AGEING AND FISCAL SUSTAINABILITY IN EUROPE

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1 Introduction[1]

The share of elderly people in the overall population is presently of the order of 15 percent in the EC, US and Japan. Due to increased life expectancy and decline of fertility this share is likely to almost double between now and 2050 in the case of the EU and Japan, while growing more modestly in the US to reach 21% at the end of the period. While the share of the elderly also grew over the last decades, increases up to the present time did not pose insurmountable problems because the population of working age was also growing rapidly and dependency ratios actually fell. Since the number of new entrants declines, sharp increases in dependency ratios are projected to emerge in all areas over the next 50 years. This paper analyses the economic and budgetary implications of current demographic projections for Europe and the US within the framework of a multi-country dynamic general equilibrium model. The results presented in this paper draw heavily on previous work by Mc Morrow and Roeger (1999) using the European Commission's QUEST II model. This paper takes a closer look at the economic mechanisms generating these results with special emphasis on the budgetary implications within a PAYG system. In particular I look at

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[1] The views represented in this paper are those of the author and should not be attributed to the European Commission.

the quantitative impact of financing additional pension and health care expenditure under a distortionary and a less distortionary tax-benefit system.

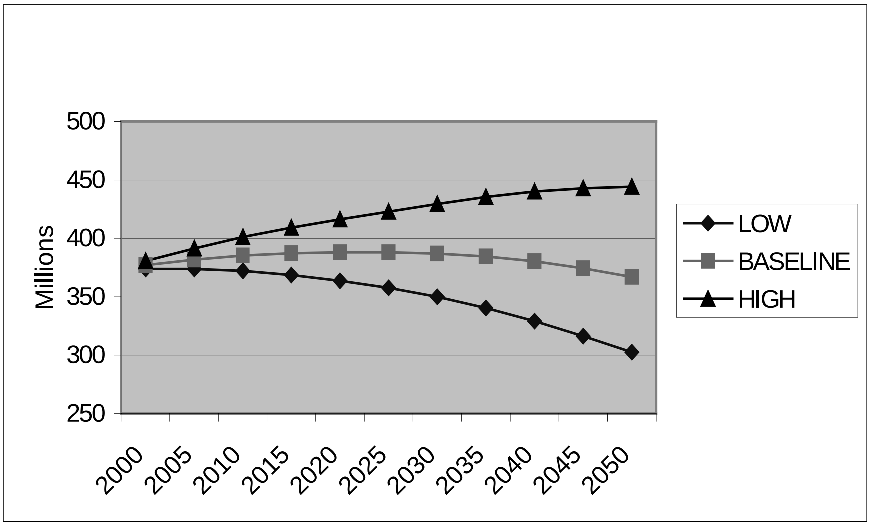
The paper is structured as follows. I first present demographic trends and our assumptions concerning public expenditure implications on pensions and health care. In section 3 I present the theoretical structure of the model used for policy simulations and also provide information on crucial parameter values. Section 5 discusses possible budgetary problems linked to ageing within a PAYG system and section 6 presents the simulation results. Section 7 contains some sensitivity analysis.

2 Demographic Trends and their Public Expenditure Implications

Demographic Trends

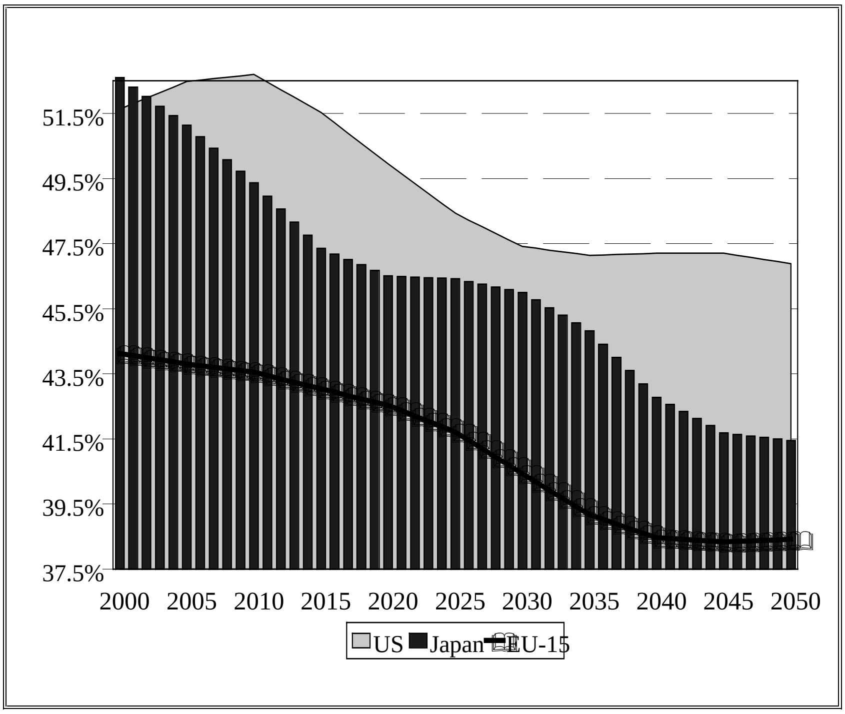
Demographic trends are fairly well predictable given stable fertility and mortality trends. Therefore it is well known that the EU will be confronted with an ageing population, due to falling fertility rates and

Figure 1. Demographic Projections, EU15 2000-2050



increased life expectancy. This process has already started, though large demographic changes are still to come. Given the latest EUROSTAT projections the EU population stays roughly constant over the next 50 years (This is based on the assumption that fertility rates stay at the current level of 1.45 children per woman that life expectancy increases from (81.1, 74.7) years to (85.1, 79.7) years and that annual net migration declines from currently 679 tsd; to 592 tsd. Persons). In terms of the population changes, the central scenario assumes that the EU's overall population will decline slightly over the 50 year period as opposed to an assumption in the baseline of the population continuing to grow modestly. In the case of Japan and the US the population is expected to decline substantially in the case of the former (-0.3% a year), and to grow by 0.4% a year in the US. Graph 1 contains the range of alternative projections. Our analysis will be based on the central scenario.

Figure 2. Labour Force to Population Ratios, EU, US, JA



These overall population changes however mask important developments with regard to the structure of the population, with declines in the relative share of the 15-64 year old age group, leading to large increases in all three regions in overall dependency ratios. These shifts in the population structure are accommodated in the model by changes in the labour force to population ratio which in the baseline is assumed to remain constant but in the central ageing scenario is expected to decline substantially in all areas.

Budgetary Consequences[2]

This has direct budgetary consequences in the form of pension and health expenditure. Public pension schemes in the EU are largely financed on a pay-as-you-go basis, i. e. they are paid from the contributions of the current working population. An increase of the old age dependency ratio between now and 2050 implies either that benefits (relative to wages) must fall or contributions must rise. Over the last 30 years only about 40% of the spending increase related to pensions (and health) was age related, 60% were due to changes in eligibility rules, benefit levels and cost push factors). Under the assumption that future increases in pension expenditure would be entirely age related, expenditures on pensions are likely to increase from around 8% of GDP to around 15%. The following graph gives the evolution over time.

Health care expenditure is more difficult to predict, since technological advances in the health care sector may play a critical role. The OECD, for example predicts that the direct effect of ageing (excluding any non-demographic cost push factors) implies that public expenditures devoted to health are likely to increase from their current level of 6.5% of GDP to around 8%.

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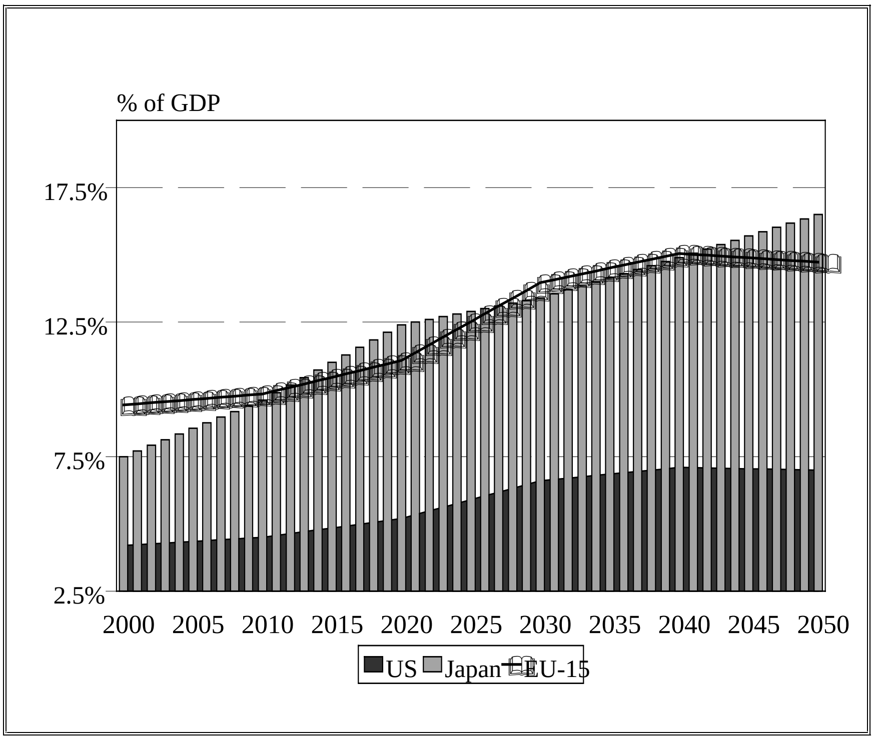
2 The long range forecasts for the public finance implications in terms of pensions, health and education are largely taken from existing OECD (Leibfritz *et al.* (1995), Roseveare *et al.* (1996)) and Commission (Franco and Munzi (1996 and 1997)) sources.

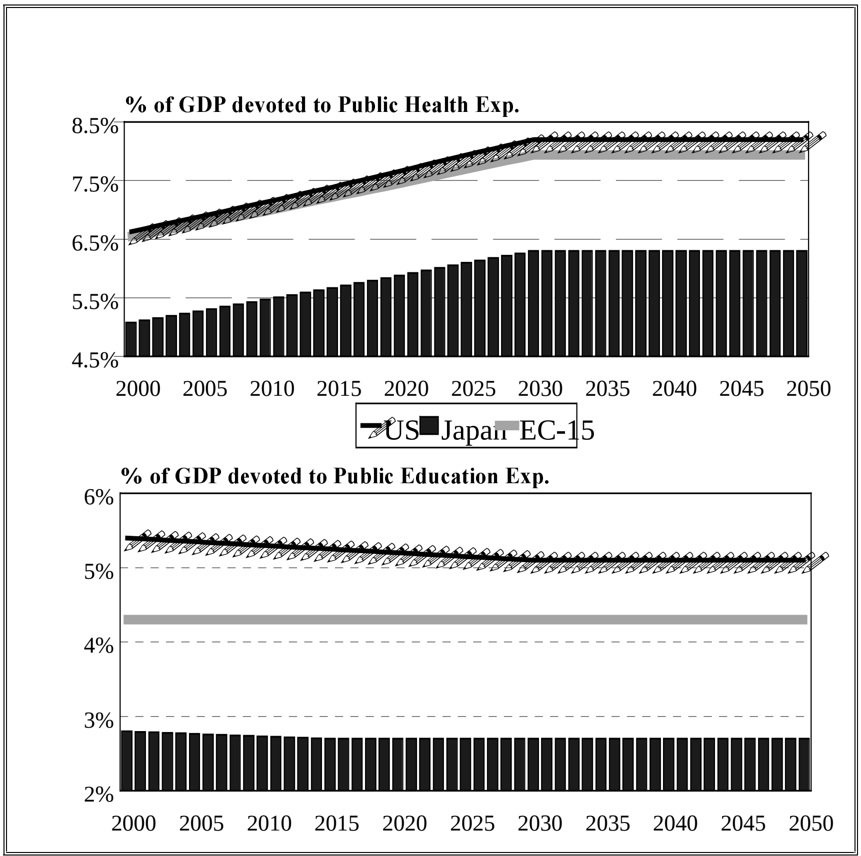
Figure 3. Public Expenditures on Pensions



The demographic impact on education expenditure, despite falling primary and secondary school populations, is not expected to provide any significant budgetary savings which could be used to alleviate the additional cost pressures on the pensions and health budgets. Using OECD and EUROSTAT sources for public expenditure on education as a percentage of GDP in 1995 allied to a per capita breakdown for the primary, secondary and tertiary sectors, it is projected that the direct budgetary effects of ageing will be small, on the assumption that expenditures per child grow in line with real productivity.

The overall impact of these budgetary changes, in the pensions, health care and education sectors, would be to increase public expenditure as a % of GDP by 6 3/4, 10 and 4 percentage points in the EU, Japan and US respectively.

Figure 4. Public Expenditures on Health and Education



3 The Model

The model I use for this paper is a 2 country version of the Commission's QUEST Model, i. e. the model only distinguishes EU15 and the US[3]. The economy in country i (i=1,2)[4] consists of a continuum

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[3] The model structure used here is identical to QUEST, there may, however, be small differences in some structural coefficients. The most important difference concerns the intertemporal elasticity of substitution of consumption. Our previous results were based on a specification with (continues)

of households, as well as a corporate sector and a government. We will describe the economy from the perspective of the home country. The goods produced in the two countries are imperfect substitutes. There exists perfect international capital mobility but zero labour mobility. Households in country i derive utility from consumption of domestic and foreign goods, C_t^d and C_t^f respectively. We assume that the utility function $C(C^d, C^f)$ is of the CES type

$$C_{t,z} = \left[\xi C_{t,z}^{d\ \rho} + (1-\xi) C_{t,z}^{f\ \rho}\right]^{1/\rho} \qquad \rho<1, \sigma=1/(1-\rho) \qquad (1)$$

where σ denotes the elasticity of substitution between domestic and foreign goods. Households objective is to maximise a time separable and logarithmic intertemporal utility function. We follow Blanchard (1985) and assume that each household faces a constant probability of death π each period. As shown for example by Cardia (1991), the household problem can be rewritten in discrete time by weighting the expected utility at time t+j with the probability that the household is alive at t+j, which is $(1+\pi)^{-j}$. Thus the household maximises

$$Max \sum_{j=0}^{\infty} \left[(1+\theta)(1+\pi)\right]^{-j} \frac{E_t\left(C_{t+j,z}\right)^{(1-\omega)}}{1-\omega} \qquad (2)$$

Unlike in conventional neo-classical growth models, there is no leisure term in the utility function. Instead it is assumed that households base their labour supply decision on a concept of permanent income maximisation when negotiating wage contracts with firms. Also, we

an elasticity equal to one, while the results presented here are based on an elasticity equal to .25, we find this parametrisation to be more closely in accordance with the empirical evidence.

4 In order to avoid excessive notation the country superscript will only be used when strictly necessary.

assume that because of important fixed costs associated with going to work, households will not choose hours of work but can only supply a fixed number of hours per period which we normalise to one. One very useful side effect of our specification in the context of open economy models will be the absence of an income effect in the labour supply decision of households. As pointed out by Devereux et al. (1992) and Correia et al. (1995)[5] , such models of labour supply are better suited in an open economy context to capture typical cross country correlation patterns.

Total financial wealth $A_{t,z}$ of an individual household consist of three types of assets, government bonds $B_{t,z}$ shares of domestic firms $q_t K_{t,z}$, where q_t is the share price and $K_{t,z}$ are units of real capital owned by the household. Households can also store wealth in the form of internationally traded bonds $F_{t,z}$ issued by private agents in both countries. We assume, without loss of generality, that internationally traded bonds are expressed in units of foreign output. Define e_t as units of domestic goods per unit of foreign goods then the value of assets expressed in units of domestic goods is given by

$$A_{t,z} = q_t K_{t,z} + B_{t,z} + e_t F_{t,z} \tag{3}$$

The budget constraint of the household is now given by

$$A_{t+1,z} = (1+\pi)\left[A_{t,z} + (1-t_r)(r_t B_{t,z} + (r_t * + \Delta e_{t+1})F_{t,z} + (d_t + \Delta q_{t+1})K_{t,z})\right] + Y^h_{t,z} - (1+t_v)(C^d_{t,z} + e_t C^f_{t,z}) + T_{t,z} \tag{4}$$

5 These authors arrive at a labour supply decision rule which neglects income effects by assuming a model with home production.

Households have a contract with an insurance company. As long as they live they receive a rate of return π on their total financial wealth. When they die their total wealth accrues to the insurance company. The variable r_t is the one period return on government bonds in the home country and r_t* is the rate of return on foreign bonds, d_t is the dividend per unit of capital, $C^d_{t,z}$ and $C^f_{t,z}$ is the consumption of domestic and foreign goods. $T_{t,z}$ is a lump sum transfer and $Y^h_{t,z}$ is household income in period t. The level of income depends on their employment status. The L_t currently employed households receive wage income after taxes $(1-t_l)w_t$ and the $(1-L_t)$ currently unemployed households receive benefits z_t[6]. Households pay taxes (t_r) on interest, dividends and capital gains of domestic and foreign assets. The tax rates do not differ with respect to the type of capital income and the residence principle applies, i.e. households pay the same tax rate irrespective of whether they hold domestic or foreign assets. Households maximise the objective function with respect to consumption of domestic and foreign goods as well as the three types of assets. This gives the following first order conditions

$$E_t(1+t_v)p^c_{t+1}(C_{t+1,z})^{-\omega} = \frac{1+r_t(1-t_r)}{1+\theta}(1+t_v)p^c_t(C_{t,z})^{-\omega} \qquad (5)$$

$$\text{with} \quad p^c_t = \left[\xi + (1-\xi)e_t^{(1-\sigma)}\right]^{1/(1-\sigma)}$$

$$\left(\frac{1-\xi}{\xi}\right)^{\sigma}\left(\frac{C^d_{t,z}}{C^f_{t,z}}\right) = e_t^{\sigma} \qquad (6)$$

6 The analysis abstracts from any transition between in and out of the labour force.

$$\frac{d_{t,z}}{q_t} + E_t\left[\frac{\Delta q_{t+1}}{q_t}\right] = r_t \tag{7}$$

$$r_t * + E_t\left[\frac{\Delta e_{t+1}}{e_t}\right] = r_t \tag{8}$$

Equation (5) gives the familiar first order condition for total consumption of household z. The term p_t^c defines the relative price between the consumption basket and domestic output. Equation (6) determines how the relative price determines consumption of domestic and foreign goods. The three types of assets are perfect substitutes. This property implies two interest arbitrage relations. Dividends plus capital gains per unit of capital must be equal to the one period return of government bonds (equation (7)) and an interest parity condition holds between domestic and foreign bonds (equation (8)).

The corporate sector in each region operates under perfect competition. Output is produced with a constant returns to scale Cobb Douglas production function

$$Y_t = F(K_t, L_t)\Gamma_t = K_t^{1-\alpha} L_t^{\alpha} (e^{\pi t})^{\alpha} \tag{9}$$

Capital stock changes according to the rate of fixed capital formation J_t and the rate of geometric depreciation

$$K_t = J_t + (1-\delta)K_{t-1} \tag{10}$$

Total investment expenditures are equal to investment purchases plus the cost of installation. The unit installation costs are assumed to be a linear function of the investment to capital ratio with a parameter ϕ. Total investment expenditure is therefore given by

$$I_t = J_t\left(1+\frac{\phi}{2}\left(\frac{J_t}{K_t}\right)\right) \tag{11}$$

In order to facilitate aggregation we interpret I as the physical requirement of a composite investment good. This composite good is composed of domestic and imported brands. These brands are combined using a CES technology which is identical to the CES sub-utility function of consumers. Workers are leaving firms at rate s. In order to recruit new workers the firm has to open up job vacancies O_t and advertise actively. The recruitment costs for each vacancy is v_t and it is assumed that it evolves proportional to the nominal wage rate at rate v_0. It is assumed that firms can fill existing vacancies within one period. Employment thus changes according to the following equation

$$L_t = O_t + (1-s)L_{t-1} \tag{12}$$

The corporate sector in country i maximises the net present value of its cash flow

$$V_t = E_t\sum_{j=0}^{\infty}\prod_{k=0}^{j}(1+r_{t+k})^{-1}\left\{(1-t_c)\left[Y_{t+j} - w_{t+j}L_{t+j} - v_{t+j}O_{t+j}\right] - (I^d_{t+j} + e_{t+j}I^f_{t+j})\right\} \tag{13}$$

subject to the technology, the adjustment cost, the capital accumulation and the employment adjustment constraint. Define with λ^k and λ^l the multipliers associated with the constraint on capital and labour respectively. Differentiating the objective function with respect to K_{t+j}, J^d_{t+j}, J^f_{t+j}, L_{t+j} and O_{t+j} (j=0,1....), gives the following system of stochastic Euler equations (subject to the transversality condition)

$$(1-t_c)(1-\alpha)\frac{Y_{t+j}}{K_{t+j}} = (r_{t+j}+\delta)\lambda^k_{t+j} - \frac{\phi}{2}\left(\frac{J_{t+j}}{K_{t+j}}\right)^2 - E_{t+j}\left[\lambda^k_{t+j+1} - \lambda^k_{t+j}\right] \tag{14}$$

$$\left(\phi\frac{J_{t+j}}{K_{t+j}}+1\right)p^c_t = \lambda^k_{t+j} \tag{15}$$

$$\left(\frac{1-\xi}{\xi}\right)^{\sigma}\left(\frac{I^d_t}{I^f_t}\right) = e_t{}^{\sigma} \tag{16}$$

$$(1-t_c)\alpha\frac{Y_{t+j}}{L_{t+j}} = (r_{t+j}+s)\lambda^l_{t+j} + (1-t_c)w_{t+j} - E_{t+j}\left[\lambda^l_{t+j+1} - \lambda^l_{t+j}\right] \tag{17}$$

$$\lambda^l_{t+j} = v_{t+j}(1-t_c) \tag{18}$$

Equation (14) is the equation of motion of the marginal shadow value of capital λ^k. Equation (15) is the first order condition for total investment and it implies that the cost of a marginal unit of capital, including both its purchase and adjustment costs, must equal the shadow value of capital λ^k. The cost of capital includes both the pure rental price and adjustment costs. Equation (16) determines the optimal choice of domestic and foreign investment goods as a function of the relative price. Equations (17) and (18) define the law of motion of the shadow value of labour and show that labour demand is a positive function of output and negative function of total labour costs. Because it is costly for firms to fill existing vacancies, total labour costs are the sum of pure wage costs and vacancy costs. It will be assumed in our analysis that vacancy costs are proportional to wages at rate v_0.

Unlike in the goods market we assume imperfect competition in the labour market in both countries. Here we follow closely the search model discussed in Pissarides (1990). The basic incentive for search activities in the labour market by both workers and firms are the profit opportunities in present value terms which are associated with a successful job match for both parties. In the case of households, this is given by the difference between the present value of labour income a household can earn in the case of a successful current job match, versus the net present value of labour income in the presence of a failure, given by $\left(H^l - H^u\right)$.

Here we observe that the human capital of employed and unemployed households which we denote with H^l and H^u respectively is given by two arbitrage equations. The return from the human capital of an employed worker consists of three components: the current net wage rate, the expected capital loss from a job separation given by $s\left(H^l - H^u\right)$, where s is an exogenous separation rate, and the expected capital gain from an expected change in H^l.

$$(\pi + r_t)H^l_{t,z} = (1 - t_l)w_t + s\left(H^u_{t,z} - H^l_{t,z}\right) + E_t\left[\Delta H^l_{t+1,z}\right] \qquad (19)$$

Corresponding to this equation we can write an arbitrage equation for the human capital of an unemployed household as

$$(\pi + r_t)H^u_{t,z} = z_t + p(.)\left(H^l_{t,z} - H^u_{t,z}\right) + E_t\left[\Delta H^u_{t+1,z}\right] \qquad (20)$$

$$\text{where } p(.) = O_t / (1 - L_t)$$

The return in this case consists of unemployment benefits, the expected capital gain from finding a job with probability p(.), and a capital gain from any expected change of H^u itself. Since we make the assumption that firms can fill vacancies within one period the probability of finding a job is equal to the ratio between vacancies and the number of unemployed workers. For the firm, the return from a successful job match is given by λ^l.

We assume that each firm employs many workers and is large enough to eliminate all uncertainty about the flow of labour. Both parties also know about the profit opportunities of the other players. Wages are determined by an implicit bargain at the individual level, *i.e.* the firm engages in Nash bargains with each individual worker by taking the wage of all other employees as given. Thus wage contracts are set such as to maximise the product

$$\underset{\{w_t\}}{Max}\left(H_t^l - H_t^u\right)^{\beta}\left(\lambda_t^l\right)^{(1-\beta)} \tag{21}$$

This agreement is based on the relative bargaining position of the two parties. The bargaining strength of workers is characterised by the parameter β (0≤β≤1) which determines the fraction of the total return from a successful job match going to workers. Maximising (26) with respect to w_t yields the familiar sharing rule for the division of the surplus where the fraction of the total surplus from a job match going to the worker depends on his bargaining strength

$$H_{t,z}^l - H_{t,z}^u = \beta\left(H_{t,z}^l - H_{t,z}^u + \lambda_t^l\right) \tag{22}$$

Using this sharing rule the following wage equation van be derived

$$w_t = (1-\beta)\frac{z_t}{(1-t_l)} + \beta\left(\alpha\frac{Y_t}{L_t} + v_t\,\frac{\Delta L_t + sL_{t-1}}{1-L_t}\right) \tag{23}$$

According to this rule, wage costs are a weighted average of the reservation wage and labour productivity plus an additional mark-up term that depends positively on labour market tightness. From this wage rule together with the labour demand equation it can easily be seen that, the gross wage rate is set by workers and firms in such a way as to guarantee a certain mark-up of net wages over unemployment benefits. The mark-up will generally depend on economic conditions such as the unemployment rate for example but also on structural characteristics of the labour market such as adjustment costs for labour, the bargaining strength of trade unions etc[7].

The government pays unemployment benefits and consumes domestic and foreign goods (G_t^d, G_t^f). It finances these expenditures by labour income and company taxes, indirect taxes on consumption and lump-sum taxes. The tax rates on wages (t_l) and corporate income (t_c) as well as the consumption tax rate (t_v) are assumed to be constant. Alternatively, the government can issue debt. Thus the government budget constraint is given by

$$B_{t+1} = (1+r_t)B_t + (1-L_t)z_t + G_t^d + e_t G_t^f + T_t - t_l w_t L_t - t_c(Y_t - w_t L_t - v_t O_t) - t_v(C_t^d + e_t C_t^f) \tag{24}$$

As can be inferred from the wage rule, the effect of labour taxes on wages depends crucially on how the government sets unemployment benefits. In this analysis we assume that governments fix benefits to gross wages at the rate z_0, thus changes in labour tax have an effect on the net replacement ratio. Lump sum transfers are adjusted proportionally to the gap between the debt to GDP ratio and its target level b_0 according to the following rule

$$\Delta T = -\psi_1\left(\frac{B_t}{Y_t} - b_0\right) - \psi_2\left(\frac{B_t}{Y_t} - \frac{B_{t-1}}{Y_{t-1}}\right) \tag{25}$$

The government fixes its consumption as a share of GDP at rate g_0 and consumes domestic and foreign goods by maximising the same

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[7] It should be pointed out that this formulation is not restricted to union bargaining models but is a feature of many labour market models. Search models and efficiency wage models of the labour market imply similar wage rules. For an exposition see, for example, Pissarides (1995).

CES sub-utility function as consumers. Government consumption of domestic and foreign goods is thus determined by the following equation

$$\left(\frac{1-\xi}{\xi}\right)^{\sigma}\left(\frac{G_t^d}{G_t^f}\right)=e_t^{\ \sigma} \tag{26}$$

Equilibrium

The market clearing conditions for the goods market in country 1 and 2 are

$$Y_{1t} = C_{1t}^d + C_{2t}^f + I_{1t}^d + I_{2t}^f + G_{1t}^d + G_{2t}^f \tag{27}$$

$$Y_{2t} = C_{2t}^d + C_{1t}^f + I_{2t}^d + I_{1t}^f + G_{2t}^d + G_{1t}^f \tag{28}$$

All bonds and equity supplied by the domestic government and the corporate sector are held by domestic households. The market clearing condition for internationally traded bonds is

$$F_{1t} + F_{2t} = 0 \tag{29}$$

Output prices in both countries serve as numéraire. The competitive equilibrium of this economy consists of a sequence of prices (r_t, r_t*, e_t) and allocations $(C_{it}^d, C_{it}^f, I_{it}^d, I_{it}^f, G_{it}^d, G_{it}^f, K_{it}, F_{it}, B_{it})$ that satisfy the first order conditions of households and firms, the budget constraints of households, governments and firms and goods and bond market equilibrium conditions. Real wages (w_{it}) are determined by the wage contracting rule (23) and firms set employment optimally according to the first order condition (17-18). The labour market equilibrium can coexist with involuntary unemployment. Furthermore, the evolution of the economy is subject to initial conditions $(K_{i0}, L_{i0}, F_{i0}, B_{i0})$ and a sequence of fiscal instruments $(t_r, t_l, t_c, t_v\ b_0, g_0)$ as well as a rule that ensures sustainability of government debt. Interest rates, wages and the exchange rate also ensure that an intertemporal equilibrium condition holds between national saving and investment in both countries. Technical details concerning model solution can be found in Roeger and In't Veld (1999).

4 Model Calibration

In order to assess some basic predictions of the model against observed correlation patterns we calibrate the model for two regions, namely the US and Europe (EU15). To select parameter values we largely follow standard procedures, i.e. we base these values on evidence from growth observations and some microeconomic evidence. In cases where this is not possible parameters are chosen close to those of existing studies. The rate of time preference θ is set equal to 0.01, which implies a steady state annual rate of interest equal to 4%. The probability of death π is set to 0.0035, which corresponds to a life expectancy of 70 years. The output elasticity of labour is set equal to the average wage share. The depreciation rate is set to 2% per quarter which corresponds to the mean rate in our data set over the sample period. The adjustment cost parameter is more difficult to pin down on the basis of information on first moments only. It has, however, been noticed before (see, for example, Mendoza (1991)) that the parameter ϕ has a crucial effect on the volatility of investment. It is therefore set in such a way as to make investment about 3 times as volatile in the US and twice as volatile in Europe. With respect to the separation rate s we draw on information provided by Layard et al. (1990) from data on gross labour market flows. According to their figures the inflow rate into unemployment fluctuates narrowly around two per cent for the reported European countries per quarter. For the US they obtain an estimate of 6.6% per quarter. Our assumption that vacancies can be filled within a quarter is based on studies on vacancy duration. A study by van Ours and Ridder (1992) reports average vacancy durations of 45 days for the Dutch economy. Similar estimates can be found for Germany (see Erdmann (1990)). Blanchard and Diamond (1989) report durations of less than one month for the US. The parameter β referred to as the bargaining strength of workers is set to .5. This implies that all relevant differences between the two parties are captured by the two

Table 1. Parameter Values

	Utility Function:		
θ	0.01	0.01	Rate of time preference
σ	1.0	1.0	Import price elasticity
ξ	0.9	0.9	Share of domestic goods
π	0.0035	0.0035	Probability of death
	Technology:		
α	0.65	0.65	Output elasticity of labour
δ	0.02	0.02	Depreciation rate
ϕ	8.0	5.0	Adjustment cost parameter (investment)
	Labour market:		
S	0.015	0.066	Separation rate
β	0.5	0.5	Bargaining strength of workers
z_0	0.40	0.20	Replacement ratio
v_0	0.13	0.09	Vacancy cost (as share of wages)
	Fiscal Parameters:		
t_π	29%	35%	Effective Corporate Tax Rate
t_l	41%	27%	Effective Labour Tax Rate
t_c	14%	4%	Effective Consumption Tax Rate
t_r	0	0	Taxes on Interest Income
g_0	21%	20%	Government Consumption (% of GDP)
ψ_1	0.025	0.025	Debt targeting rate
TR/Y	19%	9%	Government Transfers (% of GDP)

terms $\left(H_t^l - H_t^u\right)$ and λ_t^l (see Binmore, Rubinstein and Wolinsky (1986) for a discussion of the symmetry axiom).

The level of unemployment compensation determines the reservation wage. Unfortunately, internationally comparable figures on unemployment compensation are not easy to obtain, since countries do not only differ with respect to the replacement ratio but also with respect to benefit duration and coverage. To cover all these different aspects, Layard et al. (1990) have calculated expenditures on benefits per unemployed person as a per cent of output per worker for major OECD countries for the year 1987. According to these figures the ratio within Europe is highest for Denmark (42%) and lowest for Italy (4%) and no calculations are presented for Portugal and Greece. The European average is slightly below 20%. We therefore assume that unemployment benefits amount to roughly 40% of gross wages. The figures for the US suggests that the US replacement ratio is about half the European level. Given the fact that all other parameters have been chosen, the parameter vc_0 can be selected such that the model replicates the steady state unemployment rate in both countries.

We set the price elasticity of imports in both regions equal to one. A value in this neighbourhood can often be found in empirical studies on import and export equations. The share of imports in total GDP is set to 10% in both regions, which is the mean value over the period 1975 to 1992 for the US and the extra EU trade. Finally, the labour and wage tax rates are taken from Mendoza *et al.* (1994).

5 Ageing and Government Debt in a PAYG System

This section explores some of the factors which are important for how ageing affects debt dynamics under a PAYG system. It is well known with a positive level of existing debt, debt dynamics depend crucially on the real interest rate and the growth rate of the economy, both variables will be affected by the ageing process. Consider a simplified version of the government budget constraint where it is assumed that both consumption and corporate taxes are zero and unemployment benefits are indexed to wages

$$\Delta B_{t+1} = r_t B_t + (1 - L_t) z_0 w_t + G_t + TR_t - t_l w_t L_t \tag{30}$$

and let gr be the growth rate of real GDP and assume that government uses labour taxes (social security contributions) to stabilize the debt according to the following rule

$$t_l = \psi(b - btar) \text{ with } b = B/Y \tag{31}$$

then the government budget constraint can be written in intensive form as follows where it is also assumed that *z* is indexed to gross wages

$$\Delta b_{t+1} = (r_t - gr_t - \psi ws(1 - z_0 lur))b_t + g_t + tr_t + z_0 w_t \tag{32}$$

where *ws* is the wage share in GDP. Crucial for sustainability is the condition

$$r_t < gr_t + \psi ws(1 - z_0 lur) \tag{33}$$

In order to see how this condition might be violated under ageing I first look how ageing affects *gr*. Assuming a Cobb Douglas production function (eq 11) and further define

$L = er * LF$ — er : Employment rate

$LF = part * POPW$ — $part$: Participation Rate

$POPW = sw * POP$ — sw: Share, population of working age

The growth rate of real GDP can be decomposed as follows

$$gr = (1-\alpha)\Delta kl / kl + \alpha(\pi + \Delta er / er + \Delta part / part + \Delta sw / sw) + \Delta pop / pop \tag{34}$$

The effect of ageing on some of these factors can be signed, but not in all cases. For example, the effect of ageing on the capital intensity is ambiguous. Standard growth models predict that capital intensity will rise when population growth declines, what is stressed in these models is the falling replacement investment requirement with a declining population. But these models tend to neglect other demographic effects such as changes in the participation rate. Standard life cycle model provide a richer menu of possible reactions. The fall of the birth rate has a negative effect on savings because the share of high saving young households in total population declines. An increase of life expectancy has, everything else equal, a positive effect on savings, though this effect may be quantitatively negligible. The fall of the labour force as a share of total population has a negative effect on the savings rate because life cycle consumers tend to underpredict the decline of future income and therefore do not revise their savings plans sufficiently in order to preserve the historic capital labour ratio. The effect of ageing on total factor productivity is uncertain as well. To the extent that technical progress is embodied either in new capital or in newly born generations, ageing has a negative effect on technical progress. However it seems difficult to provide a quantitative assessment of this effect. In this paper I make the assumption that there is no effect from ageing on technical progress. With distortionary labour taxes the employment rate is likely to fall. How the participation rate is affected is also uncertain and depends in general on the size of income and substitution effects which work in different directions. In this paper I make the simplifying assumption that participation rate will not change. Ageing, of course will naturally be associated with an increase in the dependency ratio and the growth rate of population. The effect of ageing on real interest rates is also uncertain, the evolution of the interest rate is closely linked to capital intensity. If the savings rate declines strongly then r is likely to increase, however, since less capital is required for a declining population, the fall of investment could completely offset the fall in savings.

Thus on purely a priori grounds it is not clear to what extent ageing might violate the sustainability condition. Moreover, one could argue that because the government disposes of a labour tax instrument it can always set labour taxes (or ψ) high enough such that the sustainability condition holds. However there is the problem of the erosion of the tax base. As can be seen from (33) this can arise from two sources, a fall of the wage share and a fall of employment. Though it is likely that an increase in labour taxes leads to a fall of employment, a fall in the wage share can, however, only occur if the elasticity of substitution between capital and labour exceeds one.

6 Simulation Results

With the theoretical considerations of the last section in mind I want to look at the effects of a transfer and population shock as described in section 2. In order to analyse this effect I construct an artificial baseline under the assumption that the main demographic (labour force participation rate, dependency ratio) and fiscal ratios (tax rates, replacement rates, share of government consumption, debt to GDP ratio) remain fixed at their year 2000 levels for the next 100 years, both in the EU and the US. In particular, this also implies that no additional effort is made by governments in the baseline scenario to reduce the current debt to GDP ratios, but to keep it at around 60%. Furthermore I assume a constant growth rate for labour augmenting technical progress of 2% p. a., both in the US and the EU, which corresponds roughly to recent trend estimates.

The demographic projections described in section 2 imply that the population of working age will decline by about 13% relative to baseline over the next 50 years and stabilise thereafter. In the standard case it is assumed that labour force participation remains fixed, thus the demographic change translates directly into a 13% reduction of the labour force in Europe. Under the assumption of a fixed dependency ratios, ageing implies an increase in the share of transfers in GDP of about 7.5% in Europe[8]. The following figure shows the time path of the shocks given to the EU economy. Shocks, corresponding to the US demographic trends are given as well.

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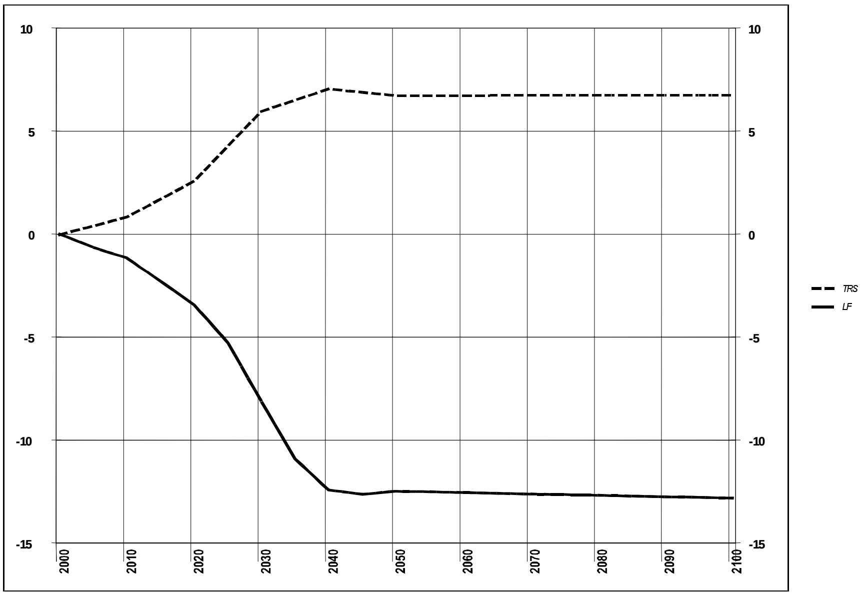
8 I assume that after 2050 both transfers and population of working age remain permanently above/below their corresponding baseline values. This assumption seems plausible on the basis of current projections.

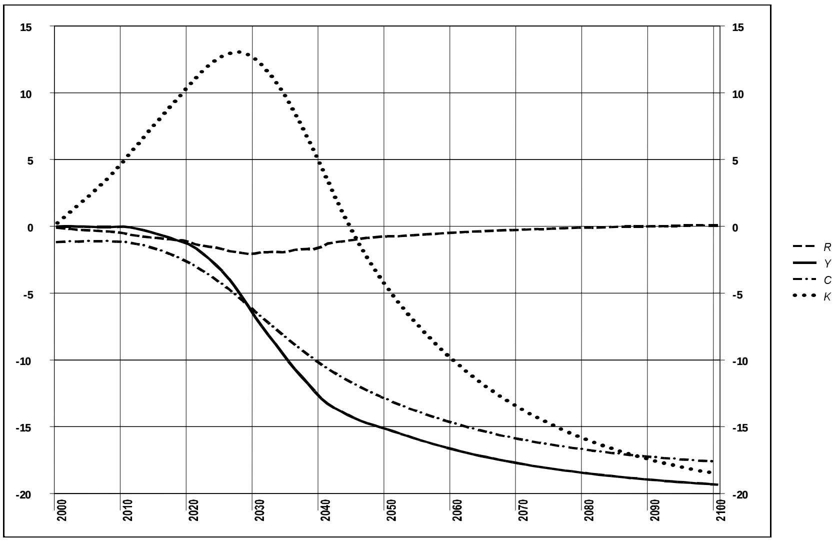
Evolution of Transfers and Labour Force 2000 to 2100



The economic consequences as indicated by the simulation results (see the following two graphs) are as follows:

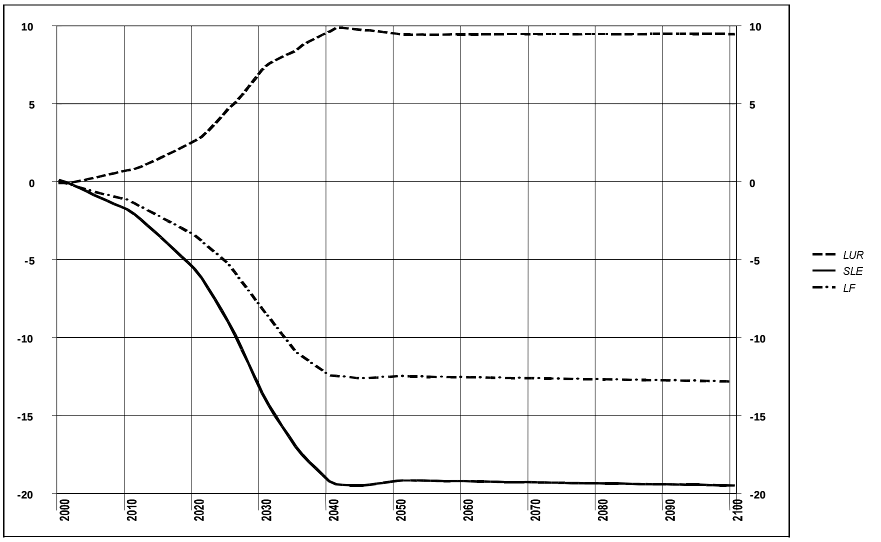
After 50 years, income per capita will decline by about 15% relative to the baseline, the share of private consumption as share of total GDP will slightly increase. Employment will fall by nearly 20%. This result can be understood from the dynamic adjustment of the economy as follows. Since in the year 2000 the tax obligations related to population ageing can be foreseen, households who want to smooth their consumption stream intertemporally find it optimal to increase savings in order to build up financial wealth to finance future consumption. Increased savings lowers real interest rates and leads to more investment and an increase in the capital stock. Once the ageing constraint really starts to bite, households run down their capital stock. Around 2040 the private savings rate (one minus the share of private consumption in GDP) starts to fall below the historical level. Since I assume a perfect capital market and no liquidity constraints for households the adjustment of consumption and investment corresponds closely to the solution of an optimal planing problem. From Table 1 it can also be seen that the fall in the savings rate will eventually lead to a slight decline in the capital output ratio and an increase in the real interest rate.

Effect of Ageing on GDP, Consumption, Capital and Interest Rates

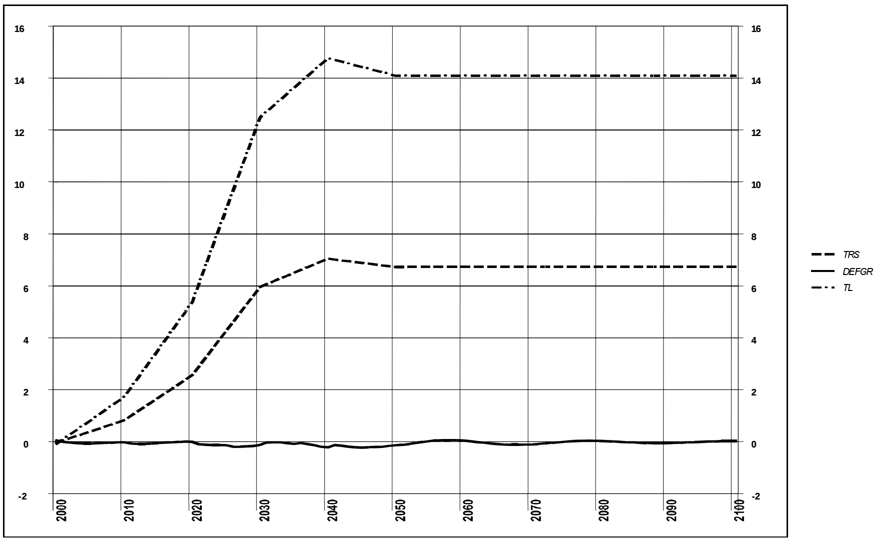


Given the fact that I make extreme assumptions on the unemployment benefit system, labour tax financing of pensions is very distortionary and leads to a large increase in the unemployment rate, which goes up by nearly 10% points. This of course implies that the tax base is eroded, though under the assumption of unit elasticity of substitution between capital and labour there is no additional tax erosion effect from a declining wage share. However, the fall of employment nevertheless means that labour taxes must be increased by about 40% more than would be implied by pure baseline ratios in order to finance the additional expenditures related to unemployment and to prevent government debt from rising (see the following figures).

Effect of Ageing on Labour Force and Employment



Budgetary Consequences of Ageing



Though the economic consequences of population ageing are significant and they would be associated with labour tax increases and an increase in the unemployment rate which seem to be unfeasible politically they would not make the budgetary situation unsustainable. In order to facilitate comparison the results are summarised in the following table.

Table 2. Simulation Results with Benefits indexed to GROSS Wages

YEAR	2000	2025	2050	2075	2100	2140
GDP	-0.00	-3.56	-15.25	-18.17	-19.34	-19.91
C	-1.19	-4.48	-13.05	-16.38	-17.64	-18.20
K	0.10	12.79	-4.84	-14.96	-18.59	-20.46
L	0.15	-9.28	-19.18	-19.33	-19.49	-19.52
W	0.56	6.53	5.11	1.70	0.44	-0.25
R*	-0.12	-1.76	-0.76	-0.12	0.08	0.25
TL*	-0.00	9.00	14.00	14.00	14.00	14.00
DEBTR*	0.00	-0.01	-0.01	-0.00	0.00	0.00

Note: If not otherwise indicated, results are presented as % deviations from baseline.

**: % point deviation from baseline*

Variable Definitions: GDP: Gross Domestic Product, per capita, C: Consumption, per capita, K: Capital Stock, per capita, L: Employment, W: Real Wages, R: Real Interest Rate, TL: Labour Tax rate, DEBTR: Debt to GDP Ratio.

7 Sensitivity Analysis

Results from simulation exercises always depend on specific numerical assumptions. Since I have identified in section 5, those factors which might be crucial for the budgetary effects of labour tax increases, namely the employment and substitution effect of changes in labour taxation, I will explore in this section the consequences of alternative assumptions. The employment effect generated by an increase in labour taxes is certainly at the upper end when compared with existing empirical evidence therefore I will first look at the fiscal impact of ageing when unemployment benefits are indexed to net wages. Second, a unit elasticity of substitution between capital and labour is often used in model studies, empirical evidence seems to indicate that the long run elasticity is likely to exceed one. In that case the budgetary consequences might be more severe. Therefore I will also explore the consequences of a higher elasticity of substitution between capital and labour.

Case I: Benefits indexed to Net Wages

Most standard macro models imply (see Pissarides 1998) that labour taxes are not distortionary if benefits are indexed to net wages. The same is true for the QUEST model. In this case labour taxes are not shifted onto wages but are fully borne by workers and the equilibrium unemployment rate is not altered by taxation. As can be seen from Table 3, income per capita falls substantially less in this scenario. Also labour taxes only need to be increased by about 11 % points in order to keep the level of government debt constant.

Case II: Higher Elasticity of Substitution (EoS) and Benefits indexed to Gross Wages

Table 4 presents simulation results with an elasticity of substitution between capital and labour equal to 1.5. Contrary to what might be expected from theoretical considerations, a higher elasticity of substitution does not change the magnitude of the economic effects substantially. The reason for this result is the increased interest elasticity of investment associated with a higher elasticity of substitution. The higher rate of capital accumulation slows down the fall of GDP. This limits the erosion of the tax base. Therefore, like in the first experiment an increase in the labour tax rate of 14% is required to stabilise

Table 3.
Simulation Results with Benefits indexed to NET Wages

YEAR	2000	2025	2050	2075	2100	2140
GDP	-0.00	-1.60	-9.78	-12.06	-13.00	-13.48
C	-0.65	-2.59	-8.79	-11.33	-12.29	-12.73
K	0.06	8.19	-2.59	-10.13	-12.94	-14.49
L	0.08	-5.12	-12.47	-12.64	-12.82	-12.85
W	0.36	3.84	3.31	0.91	0.01	-0.51
R*	-0.08	-1.09	-0.52	-0.08	0.08	0.25
TL*	-0.00	7.07	11.00	11.00	11.00	11.00
DEBTR*	0.00	-0.04	0.00	-0.01	-0.00	-0.00

Table 4.
Results with EoS=1.5 and Benefits indexed to GROSS Wages

YEAR	2000	2025	2050	2075	2100	2140
GDP	0.01	-2.23	-13.46	-17.09	-18.84	-20.00
C	-1.22	-4.01	-11.86	-15.60	-17.34	-18.39
K	0.12	16.00	0.47	-11.59	-16.96	-20.65
L	0.18	-9.30	-19.18	-19.33	-19.49	-19.52
W	0.76	5.27	4.83	2.03	0.72	-0.22
R*	-0.16	-1.47	-0.76	-0.24	0.00	0.25
TL*	-0.00	9.00	14.00	14.00	14.00	14.00
DEBTR*	0.00	0.00	-0.01	-0.00	0.00	0.00

government debt. Also the very long run effects are only marginally more severe.

8 Conclusion

This paper analyses the effects of likely demographic developments over the next 50 years using a two country dynamic general equilibrium model. The results of this analysis indicate that the effects of population ageing on income per capita can be sizeable, however they will only be felt after about 20 years from now. The model indicates that forward looking households will be able to cushion the decline in real consumption somewhat by increasing the rate of savings over the next 20 years. Special emphasis is devoted to the question on the public finance implications of increased pension payments in a PAYG system. The results show that even if distortionary taxes are used it will be possible to finance these additional expenditures, however the economic and budgetary costs will be large if not excessive.

REFERENCES

Blanchard, O.J. (1985), "Debt, Deficits and Finite Horizons", *Journal of Political Economy,* No. 93, pp. 223-247.

Blanchard, O.J. and P. Diamond (1989), "The Beveridge Curve", *Brookings Papers on Economic Activity*, pp. 1-60.

Binmore, K., A. Rubinstein and A. Wolinsky (1986), "The Nash Bargaining Solution in Economic Modelling", *Rand Journal of Economics*, No. 17, pp. 176-98.

Boucekkine, R. (1995), "An Alternative Methodology for Solving Nonlinear Forward-Looking Models", *Journal of Economic Dynamics and Control*, No. 19, pp. 711-34.

Burda, M. and C. Wyplosz (1994), "Gross Worker and Job Flows in Europe", *European Economic Review,* No. 38, pp. 1287-1315.

Devereux, M.B., A.W. Gregory and G.W. Smith (1992), "Realistic Cross-Country Consumption Correlations in a Two-Country Equilibrium Business Cycle Model", *Journal of International Money and Finance,* No. 11, pp. 3-16.

Franco, D. and T. Munzi (1996), "Public Pension Expenditure Prospects in the European Union: A Survey of National Projections", *European Economy,* No. 3.

_____________________ (1997), "Ageing and Fiscal Policies in the European Union", *European Economy,* No. 4.

Layard, R., S. Nickell and R. Jackman (1991), *Unemployment*, Oxford University Press, Oxford.

Leibfritz, W., D. Roseveare, D. Fore and E. Wurzel (1995), "Ageing Populations, Pension Systems and Government Budgets: How do they Affect Saving?", OECD Working Paper, No. 156.

Mc Morrow, K. and W. Roeger (1999), "The Economic Consequences of Ageing Populations", *Economic Papers*, No. 138, European Commission.

Mendoza, E.G. (1991), "Real Business Cycles in a Small Open Economy", *American Economic Review*, No. 81, pp. 797 – 818.

Mendoza, E.G. and L.L. Tesar (1994), "Supply-Side Economics in a Global Economy", unpublished manuscript.

Pissarides, C. A. (1990), *Equilibrium Unemployment Theory*, Basil Blackwell, Oxford.

Roeger, W. and J. in 't Veld (1999), "QUEST II A Multi Country Business Cycle and Growth Model", *Economic Papers*, No. 123, European Commission.

___________________________ (1999), "The sensitivity of Solutions to Terminal Conditions: Simulating Permanent Shocks with QUEST II", in A. Hughes Hallet and P. McAdam (eds.), *New Directions in MacroModelling*, Kluwer Academic Press.