that takes account of the interaction of decisions of households, producers, and the government. Moreover, to measure the effects of a demographic transition on the behavior and welfare of different generations, it is necessary for such a model to be disaggregated (by age cohorts) and dynamic, describing the experience of each age cohort over time as economic conditions change. The model developed in Auerbach and Kotlikoff (1987), described in some detail below, satisfies these criteria. It is based on the life-cycle model of saving behavior, augmented, however, to include bequests. It traces out and aggregates the labor supply, retirement, consumption, fertility and bequest behavior of individuals born in each year. These choices reflect fully rational responses to current and future tax rates and public pension benefits, which are assumed to be known. Aggregate behavior leads, through the production sector, to a determination of wages and interest rates and, given the stock of government debt, tax rates. Of course, even such a complex model as this lacks many important real world features. For example, it does not take account of differences among individuals within generations with respect to economic attributes or life expectancy, nor does it deal with the short-run macroeconomic problems of inflation and cyclical unemployment. These limitations should be kept in mind when evaluating the model's simulation results.

The 75 generations - 250 year demographic simulation model, presented in Auerbach and Kotlikoff (1987, Chapter 11), has been modified to incorporate bequest behavior, technological change, the possibility that the economy is open to international trade, and government consumption expenditures that depend on the age composition of the population.

We have further adapted the model, initially parameterized only for the United States (but for an arbitrary demographic transition), to simulate the general equilibrium effects of demographic changes in Japan, the Federal Republic of Germany, and Sweden as well. For each country, several questions are addressed. These include:

1. What would happen to government revenue and tax rates if current government spending patterns (i.e. by age groups) are maintained?
2. By how much must social security contribution rates be increased if the current levels of old-age pension benefits are to be maintained?
3. How would national saving rates and real wages be affected by the changing population age structure?
4. What pressures would effects on saving rates and real wages exert on international capital flows?
5. How would the overall well-being of individuals of different

generations be affected by the economic changes associated with the demographic transitions?

6. What would be the impact on economic performance and generational welfare of reductions in the generosity of public pension schemes?

Our analysis indicates that rates of national saving, real wage rates, and current accounts all appear very sensitive to the forecast increases in dependency ratios. General equilibrium analysis highlights the fact that the burden on those who must support this increasing dependent population is somewhat overstated by looking simply at social security contributions, for real wages can be expected to rise and, at least temporarily, other tax rates to fall. The fundamental lesson of general equilibrium analysis is that allowing for adjustments (and assuming that economies are sufficiently flexible for such adjustments to take place) leads to smaller costs from adverse population developments. Nevertheless, the welfare costs, and particularly their distribution across cohorts, pose serious challenges for policymakers in some cases. Thus, policies aimed at cushioning the fiscal burden of the demographic transition, including cuts in old-age pensions and other age-related government spending, can improve the welfare of future generations, although they also reduce the welfare of earlier ones. These must be carefully weighed before one concludes that program cuts are needed or even beneficial.

II. Modelling the Demographic Transition

The model contains three sectors: a household sector, a production sector, and a government sector. For each sector, there is a system of nonlinear equations relating endogenous behavioral variables (e.g. consumption or labor supply) to predetermined economic variables and taste and technological parameters. Jointly solving the equations of the different sectors determines the economy's dynamic equilibrium transition path. The individual components of the model are fairly simple, but their interactions can be quite complex. By solving for the economy's general equilibrium transition path the model takes into account all relevant feedbacks between policy and demographic changes, on the one hand, and changes in the time paths of wages, interest rates, labor supply, and the capital stock, on the other. For example, the gradual capital deepening in a closed economy associated with a baby bust gradually changes real wages and real interest rates. But changes in the time paths of these variables necessitate changes in the time path of tax rates, holding fixed the time path of government consumption. Such changes in fiscal instruments feed back to influence the time path of capital deepening by affecting the time paths of consumption demand and labor supply.

A. Household Behavior

At any given time the household sector comprises seventy-five overlapping generations. These generations correspond to children ages 1-20 and adults ages 21-75. Each year the 75 year-olds die and new children are born. Age 21 is a critical age in the model. At age 21 each individual changes status from that of a child who is cared for by a parent to that of an adult. At this age the individual also becomes a parent with the number of children determined exogenously in the model. Between ages 21 and 41 the parent cares for her (his) children, financing their consumption and receiving any of their labor earnings.

Individual tastes are assumed to be identical for all agents, with differences in behavior being generated entirely by differences in economic opportunities. Since all individuals in an age cohort are assumed identical, differences in economic opportunities are present only across cohorts. Households in the model make decisions about consumption, leisure, and bequests based on their intertemporal preferences.

1. Preferences

Each parent is assumed to have preferences that can be represented by a function whose arguments are i) utility from the parent's own current and future values of consumption and leisure, ii) her (his) children's utility from consumption and leisure through age 20, and iii) utility from the parent's bequest per child. The three components are indicated on the right side of equation (1) which gives an expression for the lifetime utility of a member of a generation who reaches age 21 and becomes an adult and parent at time t. The first term, V_{pt}, refers to the parent's lifetime utility from his or her own annual consumption and leisure from age 21 through age 75. The second term V_{kt} is the child's utility from annual consumption and leisure from age 1 through age 20 (at which time the parent is 40) multiplied by the number of children, N_t. The third term, N_tB_t, is the number of children multiplied by the parent's utility from bequests per child, B_t.

$$(1) \qquad U_t = V_{pt} + N_tV_{kt} + N_tB_t$$

The terms V_{pt} and V_{kt} are expressed in equation (2) in terms of their respective annual components u_{pjt} and u_{kjt}, where the subscript j stands for parent's age, and t still refers to the year the parent becomes age 21:

$$(2) \qquad V_{pt} + N_tV_{kt} = 1/(1-1/\gamma)\left(\sum_{j=21}^{75}(1+\delta)^{-(j-21)}u_{pjt} + N_t\sum_{j=21}^{40}(1+\delta)^{-(j-21)}u_{kjt}\right)$$

In (2) δ is the rate of time preference, and γ is the intertemporal elasticity of substitution.

The annual utility components, u_{pjt} and u_{kjt}, which are functions of annual consumption and leisure, are assumed to have the same constant elasticity of substitution functional form. The annual function takes the form:

$$(3) \qquad u_{ijt} = [c_{ijt}^{1-1/\rho} + \alpha\lambda_{ijt}^{1-1/\rho}]^{(1-1/\gamma)/(1-1/\rho)} \qquad i = p,k$$

where c_{ijt} and λ_{ijt} are, respectively, consumption and leisure of the generation t parent and her (his) child at the parent's age j. The term α is a leisure share parameter, and ρ is the static elasticity of substitution between leisure and consumption. Leisure is measured as a fraction of the maximum amount of time an individual could work in a given year, taking values between zero and one. In the model individuals endogenously retire by choosing a value of leisure equal to one.

Individuals make bequests at age 75 (the end of their lives) leaving equal amounts to each of their age 55 children. In contrast to the formulation by Robert Barro (1974), redistribution between generations, as might be associated with government deficits, is not neutral in this model because parents at age 75 receive utility from the amount of bequests they leave each of their adult children rather than from their adult children's utility. Equation (4) displays the isoelastic function chosen for the utility of bequest component, B_t:

$$(4) \qquad B_t = \nu(1+\delta)^{-54} \, b_{75t}^{1-1/\gamma}$$

In equation (4) ν is a preference parameter that influences the size of bequests, and b_{75t} stands for the bequest made per child by generation t parent when the parent is age 75.

By altering the parameters of the three components of the utility function U_t one can consider a very wide range of shapes of age-consumption and age-earnings profiles as well as levels of bequests. Given the paucity of empirical evidence about age-consumption and age-earnings profiles as well as bequests, it is not possible to identify with precision all of the preference parameters of the particular functional form assumed for U_t. There is little reason, therefore, to resort to a more general, and more complicated, functional form for utility.

2. The Household Budget Constraint

Equation (5) presents the generation t parent's lifetime budget constraint in the absence of government policy. This budget constraint states that the present value of the parent's consumption as well as that of her (his) children when young plus the present value of the parent's bequest equals the present value of the parent's labor earnings as well as that of her (his) children when young plus the present value of the parent's inheritance received at age 55.

$$(5)\quad \sum_{i=t}^{t+54} \prod_{s=t}^{i} [1+r_s]^{-1} [w_i e_j (1-\lambda_{pjt}) - c_{pjt}] + N_t \sum_{i=t}^{t+20} \prod_{s=t}^{i} [1+r_s]^{-1} [w_i e_j (1-\lambda_{kjt}) - c_{kjt}]$$

$$= N_t b_t \prod_{s=t}^{t+54} [1+r_s]^{-1} - b_{t-21} \prod_{s=t}^{t+34} [1+r_s]^{-1}$$

In equation (5) the subscript j equals the generation t parent's age in year i (i.e., $j=21+i-t$). The left hand side of the equation equals the present value difference between the earnings of the parent and her (his) children and their combined consumption, while the right hand side equals the present value of bequests given less the present value of bequests received. The term r_s is the interest rate in year s, w_i is the standardized wage rate in year i (the wage rate of a 21 year old in year i), and e_j is an age-specific adjustment factor to allow for the fact that a worker's productivity varies with age. One may think of the vector e, composed of values of e_j for all j, as the household's "human capital" profile, reflecting its change in earning capacity over time. It is taken as fixed from the household's viewpoint.

In addition to this overall budget constraint, we impose the requirement that labor supply never be negative, i.e., if the parent or child would choose to demand more than one unit of leisure in a given period (there is nothing in the decision problem specified so far to prevent this) the parent or child must "retire" for that year, supplying zero labor. In the solution we introduce shadow wages whose values are set to insure that retirees voluntarily choose to supply precisely zero labor.

The addition of government policy to the problem alters the budget constraint in a straightforward manner. If taxes are proportional, as they are in this model, the pretax wage in year i, w_i, is replaced by $w_i(1-\tau_{yi}-\tau_{wi}-\tau_{ssi})$, where τ_{yi}, τ_{wi}, and τ_{ssi} are income, wage, and payroll tax rates in year i, respectively. The pretax interest rate, r_s, in equation (5) is replaced by $r_s(1-\tau_{ys}-\tau_{ks})$, where τ_{ys} and τ_{ks} are the income and capital income tax rates in year s, respectively. The consumption expenditures of parents and children, c_{pjt} and c_{kjt}, are each multiplied by $(1+\tau_{ci})$ the consumption tax rate in year i. Finally, the right hand side of equation (5) needs to be modified to include the present value of social security benefits.

The conditions determining the parent's optimal choice of her (his) own consumption, leisure, and bequests as well as the consumption and leisure of her (his) young children are found by maximizing equation (1) subject to the version of equation (5) that holds after one includes taxes and social security. With the exception of the choice of bequests, these conditions can be found in Auerbach and Kotlikoff (1987).

B. Firm Behavior and Technological Change

The model has a single production sector that is assumed to behave competitively, using capital and labor subject to a Cobb-Douglas production function. Capital is assumed to be homogeneous and nondepreciating, while labor differs only in its efficiency. That is, all forms of labor are perfect substitutes, but individuals of different ages supply different amounts of some standard measure of labor input per unit of leisure foregone. This amount is the term e_j for age j, introduced above. Capital and labor are perfectly mobile in this version of the AK model, and firms hire capital and labor up to the point that their rental rates equal their marginal products.

The assumption of labor augmenting technological change appears frequently in analyses of growth, where labor augmenting refers here to increasing the effective labor input entering the production function. Unfortunately, unless the utility function is Cobb-Douglas, this assumption, in the presence of variable labor supply, will not be consistent with the economy's arriving at a steady state (see Auerbach and Kotlikoff, 1987). As an alternative we make the assumption that technological change is time augmenting, i.e., it increases the endowment of time entering the individual's budget constraint. Specifically, we assume that each successive cohort of parents has a 1.5 per cent greater endowment of time at each age in its lifespan than had the previous cohort. Since the utility function is homothetic, this implies, in the steady state, that each successive cohort will consume and earn 1.5 per cent more at each age than the previous cohort. While this assumption is consistent with a steady state it does not produce the steepening of the age-earnings profile over the life cycle that arises in standard models of labor augmenting technical change. To generate this feature we have multiplied the e_j factor by the term $(1.015)^{j-21}$ for $j>21$. With this modification, the individual's wage rises by 1.5 per cent per year over and above any age-specific changes in productivity.

In combination, the assumption of time-augmenting technical change and this steepening of the wage profile over the lifespan produces the equivalent of secular wage growth in the economy of 1.5 per cent per year; i.e., in the steady state labor earnings at any age are 1.5 per cent higher in year t+1 than they are in year t, and are also 1.5 per cent higher (over and above human capital accumulation) for a given cohort in year t+1 than in year t.

C. Government Behavior

To study the response of government expenditures to changing demographics we have modified the AK model to allow government expenditures to depend on the age composition of the population. In particular, we divide total government expenditure into four targeted expenditure categories. One of these categories is non age-specific expenditures including items such as defense. We refer to this category as the *per capita* expenditure category, since the expenditure benefits individuals regardless of their ages. The other expenditure categories are those targeted at three age groups, 1-24, 25-64, and 65 plus. In the simulations we use country-specific tax rates to determine the level of government expenditures between 1960 and 1985. For 1985 we apportion the model's total government expenditure to the four expenditure categories using data for each country for 1980 on the shares of expenditures allocated to the four categories. Based on these allocations and the model's 1985 age distribution of population, we determine the 1985 level of expenditure targeted and made to each individual age 1-24 in the model. Similarly, we determine the levels of expenditures targeted and made to each individual age 25-64 and to each individual age 65 plus. Finally, we determine the level of per capita non-age-specific expenditure in the model in 1985. These four numbers are then used to project total government expenditure in each year in the future. The method is simply to multiply the 1985 expenditure level in each of the four categories by the number of individuals in the corresponding four categories in each year in the future.

As mentioned, between 1960 and 1985 the level of government expenditure is determined endogenously by each country's observed level of wage, income, and consumption tax rates. Since government expenditure is fixed exogenously in the model after 1985, one of the tax instruments or the level of government deficit must be endogenous in each subsequent year. In the simulations we let the consumption tax rate adjust endogenously in response to demographics-induced changes in the level of government expenditures and changes in revenues from the other tax bases. With this adjustment process the model satisfies the government's intertemporal budget constraint that requires that the present value of the government's expenditure plus the value of its outstanding debt equal the present value of its tax receipts.

The social security system is kept logically separate in the model, because of its historical legal and financial separation from other government operations, at least in the U.S. Payroll taxes are assessed independently of whatever other taxes on labor income may exist, and benefits are paid for by payroll taxes. In this version of the AK model social security operates on a "balanced budget", "pay as you go" basis in which payroll tax rates are adjusted each year to meet that year's benefit payments.

The model's social security benefits are determined as a fraction (the replacement rate) of the average of wage-indexed labor earnings from age 21 through the social security age of retirement (which may differ from the age of true retirement). The wage-indexation procedure involves multiplying earnings in years prior to the social security retirement age by the ratio of the standardized wage at retirement, adjusted for the 1.5 per cent rate of technical change, to the standardized wage in the year in the past that the earnings were received.

D. Opening the Economy to International Trade

For purposes of this study we have modified the model to permit the possibility that the economy is open and takes factor prices from abroad. Hence, the modified model can be simulated as a closed economy, or it can be simulated as an open economy whose wage and interest rates are determined exogenously by international conditions. In the case of the closed economy simulations, the economy's ownership of assets corresponds to the domestic capital stock. In the case of the open economy simulations, the economy's ownership of assets may differ from its domestic capital stock with the difference corresponding to its net ownership of foreign assets (which could be negative). The difference in any year between the change in the economy's ownership of assets and the change in its domestic capital stock is the economy's current account. In the open economy simulations the economy's domestic capital stock is determined by multiplying its capital-labor ratio by the size of the labor input. The capital-labor ratio is determined such that the marginal products of labor and capital equal the wage and interest rates pegged from abroad. The economy's ownership of assets is determined by adding up the asset holdings of all adults alive at a point in time and adding to this the government's ownership of assets.

E. Equilibrium Under Perfect Foresight

In static general equilibrium models, a general equilibrium solution is one in which the behavior of each sector of the economy is consistent with the prices that are established, and markets clear. The concept of equilibrium is no different in this model, except that the behavior of households, firms and the government must be consistent not only with current prices, but future ones as well. Household labor supply and consumption must be optimal, given the entire future path of interest rates, wage rates, and tax rates. Firm investment decisions must adequately reflect the future behavior of interest rates and wage rates. Government's projected path of tax schedules must satisfy its intertemporal budget constraint. Given the behavior of each sector, markets for labor and capital must clear.

Because of the assumption of perfect foresight (the same would be true even with a limited degree of foresight), behavior of the economy today depends on conditions in the future. One cannot compute a "separate" equilibrium for a given year without a complete characterization of future economic developments. Hence, the solution method must treat the present and future together, with different year's products corresponding to those of different markets in the traditional large-scale static models.

The calculation of the economy's equilibrium transition path, given a particular parametrization, proceeds in three stages. First, we solve for the economy's initial steady state prior to either policy or demographic changes. Second, we solve for the final steady state to which the economy will ultimately converge. And third, we solve for the economy's transition path between the initial and final steady states. The method used to solve for steady states and transition paths is described in detail in Auerbach and Kotlikoff (1987).[1]

III. Calibrating the Model

For every simulation, projections begin in 1960 in order to produce conditions in the 1980s that actually prevailed. For each country, the model's parameters are adjusted so that simulated aggregates match those of the country itself and behavior at the household level is realistic. The targeted variables are: i)the rate of national saving; ii)the social security contribution rate; and iii)tax rates on consumption, labor income and capital income. Household behavior is characterized by lifetime patterns of labor supply, retirement and consumption broadly consistent with available empirical evidence on age-earnings and age-consumption profiles.[2] We now review the choice of parameters.

A. Demographics

The time path of values of N_t, the number of children born to individuals who become parents at time t, was chosen for each of the four countries to approximate, as closely as possible, values by decade from 1960 to 2050 of the age distribution of the population, according to data supplied by the OECD. After 2050, birth rates are fixed at replacement levels so that one may observe the transition the economy will make to its "long-run" state in the absence of further disturbances to the population structure Tables 1 through

4 present by decade the OECD age distributions and the age distributions generated by the model.

The model's age distributions are generally quite close to the OECD projected distributions particularly if one combines the categories 55-64 and 65 plus. The ability of the model to track actual age distributions this well is surprising given that in the real world parents do not all give birth to children at age 21 and do not all die at age 75.

A comparison of these tables across countries indicates that Germany and Sweden are expected to experience quite similar changes in the age distributions of their populations. This is also true of Japan and the United States, although Japan is projected to experience a more rapid aging of its population than is the United States. Compared with Germany and Sweden, Japan and the U.S. had a younger age distribution in 1960. All four age distributions show a marked increase in the fraction of the population over 55, but the timing and especially the magnitude is different. For Germany the fraction over 55 rises from 25 per cent in 1980 to 39 per cent by 2020, reaching a maximum of roughly 41 per cent by 2030. For Japan this fraction rises from 18 per cent in 1980 to 32 per cent by 2010 and reaches a peak of about 34 per cent by 2030. For Sweden the fraction is 28 per cent in 1980 and rises to 35 per cent by 2030. And for the U.S. the 1980 fraction is 21 per cent and rises to 30 per cent by 2020.

B. Preference and Production Function Parameters

For each of the four countries the intertemporal elasticity of substitution, γ, in the utility function (see equation (3)) was set equal to .35, the static elasticity of substitution, ρ, was set equal to .8, and the leisure share parameter, α, was set equal to 1.5. Since the simulation results are somewhat more sensitive to the value of γ than to other parameters, it seemed best to use a common value across countries for this parameter. The time preference rate, δ, (see equation (2)) and the bequest parameter ν were chosen to insure that the model's value for each country's rate of saving out of GDP less depreciation corresponded to the value for this saving rate derived from the OECD historic series on national income and product accounts. The model's 1960 saving rates are 23.3 per cent for Germany, 24.4 per cent for Japan, 15.9 per cent for Sweden, and 10.1 per cent for the U.S. - all of which are extremely close to their actual 1960 values. Because the actual German, Japanese, and Swedish saving rates are so high it was necessary to choose negative time preference rates and fairly large values of the bequest parameter ν to replicate their saving rates. The time preference rates chosen are -5.5 per cent for Germany, -4 per cent for Japan, and -4 per cent for Sweden. For the United States a time preference rate of 1 per cent was chosen. The value of the bequest parameter ν was chosen such that the 1960 ratio of the flow of bequests to the stock of capital equals 4.2 per cent for Germany, 5.2 per cent for Sweden, 3.1 per cent for Japan, and 3.1 per cent for the United States.

At first glance the use of negative time preference rates may seem surprising. But one needs to bear in mind that the shape of age-earnings and age consumption profiles are determined not only by this parameter, but also by the interest rate and the intertemporal elasticity of substitution. For each of the four countries the shapes of these profiles resulting from the combination of parameters and the resulting interest rates are very reasonable. Use of larger time preference rates and larger values of ν, to insure the same 1960 saving rate, would produce slightly less realistic shapes of age-earnings and age-consumption profiles and levels of bequests, but otherwise very similar simulated transition paths. Sweden's somewhat higher ratio of the bequest flow to the capital stock can be explained in the following terms. Given Sweden's high rate of consumption, income, and payroll taxation in 1960, preferences for bequests must be set relatively high in order to explain Sweden's high 1960 saving rate.

As mentioned above, the production function used is Cobb-Douglas, with a capital income share coefficient of .25. The coefficient multiplying the production function is chosen such that each country's 1960 wage is normalized to unity. This normalization does not imply that wage rates in each country are equalized in 1960.

C. Choice of Fiscal Parameters

Between 1960 and 1985, tax rates for each country on capital and labor income are set at historical values of the average rates of tax on these types of income, and the growth rate of government spending during this period is adjusted to keep consumption tax rates in accord with historical values. After 1985, each year's fiscal deficit is set to keep constant the level of national debt *per capita*, and tax rates on capital income, labor income and consumption are chosen to raise the revenue needed to finance spending (including interest payments on the national debt), after accounting for the receipts from new debt issues. In the simulations below, tax rates on capital income and labor income are kept constant, and consumption taxes are made endogenous (i.e. in accordance with budget requirements).

Ages at which public pensions may be received are based on typical behavior in each country, and, following the practice in each, benefits in the simulation model are based on individual earnings histories. For 1960 the model's social security replacement rate was set for each country to produce a payroll tax rate equal to that observed in 1960. After 1960 the social security replacement rate is held fixed and the payroll tax rate is determined endogenously.

OECD data were used to determine values for the four tax rates in the following manner: data on consumption and income tax receipts were adjusted and divided by the relevant tax consumption and income bases. The adjustments involve eliminating from the payroll tax those tax receipts used to finance government programs other than old age pensions. These non old age pension payroll tax receipts were then allocated to wage tax receipts. For a country such as Germany that uses social security receipts to finance many forms of expenditures other than old age pensions this adjustment is quite large. This adjustment explains why our estimated wage tax rates exceed capital income tax rates. It also explains, in part, why the payroll tax rates are less than their statutory tax rates. The other part of the explanation is that the payroll tax rates are being computed relative to total wages plus self employment income rather than relative to covered wage bases. Table 5 presents the values of wage, capital income, consumption, and payroll tax rates in the model for the four countries for 1960 and for 1985.

The procedure for determining the share of non-social security government expenditure targeted to the young, the middle aged, the elderly, and to society in general utilized additional country-specific unpublished OECD data for 1980, concerning the age distribution of expenditures. The method involved first adding to the reported level of general revenue-financed expenditures those payroll tax-financed social security expenditures that are not old age pension payments. The revised total non-social security expenditures were then allocated to the four spending categories. For Germany the respective 1980 shares of non social security expenditures allocated to those under 25, those 25 to 64, those 65 plus, and to society in general are .272, .119, .156, and .453. For Japan the 1980 shares are .261, .085, .083, and .571. For Sweden the 1980 shares are .292, .092, .190, and .426. And for the U.S. the 1980 shares are .291, .060, .071, and .578. The much larger share of expenditures targeted to the elderly in Germany and Sweden reflects, in part, the fact that the elderly represented a larger fraction of the population in 1980 than in Japan or the U.S.

A final fiscal variable is the initial level of government assets. The choice of these levels of net government assets was determined in large part to help achieve the observed 1960 saving rates. Unfortunately, the value of government assets, including assets such as land and mineral rights, is poorly understood. Hence, there is no firm empirical basis for choosing the level of net government assets, and we, therefore, chose an equal value of percapita government assets for each country. Fortunately, the simulation results are not very sensitive to the choice of the mix of the time preference rate, the bequest coefficient ν, or the initial level of net government assets used to achieve the observed 1960 saving rates.

IV. Simulation Results

Alternative simulations are required to analyze the economic effects of the demographic transition and the impacts of policy changes. Baseline simulations assume that there will be no change in the average replacement rate, the initial age at which such pensions may be received, or the pattern of public spending after 1985. That is, except for general growth associated with the 1.5 annual per cent rate of technical change, per capita expenditures specific to each of three age-groups (under 25, 25 to 64, and 65 and over) are held constant, while outlays not identifiably age-specific (such as national defence) are kept constant per person in the total population. These baseline projections also assume a closed economy. Alternative projections consider the impact of particular fiscal changes and of relaxing the closed economy assumption.

A. Baseline simulations

Table 6 describes the simulated transition paths for the four countries under the baseline assumptions. Listed for selected years along these paths are the consumption tax rate, the social security contribution rate, the national saving rate, the real wage rate, and the real after-tax wage rate, the latter two shown relative to their 1960 levels.[3] As explained above, due to differences in definition, the social security contribution rates shown for 1960 and 1985 are lower, and the consumption taxes higher, than the statutory rates that prevailed in those years.[4]

The net national saving rate equals the level of public and private saving (GDP less public and private consumption and depreciation) divided by net domestic product (GDP less depreciation). This broad measure is preferable to narrower measures of saving such as private and personal saving because it is independent of the country-specific differences in the allocation of activities between public and private sectors and, within the private sector, between households and firms.

The aggregate 1960 characteristics of the four countries indicate considerable differences among them. Higher consumption tax rates and social security contribution rates in Germany and Sweden mirror the generally higher rates of taxation and public share of GDP in those countries than in Japan and the United States, although the gaps in contribution rates are larger than can be explained by differences in the public share of output alone. This reflects the additional fact that Germany and Sweden in 1960 already had more slowly growing populations and higher ratios of retired persons to working adults than did Japan or the United States. Rates of national saving are also quite different, as Germany and Japan saved a greater fraction of national income than either Sweden or the United States.

To a large extent, the changes evident in Table 6 between 1960 and 1985 are associated with shifts in fiscal policy. Perhaps the most noticeable change is the considerable rise in the consumption tax in Sweden, reflecting the rapid growth in the share of GDP absorbed by the public sector in that country. However, the effects of earlier declines in birth rates are also present. Each country exhibits a decline in its national saving rate between 1960 and 1985, attributable to a movement of a relatively large cohort into the period of life when life-cycle dissaving occurs. Despite this decline in saving rates, one also observes increases in real wages, due to the scarcity of labor associated with relatively small working age populations. This effect is particularly noticeable even in 1985 in Japan, where the real wage is 2.3 per cent above trend.

Between 1985 and 2050 and thereafter, considerable changes are observed in the aggregate measures shown in Table 6. First, in each country, the consumption tax rate generally declines during the transitional period, after which it increases, although the long-run rate is lower than in 1985 in all countries except Sweden. The lower consumption tax rate reflects both the interactions of changes in the age distribution over time and differences in _per capita_ public outlays by age group, as well as the fact that the consumption base is larger in an older society than in a younger one. Cross-country differences also arise from differences in both demographic developments and the age composition of social expenditures.

Second, the social security contribution rates increase in all four countries as a consequence of population ageing, although they settle at an intermediate level in the final steady-state. The rise is particularly large in Germany, where the contribution rate nearly doubles. In all four countries, the social security contribution rate required for old-age income support is lower in the final steady-state than its transitional peak. This is due to the fact that in each country (to a varying degree), the post world-war II behavior of fertility will result in an "overshooting" of the ultimate age composition. Each population will have an interim age structure that is older, on average, than in the long run.

Third, the simulations suggest that demographic prospects may have important effects on national savings rates, given the underlying life-cycle framework of the model. Over the long term of the simulation period, population ageing would result in a general decline in the national savings rates of all four countries, although at different rates and with different intensities. In the United States, the national savings rate would remain roughly unchanged for several decades, after which it would decline gradually. This "flatness" of the trend in the national savings rate in the United States arises in large part from the fact that consumption already begins to rise early in the period given the model's assumption of perfect foresight, future real wage increases lead to lower saving today. Also, ageing is more gradual in the United States. In Japan, the quite rapid drop in the national savings rate reflects the speed of population ageing assumed in the model. This contrasts with the simulated path of German savings, which decline more gradually and only after rising for a while during the period 2000-2010. The national savings rates of Japan and Sweden rise toward the end of the period shown, reflecting a recovery from the demographic "overshoot" discussed above. This upturn in national savings rates does not occur in the other two countries until the second half of the next century.

Fourth, real wages are heavily affected by demographic developments. Differences among the countries are partially attributable to demographic factors. Germany and Sweden begin the simulation period with older populations than either Japan or the United States, leading to smaller changes in the age structure under the long-run assumption of zero population growth. As a result, the relative increases in capital intensity and real wages associated with population ageing are smaller in these two countries. The simulated poor real wage performance of Sweden relative to Germany is due to the much faster growth in the size of government in Sweden during the period 1960-85, a result due in part to the fact that the model treats all government outlays as consumption.

A useful way of isolating the overall fiscal strain one may expect from this ageing of populations is to consider evolution of real after-tax wages, with the trend attributable to technical change removed. As is evident from Table 6, increases in social security contribution rates overstate this burden; in the demographic transition, real before-tax wage rates also rise, and consumption tax rates may fall, also contributing to larger after-tax real wages. In some cases, after-tax real wages rise in spite of higher pension financing requirements. In the United States, for example, the social security contribution rate rises from 7.6 per cent to 12.5 per cent between 1985 and 2050, an increase of 4.9 percentage points in the tax rate, implying a decline of roughly the same percentage in the real after-tax wage rate. However, the consumption tax rate declines from 9.7 per cent to 6.6 per cent, implying a rise of roughly 3.1 percentage points in the real after-tax wage rate, while the real wage rate (detrended) itself rises by 4.7 percentage points. Overall, the adjusted real wage rate increases by nearly 2 per cent. Indeed, the real after-tax wage rate in the United States is lower in 1985 than in any subsequent year in the table. While this is true of no other country, each country experiences at least temporary real wage rate improvement after 1985 even as social security contributions are rising. Japan, like the United States, is projected to have a higher after-tax wage in 2050 than in 1985. This relatively favorable outcome for the United States and Japan reflects a key difference between these countries and Sweden and Germany: their old-age pensions are considerably less generous.

B. Simulations of Selected Policy Responses

The foregoing results suggest that, despite the economic changes wrought by changing population structure, the burden of higher social expenditures may not be a uniformly serious problem. Nevertheless, it is useful to consider the possible implications of changes in the level of old-age pensions or other social programmes aimed at easing the burden of rising social expenditures per worker. In this respect, three types of policies are assumed: i)a smoothing of expenditures financed by general revenues; ii)reductions in old-age pensions through increases in the age of initial benefit receipt; and iii)reductions in the "replacement rate", the ratio of benefits to pre-retirement wages. Tables 7a-d present the simulated results of such experiments for the four countries. The first column in each table repeats the baseline results from Table 6 for the country in question.

a) Constant government outlays per member of the total population

The baseline projections assume that components of government spending on the young, middle aged, elderly and overall population each grow at 1.5 per cent per year per member of the associated age group, even as the fraction of such individuals in the total population changes. In particular, as the fraction of elderly in the population increases, there is no adjustment in the level of spending per elderly individual. Suppose, instead, that the level of such expenditures is held fixed per person in the total population. This would entail cutting expenditures per retiree as the fraction of retirees in the population rises. The effectiveness of such a policy in reducing the rise in general revenues can be seen in comparing the second column with the first in each panel of Table 7.

For each country, the tax relief would be considerable during the period of greatest fiscal strain (as measured by the real after-tax wage). By 2050, the consumption tax rate in the United States could be cut to 5.4 per cent from 6.6 per cent in the baseline simulation, and from 17.2 per cent to 11.2 per cent in Germany. In Japan, the cut would be from 9.9 per cent to 7.7 per cent in 2030, while in Sweden, the reduction would be from 40.0 per cent to 34.1 per cent. The gains are clearly largest in Germany and Sweden, those countries with the highest levels of government spending and taxes. In each country, the reduction in the real after-tax wage rate remains but is considerably smaller.[6]

b) <u>Raising the retirement age</u>

The second policy simulation is a 2 year increase in the age of initial benefit receipt, the results of which are shown in the third column of each panel of Table 7. A one-year increase in retirement age is introduced for individuals reaching the previous retirement age in 2000, followed by another one-year increase in 2010. As in the previous section, this policy has a substantial impact on the social security contribution rates required after the year 2000, the period during which their sharpest rise would otherwise occur. In Germany, for example, the social security contribution rate in 2030 is projected to be 19.8 per cent instead of 24.7 per cent, the reduction being from 32.7 per cent to 25.5 per cent by 2050. A similar impact is observed for Sweden, where the policy effectively smoothes the social security contribution rate, causing it to remain between 17.4 per cent and 18.5 per cent for the entire 1985-2050 period.

Other aggregate changes are observed as well. Because this policy reduces the size of the unfunded liability of the government, the simulation of an increase in retirement age induces a rise in personal saving by prospective retirees. In Germany and Sweden, where such cuts are larger relative to lifetime resources, the national saving rates is over a percentage point above its level in the base case. This additional saving leads to higher real wages and higher incomes, and hence lower consumption tax rates necessary to fund other government programs. Thus, all three factors determining real after-tax wage rates work in the same direction, and after-tax wage rates increase substantially. The after-tax wage rate in Germany increases by 13 per cent in 2050 relative to the baseline simulation, while in Sweden, it increases by 10 per cent. The increases in the same year in Japan and the United States are 3 per cent and 5 per cent, respectively.

As indicated, it is possible to compare the benefits of these increases in after-tax income to the costs of pension benefit cuts and arrive at an overall measure of the policy's impact on individual welfare. It is important that these measurements be made for members of different generations, for the policy affects individuals born at various dates differently. Calculations for members of selected cohorts are presented in the first column of Table 8. The numbers shown are the percentage increases (or decreases) in potential lifetime consumption (including the value of leisure) induced by the policy change. In each country, individuals born in 1960 are worse off because of the reduced value of old-age pension benefits. Conversely, those born in 201 are better off because, although they receive lower benefits, they also receive the higher after-tax real wages just discussed. Except in the United States, individuals born in 1985 do not benefit from these higher real wages for long enough to offset the reduced retirement benefits.

c) Benefit reduction

The approach considered here is a uniform 20 per cent cut in benefits. The simulated transition to this regime assumes that, beginning in 1990, benefits are reduced by 1 per cent per year until the entire 20 per cent reduction has occurred, in 2010. The results, shown in the fourth column of the panels of Table 7, are similar to those of the previous set of simulations. Social security contribution rate increases are mitigated, national saving rates rise, consumption tax rates fall and real wages before-tax and after-tax increase. For Sweden and the United States, the two policies have very similar quantitative effects as well, with changes in the social security contribution rates in 2030 and 2050 being almost identical. In Germany and Japan, the benefit cut has a somewhat greater impact than the increase in age of initial benefit receipt because these countries begin benefits at an earlier age and hence pay them for more years per typical retiree.

Like the previous policy option, too, the cut in benefit levels helps some generations at the expense of others. Comparing the two columns in Table 8, one observes that in each country, as before, those born in 1960 lose and those born in 2010 gain. However, both losses and gains are of a larger magnitude. The timing of gains and losses is different, too. Individuals born in 1985 fare better under the benefit cut policy in Japan, Sweden and the United States. This difference is due to the somewhat earlier date of the policy's commencement.

d. The case of open economies

All of the previously reported simulations are based on a "closed economy" assumption (i.e. changes in domestic saving, interest rates and wages are assumed to have no impact on the country's current and capital accounts). The closed economy assumption is obviously very restrictive, but taking the OECD area as a whole, it is perhaps less unrealistic than at first glance, since most countries will be experiencing comparable demographic transitions. Nevertheless, because such transitions are not perfectly synchronized, it is useful to consider the alternative (equally) extreme "open economy" assumption. Here, each country is considered to be sufficiently small and open to international movements of both goods and capital such that domestic wage rates and interest rates are pegged from abroad. In fact, the model structure is such that international trade flows induced by the demographic shifts have no feed-back effects. Incipient changes in the domestic capital-labor ratio (such as would arise from large swings in population growth rates) induce international capital outflows or inflows to preserve the pre-existing factor returns. Hence, increased national saving generates a capital account deficit (and, consequently, a current account surplus) rather than more domestic capital formation. As a result, real wage rates do not fluctuate as in the closed economy simulations.

In the last column of the panels of Table 7 are shown simulated economic paths based on this "small open economy" assumption. For purposes of comparison, each country is assumed to begin with balanced current and capital accounts, so that the economy in 1960 is the same as in previous simulations in which such balance was imposed. After 1960, the simulations diverge from those reported for the base case because of the economic consequences of international flows. Current accounts of the four countries, expressed as a fraction of net domestic product, are shown in Table 9.

A striking result of this last set of simulations is how little the social security contribution rates are affected by the open economy assumption. This results from the fact that the model follows the normal practice of indexing old-age pension benefits for the growth in real wages occurring between years of work and year of retirement. In the open economy simulations, where real wages (relative to trend) are fixed, benefits are correspondingly also fixed, and contribution rates need not be increased to offset the lower wage base than in the closed economy simulation. However, because other government spending programs are not assumed to be indexed in the same way, consumption tax rates <u>are</u> higher in this final set of simulations. This effect is least important in Sweden, which exhibits little increase in real wages even in the base case.

In the closed economy simulations, real wage rates rise and interest rates fall as the result of capital-deepening. In the open economy case, one might expect higher saving rates during this period, since capital flowing abroad prevents domestic interest rates from falling and provides a greater incentive to save. Indeed, saving rates do rise noticeably in Japan and, to a lesser extent, in the United States relative to the baseline simulation. The effects are quite small in Sweden and Germany, however.[7]

Obviously, it would be incorrect to interpret these simulations as suggesting that gains from free international trade would not be significant.

Unchanging real wage rates over the simulation period reflect the assumption that the underlying productivity trends (i.e. the rate of technical progress, or total factor productivity) are the same in both open and closed economies. For a number of reasons, the growth in total factor productivity might be significantly and positively related to the openness of trade.

The current accounts associated with these open economy transitions are quite dramatic, reflecting the extreme assumption of perfect capital mobility and asset substitutability and no international mobility of labor. The magnitudes are relatively small for Sweden and the United States, consistent with the smoother demographic transitions projected for the two countries. Japan, and especially Germany, are simulated to have much larger swings in their current accounts, as large incipient increases in capital-labor ratios lead to significant outflows of capital and associated surpluses in their current accounts. These increases are due greatly to declines in the domestic labor force. Germany, for example, is projected to experience a significant absolute decline in total population during the transition period and a much larger decline in its labor force. All countries experience much larger current account imbalances during the transition period than are predicted for the long run, reflecting the potential effect which population swings can have on an economy's stocks of capital and labor.

Clearly, a country's capital and current accounts are influenced by many factors (e.g. differential rates of growth of domestic demand, fiscal and monetary policies, constraints on capital flows, international variations in rates of capital taxation, etc.), and the simulations presented here represent very conditional potential outcomes. Moreover, these projections, derived from a model of unlinked economies, implicitly treat the rest of the world as a sink, able to absorb the capital flows arising from the demographic transitions. The partial nature of these simulations is underscored by disparities between the current account projections from 1960 to 1985 and what actually occurred. Thus, while this exercise identifies *ex ante* pressures arising from demographic forces, it does not provide guidance concerning how they might be resolved given the general pattern of ageing populations and the simple accounting fact that capital outflows of one country must be inflows of another.

V. Conclusions

Although the model and its simulations necessarily involve restrictive assumptions that make it inappropriate to rely heavily on their specific numerical predictions for policy purposes, they do provide important insights into the complex economic effects of the demographic transition that is in progress. They confirm intuition that significant changes in demographic structure underway in Germany, Japan, Sweden and the United States will have a major impact on economic performance. One may infer that this experience will be shared by other OECD countries confronting similar population projections.

Footnotes

1. One question that may be raised with respect to the solution to any equilibrium is its uniqueness. Laitner (1988) has recently completed an extensive study of the uniqueness properties of the AK model. He computed the eigenvalues of the model and showed that the model's transition path is locally unique for the range of parameter values examined in Auerbach and Kotlikoff (1987). This range of parameters encompasses those used in this study.

2. In particular, this means consumption growth of about 2 per cent per year, a transition to full-time work in the early '20s, and a steady reduction in average hours worked late in life, with full retirement occurring before age 75.

3. Hence, each country has a relative wage of 1.0 for 1960. A value of 1.0 in 1985, for example, would represent a wage rate equal to the 1960 real wage multiplied by 1.015 raised to the 25th power. A wage rate above or below 1.0 in any year indicates an increase or decline in wages relative to this general growth trend. The real after-tax wage is this detrended real wage rate less the social security contribution rate and after accounting for the higher relative price level resulting from the consumption tax. (Other taxes on labor income are omitted from this calculation because they are held constant after 1985.) Thus, for example, if the detrended real before-tax wage rate is equal to 1.0, and the social security contribution and consumption tax rates are 0.10 and 0.15, respectively, the real after-tax wage is equal to [1-0.10]/[1+0.15], or 0.78. Hence, it measures the purchasing power of labor income.

4. In addition, the consumption tax rates for 1985 differ slightly from those

reported in Table 5 because of the computational difficulty and expense calibrating the model exactly. However, these deviations are inconsequential.

5. This estimate is clearly affected by the assumption about the rate of technical change, since Japan's post-war trend in wages exceeds that of most countries.

6. It is, of course, impossible to make overall welfare judgments about policies of this sort without knowing the value of the foregone social expenditures.

7. It must be remembered that this experiment is a complicated one; not only are rates of return increased, but the real wages out of which savings come are reduced relative to the closed economy assumption. With higher consumption tax rates, real after-tax wage rates are reduced even more than before-tax wage rates

References

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

Laitner, John, "Tax Changes and Phase Diagrams for an Overlapping Generations Model," mimeo, May 1988.

Table 1
POPULATION AGE DISTRIBUTIONS FOR GERMANY

Age Group	1960 OECD	AK Model
0 - 14	21.7	22.8
15 - 34	29.6	29.0
35 - 54	25.9	25.2
55 - 64	12.2	11.3
65 PLUS	10.6	11.6

Age Group	1970 OECD	AK Model
0 - 14	23.2	23.4
15 - 34	28.0	28.8
35 - 54	23.4	25.0
55 - 64	12.3	11.3
65 PLUS	13.2	11.5

Age Group	1980 OECD	AK Model
0 - 14	18.2	17.6
15 - 34	29.5	31.5
35 - 54	27.2	26.6
55 - 64	9.6	12.0
65 PLUS	15.5	12.2

Age Group	1990 OECD	AK Model
0 - 14	14.9	14.7
15 - 34	30.1	30.2
35 - 54	27.8	28.8
55 - 64	11.6	13.0
65 PLUS	15.6	13.3

Age Group	2000 OECD	AK Model
0 - 14	15.5	14.2
15 - 34	23.7	24.5
35 - 54	30.2	32.5
55 - 64	13.6	14.2
65 PLUS	17.0	14.6

Age Group	2010 OECD	AK Model
0 - 14	13.3	11.9
15 - 34	21.7	22.5
35 - 54	31.6	32.8
55 - 64	13.3	16.2
65 PLUS	20.2	16.6

Table 1 (cont'd)
POPULATION AGE DISTRIBUTIONS FOR GERMANY

2020

Age Group	OECD	AK Model
0 - 14	13.2	12.2
15 - 34	21.9	21.2
35 - 54	26.1	27.9
55 - 64	17.2	19.6
65 PLUS	21.6	19.1

2030

Age Group	OECD	AK Model
0 - 14	14.6	12.3
15 - 34	20.0	20.0
35 - 54	24.5	26.7
55 - 64	15.1	17.3
65 PLUS	25.9	23.7

2040

Age Group	OECD	AK Model
0 - 14	14.6	12.9
15 - 34	20.6	21.5
35 - 54	25.0	27.1
55 - 64	11.8	15.8
65 PLUS	28.0	22.7

2050

Age Group	OECD	AK Model
0 - 14	15.9	13.7
15 - 34	22.2	22.5
35 - 54	22.9	26.5
55 - 64	14.0	17.3
65 PLUS	25.0	20.0

Final Steady State

Age Group	AK Model
0 - 14	18.7
15 - 34	26.7
35 - 54	26.7
55 - 64	13.3
65 PLUS	14.7

Table 2
POPULATION AGE DISTRIBUTIONS FOR JAPAN

Age Group	1960 OECD	AK Model
0 - 14	na	29.3
15 - 34	na	31.5
35 - 54	na	22.5
55 - 64	na	8.7
65 PLUS	na	8.0

Age Group	1970 OECD	AK Model
0 - 14	na	24.6
15 - 34	na	33.6
35 - 54	na	24.0
55 - 64	na	9.3
65 PLUS	na	8.6

Age Group	1980 OECD	AK Model
0 - 14	23.6	22.6
15 - 34	30.7	32.6
35 - 54	28.1	25.7
55 - 64	8.6	10.0
65 PLUS	9.1	9.2

Age Group	1990 OECD	AK Model
0 - 14	18.6	12.1
15 - 34	28.3	33.4
35 - 54	29.8	31.2
55 - 64	11.7	12.1
65 PLUS	11.6	11.1

Age Group	2000 OECD	AK Model
0 - 14	17.5	20.0
15 - 34	27.4	23.8
35 - 54	27.8	30.8
55 - 64	12.2	13.2
65 PLUS	15.1	12.2

Age Group	2010 OECD	AK Model
0 - 14	18.5	12.7
15 - 34	23.2	23.1
35 - 54	26.3	32.5
55 - 64	14.5	16.5
65 PLUS	17.6	15.2

Table 2 (cont'd)
POPULATION AGE DISTRIBUTIONS FOR JAPAN

Age Group	2020 OECD	AK Model
0 - 14	16.8	19.6
15 - 34	24.0	23.1
35 - 54	26.9	24.3
55 - 64	11.4	15.5
65 PLUS	21.0	17.4

Age Group	2030 OECD	AK Model
0 - 14	16.8	14.4
15 - 34	25.1	24.7
35 - 54	23.9	24.5
55 - 64	14.2	17.5
65 PLUS	20.1	18.9

Age Group	2040 OECD	AK Model
0 - 14	16.9	16.4
15 - 34	23.4	27.0
35 - 54	24.8	26.8
55 - 64	12.2	9.7
65 PLUS	22.7	20.1

Age Group	2050 OECD	AK Model
0 - 14	16.6	15.1
15 - 34	23.5	25.3
35 - 54	25.9	28.9
55 - 64	11.2	17.8
65 PLUS	22.8	12.9

Final Steady State

Age Group	AK Model
0 - 14	18.7
15 - 34	26.7
35 - 54	26.7
55 - 64	13.3
65 PLUS	14.7

Table 3
POPULATION AGE DISTRIBUTIONS FOR SWEDEN

1960

Age Group	OECD	AK Model
0 - 14	22.4	22.3
15 - 34	26.0	28.7
35 - 54	28.4	25.4
55 - 64	11.4	11.6
65 PLUS	11.7	12.0

1970

Age Group	OECD	AK Model
0 - 14	20.3	20.6
15 - 34	28.7	29.4
35 - 54	24.5	26.0
55 - 64	12.3	11.8
65 PLUS	13.7	12.2

1980

Age Group	OECD	AK Model
0 - 14	19.6	19.6
15 - 34	28.6	28.9
35 - 54	23.7	26.7
55 - 64	11.8	12.2
65 PLUS	16.3	12.6

1990

Age Group	OECD	AK Model
0 - 14	17.3	16.8
15 - 34	27.5	28.4
35 - 54	27.3	28.4
55 - 64	10.1	13.0
65 PLUS	17.8	13.4

2000

Age Group	OECD	AK Model
0 - 14	17.5	17.6
15 - 34	26.0	26.0
35 - 54	28.1	28.7
55 - 64	11.9	13.7
65 PLUS	16.6	14.1

2010

Age Group	OECD	AK Model
0 - 14	17.0	16.9
15 - 34	24.3	24.7
35 - 54	27.7	28.5
55 - 64	13.6	14.7
65 PLUS	17.5	15.2

Table 3 (cont'd)
POPULATION AGE DISTRIBUTIONS FOR SWEDEN

	2020	
Age Group	OECD	AK Model
0 - 14	16.2	16.2
15 - 34	24.1	25.4
35 - 54	26.1	27.0
55 - 64	12.8	14.8
65 PLUS	20.8	16.6

	2030	
Age Group	OECD	AK Model
0 - 14	16.6	16.6
15 - 34	23.4	25.0
35 - 54	24.8	26.3
55 - 64	13.3	15.1
65 PLUS	21.8	17.0

	2040	
Age Group	OECD	AK Model
0 - 14	16.8	16.1
15 - 34	23.4	25.1
35 - 54	25.3	27.7
55 - 64	11.8	13.7
65 PLUS	22.7	17.4

	2050	
Age Group	OECD	AK Model
0 - 14	17.3	16.0
15 - 34	24.0	25.4
35 - 54	24.7	27.7
55 - 64	12.3	14.8
65 PLUS	21.8	16.1

Final Steady State

Age Group	AK Model
0 - 14	18.7
15 - 34	26.7
35 - 54	26.7
55 - 64	13.3
65 PLUS	14.7

Table 4
POPULATION AGE DISTRIBUTIONS FOR THE U.S.

Age Group	1960 OECD	AK Model
0 - 14	31.0	30.0
15 - 34	26.3	31.7
35 - 54	24.8	22.2
55 - 64	8.6	8.4
65 PLUS	9.2	7.7

Age Group	1970 OECD	AK Model
0 - 14	31.0	27.3
15 - 34	26.3	32.9
35 - 54	24.8	23.0
55 - 64	8.6	8.8
65 PLUS	9.2	8.0

Age Group	1980 OECD	AK Model
0 - 14	22.5	23.1
15 - 34	35.3	34.0
35 - 54	21.3	24.9
55 - 64	9.6	9.5
65 PLUS	11.3	8.6

Age Group	1990 OECD	AK Model
0 - 14	21.8	23.4
15 - 34	31.9	30.3
35 - 54	25.4	26.6
55 - 64	8.6	10.2
65 PLUS	12.3	9.3

Age Group	2000 OECD	AK Model
0 - 14	21.1	21.0
15 - 34	27.4	28.9
35 - 54	30.5	28.4
55 - 64	8.8	11.3
65 PLUS	12.2	10.3

Age Group	2010 OECD	AK Model
0 - 14	19.3	20.2
15 - 34	27.0	28.5
35 - 54	28.5	26.7
55 - 64	12.6	12.8
65 PLUS	12.6	11.7

Table 4 (cont'd)
POPULATION AGE DISTRIBUTIONS FOR THE U.S.

	2020	
Age Group	OECD	AK Model
0 - 14	19.0	18.3
15 - 34	26.0	27.7
35 - 54	25.2	26.6
55 - 64	13.7	13.7
65 PLUS	16.2	13.6

	2030	
Age Group	OECD	AK Model
0 - 14	18.5	19.1
15 - 34	24.9	26.5
35 - 54	25.4	27.4
55 - 64	11.5	12.2
65 PLUS	19.6	14.8

	2040	
Age Group	OECD	AK Model
0 - 14	18.2	18.2
15 - 34	25.0	26.5
35 - 54	25.4	27.5
55 - 64	11.4	14.1
65 PLUS	20.0	13.7

	2050	
Age Group	OECD	AK Model
0 - 14	18.3	19.0
15 - 34	24.9	26.1
35 - 54	24.8	26.4
55 - 64	12.2	13.4
65 PLUS	19.7	15.1

Final Steady State

Age Group	AK Model
0 - 14	18.7
15 - 34	26.7
35 - 54	26.7
55 - 64	13.3
65 PLUS	14.7

Table 5 Tax Rates for 1960 and 1985

	Wage Tax		Capital Income Tax		Consumption Tax		Payroll Tax	
	1960	1985	1960	1985	1960	1985	1960	1985
Germany	21.3	25.7	12.6	17.0	22.2	21.4	16.4	16.6
Japan	12.1	18.2	10.1	16.2	10.7	6.2	5.6	6.3
Sweden	21.9	29.1	20.4	27.6	17.3	37.1	16.8	17.6
U.S.	19.2	18.7	16.2	15.7	9.8	9.7	7.1	7.6

Table 6
Demographic Transitions in Four Countries

Year	Germany	Japan	Sweden	United States
Consumption Tax				
1960	0.222	0.107	0.173	0.098
1985	0.214	0.062	0.371	0.097
1990	0.202	0.058	0.353	0.085
2010	0.116	0.067	0.367	0.064
2030	0.113	0.099	0.400	0.064
2050	0.172	0.060	0.366	0.066
long run	0.172	0.108	0.452	0.068
Social Security Tax				
1960	0.164	0.056	0.168	0.071
1985	0.166	0.063	0.176	0.076
1990	0.169	0.066	0.180	0.079
2010	0.184	0.097	0.208	0.099
2030	0.247	0.114	0.230	0.123
2050	0.327	0.075	0.217	0.125
long run	0.202	0.090	0.200	0.121
National Saving Rate				
1960	0.233	0.244	0.159	0.101
1985	0.215	0.202	0.114	0.100
1990	0.197	0.213	0.119	0.091
2010	0.191	0.125	0.089	0.072
2030	0.139	0.031	0.063	0.051
2050	0.027	0.133	0.088	0.046
long run	0.166	0.132	0.109	0.053
Real Wage, Detrended				
1960	1.000	1.000	1.000	1.000
1985	1.000	1.023	1.008	1.007
1990	1.002	1.028	1.005	1.016
2010	1.005	1.075	1.010	1.040
2030	1.031	1.080	1.007	1.049
2050	1.061	1.058	0.998	1.054
long run	1.015	1.048	0.985	1.049
Real After-Tax Wage				
1960	0.684	0.853	0.709	0.846
1985	0.687	0.903	0.606	0.848
1990	0.693	0.908	0.609	0.862
2010	0.735	0.910	0.585	0.881
2030	0.698	0.871	0.554	0.865
2050	0.609	0.923	0.572	0.865
long run	0.691	0.861	0.543	0.863

Table 7 a
The Impact of Policy Alternatives: Germany

Year	Base Case	No Spending Rise	2 Year Rise in Ret. Age	20% Cut in Benefits	Small Open Economy
Consumption Tax					
1960	0.222	0.222	0.222	0.222	0.222
1985	0.214	0.214	0.212	0.206	0.215
1990	0.202	0.204	0.198	0.193	0.204
2010	0.116	0.115	0.109	0.105	0.117
2030	0.113	0.088	0.105	0.102	0.122
2050	0.172	0.112	0.164	0.161	0.190
long run	0.172	0.154	0.162	0.159	0.177
Social Security Tax					
1960	0.164	0.164	0.164	0.164	0.164
1985	0.166	0.166	0.165	0.160	0.166
1990	0.169	0.169	0.167	0.157	0.170
2010	0.184	0.185	0.166	0.148	0.185
2030	0.247	0.247	0.198	0.198	0.250
2050	0.327	0.326	0.255	0.262	0.336
long run	0.202	0.202	0.164	0.161	0.202
National Saving Rate					
1960	0.233	0.233	0.233	0.233	0.233
1985	0.215	0.214	0.222	0.230	0.213
1990	0.197	0.196	0.206	0.214	0.195
2010	0.191	0.189	0.205	0.208	0.192
2030	0.139	0.140	0.152	0.152	0.140
2050	0.027	0.036	0.036	0.037	0.018
long run	0.166	0.166	0.174	0.176	0.166
Real Wage, Detrended					
1960	1.000	1.000	1.000	1.000	1.000
1985	1.000	1.000	1.001	1.003	1.000
1990	1.002	1.003	1.003	1.006	1.000
2010	1.005	1.005	1.010	1.016	1.000
2030	1.031	1.030	1.041	1.048	1.000
2050	1.061	1.058	1.076	1.082	1.000
long run	1.015	1.016	1.031	1.035	1.000
Real After-Tax Wage					
1960	0.684	0.684	0.684	0.684	0.684
1985	0.687	0.687	0.690	0.699	0.686
1990	0.693	0.692	0.697	0.711	0.689
2010	0.735	0.735	0.760	0.783	0.730
2030	0.698	0.713	0.756	0.763	0.668
2050	0.609	0.641	0.689	0.688	0.558
long run	0.691	0.703	0.742	0.749	0.678

Table 7b
The Impact of Policy Alternatives: Japan

Year	Base Case	No Spending Rise	2 Year Rise in Ret. Age	20% Cut in Benefits	Small Open Economy
Consumption Tax					
1960	0.107	0.107	0.107	0.107	0.107
1985	0.062	0.062	0.061	0.059	0.063
1990	0.058	0.061	0.057	0.055	0.060
2010	0.067	0.059	0.066	0.064	0.073
2030	0.099	0.077	0.098	0.096	0.105
2050	0.060	0.059	0.058	0.057	0.063
long run	0.108	0.092	0.106	0.104	0.112
Social Security Tax					
1960	0.056	0.056	0.056	0.056	0.056
1985	0.063	0.063	0.062	0.060	0.063
1990	0.066	0.066	0.066	0.061	0.067
2010	0.097	0.097	0.089	0.077	0.101
2030	0.114	0.114	0.094	0.091	0.116
2050	0.075	0.076	0.054	0.060	0.076
long run	0.090	0.090	0.077	0.072	0.091
National Saving Rate					
1960	0.244	0.244	0.244	0.244	0.244
1985	0.202	0.201	0.204	0.208	0.202
1990	0.213	0.211	0.216	0.220	0.216
2010	0.125	0.124	0.130	0.133	0.121
2030	0.031	0.034	0.035	0.037	0.018
2050	0.133	0.128	0.135	0.136	0.139
long run	0.132	0.132	0.134	0.136	0.132
Real Wage, Detrended					
1960	1.000	1.000	1.000	1.000	1.000
1985	1.023	1.022	1.023	1.024	1.000
1990	1.028	1.028	1.029	1.031	1.000
2010	1.075	1.074	1.077	1.081	1.000
2030	1.080	1.080	1.085	1.091	1.000
2050	1.058	1.060	1.064	1.070	1.000
long run	1.048	1.049	1.054	1.058	1.000
Real After-Tax Wage					
1960	0.853	0.853	0.853	0.853	0.853
1985	0.903	0.902	0.904	0.909	0.881
1990	0.908	0.905	0.909	0.918	0.880
2010	0.910	0.916	0.920	0.938	0.838
2030	0.871	0.888	0.895	0.905	0.800
2050	0.923	0.925	0.951	0.952	0.869
long run	0.861	0.874	0.880	0.889	0.817

Table 7c
The Impact of Policy Alternatives: Sweden

Year	Base Case	No Spending Rise	2 Year Rise in Ret. Age	20% Cut in Benefits	Small Open Economy
Consumption Tax					
1960	0.173	0.173	0.173	0.173	0.173
1985	0.371	0.371	0.365	0.358	0.374
1990	0.353	0.352	0.345	0.338	0.355
2010	0.367	0.338	0.349	0.342	0.370
2030	0.400	0.341	0.373	0.369	0.403
2050	0.366	0.326	0.338	0.335	0.365
long run	0.452	0.412	0.418	0.416	0.444
Social Security Tax					
1960	0.168	0.168	0.168	0.168	0.168
1985	0.176	0.176	0.174	0.171	0.176
1990	0.180	0.180	0.178	0.169	0.179
2010	0.208	0.208	0.184	0.167	0.208
2030	0.230	0.229	0.185	0.184	0.230
2050	0.217	0.218	0.175	0.173	0.216
long run	0.200	0.200	0.158	0.160	0.200
National Saving Rate					
1960	0.159	0.159	0.159	0.159	0.159
1985	0.114	0.112	0.124	0.130	0.112
1990	0.119	0.116	0.130	0.136	0.118
2010	0.089	0.089	0.107	0.108	0.090
2030	0.063	0.067	0.079	0.077	0.061
2050	0.088	0.086	0.098	0.097	0.090
long run	0.109	0.110	0.118	0.119	0.109
Real Wage, Detrended					
1960	1.000	1.000	1.000	1.000	1.000
1985	1.008	1.008	1.009	1.012	1.000
1990	1.005	1.005	1.007	1.011	1.000
2010	1.010	1.009	1.020	1.027	1.000
2030	1.007	1.007	1.027	1.033	1.000
2050	0.998	1.001	1.024	1.028	1.000
long run	0.985	0.987	1.012	1.014	1.000
Real After-Tax Wage					
1960	0.709	0.709	0.709	0.709	0.709
1985	0.606	0.606	0.611	0.618	0.600
1990	0.609	0.610	0.615	0.628	0.606
2010	0.585	0.597	0.617	0.637	0.578
2030	0.554	0.579	0.610	0.616	0.549
2050	0.572	0.590	0.631	0.637	0.574
long run	0.543	0.559	0.601	0.602	0.554

Table 7d
The Impact of Policy Alternatives: United States

Year	Base Case	No Spending Rise	2 Year Rise in Ret. Age	20% Cut in Benefits	Small Open Economy
Consumption Tax					
1960	0.098	0.098	0.098	0.098	0.098
1985	0.097	0.097	0.096	0.095	0.159
1990	0.085	0.085	0.084	0.083	0.144
2010	0.064	0.061	0.062	0.062	0.114
2030	0.064	0.054	0.062	0.062	0.112
2050	0.066	0.054	0.064	0.064	0.115
long run	0.068	0.057	0.066	0.066	0.117
Social Security Tax					
1960	0.071	0.071	0.071	0.071	0.071
1985	0.076	0.076	0.076	0.074	0.076
1990	0.079	0.079	0.079	0.075	0.079
2010	0.099	0.099	0.088	0.080	0.100
2030	0.123	0.123	0.098	0.099	0.124
2050	0.125	0.125	0.098	0.100	0.127
long run	0.121	0.121	0.096	0.097	0.123
National Saving Rate					
1960	0.101	0.101	0.101	0.101	0.101
1985	0.100	0.100	0.102	0.103	0.103
1990	0.091	0.091	0.094	0.095	0.098
2010	0.072	0.071	0.076	0.076	0.082
2030	0.051	0.052	0.055	0.055	0.056
2050	0.046	0.046	0.048	0.048	0.048
long run	0.053	0.053	0.055	0.055	0.056
Real Wage, Detrended					
1960	1.000	1.000	1.000	1.000	1.000
1985	1.007	1.007	1.009	1.011	1.000
1990	1.016	1.016	1.018	1.020	1.000
2010	1.040	1.040	1.046	1.049	1.000
2030	1.049	1.048	1.059	1.061	1.000
2050	1.054	1.054	1.067	1.068	1.000
long run	1.049	1.050	1.064	1.064	1.000
Real After-Tax Wage					
1960	0.846	0.846	0.846	0.846	0.846
1985	0.848	0.848	0.851	0.855	0.797
1990	0.862	0.862	0.865	0.871	0.805
2010	0.881	0.883	0.898	0.909	0.808
2030	0.865	0.872	0.899	0.900	0.788
2050	0.865	0.875	0.905	0.903	0.783
long run	0.863	0.873	0.902	0.901	0.785

Table 8
Welfare Effects of Changes in Policy
(as a percentage of lifetime resources)

Country	Year of Birth	Increased Retirement Age	Cut in Replacement Rate
Germany			
	1960	-0.82	-1.67
	1985	-0.84	-0.28
	2010	0.26	0.50
	long run	0.46	0.58
Japan			
	1960	-0.23	-0.55
	1985	-0.18	0.07
	2010	0.25	0.47
	long run	0.19	0.33
Sweden			
	1960	-0.76	-1.23
	1985	-0.33	0.56
	2010	1.39	1.70
	long run	1.63	1.70
United States			
	1960	-0.18	-0.22
	1985	0.04	0.42
	2010	0.96	1.07
	long run	1.28	1.33

Table 9
Current Accounts in Transition
(relative to 1960, as a fraction of NDP)

Year	Country			
	Germany	Japan	Sweden	United States
1960	0.000	0.000	0.000	0.000
1985	0.016	0.039	-0.028	0.029
1990	0.050	0.056	-0.014	0.034
2010	0.095	0.038	0.010	0.040
2030	0.148	-0.150	-0.017	0.018
2050	0.064	0.014	-0.0002	0.015
long run	0.010	0.023	-0.007	0.014