

THE ECONOMIC DYNAMICS OF AN AGEING POPULATION : THE CASE OF FOUR OECD COUNTRIES

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CONTENTS

Introduction	98
I. Modelling the demographic transition	99
A. Household behaviour	100
B. Firm behaviour and technological change	103
C. Government behaviour	103
D. Opening the economy to international trade	105
E. Equilibrium under perfect foresight	105
II. Calibrating the model	106
A. Demographics	106
B. Preference and production function parameters	111
C. Choice of fiscal parameters	112
III. Simulation results	113
A. Baseline simulations	114
B. Simulations of selected policy responses	118
Conclusions	127
Bibliography	130

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INTRODUCTION

Despite the fact that demographic changes generally occur gradually, they can nevertheless have widespread and powerful economic consequences. The anticipated rise in the ratio of the elderly to the young, typically referred to as "population ageing", is likely to have significant effects on OECD economies. One of the most notable impacts will be the pressure which ageing can be expected to place on public pension systems and, more generally, on societies' intergenerational transfer burdens. While there are a variety of partial methods for analysing the effects of ageing on intergenerational burdens, such as used in the article by Hagemann and Nicoletti (see "Population ageing: economic effects and some policy implications for financing public pensions" in this volume), these calculations, useful in their own right, fail to reflect a number of important effects which are endogenous to the ageing process. In particular, inferences about the consequences of population ageing for the viability of the government's transfer programmes depend importantly on the extent to which *all* demographically-related public expenditures adjust to changes in the age distribution of the population.

Perhaps even more important to a "balanced" perspective on the consequences of ageing is the necessity to account for the general equilibrium effects of significant population changes. For instance, demographic changes may induce private saving and labour supply responses which, in turn, may affect the rate of capital accumulation and, consequently, capital-labour ratios and real wages, softening the increase in the tax burden due to rising old-age support. At the same time, because of the induced responses of individuals and firms to both demographic changes and government's policies with respect to its transfer programmes, a general equilibrium approach is warranted so as to account for the intergenerational welfare effects of ageing. The purpose of this paper is to explore these issues by considering population ageing using a dynamic general equilibrium model which incorporates both demographic factors and the government's fiscal policies.

The starting point for this work is the model developed by Auerbach and Kotlikoff (1987), which explicitly takes into account the interactions of household, producer and government decisions. Moreover, the model is disaggregated by age cohort, and is dynamic, making it possible to measure the effects of a demographic transition on the behaviour and welfare of different generations as economic conditions change over their lifetimes. The original model is based on the life-cycle theory

of saving behaviour, and traces out and aggregates the labour supply, retirement, consumption, and fertility behaviour of individuals born in each year. These choices reflect fully rational responses to current and perfectly foreseen future wages, interest rates, tax rates and public pension benefits. Aggregate behaviour leads, through the production sector, to a determination of wages and interest rates and, given the stock of government debt, tax rates.

In the current study, the model has been modified to incorporate bequest behaviour, technological change, the possibility that the economy is open to international trade, and the endogeneity of government expenditures with respect to the age composition of the population. To broaden its applicability, the model, initially parameterized only for the United States (but for an arbitrary demographic transition), has been calibrated so as to simulate the general equilibrium effects of projected demographic changes in the United States, Japan, the Germany, and Sweden.

For each country, several questions are addressed. These include:

- i)* What would happen to government revenue and tax rates if current government spending patterns (i.e. by age groups) are maintained?
- ii)* By how much must social security contribution rates be increased if the current levels of old-age pension benefits are to be maintained?
- iii)* How would national saving rates and real wages be affected by the changing population age structure?
- iv)* What pressures would effects on saving rates and real wages exert on international capital flows?
- v)* How would the overall well-being of individuals of different generations be affected by the economic changes associated with the demographic transitions?
- vi)* What would be the impact on economic performance and generational welfare of reductions in the generosity of public pension schemes?

I. 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 behavioural variables (e.g. consumption or labour 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 the major feedbacks between policy and demographic changes, on the one hand, and changes in the time paths of wages, interest rates, labour 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 labour supply.

A. Household behaviour

At any given time the household sector comprises seventy-five overlapping generations. These generations correspond to children aged 1-20 and adults aged 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 labour earnings.

Individual tastes are assumed to be identical for all agents, with differences in behaviour 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, $N_t B_t$, is the number of children multiplied by the parent's utility from bequests per child, B_t .

$$U_t = V_{pt} + N_t V_{kt} + N_t B_t \quad [1]$$

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 :

$$V_{pt} + N_t V_{kt} = (1/1 - 1/\gamma) \sum_{j=21}^{75} (1 + \delta)^{-(j-21)} u_{pjt} + N_t \sum_{j=21}^{40} (1 + \delta)^{(j-21)} u_{kjt} \quad [2]$$

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:

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

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 :

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

In equation [4] γ 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 , 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 . 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 labour earnings as well as that of her (his) children when young plus the present value of the parent's inheritance received at age 55.

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

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

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 standardised 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 \mathbf{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 labour 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 labour. In the solution we introduce shadow wages whose values are set to insure that retirees voluntarily choose to supply precisely zero labour.

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 pre-tax 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 pre-tax 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 maximising 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 behaviour and technological change

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

The assumption of labour augmenting technological change appears frequently in analyses of growth, where labour augmenting refers here to increasing the effective labour input entering the production function. Unfortunately, unless the utility function is Cobb-Douglas, this assumption, in the presence of variable labour 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 labour 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 labour 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 behaviour

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 defence. 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 so as to keep net government assets per capita constant from year to year. 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 initial net assets 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 United States. Payroll taxes are assessed independently of whatever other taxes on labour 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 labour 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 standardised wage at retirement, adjusted for the **1.5** per cent rate of technical change, to the standardised 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-labour ratio by the size of the labour input. The capital-labour ratio is determined such that the marginal products of labour 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 behaviour 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 behaviour of households, firms and the government must be consistent not only with current prices, but future ones as well. Household labour 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 behaviour of interest rates and wage rates. Government's projected path of tax schedules must satisfy its intertemporal budget constraint. Given the behaviour of each sector, markets for labour and capital must clear.

Because of the assumption of perfect foresight (the same would be true even with a limited degree of foresight), behaviour of the economy today depends on conditions in the future. One cannot compute a "separate" equilibrium for a given year without a complete characterisation 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.

II. 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 behaviour 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, labour income and capital income. Household behaviour is characterised by lifetime patterns of labour supply, retirement and consumption broadly consistent with available empirical evidence on age-earnings and age-consumption profiles*. 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 age distributions of the model provide a reasonably good approximation to those of the OECD, at least if the age groups 55 - 64 and 65 years and over are combined. However, it is important to note that the model yields systematically lower shares of the over 65 and older age group after 1990, and this will clearly affect the magnitudes of estimated impacts of ageing on all endogenous variables sensitive to the distribution across the ages 55 and over. The qualitative results generated by the model should remain unaffected, however.

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 ageing of its population than is the United States. Compared with Germany and Sweden, Japan and the U.S. had a

Table 1. Population age distributions for Germany

1960			1970		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	21.7	22.8	0-14	23.2	23.4
15-34	29.6	29.0	15-34	28.0	28.8
35-54	25.9	25.2	35-54	23.4	25.0
55-64	12.2	11.3	55-64	12.3	11.3
65 plus	10.6	11.6	65 plus	13.2	11.5
1980			1990		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	18.2	17.6	0-14	14.9	14.7
15-34	29.5	31.5	15-34	30.1	30.2
35-54	27.2	26.6	35-54	27.8	28.8
55-64	9.6	12.0	55-64	11.6	13.0
65 plus	15.5	12.2	65 plus	15.6	13.3
2000			2010		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	15.5	14.2	0-14	13.3	11.9
15-34	23.7	24.5	15-34	21.7	22.5
35-54	30.2	32.5	35-54	31.6	32.8
55-64	13.6	14.2	55-64	13.3	16.2
65 plus	17.0	14.6	65 plus	20.2	16.6
2020			2030		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	13.2	12.2	0-14	14.6	12.3
15-34	21.9	21.2	15-34	20.0	20.0
35-54	26.1	27.9	35-54	24.5	26.7
55-64	17.2	19.6	55-64	15.1	17.3
65 plus	21.6	19.1	65 plus	25.9	23.1
2040			2050		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	14.6	12.9	0-14	15.9	13.7
15-34	20.6	21.5	15-34	22.2	22.5
35-54	25.0	27.1	35-54	22.9	26.5
55-64	11.8	15.8	55-64	14.0	17.3
65 plus	28.0	22.7	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

1960			1970		
Agegroup	OECD	AK Model	Age group	OECD	AK Model
0-14	n.a.	29.3	0-14	n.a.	24.6
15-34	n.a.	31.5	15-34	n.a.	33.6
35-54	n.a.	22.5	35-54	n.a.	24.0
55-64	n.a.	8.7	55-64	n.a.	9.3
65 plus	n.a.	8.0	65 plus	n.a.	8.6
1980			1990		
Agegroup	OECD	AK Model	Age group	OECD	AK Model
0-14	23.6	22.6	0-14	18.6	12.1
15-34	30.7	32.6	15-34	28.3	33.4
35-54	28.1	25.7	35-54	29.8	31.2
55-64	8.6	10.0	55-64	11.7	12.1
65 plus	9.1	9.2	65 plus	11.6	11.1
2000			2010		
Agegroup	OECD	AK Model	Age group	OECD	AK Model
0-14	17.5	20.0	0-14	18.5	12.1
15-34	27.4	23.8	15-34	23.2	23.1
35-54	27.8	30.8	35-54	26.3	32.5
55-64	12.2	13.2	55-64	14.5	16.5
65 plus	15.1	12.2	65 plus	17.6	15.2
2020			2030		
Agegroup	OECD	AK Model	Age group	OECD	AK Model
0-14	16.8	19.6	0-14	16.8	14.4
15-34	24.0	23.1	15-34	25.1	24.1
35-54	26.9	24.3	35-54	23.9	24.5
55-64	11.4	15.5	55-64	14.2	17.5
65 plus	21.0	17.4	65 plus	20.1	18.9
2040			2050		
Age group	OECD	AK Model	Agegroup	OECD	AK Model
0-14	16.9	16.4	0-14	16.6	15.1
15-34	23.4	27.0	15-34	23.5	25.3
35-54	24.8	26.8	35-54	25.9	28.9
55-64	12.2	9.7	55-64	11.2	17.8
65 plus	22.7	20.1	65 plus	22.8	12.9

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			1970		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	22.4	22.3	0-14	20.3	20.6
15-34	26.0	28.7	15-34	28.7	29.4
35-54	28.4	25.4	15-54	24.5	26.0
55-64	11.4	11.6	55-64	12.3	11.8
65 plus	11.7	12.0	65 plus	13.7	12.2
1980			1990		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	19.6	19.6	0-14	17.3	16.8
15-34	28.6	28.9	15-34	27.5	28.4
35-54	23.7	26.7	35-54	27.3	28.4
55-64	11.8	12.2	55-64	10.1	13.0
65 plus	16.3	12.6	65 plus	17.8	13.4
2000			2010		
Agegroup	OECD	AK Model	Agegroup	OECD	AK Model
0-14	17.5	17.6	0-14	17.0	16.9
15-34	26.0	26.0	15-34	24.3	24.7
35-54	28.1	28.7	35-54	27.7	28.5
55-64	11.9	13.7	55-64	13.6	14.7
65 plus	16.6	14.1	65 plus	17.5	15.2
2020			2030		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	16.2	16.2	0-14	16.6	16.6
15-34	24.1	25.4	15-34	23.4	25.0
35-54	26.1	27.0	35-54	24.8	26.3
55-64	12.8	14.8	55-64	13.3	15.1
65 plus	20.8	16.6	65 plus	21.8	17.0
2040			2050		
Agegroup	OECD	AK Model	Age group	OECD	AK Model
0-14	16.8	16.1	0-14	17.3	16.0
15-34	23.4	25.1	15-34	24.0	25.4
35-54	25.3	27.7	35-54	24.7	27.7
55-64	11.8	13.7	55-64	12.3	14.8
65 plus	22.7	17.4	65 plus	21.8	16.1

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 United States

1960			1970		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	31.0	30.0	0-14	31.0	27.3
15-34	26.3	31.7	15-34	26.3	32.9
35-54	24.8	22.2	35-54	24.8	23.0
55-64	8.6	8.4	55-64	8.6	8.8
65 plus	9.2	7.7	65 plus	9.2	8.0
1980			1990		
Agegroup	OECD	AK Model	Age group	OECD	AK Model
0-14	22.5	23.1	0-14	21.8	23.4
15-34	35.3	34.0	15-34	31.9	30.3
35-54	21.3	24.9	35-54	25.4	26.6
55-64	9.6	9.5	55-64	8.6	10.2
65 plus	11.3	8.6	65 plus	12.3	9.3
2000			2010		
Age group	OECD	AK Model	Age group	OECD	AK Model
0-14	21.1	21.0	0-14	19.3	20.2
15-34	21.4	28.9	15-34	27.0	28.5
35-54	30.5	28.4	35-54	28.5	26.7
55-64	8.8	11.3	55-64	12.6	12.8
65 plus	12.2	10.3	65 plus	12.6	11.7
2020			2030		
Agegroup	OECD	AK Model	Agegroup	OECD	AK Model
0-14	19.0	18.3	0-14	18.5	19.1
15-34	26.0	27.7	15-34	24.9	26.5
35-54	25.2	26.6	35-54	25.4	27.4
55-64	13.7	13.7	55-64	11.5	12.2
65 plus	16.2	13.6	65 plus	19.6	14.8
2040			2050		
Agegroup	OECD	AK Model	Age group	OECD	AK Model
0-14	18.2	18.2	0-14	18.3	19.0
15-34	25.0	26.5	15-34	24.9	26.1
35-54	25.4	27.5	35-54	24.8	26.4
55-64	11.4	14.1	55-64	12.2	13.4
65 plus	20.0	13.7	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

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 United States 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 0.35, the static elasticity of substitution, ρ , was set equal to 0.8, and the leisure share parameter, a , 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, β , (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 historical 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 United States – 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 higher 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 0.25. The coefficient multiplying the production function is chosen such that each country's 1960 wage is normalised to unity. This normalisation does not imply that wage rates in each country are equalised in 1960.

C. Choice of fiscal parameters

Between 1960 and 1985, tax rates for each country on capital and labour 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, labour 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 labour 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 behaviour 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 programmes 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 (hereafter social security contribution 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

	Wage Tax		Capital income tax		Consumption tax		Social security contribution rate	
	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
United States	19.2	18.7	16.2	15.7	9.8	9.7	7.1	7.6

general utilised 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 0.272, 0.119, 0.156, and 0.453. For Japan the 1980 shares are 0.261, 0.085, 0.083, and 0.571. For Sweden the 1980 shares are 0.292, 0.092, 0.190, and 0.426. And for the United States the 1980 shares are 0.291, 0.060, 0.071, and 0.578. 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 United States.

A final fiscal variable is the initial level of net government debt. While data on gross public sector debt are readily available, data on government assets, including land and mineral rights, are less observable. Hence, there is no firm empirical basis for determining the level of government assets, and the choice was made of equal per capita government assets for each country. The primary objective here is to help achieve the observed 1960 saving rates. Fortunately, the simulation results are not very sensitive to the choice of the mix of the time preference rate, the bequest coefficient v , or the initial level of net government assets used to calibrate to the observed 1960 saving rates.

III. SIMULATION RESULTS

Alternative simulations are required to analyse 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 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 levels³. 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 years⁴.

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

**Table 6. impact of the demographic transition
on macroeconomic variables in four countries**

Figures in per cent

	Germany	Japan	Sweden	United States
Consumption tax				
1960	22.2	10.7	17.3	9.8
1985	21.4	6.2	37.1	9.7
1990	20.2	5.8	35.3	8.5
2010	11.6	6.7	36.7	6.4
2030	11.3	9.9	40.0	6.4
2050	17.2	6.0	36.6	6.6
Long run	17.2	10.8	45.2	6.8
Social security contribution rate				
1960	16.4	5.6	16.8	7.1
1985	16.6	6.3	17.6	7.6
1990	16.9	6.6	18.0	7.9
2010	18.4	9.7	20.8	9.9
2030	24.7	11.4	23.0	12.3
2050	32.7	7.5	21.7	12.5
Long run	20.2	9.0	20.0	12.1
National saving rate				
1960	23.3	24.4	15.9	10.1
1985	21.5	20.2	11.4	10.0
1990	19.7	21.3	11.9	9.1
2010	19.1	12.5	8.9	7.2
2030	13.9	3.1	6.3	5.1
2050	27	13.3	8.8	4.6
Long run	16.6	13.2	10.9	5.3
Real wage, detrended				
1960	100.0	100.0	100.0	100.0
1985	100.0	102.3	100.8	100.7
1990	100.2	102.8	100.5	101.6
2010	100.5	107.5	101.0	104.0
2030	103.1	108.0	100.7	104.9
2050	106.1	105.8	99.8	105.4
Long run	101.5	104.8	98.5	104.9
Real after-tax wage^{a/}				
1960	68.4	85.3	70.9	84.6
1985	68.7	90.3	60.6	84.8
1990	69.3	90.8	60.9	86.2
2010	73.5	91.0	58.5	88.1
2030	69.8	87.1	55.4	86.5
2050	60.9	92.3	57.2	86.5
Long run	69.1	86.1	54.3	86.3

a/ Calculated as the before-tax wage times 100 minus the social security contribution rate, divided by 100 plus the consumption tax rate.

scarcity of labour 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.

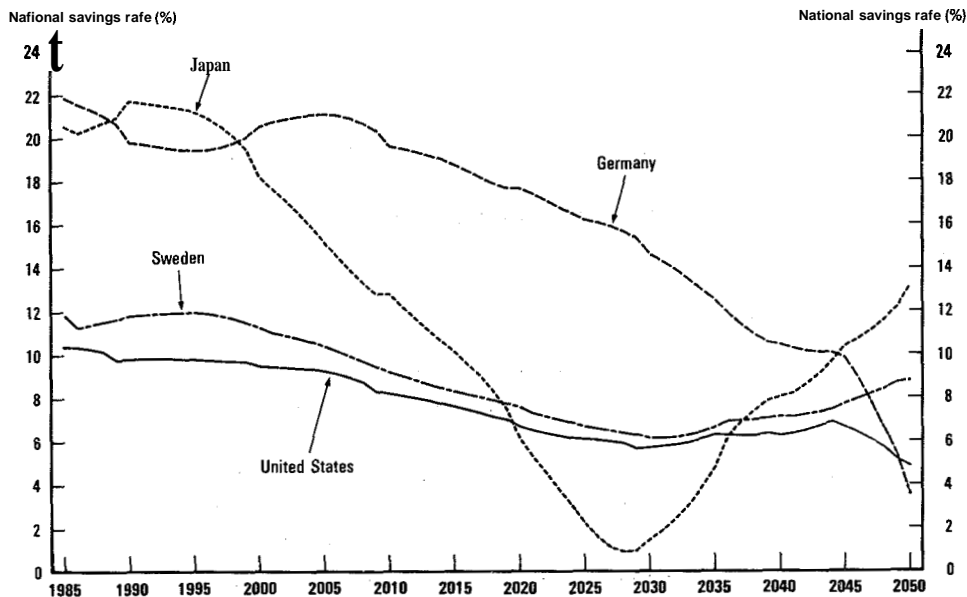
Between **1985** and **2050** and thereafter, considerable changes are observed in the aggregate measures shown in Table **6**. First, in each country, the consumption tax rate generally declines during the transitional period, after which it increases, although the long-run rate is lower than in **1985** 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 behaviour 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 (Chart **1**). 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

CHART 1
SIMULATED NATIONAL SAVING RATES



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 the 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 after-tax 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 favourable 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 Ger-

Table 7a. The impact of policy alternatives : United States
Figures in per cent

Year	Basecase	No spending rise	Two year rise in retirement ane	20 percent cut in benefits	Small open economy
Consumptiontax					
1960	98	98	98	98	98
1985	97	97	96	95	15.9
1990	8.5	8.5	84	83	14.4
2010	64	6.1	62	62	11.4
2030	64	54	62	62	112
2050	6.6	54	64	64	115
Longrun	6.8	57	66	66	117
Social security contribution rate					
1960	7.1	7.1	7.1	7.1	7.1
1985	7.6	7.6	7.6	7.4	7.6
1990	7.9	7.9	7.9	7.5	7.9
2010	9.9	9.9	8.8	8.0	10.0
2030	12.3	12.3	9.8	9.9	12.4
2050	12.5	12.5	9.8	10.0	127
Longrun	12.1	12.1	9.6	9.7	123
National saving rate					
1960	10.1	10.1	10.1	10.1	10.1
1985	10.0	10.0	10.2	10.3	10.3
1990	9.1	9.1	9.4	9.5	9.8
2010	7.2	7.1	7.6	7.6	8.2
2030	5.1	5.2	5.5	5.5	5.6
2050	4.6	4.6	4.8	4.8	4.8
Longrun	5.3	5.3	5.5	5.5	5.6
Real wage, detrended					
1960	100.0	100.0	100.0	100.0	100.0
1985	100.7	100.7	100.9	101.1	100.0
1990	101.6	101.6	101.8	102.0	100.0
2010	104.0	104.0	104.6	104.9	100.0
2030	104.9	104.8	105.9	106.1	100.0
2050	105.4	105.4	106.7	106.8	100.0
Longrun	104.9	105.0	106.4	106.4	100.0
Real after-tax wage^a					
1960	84.6	84.6	84.6	84.6	84.6
1985	84.8	84.8	85.1	85.5	79.7
1990	86.2	86.2	86.5	87.1	80.5
2010	88.1	88.3	89.8	90.9	80.8
2030	86.5	87.2	89.9	90.0	78.8
2050	86.5	87.5	90.5	90.3	78.3
Longrun	86.3	87.3	90.2	90.1	78.5

a/ See Table 6.

Table 7b. **The impact of policy alternatives : Japan**
 Figures in per cent

Year	Base case	No spending rise	Two year rise in retirement age	20 percent cut in benefits	Small open economy
Consumption tax					
1960	10.7	10.7	10.7	10.7	10.7
1985	6.2	6.2	6.1	5.9	6.3
1990	5.8	6.1	5.7	5.5	6.0
2010	6.7	5.9	6.6	6.4	7.3
2030	9.9	7.7	9.8	9.6	10.5
2050	6.0	5.9	5.8	5.7	6.3
Long run	10.8	9.2	10.6	10.4	11.2
Social security contribution rate					
1960	5.6	5.6	5.6	5.6	5.6
1985	6.3	6.3	6.2	6.0	6.3
1990	6.6	6.6	6.6	6.1	6.7
2010	9.7	9.7	8.9	7.7	10.1
2030	11.4	11.4	9.4	9.1	11.6
2050	7.5	7.6	5.4	6.0	7.6
Long run	9.0	9.0	7.7	7.2	9.1
National saving rate					
1960	24.4	24.4	24.4	24.4	24.4
1985	20.2	20.1	20.4	20.8	20.4
1990	21.3	21.1	21.6	22.0	21.6
2010	12.5	12.4	13.0	13.3	12.1
2030	3.1	3.4	3.5	3.7	1.8
2050	13.3	12.8	13.5	13.6	13.9
Long run	13.2	13.2	13.4	13.6	13.2
Real wage, detrended					
1960	100.0	100.0	100.0	100.0	100.0
1985	102.3	102.2	102.3	102.4	100.0
1990	102.8	102.8	102.9	103.1	100.0
2010	107.5	107.4	107.7	108.1	100.0
2030	108.0	108.0	108.5	109.1	100.0
2050	105.8	106.0	106.4	107.0	100.0
Long run	104.8	104.9	105.4	105.8	100.0
Real after-tax wage ^a					
1960	85.3	85.3	85.3	85.3	85.3
1985	90.3	90.2	90.4	90.9	88.1
1990	90.8	90.5	90.9	91.8	88.0
2010	91.0	91.6	92.0	93.8	83.8
2030	87.1	88.8	89.5	90.5	80.0
2050	92.3	92.5	95.1	95.2	86.9
Long run	86.1	87.4	88.0	88.9	81.7

a/ See Table 6.

Table 7c. The impact of policy alternatives : Germany
Figures in per cent

Year	Base case	No spending rise	Two year rise in retirement age	20 per cent cut in benefits	Small open economy
Consumption tax					
1960	22.2	22.2	22.2	22.2	22.2
1985	21.4	21.4	21.2	20.6	21.5
1990	20.2	20.4	19.8	19.3	20.4
2010	11.6	11.5	10.9	10.5	11.7
2030	11.3	8.8	10.5	10.2	12.2
2050	17.2	11.2	16.4	16.1	19.0
Long run	17.2	15.4	16.2	15.9	17.7
Social security contribution rate					
1960	16.4	16.4	16.4	16.4	16.4
1985	16.6	16.6	16.5	16.0	16.6
1990	16.9	16.9	16.7	15.7	17.0
2010	18.4	18.5	16.6	14.8	18.5
2030	24.7	24.7	19.8	19.8	25.0
2050	32.7	32.6	25.5	26.2	33.6
Long run	20.2	20.2	16.4	16.1	20.2
National saving rate					
1960	23.3	23.3	23.3	23.3	23.3
1985	21.5	21.4	22.2	23.0	21.3
1990	19.7	19.6	20.6	21.4	19.5
2010	19.1	18.9	20.5	20.8	19.2
2030	13.9	14.0	15.2	15.2	14.0
2050	2.7	3.6	3.6	3.7	1.8
Long run	16.6	16.6	17.4	17.6	16.6
Real wage, detrended					
1960	100.0	100.0	100.0	100.0	100.0
1985	100.0	100.0	100.1	100.3	100.0
1990	100.2	100.3	100.3	100.6	100.0
2010	100.5	100.5	101.0	101.6	100.0
2030	103.1	103.0	104.1	104.8	100.0
2050	106.1	105.8	107.6	108.2	100.0
Long run	101.5	101.6	103.1	103.5	100.0
Real after-tax wage^a					
1960	68.4	68.4	68.4	68.4	68.4
1985	68.7	68.7	69.0	69.9	68.6
1990	69.3	69.2	69.7	71.1	68.9
2010	73.5	73.5	76.0	78.3	73.0
2030	69.8	71.3	75.6	76.3	66.8
2050	60.9	64.1	68.9	68.8	55.8
Long run	69.1	70.3	74.2	74.9	67.8

a/ See Table 6.

Table 7d. The impact of policy alternatives: Sweden
 Figures in per cent

Year	Base case	No spending rise	Two year rise in retirement age	20 per cent cut in benefits	Small open economy
Consumption tax					
1960	17.3	17.3	17.3	17.3	17.3
1985	37.1	37.1	36.5	35.8	37.4
1990	35.3	35.2	34.5	33.8	35.5
2010	36.7	33.8	34.9	34.2	37.0
2030	40.0	34.1	37.3	36.9	40.3
2050	36.6	32.6	33.8	33.5	36.5
Long run	45.2	41.2	41.8	41.6	44.4
Social security contribution rate					
1960	16.8	16.8	16.8	16.8	16.8
1985	17.6	17.6	17.4	17.1	17.6
1990	18.0	18.0	17.8	16.9	17.9
2010	20.8	20.8	18.4	16.7	20.8
2030	23.0	22.9	18.5	18.4	23.0
2050	21.7	21.8	17.5	17.3	21.6
Long run	20.0	20.0	15.8	16.0	20.0
National saving rate					
1960	15.9	15.9	15.9	15.9	15.9
1985	11.4	11.2	12.4	13.0	11.2
1990	11.9	11.6	13.0	13.6	11.8
2010	8.9	8.9	10.7	10.8	9.0
2030	6.3	6.7	7.9	7.7	6.1
2050	8.8	8.6	9.8	9.7	9.0
Long run	10.9	11.0	11.8	11.9	10.9
Real wage, detrended					
1960	100.0	100.0	100.0	100.0	100.0
1985	100.8	100.8	100.9	101.2	100.0
1990	100.5	100.5	100.7	101.1	100.0
2010	101.0	100.9	102.0	102.7	100.0
2030	100.7	100.7	102.7	103.3	100.0
2050	99.8	100.1	102.4	102.8	100.0
Long run	98.5	98.7	101.2	101.4	100.0
Real after-tax wage^a					
1960	70.9	70.9	70.9	70.9	70.9
1985	60.6	60.6	61.1	61.8	60.0
1990	60.9	61.0	61.5	62.8	60.6
2010	58.5	59.7	61.7	63.7	57.8
2030	55.4	57.9	61.0	61.6	54.9
2050	57.2	59.0	63.1	63.7	57.4
Long run	54.3	55.9	60.1	60.2	55.4

a/ See Table 6.

many 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 smaller⁶.

b) Raising the retirement age

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. In the case of the United States, this corresponds in general to one of the measures adopted in 1983. 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 rate 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 programmes. 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 2010 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

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

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 synchronised, 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-labour 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 programmes are not assumed to be indexed in the same way, consumption tax rates **are** 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.

Year	Germany	Japan	Sweden	United States
1960	0.0	0.0	0.0	0.0
1985	1.6	3.9	-2.8	2.9
1990	5.0	5.6	-1.4	3.4
2010	9.5	3.8	1.0	4.0
2030	14.8	-1.5	-1.7	1.8
2050	6.4	1.4	-0.0	1.5
Longrun	1.0	2.3	-0.7	1.4

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, however⁷.

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 labour. 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-labour ratios lead to significant outflows of capital and associated surpluses in their current accounts. These increases are due greatly *to declines* in the domestic labour 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 labour 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 labour.

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.

CONCLUSIONS

The analysis presented above indicates that demographic transitions in the United States, Japan, Germany and Sweden are likely to have significant effects on rates of national saving, real wage rates, and current accounts. General equilibrium analysis highlights the fact that the burden on those who must support the larger dependent population is somewhat overstated by looking simply at social security contributions, since real wages can be expected to rise and, at least temporarily, other tax rates to fall if the government allows aggregate youth-related outlays to decline along with a fall in the size of the younger population. 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 programme cuts are needed or even beneficial.

Of course, even such a complex model as the one used here 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.

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 under way 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.

NOTES

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 1920s, 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 labour 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 labour 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 of 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 judgements 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.

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