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Public Saving and Policy Coordination in Aging Economies

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Abstract

In the coming decades, the share of people of working age will fall significantly in most developed countries. According to optimal taxation theory, public debts should be reduced before the baby-boom generation retires. I find that if debts are instead maintained at current levels, welfare may be reduced substantially in countries with a large public sector and/or a large demographic change. Since population aging will be less dramatic in the United States than in Europe and Japan, capital will move from Europe and Japan to the United States. These capital movements will facilitate the US demographic transition but aggravate the transition in most European countries.

Keywords: Demographics; international capital flows; public debt; optimal taxation

JEL classification: *E*62; *F*21; *H*21; *H*60; *J*18

I. Introduction

Owing to falling birth rates, increased longevity and the retirement of the baby-boom generation, the share of people of working age is predicted to fall substantially in most developed countries during the coming three or four decades. It is clear that this demographic change will present major challenges for public finances. By now, awareness of population aging is well established, and these challenges are well documented and examined in a number of reports and research papers.[1]

In this paper I address two issues. First, how should public savings respond to population aging, and does the choice of policy matter? If today's generosity in welfare and pension systems is to be maintained, future

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[1] The OECD Economics Department Working Papers and the IMF Working Papers series contain a number of these reports. See also OECD (1998). A few examples of research papers are De Nardi, Imrohoroglu and Sargent (1999), Bohn (1999), Cutler, Poterba, Sheiner and Summers (1990), Auerbach and Kotlikoff (1992), and Elmendorf and Sheiner (2000a, 2000b).

tax rates may have to be increased dramatically. For example, Kotlikoff, Smetters and Walliser (2001) argue that US payroll tax rates may have to double between 2010 and 2030. If taxes are increased today, they need not be increased as much in the future. Several European countries therefore aim at reducing public debt to strengthen public finances before the baby-boom generation retires, and this seems to be the policy endorsed by the European Commission.[2]

Cutler *et al.* (1990) argue that this optimal taxation argument for increased public saving is unimportant, at least for the United States. In this paper, I find that this is true for the United States, but that many European countries could suffer substantial welfare losses if tax increases were delayed.[3] This is because tax distortions become more severe as tax rates increase, and the typical European country has a large public sector with an extensive welfare system and high tax rates.

Second, I ask how the demographic transition of an open economy is affected by similar demographic development in other countries. Most previous research has either focused on closed economies, or on open economies where the world economy is not subject to demographic change.[4] For example, Higgins (1998) finds that increasing dependency ratios tend to reduce the current-account balance.[5] But, as also pointed out by Higgins, if all countries experience higher dependency ratios, they cannot all experience current-account deficits. It is therefore necessary to use a general equilibrium framework in order to understand how population aging affects international capital flows, and then how these capital flows affect the demographic transition. I find that capital will move from Europe and Japan to the United States, where the demographic change is somewhat smaller and where fiscal problems will be less severe. This capital flight will aggravate the demographic transition in most European countries, but facilitate the US transition.

In this framework, it is also possible to consider policy coordination between countries. In particular, if a number of small economies coordinate on some policy, they may be able to affect factor prices. With the Stability and Growth Pact, the countries of the European union have imposed restrictions on each other's public budget deficits. The main argument for

[2]See European Commission (2002).

[3]The policy implications of population aging were also analyzed in Flodén (2003). In that paper, factor prices did not clear the world market for capital. The main conclusions were nevertheless the same.

[4]An exception is Attanasio and Violante (2000). They consider how the (aggregated) US and European demographic transition would be affected by increased capital mobility to and from Latin America.

[5]Higgins's paper is purely empirical. Auerbach, Kotlikoff, Hagemann and Nicoletti (1989) analyze current-account implications of aging in simulated economies.

this stability pact obviously relates to monetary policy, but there might be other reasons for wanting sound public finances in neighboring countries. I find, however, that policy choices abroad have little effect on domestic welfare.

The model underlying the study is introduced in Section II. In this model, households choose consumption, labor supply and savings, the interest rate path equilibrates the world supply and demand for capital, and the government has a budget constraint to fulfill. The government either balances its budget in each period or chooses the optimal path for public savings. In the main scenario, countries are treated as small, taking factor prices as given.[6]

Section III describes the parameterization of the model. The findings are reported in Section IV, and Section V concludes.

II. The Model and Optimal Public Policy

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

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

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

Let ν denote the efficiency of a worker, and let $h = \eta\nu h^a$ denote a household's total labor supply in efficiency units relative to household size.[7] The household budget constraint is then

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

where a_{t+1} is savings from period t to period $t+1$, $R = 1 + r$ is the gross interest rate, τ^h is the labor-income tax rate, w is the wage rate, b is

[6]Factor prices are nevertheless affected by what happens in the countries. Capital is mobile between countries, labor is immobile, and factor prices have to clear the world market for capital.

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

a lump-sum transfer from the government to each household member, τ^c is the consumption tax and $c = \eta c^a + (1-\eta)c^i$ is the household's total consumption.

The household's budget constraint can be rewritten as a lifetime constraint,

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

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

The household's first-order conditions are then

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

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

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

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

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

Production

A large number of competitive firms maximize profits,

$$\max k^\theta (ph)^{1-\theta} - wph - [(1+\tau^\pi)r + \delta]k,$$

where δ is the depreciation rate of capital and τ^π is the tax rate on capital income. Competition among firms ensures that

$$(1+\tau^\pi)r = \theta \frac{y}{k} - \delta \tag{8}$$

and

$$w = (1-\theta)\frac{y}{ph}, \tag{9}$$

where $y = k^{\theta}\,(ph)^{1-\theta}$ denotes production.

The Government

The government levies taxes on labor earnings, capital income and 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 and let d denote public debt. The government's budget constraint is then

$$d_{t+1} = R_t d_t + p_t g_t + p_t b_t - \tau_t^h w_t p_t h_t - \tau^{\pi} r_t k_t - \tau^{c} p_t c_t. \tag{10}$$

By substituting the household budget constraint (2) into (10), the government's budget constraint can be rewritten as

$$\sum q_t p_t (g_t + c_t - \tau^{\pi} r_t k_t / p_t - w_t h_t) = R_0 (a_0 - d_0). \tag{11}$$

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 (8). By using the production function and equation (9) we can substitute for k and w in (11) and obtain

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

A feasible government policy is a sequence of tax rates $\{\tau_t^h\}$ fulfilling the budget constraint and a transversality condition. Three policy scenarios will be considered: optimal policy in a small open economy, optimal policy in a closed economy, and a balanced-budget policy. 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.[8,9] The Ramsey allocation problem in a small open economy is

[8]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.
[9]I use the term "optimal policy" to denote the optimal choice of $\{\tau_t^h\}$ under the restriction that τ^{π} and τ^{c} cannot be changed.

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

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.[10]

The Ramsey allocation problem in a closed economy is

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

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

$$p_t[c_t + g_t] + k_{t+1} = k_t^{\theta}(p_t h_t)^{1-\theta} + (1-\delta)k_t. \tag{13}$$

A balanced-budget policy is a sequence of tax rates, $\{\hat{\tau}_t^h\}$, that holds public debt d_t constant in equation (10) for each t, under the assumption that the sequences for factor prices are exogenous (for an open economy) or under the assumption that the resource constraint is fulfilled (for a closed economy).

World Market Equilibrium

When countries are treated as small and open, the interest rate path equilibrates the world capital market. There are N countries, and the size of country i at time t is p_{it}. The aggregate capital stock is $K_t = \sum_{i=1}^N k_{it}$, 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 $t \geqslant 1$. It is straightforward to verify that the world resource constraint,

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

is fulfilled if the capital market is in equilibrium and the budget constraints (7) and (12) are fulfilled in all countries. The method for finding the equilibrium interest rate path is described in the Appendix.[11]

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

[11] For further details, see the Matlab code available at www.hhs.se/personal/floden/.

III. Calibration

The utility function is

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

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).[12] 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.[13]

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, also based on US data, are estimated by Fullerton (1999). These age-specific values for productivity and participation (reported in Table 1) are then multiplied by the number of workers in that age group relative to the total number of workers. Initial efficiency, ν_0, was normalized to unity in the United States. In the other countries, ν_0 was chosen to obtain the respective country's output per capita relative to the United States.[14] Note that the same adjustment factor for the age composition was used for all countries. In reality, age-specific participation rates may differ considerably among countries because of different education or retirement patterns. However, the quantitative importance of ν is small, so such differences are likely to be negligible.

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

[12]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.

[13]The demographic data for all countries except Japan are annual data (or forecasts) from the United Nations, 1998. The Japanese data are based on the United Nations' 2002 Revision Population Database and have been annualized by interpolation. I have assumed that population growth is zero in both the initial and the final steady states.

[14]Output per capita is based on purchasing-power adjusted OECD data and is the average from 1995 to 2000.

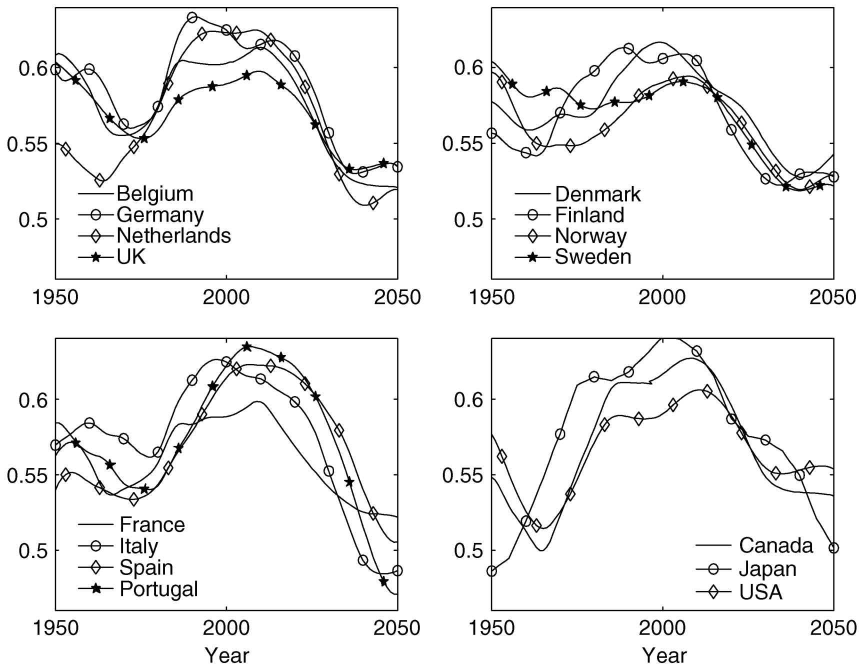

Fig. 1. Fraction of workers (age 20–64) in population

effective average tax rates for OECD countries using an improved version of the method suggested by Mendoza, Razin and Tesar (1995). Note that τ^c is constant over time, whereas τ^h is a choice variable from period 1 and onward. The first two columns in Table 2 summarize these country-specific tax rates.

I assume that future transfers and public consumption per capita are held constant. Public transfers, b, are based on the OECD's Social Expenditure

Table 1. *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	1.11	59.3

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

Data Base. Transfers per capita 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 the OECD are gross and may be subject to taxation in some countries. The adjustment factors reported in Adema's (2001, Table 3, row 2) were therefore used to adjust the OECD figures.[15] Table 2 reports the country-specific parameter values and the initial levels of public debt (see below) and population weights.[16]

When assuming that public expenditure per capita will be constant, I implicitly assume 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 of the population. This is obviously a simplistic approach to calibrating future public expenditure. In related work, I found that by allowing for age-specific components in public expenditure, the development of public finances would be even more problematic than what is suggested here; see Flodén (2003). But allocating

Table 2. *Country-specific parameters and initial conditions*

	τ_0^h	τ^c	d_0	b_0	g_0	ν_0	p_0	reduc.
Belgium	0.397	0.187	1.110	0.162	0.193	0.779	1.29	0.090
Canada	0.287	0.131	0.825	0.069	0.193	0.778	3.96	0.129
Denmark	0.428	0.257	0.516	0.136	0.275	0.838	0.67	0.239
Finland	0.445	0.227	0.406	0.169	0.248	0.716	0.66	0.195
France	0.402	0.180	0.646	0.177	0.192	0.742	7.50	0.076
Germany	0.359	0.158	0.617	0.153	0.179	0.737	10.44	0.076
Italy	0.363	0.160	1.152	0.147	0.173	0.711	7.28	0.128
Japan	0.240	0.067	1.234	0.072	0.117	0.746	15.37	0.024
Netherlands	0.410	0.187	0.606	0.140	0.232	0.771	2.01	0.230
Norway	0.355	0.269	0.332	0.114	0.265	0.932	0.57	0.170
Portugal	0.227	0.205	0.554	0.106	0.172	0.492	1.25	0.128
Spain	0.304	0.137	0.706	0.127	0.158	0.552	5.03	0.128
Sweden	0.485	0.187	0.644	0.145	0.267	0.777	1.13	0.221
UK	0.210	0.169	0.492	0.146	0.112	0.716	7.47	0.028
USA	0.226	0.061	0.571	0.070	0.126	1.000	35.36	0.040
World	0.283	0.114	0.742	0.106	0.149	0.821	100.00	0.068

Note: d, b and g are relative to GDP, p is percent of world population, reduc. is Adema's reduction factor.

[15] 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.

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

Table 3. *Parameter values and initial steady state*

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

Note: Parameter values refer to the baseline specification.

costs to different age groups is also problematic. For example, people of any given age are likely to become healthier and demand less healthcare as life expectancy increases. Political ambitions may also vary over time. As the population grows older, maintaining today's generosity in welfare systems may be judged to be too costly or, alternatively, the elderly may become politically more important and demand better healthcare, etc.

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, hence $a = d + k$. I further assume that $\tau^{\pi} = 0.4$ in all countries.[17] Public debt is gross government debt in year 2000 from the OECD's Economic Outlook, relative to GDP from the same data set.

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 $(1 + \tau^{\pi})r = 0.044$.

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 US 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 $\bar{x} \equiv x/y$. The seven equations below then determine the remaining variables in a country's steady state, c^a, c^i, h^a, w, y, g and r,

[17]Estimates of tax rates on capital income vary substantially among studies and appear unreliable. However, estimates around 40 percent are common; see for example Carey and Tchilinguirian (2000).

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

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

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

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

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

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

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

These seven equations 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^a.

Table 3 summarizes the parameter values that are common to all economies.

IV. Findings

Changes in Labor Force and Public Expenditure

The demographic development (changes in p and η) is exogenous to the model. The age structure of the population also directly determines the average efficiency of the labor force (ν). Table 4 summarizes 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 fall in the effective labor supply per capita will be most dramatic in Spain, Italy, Japan and the Netherlands, and significantly smaller in the United States and the United Kingdom.

Development of Factor Prices

Figure 2 shows the interest rate paths that are consistent with capital-market equilibrium when all countries choose the optimal policy and

Table 4. *Decomposition of change in labor force from 2000 to 2030 and 2050*

	2030			2050		
	Δp	$\Delta \eta$	$\Delta \nu$	Δp	$\Delta \eta$	$\Delta \nu$
Belgium	−3.8	−9.8	−1.9	−12.2	−13.6	−2.7
Canada	25.2	−11.1	−1.9	35.8	−13.1	−2.8
Denmark	−2.2	−10.8	−2.0	−9.4	−11.9	−1.8
Finland	0.6	−13.1	−1.5	−5.4	−12.9	−2.4
France	4.3	−7.9	−2.0	1.4	−11.3	−1.9
Germany	−3.6	−10.6	−1.3	−10.8	−14.5	−2.0
Italy	−13.6	−11.6	−2.4	−28.1	−22.1	−1.8
Japan	−3.9	−10.7	1.0	−13.1	−21.8	0.0
Netherlands	−1.1	−12.2	−2.8	−10.3	−16.6	−3.5
Norway	8.4	−8.3	−2.5	6.6	−10.4	−2.4
Portugal	−7.2	−3.9	0.0	−17.6	−17.7	−0.1
Spain	−10.1	−6.4	−0.9	−23.7	−24.3	−0.2
Sweden	1.5	−8.8	−0.8	−2.8	−11.2	−2.7
UK	1.3	−7.2	−1.5	−3.7	−9.2	−2.1
USA	19.5	−6.1	−1.8	25.5	−6.2	−2.5
World	5.7	−8.4	−1.3	3.2	−13.0	−1.8

Note: The table shows changes in percent.

when all countries balance their budgets. 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, increase

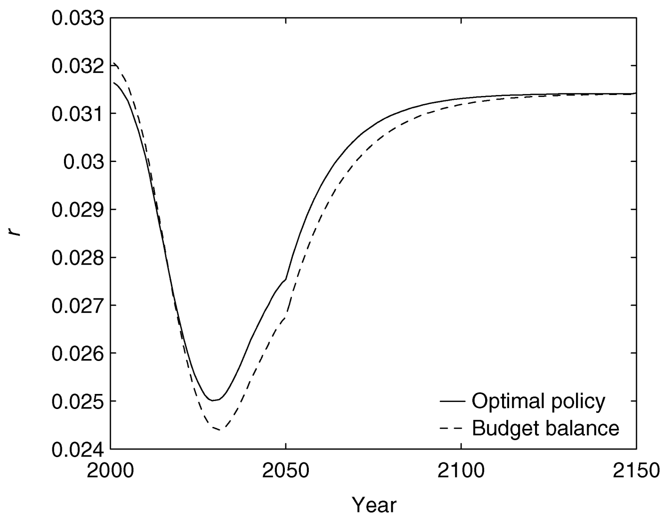

Fig. 2. Development of the interest rate
Note: "Budget balance" denotes the scenario where all countries balance the public budget.

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 rather than optimal policies. This 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.

Optimal Policy

The optimal policy is to immediately choose a level for the labor-income tax rate and then hold this tax rate approximately constant.[18] For most countries, the dependency ratio will increase sharply between 2010 and 2040. The optimal policy is therefore to increase taxes and public saving immediately so that debt levels are reduced before the demographic deterioration takes off. Table 5 reports the budget surpluses and tax increases implied by optimal policy. The table shows that average annual budget surpluses should be between 0.4 percent for the United States and 3.5 percent for

Table 5. *Implications of optimal policy: budget surplus and tax increase*

	Budget surplus		
	until 2010	until 2030	Tax increase
Belgium	2.6	2.9	4.1
Canada	1.7	1.7	2.3
Denmark	2.5	2.1	6.0
Finland	3.1	2.2	7.0
France	2.1	2.1	3.3
Germany	2.2	2.5	3.9
Italy	3.5	4.0	6.0
Japan	1.7	2.1	2.3
Netherlands	3.5	3.4	6.5
Norway	2.1	2.0	4.0
Portugal	1.6	2.4	1.2
Spain	2.7	3.6	2.5
Sweden	2.2	2.4	4.3
UK	1.1	1.3	1.5
USA	0.4	0.5	0.3

Note: The table shows the average annual budget surplus and tax increase (in percentage points) implied by optimal policy.

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

Italy and the Netherlands during the first 10 years and similar during the following decades. The optimal tax increase varies from 0.3 percent for the United States to 7.0 percent for Finland. The optimal policies are not particularly sensitive to the choice of labor-supply elasticity or risk aversion.

The implied budget surpluses mostly follow the pattern in Table 4—countries severely affected by population aging (Italy, Spain and the Netherlands) should increase public savings substantially. 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 increase generates less tax revenue in a country where taxes are already high. This explains why substantial tax increases are required in Finland and Sweden (with high initial taxes) and why this is not the case in Japan and Spain (with low initial taxes) although these countries anticipate a more severe demographic change.

Is it important whether 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 which balances the public budget in each period.[19] With a balanced-budget policy, tax rates can be held down initially but substantial increases are required between 2020 and 2050 when the number of retirees increases. Consequently, hours worked and output are lower in the long run with the balanced-budget policy. Table 6 reports the welfare loss of adhering to a balanced-budget policy instead of the optimal policy.

Cutler *et al.* (1990) argue that although the optimal policy for the US government is probably 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 6 support their story, but also indicate that their arguments are not valid for typical European countries, where the public sector is larger and demographic development is more problematic. The welfare loss of adhering 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 baseline specification.[20]

Table 6 also shows that pursuing a balanced-budget policy may be infeasible in some countries if the labor-supply elasticity is high. This is due to a Laffer-curve effect. To balance the budget, year-to-year fluctuations in

[19]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.

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

Table 6. *Welfare loss with a balanced-budget policy*

	Benchmark	$\gamma = 0.1$	$\gamma = 0.5$	$\mu = 1$
Belgium	0.21	0.05	0.61	0.26
Canada	0.02	0.01	0.04	0.03
Denmark	0.19	0.05	0.54	0.24
Finland	0.28	0.06	n.s.	0.37
France	0.09	0.03	0.21	0.12
Germany	0.11	0.03	0.23	0.13
Italy	0.52	0.11	n.s.	0.62
Japan	0.04	0.01	0.07	0.05
Netherlands	0.45	0.09	n.s.	0.55
Norway	0.07	0.02	0.13	0.09
Portugal	0.05	0.02	0.09	0.06
Spain	0.21	0.06	0.47	0.24
Sweden	0.35	0.07	n.s.	0.45
UK	0.01	0.00	0.01	0.01
USA	0.00	0.00	0.00	0.00

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

the tax base may require sharp fluctuations in the tax rate. But if taxes are already high, a further tax increase may induce households to substitute labor supply into periods with lower taxes. Countries with a large public sector may then not be able to balance their budget.

Capital Flows and Coordinated Policy Choices

So far, I have assumed that countries are small and unable to affect factor prices. It may, however, be both feasible and desirable for even 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 7 and Figure 3, it is evident that Japan and the European countries will export capital to the United States during the demographic transition.[21] The main explanation is that the effective labor force will decline more in Japan and the European countries than in the United States. Compared to a world with no capital mobility between countries, the United States will benefit by having more capital in production and thus higher wages.

Table 8 shows how factor prices as well as policies that affect factor prices could affect household welfare. The first column reports the welfare gain that would result if factor prices were constant but capital mobile (i.e., a

[21]The capital flows are dramatic for some Southern European countries since the model unrealistically assumes that capital is perfectly mobile between countries.

Table 7. *Net foreign wealth and investment income in new equilibrium*

	Net foreign wealth	Investment income from abroad
Belgium	92.1	2.9
Canada	4.5	0.1
Denmark	18.9	0.6
Finland	28.6	0.9
France	12.7	0.4
Germany	78.0	2.5
Italy	274.1	8.6
Japan	183.7	5.8
Netherlands	145.0	4.6
Norway	2.9	0.1
Portugal	201.8	6.3
Spain	367.7	11.6
Sweden	50.9	1.6
UK	−24.8	−0.8
USA	−90.7	−2.8

Note: Values in percent of GDP per capita.

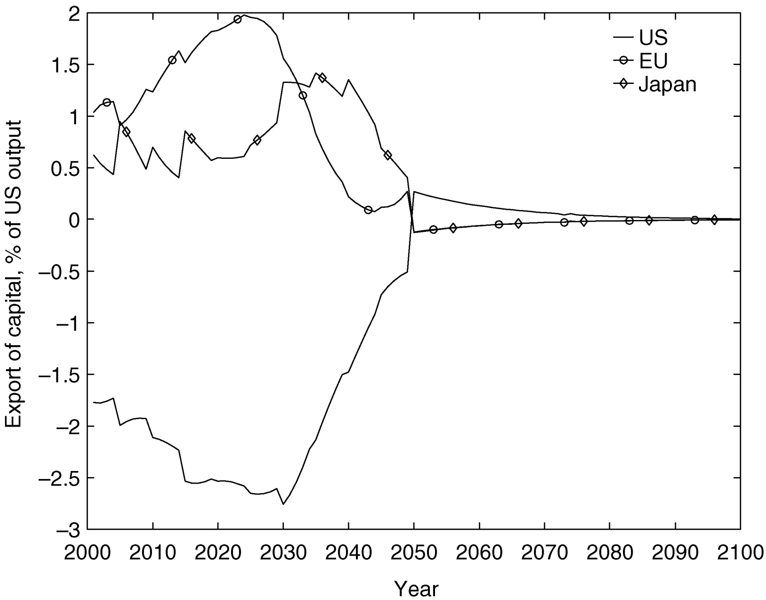

Fig. 3. Net export of capital
Note: The figure shows the net export of capital for the US, Japan, and the sum of net capital exports in the 11 EU countries included in the study. All values are in percent of US output. Benchmark model specification.

Table 8. *Welfare gain with alternative factor prices*

	Constant *r*	Autarky	EU	All countries balance budget	Other countries balance budget
Belgium	−0.16	0.33	0.24	−0.19	0.01
Canada	−0.10	0.10	–	0.01	0.04
Denmark	−0.48	0.56	0.42	−0.12	0.05
Finland	−0.43	0.65	0.41	−0.20	0.05
France	−0.32	0.14	0.34	−0.04	0.04
Germany	−0.03	0.23	0.19	−0.09	0.01
Italy	0.28	0.27	0.00	−0.55	−0.06
Japan	0.20	0.05	–	−0.06	−0.03
Netherlands	0.07	0.54	0.14	−0.44	−0.02
Norway	−0.31	0.18	–	−0.02	0.05
Portugal	0.22	−0.16	0.03	−0.09	−0.04
Spain	0.51	−0.36	−0.13	−0.29	−0.09
Sweden	−0.55	0.42	0.43	−0.27	0.04
UK	−0.16	−0.04	0.26	0.03	0.04
USA	−0.34	−0.23	–	0.07	0.07

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

non-equilibrium scenario). Countries relying on large exports of capital (Spain, Italy, Portugal and Japan) 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 United States prefer free capital mobility as they benefit from the imported capital. Furthermore, households in Portugal and Spain would prefer having high interest rates and exporting capital to the United States 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. Welfare in this scenario is similar to a situation where each European country is autarkic. Such a policy would, however, meet with less resistance from Portugal and Spain.

These results indicate that the European demographic transition will be aggravated by capital flight to the United States, but they do not provide an argument for European countries to actually restrict capital mobility. The model abstracts from many potential benefits of capital mobility, such as effects on technological development and economic growth. Furthermore, restricting capital mobility is not efficient even if the model is taken literally since the potential welfare gains for the European countries are offset by welfare losses in the United States. Some policy where capital is mobile but resources are transferred from the United States to Europe would therefore result in higher welfare in both the United States and Europe.[22]

Since the interest rate is determined by aggregate world behavior, some countries could theoretically benefit by coordinating on policies that deviate from the optimal policy in a small economy. The fourth column in Table 8 shows the welfare gain if all countries 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).

V. Concluding Remarks

The European Commission and several European governments have expressed a desire to reduce public debts before population aging takes off.[23] Cutler *et al.* (1990), however, claim that the optimal taxation argument is relatively unimportant and consequently that there is no need to begin strengthening public budgets right away. Both these (apparently conflicting) viewpoints are supported by the present study. Cutler *et al.* only considered the US economy, and here we have seen that all welfare effects for the United States are negligible. But the welfare loss from ignoring the optimal debt and tax policy may be important in many European economies.

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

Implicitly, this study has also assumed that the generosity and structure of welfare and pension systems and public services are unaffected by demographic change. Internationalization and population aging may imply that the generosity of welfare systems has to be reduced or that welfare systems

[22]Maybe surprisingly, total world welfare is marginally higher when all countries are autarkic than when capital is mobile. There are two explanations for this result. First, consumption is higher in the United States than in Europe since TFP is higher in the United States. A policy that restricts capital mobility benefits European households and consequently redistributes to households with relatively little consumption. Second, policy is not identical in the two scenarios. In particular, governments do not internalize the effects of policy on factor prices when capital is mobile, but they are assumed to internalize that effect in autarky.

[23]See for example European Commission (2002, Part I.4).

should be reformed.[24] Households may then respond by increasing savings and labor supply, and thus reduce the importance of debt reduction today.

A further limitation is that demographic development is assumed to be exogenous. Both economic development in itself, as well as direct policy may affect demographic variables. For example, Storesletten (2000) argues that increased immigration from developing countries may facilitate the demographic transition. The study has also abstracted from capital flows between developing and developed countries. Since the demographic transition in most developing countries lags that of the developed world, these countries have lower (old-age) dependency ratios, and could possibly import capital from the developed world.

Appendix

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

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

The Lagrangian to the Ramsey problem is then

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

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

[24] Gruber and Wise (2001) found that non-health-related public expenditure has typically been reduced in OECD countries when the share of the elderly has increased.

$$0 = p_0 W_{10} - \frac{\rho_1 U_{110} R_0 a_0}{\eta_0(1+\tau^c)} + \rho_2 p_0 \eta_0 + \rho_{30}(1-\eta_0)U_{110} - \frac{\rho_{40} U_{110}}{\eta_0}$$
$$0 = p_0 W_{20} + \rho_2 p_0 (1-\eta_0) - \rho_{30}\eta_0 U_{220}$$
$$0 = p_0 W_{30} - \frac{\rho_1 U_{130} R_0 a_0}{\eta_0(1+\tau^c)} - \rho_2 p_0 \eta_0 \nu_0 \left(\tau^\pi r_t \kappa_t^{\frac{1}{1-\theta}} + (1-\theta)\kappa_t^{\frac{\theta}{1-\theta}}\right)$$
$$+ \rho_{30}(1-\eta_0)U_{130} - \frac{\rho_{40} U_{130}}{\eta_0}.$$

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

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

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

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

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

The Lagrangian to the Ramsey problem is then

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

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

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

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

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

Solving for the World Market Equilibrium

All countries are assumed to be in an initial steady state in year 2000. Then, in the beginning of year 2001, demographics (surprisingly) starts changing, and all agents learn about the future development of demographics and policy. After year 2050, the demographic structure and population size are assumed to be constant in each country. By year 2150, all economies are assumed to have reached the new steady state.

The solution method can be summarized as follows:

(1) Solve for the initial steady states.
(2) Guess a path for the interest rate, $\{r_t\}_{2001}^{2150}$.
(3) Solve for the optimal policy in each country, given these prices.
(4) Calculate the implied aggregate capital stock, K_t, asset holdings, A_t, and government debts, D_t, for all years. World capital markets are in equilibrium if $A_t \approx K_t + D_t$ for all t. If world capital markets are not in equilibrium, update the guess for $\{r_t\}$ and repeat from point 3.

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