Public saving and policy coordination in aging economies*

Martin Floden**
Stockholm School of Economics and CEPR

April 8, 2002
Preliminary

Abstract

In the coming 30 to 40 years, the share of people in working age is predicted to fall significantly in most developed countries. Considering this reduction in the relative size of the labor force, it may be wise to start adjusting public policy already now. I examine 12 European countries, Canada, and the U.S., and find that for all these countries, the optimal policy is to start reducing public debt immediately and continuously until sometime between year 2030 and 2045. If instead debt is maintained at the current level, welfare may be reduced substantially in countries with a large public sector and/or a large demographic change. The U.S. will be less affected than the European countries. The U.S. demographic transition will therefore be facilitated by imports of capital from Europe. The capital flight will aggravate the transition in most European countries.
Keywords: public policy, public debt, optimal taxation, demographics
JEL Classification: E62, H21, H60, J18

*I thank Torben M. Andersen and Per Molander for helpful suggestions. This work was initiated by a project on 'The scope and size of the public sector' funded by SNS (Center for Business and Policy Studies). I also thank the Wallander and Hedelius Foundation at Svenska Handelsbanken for generous funding.
**Department of Economics, Stockholm School of Economics, Box 6501, SE-113 83 Stockholm, Sweden. martin.floden@hhs.se, ph: +46-8-7369263.

1 Introduction

Due to falling birth rates, increased longevity, and the retirement of the baby-boom generation, the share of people in working age is predicted to fall significantly in most developed countries in the coming 30 to 40 years. This demographic change will have severe effects on public budgets, particularly in European countries, where extensive welfare programs were introduced and large public debts were accumulated during the final decades of the previous century. The present paper attempts to quantify these effects, to examine appropriate responses for public savings, and to consider the scope for policy coordination between countries in order to affect the flow of capital.

There is a large literature that already studies these issues. Much of the previous literature has, however, either focused on the demographic impact on specific policy programs, typically on pensions or health care, or on the U.S. economy.[1] I argue in this paper that the conclusions drawn for the U.S. economy cannot be directly applied on European economies where the public sector is larger and where the demographic change in itself will be more severe. Further, even to study the U.S. economy it may be necessary to understand what happens in the rest of the world. The population aging and consequent fall in total labor supply will be smaller in the U.S. than in other developed countries. Imports of capital will therefore facilitate the U.S. demographic transition by increasing production and wages.[2]

The model underlying the study is outlined in Section 2. In this model, households choose consumption, labor supply and savings, the interest rate path equalizes the world supply and demand for capital, and the government has a budget constraint to fulfill. A model with these ingredients is needed to obtain a proper understanding of the demographic change. First, individuals may change their behavior in response to changing demographic structures. For example, Bohn (1999) and Domeij and Floden (2001) show that if life expectancy increases, incentives to save and work as young may be strengthened since people then want to accumulate more reserves for their old age. Since people save more, the capital stock may increase and productivity per worker will increase. The increase in savings can therefore mitigate the demographic impact on production. These offsetting effects are most likely to occur in countries with little distortive taxation. Consequently, countries with a large public sector are least likely to be helped by the individual response to population aging.

Second, the interest rate and wage rate are likely to change during the demographic transition. As the number of workers falls, capital will become less productive and the interest rate will fall. Cutler et al. (1990) and Elmendorf and Scheiner (2000a, 2000b) therefore argue that the optimal response to an increased dependency burden is to reduce the national savings rate.

Third, due to the demographic change public expenses must be cut or revenue increased. The model used below is developed to examine how revenue should vary if expenses are held fixed at the current level. To some extent, the tax increases can equivalently be interpreted as expenditure cuts. However, Domeij and Floden (2001) show that savings responses to tax increases and benefit cuts can be very different, at least if individuals are not altruistic to other household members. For example, workers will increase savings today if they expect future pension benefits to be low, while an increase in future social security taxes does not directly affect today's workers.

[1] See for example De Nardi et al. (1999), Bohn (1999), Cutler et al. (1990), and Elmendorf and Sheiner (2000a, 2000b).

[2] Attanasio and Violante (2000) consider how the (aggregated) U.S. and European demographic transition would be affected by an increased capital mobility to and from Latin America.

The government's (restricted) optimal taxation problem is also described in Section 2. The problem is restricted in that it is formulated as an optimal savings problem where only the labor income tax rate is a choice variable. Countries are in the main scenario treated as small, with no possibility to influence world factor prices. The optimal policy in autarky (where factor prices are affected) is also considered.

Section 3 describes the parameterization of the model, and in particular assumptions and estimates about future public expenses. Effective labour supply is adjusted for age-specific productivity and participation rates. Throughout the study, public spending and public transfers per capita are assumed to be held constant at the present level. Inferring the present level from the data is, however, not unproblematic. As the benchmark, all public outlays are assumed to be uniformly divided between age groups. An alternative parameterization of the model attempts to assign age-specific values to public outlays.

Health care costs account for a substantial part of public outlays. Since the elderly consume more health care than other groups, one could expect these costs to increase as the population grows older. But, as life expectancy increases people of a certain age will become healthier and thus demand less care. Several studies indeed indicate that health care costs are more closely related to the remaining life time than to age. The model specification with age-specific public expenses may therefore exaggerate the future increase in public outlays.

The findings are reported in Section 4, and Section 5 concludes.

2 The model and optimal public policy

2.1 Households

Consider an economy populated by a large number of identical and infinitely lived households. Let p denote the mass of household members (the population size). A fraction η of household members are active in the labor market and have one unit of time to dispose of. Members of the household maximize their joint utility, described by

$$\sum_{t=0}^{\infty} \beta^t p_t U\left(c_t^a, c_t^i, h_t, g, \eta_t\right) \tag{1}$$

where U is the instantaneous utility, c^a and c^i are consumption per active and inactive household member, respectively, h is labor supply per worker, and g is public consumption.

Let ν denote the efficiency of a worker, and let $H = \eta\nu h$ denote a household's total labor supply in efficiency units relative to the household size.[3] The household budget constraint is then

$$a_{t+1} = R_t a_t + \left(1-\tau_t^h\right) w_t p_t H_t + p_t b_t - (1+\tau^c)\, p_t \left[\eta_t c_t^a + (1-\eta_t)\, c_t^i\right] \tag{2}$$

where a_{t+1} is savings from period t to period $t+1$, $R_t = 1 + r_t$ is the gross interest rate, τ^h is the labor-income tax rate, w is the wage rate, b is a lump sum transfer from the government to each household member, and τ^c is the consumption tax.

The household's budget constraint can be rewritten as a life-time constraint,

$$\sum q_t p_t \left[(1+\tau^c)\left(\eta_t c_t^a + (1-\eta_t)\, c_t^i\right) - \left(1-\tau_t^h\right) w_t H_t - b_t\right] = R_0 a_0 \tag{3}$$

[3] Productivity and labor-market participation varies with the age-composition of the labor force and between countries. These effects are captured by ν.

where $q_t/q_{t-1} = 1/R_t$.

The household's first order conditions are then

$$\frac{U_{1t}}{\eta_t} = \frac{U_{2t}}{1-\eta_t} \tag{4}$$

$$\frac{U_{3t}}{U_{1t}} = \frac{-\left(1-\tau_t^h\right)\nu_t w_t}{1+\tau^c} \tag{5}$$

$$\beta^t U_{1t} = \lambda q_t \eta_t \left(1+\tau^c\right) \tag{6}$$

where λ is the Lagrange multiplier on the budget constraint. If q_0 is normalized to unity, the household budget constraint can be rewritten as

$$\sum \beta^t p_t \left[U_{1t}\left(c_t^a - \frac{b_t}{\eta_t\left(1+\tau^c\right)}\right) + U_{2t}c_t^i + U_{3t}h_t\right] = \frac{U_{10}R_0 a_0}{\eta_0\left(1+\tau^c\right)} \tag{7}$$

2.2 The government

The government levies taxes on labor earnings, capital income, and on consumption spending. The tax rates on capital income, τ^π, and consumption, τ^c, are held constant over time. Let k denote the capital stock. The government's budget constraint is then

$$d_{t+1} = R_t d_t + p_t g_t + p_t b_t - \tau_t^h w_t p_t H_t - \tau^\pi r_t k_t - \tau^c p_t\left[\eta_t c_t^a + \left(1-\eta_t\right)c_t^i\right] \tag{8}$$

where d is the public debt.

By substituting the household budget constraint (2) into (8), the government's budget constraint can be rewritten as

$$\sum q_t p_t\left(g_t + \eta_t c_t^a + \left(1-\eta_t\right)c_t^i - \tau^\pi r_t k_t/p_t - w_t H_t\right) = R_0\left(a_0 - d_0\right). \tag{9}$$

2.3 Production

A large number of competitive firms maximize profits,

$$\max k^\theta \left(pH\right)^{1-\theta} - wpH - \left[\left(1+\tau^\pi\right)r + \delta\right]k$$

where δ is the depreciation rate of capital. Competition among firms ensures that

$$\left(1+\tau^\pi\right)r = \theta\frac{y}{k} - \delta \tag{10}$$

and

$$w = \left(1-\theta\right)\frac{y}{pH} \tag{11}$$

where $y = k^\theta\left(pH\right)^{1-\theta}$ denotes production.

2.4 Optimal policy in a small open economy

The interest rate path $\{r_t\}$ is exogenous to the small open economy. Capital can move freely between countries but labor is immobile. The capital-output ratio, $\kappa = k/y$, is therefore implied by the world market interest rate from equation (10). By using the production function and equation (11) we can substitute for k and w in (9) and get

$$\sum q_t p_t \left[g_t + \eta_t c_t^a + (1-\eta_t) c_t^i - \left(\tau^\pi r_t \kappa_t^{\frac{1}{1-\theta}} - (1-\theta) \kappa_t^{\frac{\theta}{1-\theta}} \right) H_t \right] = R_0 (a_0 - d_0). \qquad (12)$$

A feasible government policy is a sequence of tax rates $\left\{ \tau_t^h \right\}$ fulfilling the budget constraint and a transversality condition. To find the optimal policy, it is convenient to reformulate the government's optimization problem as a Ramsey allocation problem where the government chooses sequences of consumption and labor supply under the additional constraint that these sequences are consistent with household optimization.[4,5] The Ramsey allocation problem is

$$\max_{\left\{ c_t^a, c_t^i, h_t \right\}} \sum \beta^t p_t U \left(c_t^a, c_t^i, h_t, g_t, \eta_t \right)$$

subject to the household and government budget constraints, (7) and (12), and household optimization, (4) and (6). Note that one of the household optimization conditions, equation (5), is used to solve for the labor tax as a function of allocations.[6]

2.5 World market equilibrium

The world market consists of N countries. The size of country i at time t is p_{it}. The aggregate capital stock is $K_t = \sum_{i=1}^N k_{it}$. Similarly, aggregate savings is $A_t = \sum_{i=1}^N a_{it}$ and the sum of public debts is $D_t = \sum_{i=1}^N d_{it}$. The capital market is in equilibrium if $A_t = (K_t + D_t)$ for all $t \geq 1$. It is straightforward to verify that the world resource constraint,

$$\sum_{i=1}^N p_{it} \left(C_{it} + g_{it} \right) + K_{t+1} = \sum_{i=1}^N y_{it} + (1-\delta) K_t,$$

is fulfilled if the capital market is in equilibrium and the budget constraints (7) and (12) are fulfilled in all countries.

2.6 Optimal policy in a closed economy

The Ramsey allocation problem in a closed economy is

$$\max_{\left\{ c_t^a, c_t^i, h_t, k_{t+1} \right\}} \sum \beta^t p_t U \left(c_t^a, c_t^i, h_t, g_t, \eta_t \right)$$

subject to the household budget constraint, (7), household optimization, (4) and (6), and a resource constraint

$$p_t \left[C_t + g_t \right] + k_{t+1} = k_t^\theta \left(p_t H_t \right)^{1-\theta} + (1-\delta) k_t. \qquad (13)$$

[4] For more on the Ramsey allocation problem, see Chari and Kehoe (1999) and Atkeson, Chari, and Kehoe (1999). Their sections on open economy models are particularly relevant.

[5] I use the term 'optimal policy' to denote the optimal choice of $\left\{ \tau_t^h \right\}$ under the restriction that τ^π and τ^c cannot be changed.

[6] The Appendix contains details on the Ramsey problem.

3 Calibration

The utility function is

$$U\left(c^a, c^i, h, g, \eta\right) = \eta \frac{(c^a)^{1-\mu}}{1-\mu} \exp\left[-\zeta (1-\mu) h^{1+1/\gamma}\right] + (1-\eta) \frac{(c^i)^{1-\mu}}{1-\mu} + v(g)$$

where v is some increasing function. Risk aversion, μ, is set to 2 for the baseline calibration. Estimates of the intertemporal labor supply elasticity, γ, typically range between 0 and 0.5 – see for example Altonji (1986) and Flood and MaCurdy (1992).[7] As the benchmark I set $\gamma = 0.3$ but I also consider a lower (0.1) and a higher (0.5) elasticity.

The effective potential labor supply depends on the size of the labor force (captured by p and η) and by its efficiency (captured by ν). The fraction of individuals that is active in the labor market, η, is shown in Figure 1. People aged 20 to 64 are assumed to be workers.[8]

Worker efficiency is affected by the age structure of the labor force. Middle-aged workers appear to be both more productive (reflected by a higher wage rate) and to participate in the labor market to a higher extent than young and old workers. The variable ν captures these effects. Age-specific productivity is based on estimates for the United States reported in Hansen (1993). Participation rates are estimated by Fullerton (1999) and are also based on U.S. data. These age-specific values for productivity and participation (reported in Table I) are then multiplied by the number of workers in that age group relative to the total number of workers. Finally, initial efficiency, $\bar{\nu}$, was normalized to unity in the United States. In the other countries, $\bar{\nu}$ was chosen to obtain the respective country's output per capita relative to the United States.[9] Note that the same adjustment factor for the age composition was used for all countries. In reality, age-specific participation rates may be quite different in different countries because of different education or retirement patterns. However, the quantitative importance of ν is small, so such differences are likely to be negligible.

Table I
Calculation of ν

Age	Productivity relative to average[a]	Participation rate[b]
20-24	0.71	65.9[c]
25-34	0.99	84.6
35-44	1.15	84.7
45-54	1.15	82.5
55-64	0.84	59.3

Notes: a) Hansen (1993) b) Fullerton (1999) c) The value refers to ages 16-24.

The consumption tax rate, τ^c, and the initial tax rate on labor income, τ_0^h, are taken from table 4 in Carey and Tchilinguirian (2000). They calculate effective average tax rates for OECD countries using an improved version of the method suggested by Mendoza et al. (1995). The first two columns in Table II summarize these country-specific tax rates.

[7] The intertemporal labor supply elasticity is equal to γ when $\mu = 1$, and approximately equal to γ otherwise. In practice, estimates of the elasticity are often estimates of γ rather than of the elasticity.

[8] The demographic forecasts are based on the United Nation's estimates from 1998. Thomas Lindh kindly provided this data. I have assumed that population growth is zero both in the initial and in the final steady states. The first assumption is obviously counterfactual, but of little importance.

[9] Output per capita is based on OECD data (with no purchasing power adjustment) and is the average from 1995 to 2000.

Table II
Country-specific parameters

	τ_0^h	τ^c	$\bar{d}$	$\bar{b}$	$\bar{g}$	$\bar{\nu}$	w (%)	reduc.
Belgium	0.397	0.187	1.110	0.163	0.192	0.758	1.53	0.087
Denmark	0.428	0.257	0.516	0.144	0.269	0.992	0.79	0.194
Finland	0.445	0.227	0.406	0.167	0.250	0.777	0.78	0.207
France	0.402	0.180	0.646	0.179	0.190	0.785	8.87	0.066
Germany	0.359	0.158	0.617	0.154	0.178	0.777	12.34	0.066
Italy	0.363	0.160	1.152	0.150	0.171	0.621	8.60	0.114
Netherlands	0.410	0.187	0.606	0.137	0.264	0.770	2.37	0.247
Norway	0.355	0.269	0.332	0.115	0.264	1.076	0.67	0.162
Portugal	0.227	0.205	0.554	0.108	0.170	0.334	1.48	0.114
Spain	0.304	0.137	0.706	0.129	0.156	0.464	5.95	0.114
Sweden	0.485	0.187	0.644	0.147	0.265	0.863	1.34	0.209
U.K.	0.210	0.169	0.492	0.147	0.112	0.727	8.83	0.023
Canada	0.287	0.131	0.825	0.070	0.192	0.603	4.68	0.117
USA	0.226	0.061	0.571	0.071	0.126	1.000	41.78	0.034
World	0.291	0.122	0.653	0.114	0.156	0.825	100.00	0.068

Note: w is the country's initial population weight, reduc. is Adema's reduction factor.

3.1 Initial steady state

All economies are assumed to be in a steady state in year 2000. These steady states are calibrated to be similar to the actual economies in the recent past. I assume that the initial net position of households against the rest of the world is zero in each economy (see Nordin et. al., 1992, for Swedish evidence), hence $a = d + k$. I further assume that $\tau^\pi = 0.4$ in all countries.[10]

The time discount factor, β, is calibrated so that the capital-output ratio equals 2.5 in all countries. The capital share in production, θ, is set to 0.36, and the depreciation rate of capital, δ, is set to 10 percent per year. Consequently $(1 + \tau^\pi)\, r = 0.044$.

Public transfers, b, are based on OECD's Social Expenditure Data Base. Transfers per capita for the initial steady state are calculated as the sum of public spending on old-age cash benefits, disability cash benefits, occupational injury and disease, sickness benefits, survivors pensions, family cash benefits, unemployment benefits, and housing benefits. The values are from 1995 or 1996 depending on availability, and all values are relative to GDP per capita. The transfers reported by OECD are gross and may be subject to taxation in some countries. The adjustment factors reported in Adema's (1999) table 3, row 1, have therefore been used to adjust the OECD figures.[11]

Public debt is gross government debt in year 2000 from OECD's Economic Outlook, relative to GDP from the same data set. Table II reports the country-specific parameter values used in the initial steady-state.[12] The initial population weights are also reported in Table II.

[10] Estimates of tax rates on capital income varies substaintially between studies and appear unreliable. However, estimates around 40 percent are common, see for example Carey and Tchilinguirian (2000).

[11] Adema does not report adjustment factors for France, Spain and Portugal. The German adjustment factor was used for France, while the Italian factor was used for Spain and Portugal.

[12] The levels of public consumption reported in the table are solved from the equilibrium conditions as described below.

The preference for leisure, captured by ζ, is set so that labor supply is approximately 33 percent of available time in the initial steady state for the U.S. economy. Further, it is assumed that $\beta R = 1$ (otherwise no steady state would exist under optimal policy), and that there is no population growth in the steady state. For any variable x, let $\bar{x} \equiv x/y$, and let $C \equiv \eta c^a + (1-\eta) c^i$. The seven equations below then determine the remaining variables in a country's steady state, c^a, c^i, h, w, y, g, and r,

$$(1+\tau^c)\bar{C} = r\bar{a} + \left(1-\tau^h\right)\eta\nu h\bar{w} + \bar{b} \tag{14}$$

$$\bar{g} + \bar{b} + r\bar{d} = \tau^h\eta\nu h\bar{w} + \tau^\pi r\bar{k} + \tau^c\bar{C} \tag{15}$$

$$\bar{k} = \frac{\theta}{(1+\tau^\pi) r + \delta} \tag{16}$$

$$y = \bar{k}^{\frac{\theta}{1-\theta}}\eta\nu h \tag{17}$$

$$\bar{w} = \frac{1-\theta}{\eta\nu h} \tag{18}$$

$$\frac{U_1}{\eta} = \frac{U_2}{1-\eta} \tag{19}$$

$$\frac{\left(1-\tau^h\right)\bar{w}\nu y}{1+\tau^c} = -\frac{U_3}{U_1} \tag{20}$$

The seven equations above are the household budget constraint; the government budget constraint; the production function; the first order conditions for factor prices (two equations); and the first order conditions for c^i and h.

Table III summarizes the parameter values that are common to all economies.

Table III
Parameter values and initial steady state

Risk aversion	μ	2.000
Labor-supply elasticity	γ	0.300
Time discount factor	β	0.969
Capital-output ratio	$\bar{k}$	2.500
Capital share	θ	0.360
Interest rate	r	0.031
Preference for leisure	ζ	30.000
Tax on firm profits	τ^π	0.400

Note: Parameter values refer to the baseline specification.

3.2 Future development of public expenditure

Two alternative approaches are used for choosing the future paths of transfers and public consumption. Both approaches attempt to predict what happens if there are no changes in policies. The first approach assumes that these variables remain constant at the level from the initial steady state. The implicit assumptions are then that costs grow proportionally with technological development (recall that there is no such development in the model), and that costs are independent of the age structure in the population.

The alternative approach tries to predict how the demographic development will affect public expenditure. Per capita levels of public expenditure in the initial steady state are then calculated separately for the young, for workers, and for the old. These per capita levels are then assumed to remain constant, but total expenditure will be affected by the demographic composition of the population. When calculating the group-specific transfer levels, it is assumed that disability cash benefits, survivors pensions, and housing benefits are evenly divided in the full population, that family cash benefits are evenly divided among the young and the workers, that old-age cash benefits only accrues to the old, and that occupational injury and disease benefits, sickness benefits, and unemployment benefits only accrues to the workers. Many items in public consumption are (implicitly) assumed to be independent of the age structure (for example police and defence). Health care costs, education costs, and spending on day care and long term care are allocated to the different age groups.

Health care costs are assumed to be four times higher per capita for old persons (aged 65+) than for others (see Batljan and Lagergren, 2000, section 3.2). Further, it is assumed that only the old consume long term care, only the young consume day care and primary and secondary education, and only workers consume tertiary education. The data sources are OECD (1998, table VI.3.) for health care and long term care, and OECD (2001, table B2) for education costs.[13] The resulting age structure of transfers and public consumption is reported in Table IV.

Table IV
Age structure of public expenditure

	transfers			public consumption		
	young	worker	old	young	worker	old
Belgium	6.3	11.9	45.5	27.3	13.2	29.7
Denmark	4.1	11.2	43.1	41.9	18.4	38.7
Finland	6.9	13.2	46.9	35.4	18.6	33.7
France	6.1	10.4	64.6	27.1	12.5	30.2
Germany	3.0	7.8	60.5	25.3	11.7	31.3
Italy	4.0	6.1	57.2	28.3	11.9	22.9
Netherlands	4.9	11.1	40.6	28.1	17.3	42.8
Norway	5.0	8.3	34.2	35.6	17.2	46.5
Portugal	3.6	6.5	38.3	28.4	11.6	21.5
Spain	2.4	7.6	45.3	25.0	10.4	23.2
Sweden	5.5	10.7	40.7	38.9	17.0	41.6
U.K.	7.4	9.5	44.8	18.9	5.1	21.7
Canada	1.7	4.3	30.6	25.7	13.7	32.5
USA	1.2	2.3	42.5	17.6	7.5	25.4

Note: Values reported as per capita transfer and consumption relative to gdp per capita.

Obviously, allocating the different components of public expenditure to specific age groups is problematic and associated with many approximations and assumptions. Moreover, even if today's expenditure could be allocated to different age groups with precision, the age structure of spending may change over time. Health care and long term care are important components in public expenditure – the amount to a significant fraction of public expenditure and the costs

[13] Public spending on long term care is not reported for all countries. It is assumed to be 50 percent of total spending in Italy, Spain, and Portugal, and 80 percent in Denmark.

are mostly attributed to the old. When life expectancy increases, it is quite possible that the young retirees will become healthier so that the per capita consumption of these services will fall for the average retiree. The calculations in the alternative approach will then overestimate the demographic impact on public expenditure. Arguably, the two approaches for calibrating the path of future public expenditure result in one too optimistic path (the first approach) and one too pessimistic path (the second approach).

4 Findings

4.1 Changes in labor force and public expenditure

Both the demographic development (changes in p and η) and public expenditure per capita are exogenous to the model. The population's age structure also directly determines the average efficiency of the labor force (ν), and total transfers and public consumption (under the pessimistic scenario for public expenditure). Tables V and VI summarize how these changes affect different countries. The general pattern in this development is similar for all countries, except for the population growth rates which are positive in Canada and the United States but typically negative or small in Europe. The demographic change and its impact on public expenditure will be most severe in Spain and Italy and significantly smaller in the United States and the U.K.

Table V
Decomposition of change in labor force from 2000 to

	2030			2050		
	Δp	$\Delta \eta$	$\Delta \nu$	Δp	$\Delta \eta$	$\Delta \nu$
Belgium	−3.7	−9.9	−3.6	−12.2	−13.7	−4.3
Denmark	−2.2	−10.6	−3.4	−9.4	−11.8	−2.7
Finland	0.6	−13.2	−2.5	−5.4	−13.0	−3.6
France	4.3	−8.0	−3.6	1.4	−11.4	−3.2
Germany	−3.6	−10.6	−2.5	−10.8	−14.2	−2.9
Italy	−13.6	−11.4	−4.8	−28.1	−21.9	−3.4
Netherlands	−1.1	−12.2	−5.0	−10.3	−16.6	−5.4
Norway	8.4	−8.5	−4.1	6.6	−10.5	−3.7
Portugal	−7.2	−4.2	−1.9	−17.6	−18.0	−1.6
Spain	−10.1	−6.8	−3.7	−23.7	−24.6	−2.2
Sweden	1.5	−9.0	−1.8	−2.8	−11.3	−4.1
U.K.	1.3	−7.3	−2.7	−3.7	−9.3	−3.3
Canada	25.2	−11.3	−3.4	35.8	−13.3	−4.4
USA	19.5	−6.4	−3.0	25.5	−6.5	−4.1

Note: The table shows changes in percent.

Table VI
Change in public expenditure from 2000 to

	2030		2050	
	$\Delta \frac{g}{y/p}$	$\Delta \frac{b}{y/p}$	$\Delta \frac{g}{y/p}$	$\Delta \frac{b}{y/p}$
Belgium	1.0	3.0	1.4	3.8
Denmark	1.3	2.6	1.4	3.0
Finland	1.2	3.6	1.1	3.7
France	0.9	3.9	1.3	5.2
Germany	1.5	5.1	1.9	6.3
Italy	0.6	5.5	1.4	8.4
Netherlands	2.5	3.7	3.2	4.4
Norway	1.7	2.0	2.2	2.5
Portugal	0.0	2.4	0.8	5.0
Spain	0.4	3.7	1.9	7.7
Sweden	1.4	2.6	1.7	2.9
U.K.	0.8	2.5	1.0	3.2
Canada	1.5	2.6	1.7	2.9
USA	1.0	3.3	1.1	3.8

Note: The table shows changes in percentage points under the assumption that y/p is constant. Pessimistic scenario for public expenditure.

4.2 Development of factor prices

Figure 2 shows the interest rate paths that are consistent with capital market equilibrium under different assumptions about policy choices and the development of public expenditure. The interest rate falls during the population aging episode since the smaller number of workers implies that less capital is needed in production. Wages, on the other hand increases during the transition. In the long run, the interest rate and wage return to the equilibrium levels.

Figure 2 also shows that the effects on the interest rate are larger if countries choose balanced-budget policies (the dashed line) rather than optimal policies (the solid line), and if public expenditure develops according to the pessimistic scenario (the dotted line). Both these effects can be understood by looking at the paths for labor-income taxes. With the balanced-budget policy, taxes will be higher in the new equilibrium and consequently output will be lower. The necessary reduction of the capital stock is therefore larger, and the interest rate has to be lower than with optimal policy at some point in time. In the pessimistic scenario for public expenditure, taxes are consistently higher than in the optimistic scenario. Output in the new equilibrium is again lower.

4.3 Optimal policy

The optimal policy is to immediately choose a level for the labor-income tax rate and then to hold this tax rate approximately constant.[14] For most countries, the dependency ratio will fall sharply between year 2010 and 2040. The optimal policy is therefore to increase taxes and public

[14] The optimal tax rate would be constant if the interest rate was constant and utility separable in consumption and leisure.

saving immediately so that debt levels are reduced before the demographic deterioration takes off. Table VII reports the increase in tax rates implied by optimization, and Table VIII reports the implied budget surpluses.[15] Table VII shows that the optimal tax increase varies from 2.0 percent for the U.K. to 8.2 percent for Finland. Table VIII shows that average annual budget surpluses should be between 1.3 percent for the U.K. and 4.1 percent for the Netherlands during the first ten years and similar during the following decades.

The implied budget surpluses follow the pattern in Table V – the countries most severely affected by population aging (Italy, Spain, and the Netherlands) should increase public savings the most. To understand the tax increases that are necessary to obtain these levels of public saving, we also have to consider the initial size of the public sector. Since the excess burden of taxation increases with the size of the public sector, a specific tax raise generates less tax revenue in a country where taxes are already high. This explains why substantial tax raises are required in Finland and Sweden (with high initial taxes) and why this is not the case in Spain (with low initial taxes) although Spain anticipates a more severe demographic change.

The optimal policies are not particularly sensitive to the choice of labor-supply elasticity or risk aversion, but the assumption about future public expenditure is important. The implied policies under the pessimistic assumption are indeed drastic and implausible. Clearly, raising taxes by almost 20 percentage points is not a policy option. For most countries, therefore, current public expenditure levels (per capita) are not sustainable under the pessimistic scenario.

Table VII
Implications of optimal policy: initial tax effect

	benchmark	$\{g_t, b_t\}$	$\gamma = 0.1$	$\gamma = 0.5$	$\mu = 1$
Belgium	5.1	11.5	5.0	5.4	5.8
Denmark	6.8	14.1	6.7	7.1	7.5
Finland	8.2	17.3	7.8	8.8	8.9
France	4.3	12.9	4.3	4.3	4.9
Germany	4.2	15.9	4.4	4.1	4.7
Italy	6.8	19.2	6.7	7.0	7.4
Netherlands	7.8	19.9	7.6	8.1	8.3
Norway	5.1	11.1	5.3	4.9	5.6
Portugal	1.7	6.3	2.0	1.5	2.1
Spain	3.3	11.6	3.6	3.2	3.7
Sweden	5.1	12.3	5.0	5.4	5.9
U.K.	2.0	6.4	2.1	1.8	2.4
Canada	3.0	8.8	3.5	2.7	3.4
USA	0.7	5.9	0.9	0.6	1.2

The table shows the tax increase, in percentage points, the first year with optimal policy. $\{g_t, b_t\}$ is the specification where public expenditure depends on the population's age-structure.

[15] Results for Canada and the United States are also reported here. Note, however, that these countries are not considered part of the study, and the small-economy assumptions are not plausible for the United States.

Table VIII
Implications of optimal policy: necessary budget surplus

	until 2010		until 2030	
	benchmark	$\{g_t, b_t\}$	benchmark	$\{g_t, b_t\}$
Belgium	3.1	6.8	3.2	6.1
Denmark	2.7	6.1	2.2	4.4
Finland	3.3	7.4	2.3	4.7
France	2.4	7.1	2.3	5.9
Germany	2.6	7.6	2.7	6.9
Italy	4.1	10.1	4.3	9.7
Netherlands	4.0	9.9	3.7	8.0
Norway	2.4	6.0	2.1	4.8
Portugal	1.9	4.9	2.6	5.6
Spain	3.3	8.4	4.0	9.0
Sweden	2.4	5.9	2.7	5.1
U.K.	1.3	4.2	1.4	3.6
Canada	2.0	5.7	1.9	4.6
USA	0.7	4.2	0.7	3.3

The table shows the average annual budget surplus (in percentage points) implied by optimal policy.

Is it important that the government tries to follow the optimal debt strategy? Would welfare be significantly reduced if mistakes were made or if the government pursued other objectives? To answer these questions, the optimal policy was compared to a policy balancing the public budget in each period.[16] The alternative policy is thus a sequence of tax rates, $\left\{\hat{\tau}_t^h\right\}$, that holds public debt d_t constant in equation (8) for each t under the assumption that the sequences for interest rates and wages are exogenous. With a balanced-budget policy, tax rates can be held down initially but substantial raises are required between years 2020 and 2050 when the number of retirees increases. Consequently, hours worked and output is lower in the long run with the balanced-budget policy. Table IX reports the welfare loss of sticking to a balanced-budget policy instead of the optimal policy.

Cutler et al. (1990) argue that although the optimal policy for the U.S. government probably is to reduce the public debt in the years before the dependency ratio deteriorates, the welfare gains of such a policy are likely to be small since taxes are not particularly distortionary. The results reported in Table IX support their story, but also indicates that their arguments are not valid for the typical European countries, where the public sector is larger and where the demographic development is more problematic. The welfare loss of sticking to a balanced-budget policy can be substantial in countries with a large public sector and a severe demographic change, in particular if the labor-supply elasticity is somewhat higher than in the benchmark specification.[17]

Table IX also shows that under the pessimistic assumption for public expenditure, pursuing a balanced-budget policy will be infeasible in most countries. This is due to a Laffer-curve effect. To balance the budget, year-to-year fluctuations in public expenditure and in the tax base, may

[16] Note that the study ignores business cycle fluctuations. A balanced-budget policy in the model economy is therefore less drastic than a real-world ditto.

[17] A welfare loss of 0.5 percent of annual consumption amounts to approximately USD 100 per person and year.

require sharp fluctuations in the tax rate. But if taxes are already high, further tax increase may induce households to substitute labor supply into periods with lower taxes. Thus only the countries with low public expenditure (the U.K. and Portugal) or a small initial debt (Norway) appear able to balance the budget in that scenario.

Table IX
Welfare loss with a balanced-budget policy

	benchmark	$\{g_t, b_t\}$	$\gamma = 0.1$	$\gamma = 0.5$	$\mu = 1$
Belgium	0.30	*n.s.*	0.06	1.16	0.36
Denmark	0.24	*n.s.*	0.05	0.82	0.31
Finland	0.38	*n.s.*	0.07	*n.s.*	0.49
France	0.13	*n.s.*	0.03	0.32	0.16
Germany	0.14	*n.s.*	0.04	0.31	0.16
Italy	0.70	*n.s.*	0.13	*n.s.*	0.84
Netherlands	0.66	*n.s.*	0.12	*n.s.*	0.81
Norway	0.09	0.85	0.03	0.19	0.11
Portugal	0.06	0.43	0.02	0.11	0.07
Spain	0.27	*n.s.*	0.07	0.67	0.30
Sweden	0.55	*n.s.*	0.09	*n.s.*	0.69
U.K.	0.01	0.11	0.01	0.02	0.02
Canada	0.03	0.29	0.01	0.06	0.04
USA	0.00	0.08	0.00	0.00	0.00

Note: Welfare loss in percent of annual consumption. N.s. = no solution with balanced-budget policy.

4.4 Coordinated policy choices

So far, countries have been assumed to be small and unable to affect factor prices. It may, however, be both feasible and desirable even for a small country to affect these prices. Countries can affect factor prices by restricting capital mobility, or by cooperating and coordinating policies with other countries.

From Table X and Figure 3, it is evident that the European countries will export capital to the U.S. during the demographic transition. The main explanation is that the U.S. the effective labor force will decline more in the European countries than in the U.S. Compared to a world with no capital mobility between countries, the U.S. will benefit by having more capital in production and thus higher wages. The opposite is true for the European countries.

Table X
Net foreign wealth and investment income in new equilibrium

	net foreign wealth	investment income from abroad
Belgium	117.4	3.8
Denmark	29.7	1.0
Finland	44.4	1.5
France	30.4	1.1
Germany	101.5	3.3
Italy	301.7	9.7
Netherlands	174.1	5.6
Norway	20.0	0.7
Portugal	232.6	7.4
Spain	404.3	12.9
Sweden	79.7	2.6
U.K.	−2.8	0.0
Canada	24.5	0.9
USA	−68.3	−2.1

Note: Values in percent of gdp per capita.

Table XI shows how factor prices and policies that affect factor prices could affect household welfare. The first column shows the welfare gain that would result if factor prices were constant but capital mobile (i.e. a non-equilibrium scenario). Countries relying on large exports of capital (Italy, Portugal, and Spain) would benefit from higher returns on their capital exports whereas all other countries would lose from lower wages. The second column shows that most European countries would be better off if they could maintain the capital stock within the country. By restricting capital mobility, the return to capital falls in a country that otherwise would export capital, but the benefit of this is an increase in wages and domestic production. Obviously, households in the U.S. prefer free capital mobility as they benefit from the capital imported. Furthermore, households in Portugal and Spain would prefer having high interest rates and exporting capital to the U.S. rather than using the capital in domestic production. The third column shows the outcome of a scenario where capital is mobile only within the European Union. The welfare in this scenario is similar to when each European country is autarkic. Such a policy would, however, obtain less resistance from Portugal and Spain.

The fourth column in Table XI shows the welfare gain if all countries can coordinate on balanced-budget policies. There would be virtually no support for coordinating on budget-balance. Even if a country does not plan to balance its own budget it would have little to gain by encouraging budget balance abroad (see final column).

Table XI
Welfare gain with alternative prices

	constant r	autarky	EU	all countries balance budget	other countries balance budget
Belgium	−0.19	0.39	0.26	−0.27	0.00
Denmark	−0.55	0.60	0.50	−0.15	0.06
Finland	−0.51	0.76	0.49	−0.28	0.06
France	−0.34	0.20	0.38	−0.07	0.04
Germany	−0.03	0.23	0.19	−0.13	0.00
Italy	0.26	0.25	−0.03	−0.73	−0.07
Netherlands	0.05	0.61	0.13	−0.65	−0.03
Norway	−0.32	0.25	-	−0.04	0.05
Portugal	0.23	−0.20	−0.01	−0.12	−0.05
Spain	0.53	−0.44	−0.21	−0.38	−0.11
Sweden	−0.63	0.46	0.48	−0.45	0.04
U.K.	−0.15	−0.01	0.29	0.03	0.04
Canada	−0.08	0.14	-	0.00	0.03
USA	−0.31	−0.17	-	0.07	0.08

Note: The table shows the welfare gain in percent of annual consumption relative to the benchmark economy with all countries optimizing.

5 Concluding remarks

The above analysis ignores several factors that can have important effects on public finances in the future. For example, the process of increased internationalization, tax competition between EU countries, and a more mobile labor force can make the collection of taxes more difficult. Such changes would be similar to an increased labor-supply elasticity, making taxes more distortive over time. Taking these factors into account would therefore make the case for reducing the debt today even stronger.

Implicitly, the study has also assumed that the generosity and structure of welfare and pension systems and public services are unaffected by the demographic change. The internationalization and population aging may imply that the generosity of welfare systems must be reduced or that welfare systems must be reformed.[18] Households may then respond by increasing savings and labor supply, and thus reduce the importance of debt reduction today.

Furthermore, maintaining an unaltered level of public services may be difficult when the demographic structure changes. For example, even if consumption needs for children and old are identical and do not change over time, population aging requires investments in the infrastructure (schools cannot easily be transformed into hospitals). Evidence reported in Bucht et al. (2000) shows that, at least in the short run, school expenditure does not seem to vary directly with the number of students.

The analysis has also neglected intergenerational issues by assuming that households are dynastic. Bohn (1999) argues that the baby-boom generation is the potential loser. This generation will benefit from the increase in wages during the demographic transition (since it is then

[18] Gruber and Wise (2001) found that, historically, non-health related public expenditure has been reduced when the share of old has increased.

retired) and the return on its savings will be low. This fact may provide an argument against raising public savings already now.

There is little doubt that most developed countries will see an aging of their populations in the coming 30 to 40 years. Still, forecasting the long-term future is difficult and associated with many sources of uncertainty. Previous forecasts of survival probabilities have been biased downwards, and nativity is both volatile and difficult to predict. Nativity may also be influenced by policy, something which has been neglected here. Migration is another factor that is difficult to forecast (for example, migration flows may be influenced by war episodes or changes in immigration policies) but that can influence demographic structures.

Considering the above caveats, the implications of the model and experiments conducted should be interpreted cautiously. The following conclusions, however, do not appear daring. First, population aging will put pressure on future public finances. In the long run taxes must be raised or public spending cut. Second, at least if intergenerational issues are ignored, welfare is enhanced if public debts are reduced during the next two or three decades. Third, the welfare benefits of such policies compared to policies that hold debts constant are likely to be small or modest, except in countries with a large public sector and/or a large demographic change. Finally, the United States will be less affected by the demographic transition than the typical European country. This is partly because of a less severe demographic change in the U.S., partly because the small public sector in the U.S., and partly because the U.S. will benefit from capital imports from the European countries.

6 Appendix

6.1 Ramsey problem in a small open economy

Let ρ_1, ρ_2, ρ_{3t}, and ρ_{4t} be the Lagrange multipliers associated with (7), (12), (4) and (6), respectively. Further, let

$$\begin{aligned} W_t &= W\left(c_t^a, c_t^i, h_t, g_t, \eta_t, \rho_1\right) \\ &= U\left(c_t^a, c_t^i, h_t, g_t, \eta_t\right) + \rho_1\left[U_{1t}\left(c_t^a - \frac{b_t}{\eta_t\left(1+\tau^c\right)}\right) + U_{2t}c_t^i + U_{3t}h_t\right]. \end{aligned}$$

The Lagrangian to the Ramsey problem is then

$$\begin{aligned} \mathcal{L} = & \sum_{t=0}^{\infty} \beta^t p_t W_t + \\ & \rho_2 \sum_{t=0}^{\infty} q_t p_t \left[g_t + \eta_t c_t^a + (1-\eta_t) c_t^i - \left(\tau^\pi r_t \kappa_t^{\frac{1}{1-\theta}} + (1-\theta)\kappa_t^{\frac{\theta}{1-\theta}}\right)\eta_t v_t h_t\right] + \\ & \sum_{t=0}^{\infty} \rho_{3t}\left[(1-\eta_t) U_{1t} - \eta_t U_{2t}\right] + \sum_{t=0}^{\infty} \rho_{4t}\left[\beta R_{t+1} U_{1t+1}/\eta_{t+1} - U_{1t}/\eta_t\right] - \\ & \rho_1 \frac{U_{10} R_0 a_0}{\eta_0\left(1+\tau^c\right)} - \rho_2 R_0\left(a_0 - d_0\right) \end{aligned}$$

and the first order conditions with respect to c_0^a, c_0^i, and h_0 (assuming utility of c^i is separable from c^a and h) are

$$0 = p_0 W_{10} - \frac{\rho_1 U_{110} R_0 a_0}{\eta_0\left(1+\tau^c\right)} + \rho_2 p_0 \eta_0 + \rho_{30}\left(1-\eta_0\right) U_{110} - \frac{\rho_{40} U_{110}}{\eta_0}$$

$$
\begin{aligned}
0 &= p_0 W_{20} + \rho_2 p_0 (1-\eta_0) - \rho_{30}\eta_0 U_{220} \\
0 &= p_0 W_{30} - \frac{\rho_1 U_{130} R_0 a_0}{\eta_0 (1+\tau^c)} - \rho_2 p_0 \eta_0 \nu_0 \left(\tau^\pi r_t \kappa_t^{\frac{1}{1-\theta}} + (1-\theta) \kappa_t^{\frac{\theta}{1-\theta}} \right) \\
&\quad + \rho_{30} (1-\eta_0) U_{130} - \frac{\rho_{40} U_{130}}{\eta_0}
\end{aligned}
$$

The first order conditions with respect to c_t^a, c_t^i, and h_t, for $t > 0$ are

$$
\begin{aligned}
0 &= \beta^t p_t W_{1t} + \rho_2 q_t p_t \eta_t + \rho_{3t} (1-\eta_t) U_{11t} - \rho_{4t} U_{11t}/\eta_t + \rho_{4t-1} \beta R_t U_{11t}/\eta_t \\
0 &= \beta^t p_t W_{2t} + \rho_2 q_t p_t (1-\eta_t) - \rho_{3t} \eta_t U_{22t} \\
0 &= \beta^t p_t W_{3t} - \rho_2 q_t p_t \eta_t \nu_t \left(\tau^\pi r_t \kappa_t^{\frac{1}{1-\theta}} + (1-\theta) \kappa_t^{\frac{\theta}{1-\theta}} \right) + \rho_{3t} (1-\eta_t) U_{13t} \\
&\quad - \rho_{4t} U_{13t}/\eta_t + \rho_{4t-1} \beta R_t U_{13t}/\eta_t
\end{aligned}
$$

Clearly, there can only be a stationary equilibrium if $q_{t+1}/q_t = \beta$ in the long run. In steady state, therefore, $\beta R = 1$.

6.2 Ramsey problem in a closed economy

Let ρ_1, ρ_{2t}, ρ_{3t}, and ρ_{4t} be the Lagrange multipliers associated with (7), (13), (4) and (6), respectively. Further, let

$$
\begin{aligned}
W_t &= W\left(c_t^a, c_t^i, h_t, g_t, \eta_t, \rho_1\right) \\
&= U\left(c_t^a, c_t^i, h_t, g_t, \eta_t\right) + \rho_1 \left[U_{1t} \left(c_t^a - \frac{b_t}{\eta_t (1+\tau^c)} \right) + U_{2t} c_t^i + U_{3t} h_t \right].
\end{aligned}
$$

The Lagrangian to the Ramsey problem is then

$$
\begin{aligned}
\mathcal{L} = & \sum_{t=0}^{\infty} \beta^t p_t W_t + \\
& \sum_{t=0}^{\infty} \rho_{2t} \left[p_t \left(\eta_t c_t^a + (1-\eta_t) c_t^i + g_t \right) + k_{t+1} - k_t^\theta (p_t \eta_t \nu_t h_t)^{1-\theta} - (1-\delta) k_t \right] + \\
& \sum_{t=0}^{\infty} \rho_{3t} \left[(1-\eta_t) U_{1t} - \eta_t U_{2t} \right] + \sum_{t=0}^{\infty} \rho_{4t} \left[\beta R_{t+1} U_{1t+1}/\eta_{t+1} - U_{1t}/\eta_t \right] - \\
& \frac{\rho_1 U_{10} R_0 a_0}{\eta_0 (1+\tau^c)}
\end{aligned}
$$

and the first order conditions with respect to c_0^a, c_0^i, and h_0 (assuming utility of c^i is separable from c^a and h) are

$$
\begin{aligned}
0 &= p_0 W_{10} - \frac{\rho_1 U_{110} R_0 a_0}{\eta_0 (1+\tau^c)} + \rho_{20} p_0 \eta_0 + \rho_{30} (1-\eta_0) U_{110} - \rho_{40} U_{110}/\eta_0 \\
0 &= p_0 W_{20} + \rho_{20} p_0 (1-\eta_0) - \rho_{30} \eta_0 U_{220} \\
0 &= p_0 W_{30} - \frac{\rho_1 (U_{130} R_0 + U_{10} R_{h0}) a_0}{\eta_0 (1+\tau^c)} - \rho_{20} (1-\theta) k_0^\theta (p_0 \eta_0 \nu_0)^{1-\theta} h_0^{-\theta} \\
&\quad + \rho_{30} (1-\eta_0) U_{130} - \rho_{40} U_{130}/\eta_0
\end{aligned}
$$

The first order conditions with respect to c_t^a, c_t^i, h_t, and k_t for $t > 0$ are

$$
\begin{aligned}
0 &= \beta^t p_t W_{1t} + \rho_{2t} p_t \eta_t + \rho_{3t} \left(1 - \eta_t\right) U_{11t} - \rho_{4t} U_{11t}/\eta_t + \rho_{4t-1} \beta R_t U_{11t}/\eta_t \\
0 &= \beta^t p_t W_{2t} + \rho_{2t} p_t \left(1 - \eta_t\right) - \rho_{3t} \eta_t U_{22t} \\
0 &= \beta^t p_t W_{3t} - \rho_{2t} \left(1 - \theta\right) k_t^{\theta} \left(p_t \eta_t \nu_t\right)^{1-\theta} h_t^{-\theta} + \rho_{3t} \left(1 - \eta_t\right) U_{13t} \\
& \quad - \rho_{4t} U_{13t}/\eta_t + \rho_{4t-1} \beta \left(R_t U_{13t} + R_{ht} U_{1t}\right)/\eta_t \\
0 &= \rho_{2t-1} - \rho_{2t} \left[\theta k_t^{\theta-1} \left(p_t \eta_t \nu_t h_t\right)^{1-\theta} - \left(1 - \delta\right)\right] + \rho_{4t-1} \beta R_{kt} U_{1t}/\eta_t
\end{aligned}
$$

References

Adema, Willem 1999, 'Net social expenditure', OECD labor Market and Social Policy Occasional Papers, No. 39.

Altonji, Joseph G. 1986, 'Intertemporal substitution in labor supply: evidence from micro data', Journal of Political Economy 94: S176-S215.

Aronsson, Thomas, and Palme, Mårten 1998, 'A decade of tax and benefit reforms in Sweden: Effects on labor supply, welfare and inequality', Economica 65: 39-67.

Atkeson, Andrew, Chari, V. V., and Kehoe, Patrick J. 1999, 'Taxing capital income: a bad idea', Federal Reserve Bank of Minneapolis Quarterly Review, Summer 1999.

Attanasio, Orazio P., and Giovanni L. Violante 2000, 'The demographic tranistion in closed and open economy: a tale of two regions', manuscript, University College London.

Batljan, Ilija, and Lagergren, Mårten 2000, 'Kommer det att finnas en hjälpande hand?' (in Swedish), Bilaga 8 till Långtidsutredningen 1999/200.

Bohn, Henning 1999, 'Will Social Security and Medicare Remain Viable as the U.S. Population Is Aging?', Carnegie-Rochester Conference Series on Public Policy 50: 1-53 .

Bucht, Charlotte, Bylund, Jessica, and Norlin, Jonas 2000, 'En åldrande befolkning -konsekvenser för svensk ekonomi' (in Swedish), Bilaga 9 till Långtidsutredningen 1999/2000.

Carey, David, and Tchilinguirian, Harry 2000, 'Average effective tax rates on capital, labor and consumption', OECD Economics Department Working Papers No. 258.

Chari, V. V., and Kehoe, Patrick J. 1999, 'Optimal fiscal and monetary policy', in: Taylor, J. B., and Woodford, M. (eds.), Handbook of Macroeconomics 1C, Elsevier Science.

Cutler, David M., Poterba, James M., Sheiner, Louise M., and Summers, Lawrence H. 1990, 'An aging society: opportunity or challenge?', Brookings Papers on Economic Activity 1: 1-73.

De Nardi, Mariacristina, Selahattin Imrohoroglu, and Thomas J. Sargent 1999, 'Projected U.S. demographics and social security', Review of Economic Dynamics 3: 575-615.

Domeij, David, and Martin Floden 2001, 'Macroeconomic adjustment to demographic change', manuscript, Stockholm School of Economics.

Elmendorf, Douglas W., and Sheiner, Louise M. 2000a, 'Should America save for its old age? Population aging, national saving, and fiscal policy', manuscript, Federal Reserve Board.

Elmendorf, Douglas W., and Sheiner, Louise M. 2000b, 'Should America save for its old age? Fiscal policy, population aging, and national saving', Journal of Economic Perspectives: 14: 57-74.

Flood, Lennart, and MaCurdy, Thomas E. 1992, 'Work disincentive effects of taxes: an empirical analysis of Swedish men', Carnegie-Rochester Conference Series on Public Policy 37: 239-278.

Fullerton, Howard N., Jr. 1999, 'Labor force participation: 75 years of change, 1950-98 and 1998-2025', Monthly Labor Review 122: 3-12.

Gruber, Jonathan, and David Wise 2001, 'An international perspective on policies for an aging society', NBER Working Paper 8103.

Hansen, Gary D. 1993, 'The cyclical and secular behaviour of the labor input: comparing efficiency units and hours worked', Journal of Applied Econometrics 8: 71-80.

Mendoza, Enrique G., Razin, Assaf, and Tesar, Linda L. 1995, 'Effective tax rates in macroeconomics: Cross-country estimates of tax rates on factor incomes and consumption', Journal of Monetary Economics 34: 297-324,

Nordin, Maj, Olsson, Hans, Wickman-Parak, Barbro, and Tengblad, Åke 1992, 'Nationalförmögenheten' (in Swedish), SOU 1992:19, Appendix11 to Långtidsutrendingen 1992.

OECD (1998), 'Maintaining prosperity in an aging society'.

OECD (2001), 'Education at a glance'.

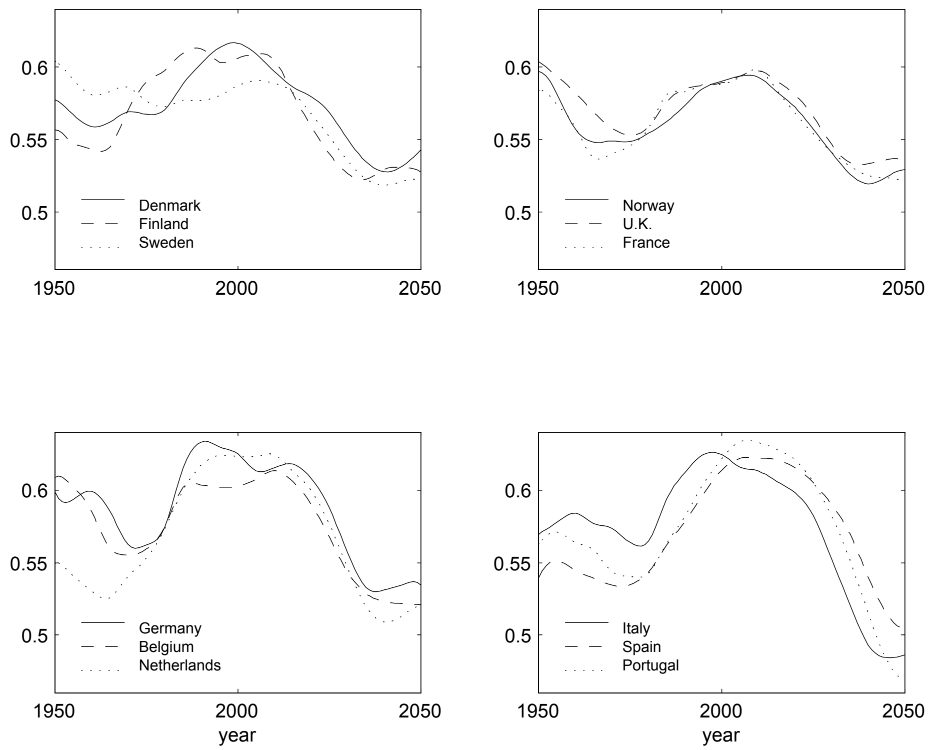

Figure 1: Fraction of workers (age 20-64) in population

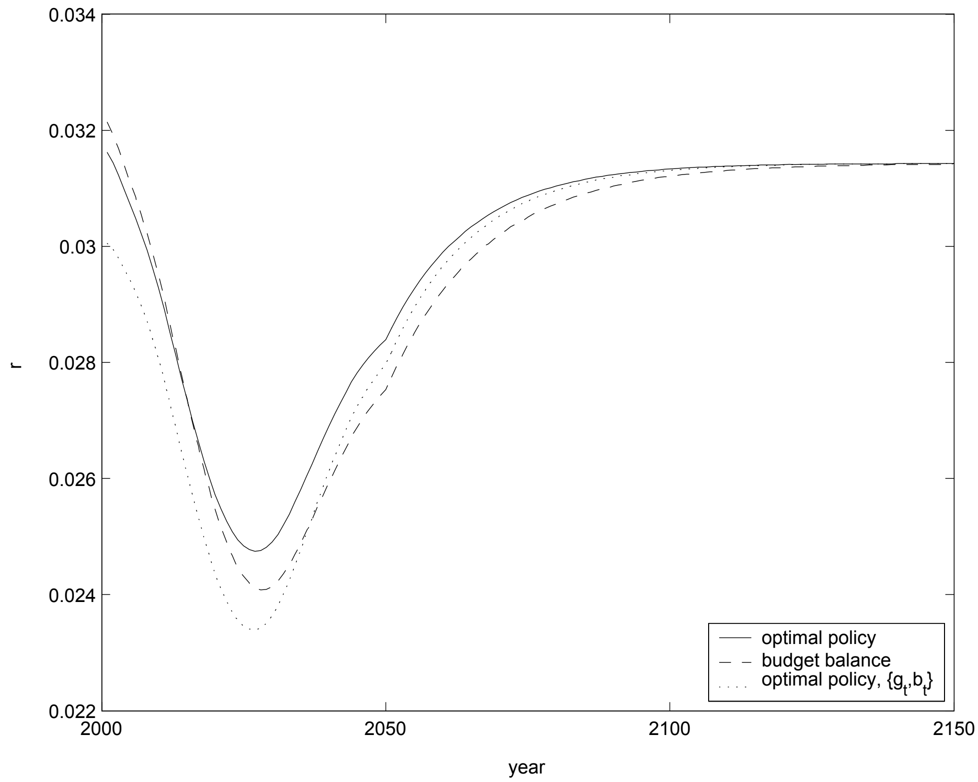

Figure 2: Development of the interest rate
Note: 'Budget balance' denotes the scenario where all countries balance the public budget, $\{g_t, b_t\}$ denotes the scenario where public expenditure depends on the population's age structure.

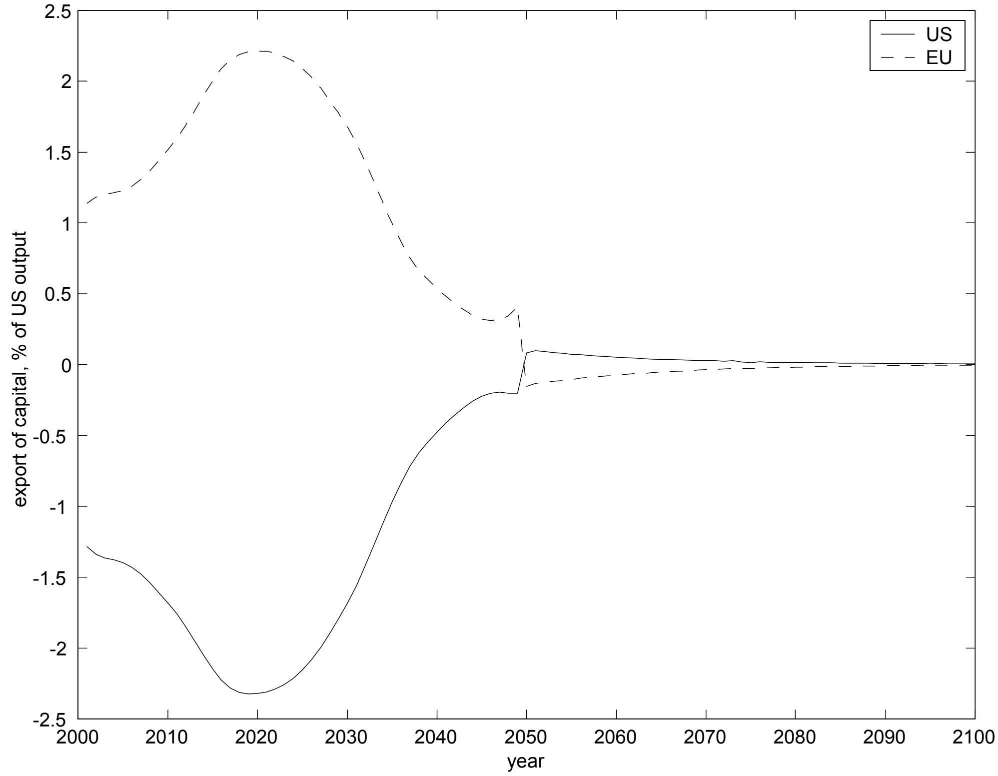

Figure 3: Net export of capital
Note: The figure shows the net export of capital for the US and the sum of net capital exports in the eleven EU countries that are included in the study. All values are in percent of U.S. output. Benchmark model specification.