Growth and Welfare Distribution in an Ageing Society: An Applied General Equilibrium Analysis for the Netherlands.

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Abstract

This paper studies the effects of the imminent ageing of the population on economic growth and the distribution of welfare in the Netherlands. It shows that in the current system of social security ageing leads to a considerable welfare loss for future generations. It discusses the effect of reform measures in the pay-as-you-go social security system. It shows that a cut in PAYG pensions is efficiency-improving, but hurts the lower income groups of current generations. This effect can be ameliorated by a debt-financed cut in indirect taxes. In that case the negative welfare effect of the reform for current generations is smaller than the redistribution caused by the demographic shift itself.

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Contents

Introduction

The age composition of the population in developed countries is shifting rapidly in favour of the elderly. Projections by the United Nations indicate that for the OECD area as a whole the share of the elderly (people of age 65 or above) will increase from 15% in 1990 to 22% in 2040. At the same time, the old-age dependency ratio (the ratio of the elderly to the working-age population) is expected to rise from 20% to 37%. For developing countries, a similar change is expected at a later stage (United Nations (1994)). Since the last decade, it is recognized that this worldwide change in the age structure of the population will have far-reaching economic consequences.

The demographic change should give rise to substantial shifts in the distribution of the net financial burden of the public sector across generations, mostly as a result of declining labour force participation. Rising dependency ratios imply a decline in the size of the tax base that can be used to finance public expenditure and social security transfers. In addition, they will increase the outlays for health care and social security. In OECD countries, social security is largely on a pay-as-you-go (PAYG) basis, *i.e.* the currently active population pays for the pensions of the retired population. Without a substantial cut in public expenditure programmes and transfers, the ageing process will therefore cause a substantial increase in the net tax burden for younger generations.

Apart from the direct effects of an increasing dependency ratio on the tax base and public expenditure, the ageing process will also affect the relative scarcity of production factors. On the transition path, the decline in the labour force will cause a reduction in labour supply that will depress investment and the demand for capital. On the other hand, life-cycle saving will, during the first stage of the transition, be at a maximum. Therefore, for individual OECD countries a relative scarcity of labour may be expected during the transition. To the extent that ageing is synchronized over countries, international capital flows will not be able to equalize capital returns over time, which will lead to a movement along the factor price frontier, boosting wages and depressing interest rates (see Auerbach and Kotlikoff (1987), Börsch-Supan (1996), Chauveau and Loufir (1997), Miles (1999)).

In the literature, there is some debate as to the likelihood of a fall in interest rates. The life-cycle model is not generally accepted as a good description of saving by individual households. Poterba (1998) for the US and Alessie, Kapteijn and Klijn (1997) for the Netherlands show that old-age households generally dissave less than predicted by the life-cycle model. However, Miles (1999) argues that once saving through pension funds is taken into account the life cycle model is much closer to observed saving profiles. In addition, Auerbach, Cai, and Kotlikoff (1991) show that the projected macroeconomic savings rate is not sensitive to the precise model of household behaviour used. Things may be different for open economies. Bovenberg and van der Linden (1997) and Turner *et al.* (1998), in a multi-country study, argue that the lack of synchronization of ageing is sufficient to prevent a decline in interest rates. Lack of synchronization does not preclude a shift in relative factor prices, however. The classic study of Feldstein and Horioka (1980) suggests that the degree of international capital mobility is limited. Furthermore, if physical capital flows are slow to adjust in response to changing returns, ageing will boost wages even with perfect financial capital mobility.

In itself, the capital deepening that results from a decline in population growth should boost output per capita. On this account, Cutler *et al.* argue that a slowdown in population growth need not be a problem. However, the rising excess burden of social security will have adverse supply effects on saving and labour supply that may dominate the capital deepening effect. Thus Chauveau and Loufir (1997) predict that output will fall some ten to fifteen percent below its balanced growth path in the major OECD economies as a result of the social security burden.

Not all generations suffer to the same extent from an ageing-induced slowdown in economic activity. The resulting movement in factor prices affects the intergenerational distribution in several ways. On the one hand, rising wages should lead to a partial restoration of the intergenerational balance. On the other hand, rising production costs of health care and wage indexation of pensions may lead to further increases in contribution rates for health care and social security. The net effect of factor price movements on the distribution of welfare is therefore difficult to ascertain a priori. It is however unlikely to outweigh the redistributional effect of the social security system.

The distributional impact of the existing system of social security in the presence of population ageing has led to a reconsideration of its merits. As pointed out by Aaron (1966), the rate of return on PAYG social security is the population growth rate plus the real growth of wages. This rate of return must be compared with that of a funded system, the rate of interest. In the sixties and seventies, the rate of return on PAYG systems easily exceeded that on a funded system. In the eighties and nineties, the ranking was reversed. In the next century, a lower population growth rate lowers the return on a PAYG system, making a funded system more attractive. Many proposals to switch to funding have been made in recent years, *e.g.* Feldstein (1995, 1996), Börsch-Supan (1998). Generally, these proposals aim at a reduction in the size of the intergenerational redistribution that is caused by the PAYG system. However, if ageing also lowers the rate of return on capital, the case for funding is less clear-cut. In particular, a *transition* to a funded system would incur substantial costs in the presence of falling interest rates.

A transition to a funded system requires that some generations pay both the PAYG contribution rate for the pensions of the currently retired, as well as the contribution to the new funded system. Therefore a difference between the rates of return on a PAYG versus a funded system in itself is not an indication of a possible efficiency gain. What it does is primarily to affect the size of the redistribution between generations. To enable a Pareto-improving transition, the funded system must raise its revenues in a different way from the PAYG system.

The issue of a Pareto-improving conversion from a PAYG system to a funded system has been investigated by Raffelhüschen (1993), Breyer and Straub (1993), Broer *et al.* (1994), Kotlikoff (1996) and Fehr (1999). From these analyses, it appears that such a transition is feasible if it reduces the distortion of the labour supply decision sufficiently to enable current and future generations to pay off the burden of the PAYG system from the reduced deadweight loss. A limitation of these models is that they assume that households differ only by age. Intragenerational heterogeneity is introduced by Kotlikoff *et al.* (1998), and by Fehr (1999). From these studies, it appears that a Pareto-improving transition is more difficult to achieve if intragenerational heterogeneity is also taken into account. Different income groups are affected differently by alternative financing modes of the reform, and have different tax-benefit linkages.

This paper studies the effects of population ageing on economic growth and the distribution of welfare in the Netherlands. For this, I use an extension of the OLG general equilibrium model of Broer, Westerhout and Bovenberg (1994). The model is calibrated on the Dutch economy as of 1994 to compute the expected time path of the Dutch economy over the next century.[1] To obtain some idea of the quantitative importance of this uncertainty, I compare the effects of the expected development of the population on the growth path of the economy with those of the upper and lower boundary paths of a prediction interval for the population. Another source of uncertainty is the effect of ageing on international interest rates. Lower interest rates negatively affect the yield of the funded supplementary pension scheme and make a transition towards funding of the PAYG scheme less attractive. I use an alternative low projection of the interest rate to evaluate the importance of this source of uncertainty.

Given the considerable increase of the tax burden that is to be expected and the adverse effects on the distribution of welfare over generations, it seems prudent to reform the social security system to make it better suited to cope with high dependency ratios. I use the model to investigate the effects of a transition to a funded pension system. In Broer *et al.* (1994), we showed that a Pareto-improving transition would be possible in the absence of intragenerational heterogeneity. In this paper I take up the same issue, but with intragenerational heterogeneity included. In comparison with both our previous work and the studies by Kotlikoff *et al.* (1998) and Fehr (1999), I use a calibration of the model to a baseline solution that includes the projected ageing of the population, *i.e.* outside of the steady state. Since the demographic transition produces its own redistribution of welfare across generations, this redistribution should properly be looked at in conjunction with the redistributive effects of the social security reform. This means that a reform that in itself would harm certain generations may nevertheless be considered equitable if considered together with the distributive effects of the demographic shock. Whether such a reform is also politically sustainable depends on the voting behaviour of the electorate. I investigate the feasibility of the reforms under simple majority rule.

The paper considers two reforms: first, a straightforward reduction in PAYG benefits, and second a combined cut in PAYG benefits and consumption taxes, to compensate current old generations for the loss in income. The first option comes close to the international privatization literature, whereby PAYG saving is replaced by private life-cycle saving, but it incorporates an idiosyncrasy of the Dutch pension system, that provides for a built-in compensation of existing elderly. This occurs through the supplementary occupational pension schemes that apply for most households participating in the labour market. The second option uses government debt to transfer part of the efficiency gain of the PAYG cut to current generations. This transfer is achieved by implementing a maximal sustainable cut in consumption taxes.[2]

The rest of the paper is organized as follows. Section 2 presents an overview of the model,

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[1] A companion paper (Beetsma *et al.* (1999)), also discusses the effects of ageing on the Dutch economy. The main difference with that paper lies in the financing of basic pension system and the investigated reform measures. The calibration also differs.

[2] Note that a cut in consumption taxes is partly a lump-sum subsidy to the accumulated wealth of existing generations.

Section 3 discusses the effects of population ageing for the Dutch economy, in terms of a baseline projection with a constant interest rate and the expected development of the population. Section 3.1 shows how demographic uncertainty affects these results, and Section 3.2 discusses the effects of a falling interest rate. Section 4 discusses some policy options to combat the adverse effects of population ageing, and Section 5 summarises and offers a few conclusions. Appendix 1 contains a full description of the equations of the model. Appendix 2 discusses the calibration.

2. The Model

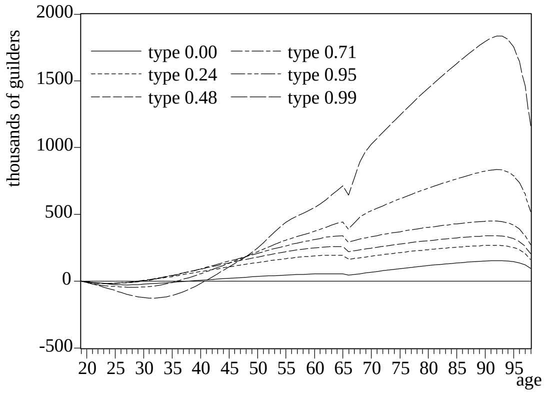
The model is of the same type as the familiar Auerbach-Kotlikoff (1987) overlapping generations model, adapted for a small open economy. It is an extension of Broer, Westerhout en Bovenberg (1994) and Broer and Westerhout (1997). It consists of the following sectors: households, a private enterprise sector producing tradables, private health insurance firms, public health insurance (subdivided in two categories), health care, a pension sector (with both a basic and a supplementary pension scheme), a government sector, and a foreign sector. Four markets are distinguished, the labour market, the tradable goods market, the health care market, and the capital market. All markets clear, prices for tradables and capital are determined on world markets through arbitrage, the wage rate and the price for health care are determined on the domestic markets. The main extensions with respect to our previous work are:[3]

- A disaggregation of households by both age and productivity, so that the model now also features intragenerational heterogeneity,
- Age-dependent productivity gives rise to a separate wage profile for each (productivity-defined) type of household,
- Age-dependent demand for health care per household,
- Inclusion into the model of a health care sector,
- A separate health insurance sector,
- A calibration on a recent, non-steady-state, demographic projection of population growth.

Below I give a summary description of the main characteristics of the model. Technical details can be found in the Appendix.

Households choose their consumption of goods, health care, and leisure by maximizing expected lifetime utility subject to a lifetime budget constraint and a time constraint per period. Lifetime is uncertain, and the death hazard increases with age. Households insure against this hazard by buying annuities. Preference for the consumption of leisure and health care is age-dependent. Households are free to retire when they choose, but they are eligible for old-age pensions from their 65th birthday, irrespective of their actual retirement date. Households differ both by age and by productivity (human capital). Productivity is exogenous to the individual household, but it varies by age. The wage level of a household determines whether it contributes

[3] Minor adjustments are: a) government consumption of goods is a constant fraction of GDP, b) the budget of the PAYG social security fund has been integrated in the budget of the government, c) extension of the capital income tax to the annuity provided by life insurance companies, d) age-dependent disability payments to households, e) demand for teachers and government expenditure on education depend on the age structure of the population.



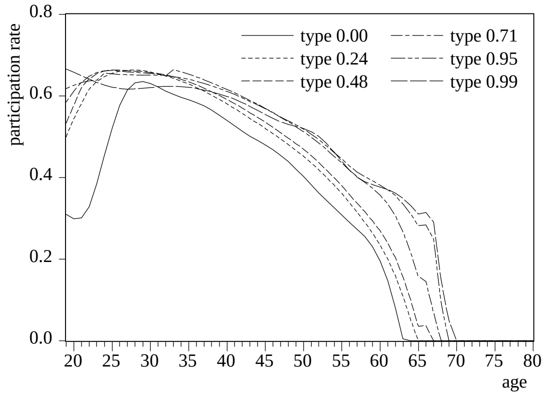


Figure 1
Wealth distribution by age in 1995

Figure 2
Labour supply distribution by age in 1995

to the supplementary pension scheme, and whether it is insured with the public health insurance system or with the private health insurance system. Both transitions define a discontinuity in the marginal tax rate facing the household, the first one upward, and the second one downward.

Figures 1and 2 present wealth and labour supply of households by age and position in the productivity distribution as these follow from the model for the starting year (1995).[4] E.g. type 0.48 is the household type for which 48% of households has a lower productivity at the same age (it is therefore nearly the median household). The wealth accumulation profiles show that households incur some debt in the early parts of their life, to be able to smooth their consumption over the life cycle in spite of their low initial wage. The effect is most pronounced for the highest productivity type. Note that households do not dissave until high age. This is a consequence of the assumption that households insure against death by selling their assets against life-time annuities. The return to wealth increases with age as a result of the increasing death hazard. For the median household, the wealth profile matches observed saving behaviour reasonably well. For the upper 5% of the distribution, the wealth profile after retirement is probably less realistic.

Labour supply profiles show participation rates for the base year that show a similar hump-shaped age pattern as do observed participation rates. Participation rates for young low-productivity households are lower than for other types. Qualitatively, this conforms with reality. The model generates participation rates for households in their early fifties that may be too low. However, a direct comparison of the results with the data is hindered by the lack of observations on participation by hours worked.[5]

The pension sector consists of two different pension schemes that represent actual pension institutions in the Netherlands. They differ with respect to their financing structure, the formulas that define the benefit levels and their contribution bases. The PAYG scheme provides a flat minimum benefit to residents who are 65 years and older. The contributions to this scheme are levied on the labour and capital income of those below 65 years of age. Residents of age 65 or

[4] Due to a lack of suitable data, these distributions have not been calibrated to observations.

[5] Observed participation rates are given in terms of persons with a job of at least 12 hours per week. These rates start declining around age 55. At age 62, participation rates are only a few percent of the available population.

older are exempt from PAYG contributions. The PAYG contribution rate is fixed and deficits of the PAYG scheme are part of the general government deficit.[6]

The other pension scheme provides benefits that supplement those from the PAYG scheme for retired workers that used to earn wages above the social minimum. This scheme involves capital funding and a partial linkage between contributions and benefits. It is therefore called the funded collective (FC) scheme. Benefits are based on final pay (i.e. the wage prevailing in the year before the household becomes eligible for pension benefits) and are positive only so far as this pay exceeds a threshold linked to the PAYG benefit. The rights to FC benefits depend on the number of hours worked when younger than 65 years. FC contributions are levied on labour income above a certain threshold (the franchise). Contributions to the FC scheme are deductible for both the income tax and PAYG contributions but FC benefits are subject to income taxation. By adjusting its contribution rate, the FC scheme tries to match its assets and its projected benefit obligations to households that are currently participating in the fund.

The tradable goods sector uses capital, labour, and raw materials to produce goods and services that are freely traded on domestic and international markets at internationally determined prices. Investment in physical capital is subject to internal adjustment costs, which makes it internationally immobile in the short run. Firms issue debt in fixed proportion to the value of their capital, so that the marginal source of finance for investment is retained earnings. The labour input of different productivity types is perfectly substitutable.

The health sector uses only labour to produce health care services. Different productivity types are complementary in production, so that the skill distribution in the health sector is fixed. The form of health care insurance depends on the wage level of the household. Low-productivity households are publicly insured. The public health insurance firm levies both a proportional tax on labour income and a small, nominally fixed, contribution. It reimburses (nearly) all health care expenditures of its clients. The private health insurance sector levies a lump sum contribution on households. In the model, it reimburses a fixed proportion of the health care expenditures of its clients. Both insurance firms close their budget annually by adjusting their contribution rate.

3. **The Effects of Ageing on Economic Growth**

Figures 3a and 3b show the ageing of the population as projected by the Central Statistical Office (see de Beer (1999)).[7] The solid lines give the expected development and the broken lines represent upper and lower probability bounds. Demographic forecasts suffer from considerable uncertainty, both on account of the projections of the fertility rates and because of the projections of the mortality rates. Figure 3a presents the upper and lower 66% probability bounds of

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[6] Officially, only a *ceiling* has been imposed on contribution rates. In view of the expected increase in contribution rates, this amounts to the same thing. This change in the financing method of the Dutch basic pension scheme implies that it is no longer strictly pay-as-you-go if the government uses debt financing.

[7] The projections have been extended beyond 2100 by extrapolating the fertility and mortality rates for 2050 to later years. The CSO projections also entail assumptions about immigration rates. In the model, these have been balanced with the mortality rates to obtain mortality rates that are slightly *negative* for young households. Hence, immigration is assumed to continue at the rates projected for 2100.

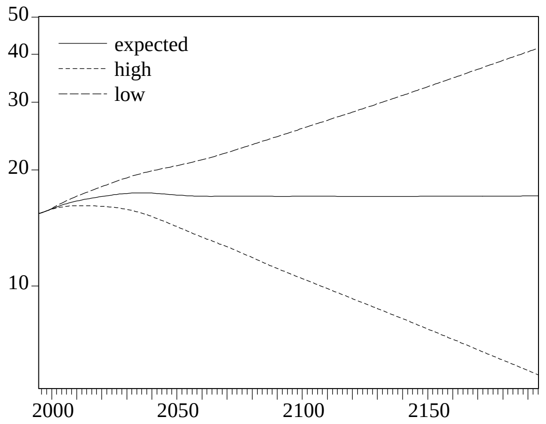

Figure 3a
Population forecasts (millions)

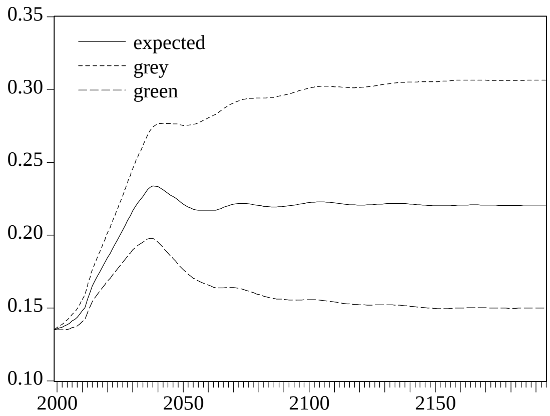

Figure 3b
Share of elderly

the distribution of population forecasts. These bounds combine a high fertility and immigration rate with a low mortality rate and vice versa. Figure 3b shows the effects on the forecasted share of elderly of reversing the assumptions about the fertility and mortality rates. Both the population growth rate and the share of elderly display a large degree of uncertainty. The impact of this uncertainty on the projections of the Dutch economy will be discussed in Section 3.2 below.

The model of the Dutch economy in this paper assumes that the Dutch capital market and output market are small and perfectly integrated into competitive world markets. Labour on the other hand is completely immobile. As a result, next to demographic shocks, the only outside shocks that can affect the economy are world interest rate fluctuations. Section 3.1 discusses the projected baseline solution of the model. The baseline solution assumes that world interest rates are constant and that domestic exogenous variables are either constant, or grow at constant rates, except for the population, which follows the expected demographic path shown in Figure 3. In a sense, this baseline solution can therefore be interpreted as the response of the economy to the expected demographic shock. Section 3.2 discusses the sensitivity of the baseline solution to the demographic uncertainty shown in Figures 3a and 3b above. As discussed in the introduction, the global nature of the demographic shock may be expected to affect world interest rates as well. Section 3.3 discusses the effects of superimposing fluctuations in world interest rates on the demographic shock.

3.1 **The Baseline Growth Path**

The baseline path has been computed using the income tax rate $t_y(t)$ as a closure variable for the government budget constraint and assuming that government debt as a fraction of GDP is kept constant at the calibrated value of 71%. At a steady-state growth rate of 2%, this implies a long-term government deficit of 1.4% of GDP (see Figure 13). The path of the income tax rate that follows from this financing rule is displayed in Figure 11 below (using the right y-axis as a scale).

In the long run, the growth rate of the economy is determined by the rate of technical progress (2%) and the growth rate of the population (-0.0%). On the transition path, the growth rate deviates from this benchmark value as a result of demographic shifts. Figure 6 shows the change in the labour market participation rate of the population. Overall participation rates fall until about 2035, to recover only partially thereafter. The end result is a fall in participation rates by about 4%-points. Obviously, this decline represents the increasing dependency ratio as a result of the ageing of the population. The endogenous part of this shift is largely captured by the participation rate of the working-age population. It appears from Figure 6 that after an initial decline, this participation rate is expected to recover in the second half of the next century. Figure 8 shows the consequences of these participation rate shifts for aggregate efficiency-corrected labour supply and labour supply employed in the tradable goods sector. Initially, labour supply in efficiency units grows, because the working-age population grows older and, therefore, more productive. From about 2010 on, these older cohorts retire, and labour supply stagnates. This effect is reinforced by the temporary decline in the participation of the working-age population. The resulting fall in employment in the tradable goods sector is particularly severe. This discrepancy reflects the weight of both government labour demand and labour demand by the health care sector. Government employment is constant as a percentage of the population, and health sector employment actually increases as a result of the ageing process. The result is a shortage of labour in the first half of the next century, which is at its maximum around 2030. This scarcity is also reflected in a sharp peak in wage growth at that time (Figure 14).

Figure 7 decomposes the aggregate participation rate by age for a selected number of years. According to the baseline projection of the model, the labour participation of young households will decline by about 1.5%-points in the next century, whereas the labour participation of households of age 60 will increase by about 5%-points. The increase in the participation rate of households just above the statutory retirement age is even larger at 7%-points. For young households, the most important determinant of the participation change is the intratemporal substitution between time-related consumption (leisure and health care) and goods. It is negative because of the increase in the tax wedge.[8] Its effect is largely compensated by the wealth effect, so that only a small net negative labour supply effect remains. The single most important determinant of the increase over time in the labour market participation of older workers is the intertemporal substitution effect. Since the after-tax wage falls, the increase in the intertemporal distortion of labour supply must be attributed exclusively to the decline in the net interest rate. The intertemporal distortion therefore originates with the increase in the rate of capital income taxation. It causes households to decrease their saving in the earlier periods of life. When middle-aged, these households have accumulated less wealth and therefore supply more labour.

The preceding analysis showed that the rising tax burden is an important factor in the evolution of the labour market participation of the population. The increase in the total tax burden as a percentage of GDP reflects both the decline in the labour income tax base and an increase in age-related government expenditures, *viz.* PAYG fund subsidies, disability insurance, and health

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[8] The wedge is defined as $(1+t_c)/(1-t_l)$, where tc denotes the consumption tax and tl the tax and contribution rates on labour The contribution rates consist of health insurance, AWBZ insurance, and basic pension contributions. The contributions to the FC pension fund have not been included in this measure, even though they are distortionary. The contribution to the public health care insurance has been included, even though a minority of households is privately insured.

care subsidies (Figure 12). The larger part of the rise in expenditures can be attributed to government contributions to the PAYG fund (Figure 9). The main components of government tax receipts are consumption taxes and income taxes.[9] Consumption tax receipts rise as a consequence of the increase in consumption (Figure 15). This increase reflects the higher propensity to consume of the elderly. The 6% rise in the consumption-GDP ratio explains 1.5%-points of the increase in the total tax burden. As a result, income tax rates need to be raised by only 3.5%-points (Figure 11). The total increase in the marginal burden on labour is larger, due to the increase in health insurance contribution rates (Figure 10).[10] Health care consumption depends strongly on age, and the increasing share of elderly will boost expenditures by about 3% of GDP (Figure 15). As private health insurance contribution rates are lump-sum, high-income households escape part of the increase in the marginal tax burden.

The sharp increase in government subsidies for the PAYG fund stands in marked contrast to the modest 2% increase of the contribution rate for the (funded) supplementary pension fund. This relative constancy arises from the substantial assets owned by the pension fund in the base period. By legal obligation, these assets are sufficient to cover the accumulated pension rights by households that are currently participating in the fund (see Section 7 in Appendix 1). A rise in contribution rates must therefore reflect a rise in projected benefit obligations that exceeds the current accumulation rate of the fund. This can occur because of a future acceleration in wage growth, as a result of a fall in future interest rates (that increase the present value of the obligations), or due to shifts in the age composition of the contributing members of the fund. All these events lead to intergenerational redistribution as a consequence of the lack of actuarial fairness of the pension fund. Figure 9 shows that shifts in the age composition lead to an increase in contribution rates of about 1.5%-points. A discussion of the effect of a fall in interest rates is postponed until Section 3.3.

The propensity to consume reaches a maximum a few years after the share of elderly, demonstrating the aggregate effect of the life cycle behaviour of individual households (Figure 15). Subsequently the health care consumption ratio declines less than the consumption ratio of other goods and services, as a result of the extreme age-dependence of health care expenses. The boost of the propensity to consume is preceded by a more short-lived boost in the national savings rate, as shown in Figure 19. The current account reaches an all-time high of 11% of GDP around 2010, at a time when a large proportion of households are net savers, to fall back to a minimum value of 2% around 2050 because of the retirement of these large cohorts of savers. The current account remains positive however as a result of a substantial surplus on the primary factor income account. The trade balance of course shows a substantial deficit in later years.

The shortage of labour, which is projected to occur in the first few decades of the next century, has an adverse effect on investment and output growth. Figure 16 shows that the investment-output ratio declines in line with labour supply until 2030. The aggregate

[9] Corporate taxes contribute only 10% of total tax receipts.

[10] Note that the AWBZ tax base also consists of capital income and pension benefits.

investment-output ratio remains permanently below its current level, because of a shift to labour-intensive sectors. The tradable goods sector actually shows an *increase* in capital intensity, as a result of the increased tax burden on capital income, that lowers the required return on capital (see **(11)** in Appendix 1).[11] The investment-output ratio of this sector therefore eventually recovers (Figure 17). Output growth falls by half a percent compared with the steady-state rate when the ageing process reaches its maximum. Then, as labour supply recovers because of both the demographic swing and the increase in the participation rate of the working age population, output growth is boosted for over a decade.

The intergenerational distribution that corresponds with this baseline scenario is given in Figure 4. The distribution is defined in terms of the compensating variations required to bestow the same lifetime utility on all generations as the 1976 generation (that enters the labour market in 1994), *corrected for technological progress*. This correction is required because, on a steady state growth path, successive generations will experience ever-increasing lifetime consumption and utility. To measure the extent of intergenerational redistribution, we must therefore compare the actual utility levels with those on a steady state growth path. On this growth path the correction used would result in compensating variations equal to zero. It is equivalent to a

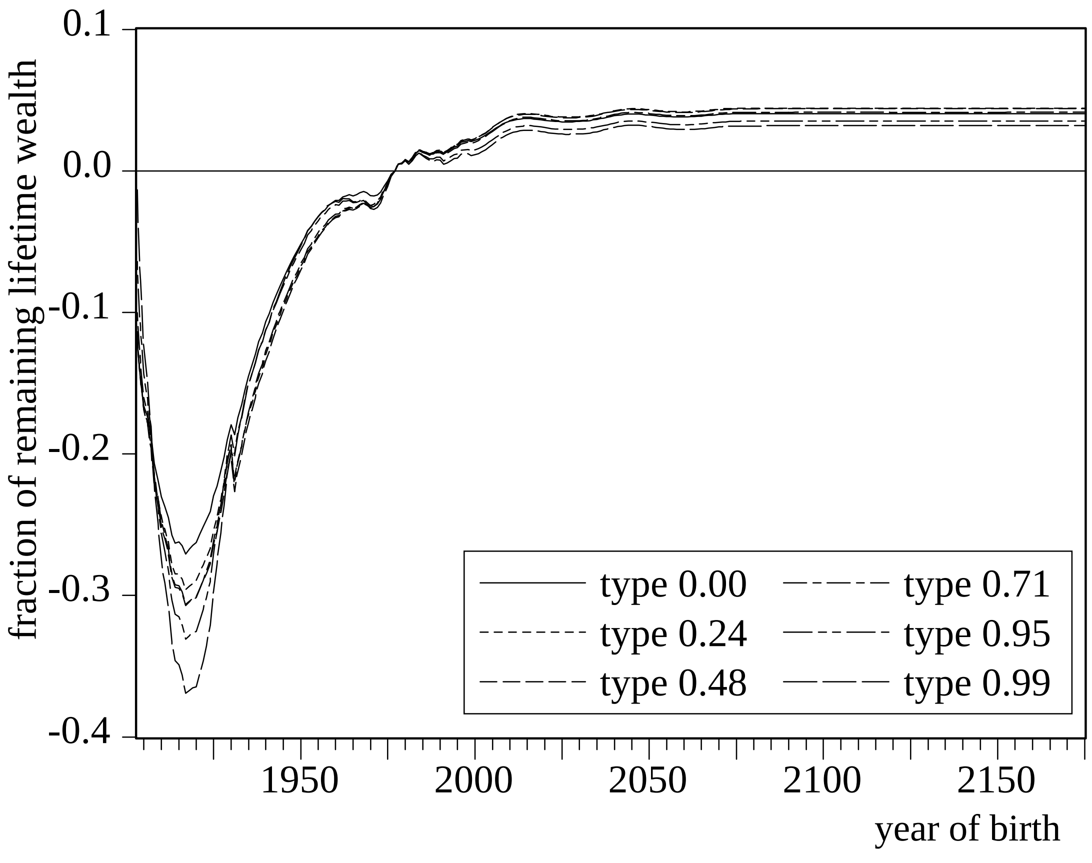

Figure 4
Compensating variations per generation, relative to the 1976 generation

[11] The numbers in bold print refer to the equations in Appendix 1.

multiplication of the utility functional **(22)** by a time trend.[12] The compensating variations in Figure 4 show that, after correction, future generations do about 4% worse than current young generations. This is equivalent to only two years of growth, so all future generations are still better off than the 1976 generation, despite the demographic shock. Regarding the intra-generational distribution, high-productive households do somewhat better than low-productive households, because they escape the increase in public health contribution rates. The intergenerational balance worsens until about 2035 (generation 2016), when the ageing shock is maximal. This coincides with the peak in the labour tax burden (see Figure 11), and the minimum labour participation ratio (Figure 6). Afterwards, the distribution remains fairly stable.

Though future generations are not much worse off than the 1976 generation, generations born before 1976 do considerably better. In Figure 4, the comparison is made in terms of remaining lifetime utility, again corrected for technical progress. Generations born around 1930 are on the brink of retirement, so they largely escape the coming rise in tax rates. In comparison with the 1976 generation, this implies a 16% higher net wage over their time in the labour force (corrected for technical progress). The remaining part of the compensating variation is largely due to a different saving profile over the life cycle. Future generations save less, because of a lower net interest rate, and so have comparatively fewer assets and lower remaining lifetime utility than current generations at the same stage of their life. The lower life-time interest rate of future generations therefore generates an additional source of inequality.[13]

3.2 **Demographic Uncertainty**

Demographic uncertainty comes from three possible sources, the fertility rate, the mortality rate, and net immigration. I consider only the first two sources and neglect the immigration uncertainty. To assess the impact of uncertainty on the projection of the growth path of the Dutch economy, I conduct a sensitivity analysis using the same alternative demographic projections that define Figure 3a and Figure 3b. This generates a total of four alternative projections or scenarios.[14] The grey scenario uses a combination of low fertility rates and low mortality rates, the green scenario is the opposite, and the low scenario uses a combination of low fertility rates and *high* mortality rates, with the high scenario again as the opposite. The grey-green scenario focuses on ageing uncertainty, and the low-high scenario focuses on population growth uncertainty.

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[12] The time trend equals $(1+\alpha)^{-t/(1-1/\gamma)}$

[13] It is not correct, however, to conclude from Figure 3 that the elderly are up to 40% better off if evaluated over their entire life. A comparison in terms of remaining lifetime utility does not take into account past events, that may have adversely affected the utility of these generations. Calvo and Obstfeld (1988) show that a time-consistent treatment of utility by a social planner requires discounting back to the birth dates of the generations involved.

[14] See De Beer and Beetsma (1999). The implementation of these scenarios generates some problems, because a change in future mortality rates directly affects the utility function of most existing households. This leads to a change in lifetime consumption profiles and generates a jump in consumption and labour supply in the base year. To generate the observed aggregate outcomes for the base year, it is necessary to change both the “share” parameters in the utility function and the intertemporal elasticity of substitution. This latter parameter however also strongly affects the life cycle profile of saving. I decided to keep the intertemporal elasticity of substitution at its base value and allow for a deviation of consumption from its benchmark level in the base year.

From the results, it appears that, by and large, ageing uncertainty has a stronger impact on the model projections than population growth uncertainty. This result does not hold uniformly, though. The growth rate of GDP per capita, income taxes, and the after-tax wage appear to be more sensitive to the rate of growth of the population. Also, the surplus on the current account and the Funded Collective pension contribution rate are about equally affected by both types of uncertainty.

The basic mechanisms at work are, first, that high population growth is bad for per capita growth, both because it depresses capital per worker and because it requires larger government expenditures on education and civil employment. Education in particular is expensive. Combined with the slower growth of output per capita, these expenditures require higher tax rates. Second, a larger share of elderly is bad for the tax base, but beneficial for labour productivity, both on account of the higher amount of capital per worker, and because of the higher labour productivity of middle-aged workers. That is, both the amount of physical capital per capita and the per capita amount of human capital are higher in an ageing society. As a result, ageing boosts the (gross) wage rate, which partially compensates for the increase in tax rates. In the figures below, I present the effects of the demographic variable that generates the larger amount of uncertainty for the variable under consideration.

From Figures 20 to 23 below, the sensitivity of taxes and contribution rates to the share of elderly can be inferred. Obviously, a larger share of elderly reduces the tax base and boosts social security payments. Figure 21 shows that the burden of PAYG pensions may exceed the expected 6% of GDP by another 4%. This explains the larger part of the uncertainty in the development of the total tax burden (Figure 20). Income tax rates are less sensitive to ageing, because an older population pays more consumption taxes. FC pension contribution rates are not very sensitive either, as a result of funding. Figure 22 shows that the uncertainty range is about 1%-point.[15]

Figure 23 shows that the negative effect of ageing on overall labour participation (lower half of the figure) are to a large extent dampened by the induced increase in the participation rate of the working-age population (upper half). This increase is due to a negative income effect of ageing on lifetime income of -10%. In the grey scenario, the consumption of both goods and health care increases substantially. The rise in consumption of health care is *not* due to the increase in life expectancy as such, since the health consumption profile is linked to mortality rates, not to age. The increase in health care demand boosts health care contribution rates by about 1% point.

The tax wedge on labour and the growth rate of GDP per capita are two variables that are more sensitive to population growth than to ageing. Figure 24 gives the development of the tax wedge under the high and low population growth scenarios. The wedge increases more in the high-growth scenario, as a result of the increase of the income tax rate. Two causes for this rise can be identified. The first is that the increase in government expenditure is no less than in the grey scenario. This is in large part due to the increase in expenditure for education, that rises an

[15] The contribution rate varies right from the start as a result of the variation in projected benefit obligations.

additional 1.2% of GDP in the high growth scenario, as a result of higher fertility rates. Another contributing factor is the government wage bill. Civil servants are by assumption a constant fraction of the population, and GDP growth per capita is lower in this scenario. The government wage bill therefore takes a larger share of GDP. Figure 25 presents the per capita growth rate of GDP. The familiar result from neoclassical growth models, that population growth is bad for per capita GDP, appears in the form of a lower rate of per capita growth on the transition path. The main reason is that the amount of capital per capita is lower.

3.3 **Interest Rate Uncertainty**

The projection in the previous section assumes that the world interest rate remains unchanged during the transition path. This is not a very plausible assumption, given that a similar demographic shock affects all OECD countries. In fact, Figure 19 shows that one consequence of the ageing process is a temporary increase in the Dutch current account surplus. Obviously, such a surplus cannot occur for all countries simultaneously. The resulting surplus in world savings must bring down interest rates and provide a negative feedback on saving. Therefore most closed-economy general equilibrium life-cycle models predict that interest rates are going to fall in the next few decades, see, e.g., Auerbach *et al.* (1989), Börsch-Supan (1996), Chauveau and Loufir (1997).

The fall in interest rates has a number of side effects that limit the possibilities to counteract the adverse effects of the fluctuations in the tax burden that follow from the demographic shift. The natural response to these fluctuations would be to apply tax smoothing through the creation of either a temporary buffer fund of savings or, equivalently, an accelerated reduction in government debt. This option is less attractive in the face of an expected decline in interest rates, since it would mean the intertemporal transfer of capital to periods in which it earns a lower rate of return. As a consequence tax smoothing becomes less attractive. Also, as Cutler *et al.* (1990) point out, an optimal response to declining interest rates is to increase consumption.[16] A similar dilemma is faced by the funded supplementary pension funds that, in the Netherlands, provide about half of total old-age social security. An expected decline in the return on the investments of these funds would force them to raise their contribution rates to maintain the required coverage of their obligations.

The inevitability of a decline in world interest rates is not generally accepted, however. Using a multi-country macroeconometric model, Masson and Tryon (1990) predict an increase in interest rates, as a result of a decline in saving and labour supply. Bovenberg and van der Linden (1997) point to the consequences of a phase difference in ageing between developed countries and developing countries, which may prevent capital productivity from falling. Turner *et al.* (1998) show that the net effect is sensitive to the assumptions about saving behaviour. In their baseline scenario, the interest rate remains nearly constant.

In this section, I quantify the interest rate uncertainty by considering the effects of two alternative projections of the world interest rate for the projected growth path of the Dutch

[16] However, this argument foregoes intergenerational distribution effects by concentrating on infinitely-lived households.

economy, a constant rate and a future decline (an *increase* does not seem plausible). Figure 5 shows the alternative time paths. The lower path is based on Chauveau and Loufir (1997), who position the largest decline in the interest rate in the mid-twenties of the next century. This pattern is broadly consistent with the timing of the decline in labour supply in the base-line scenario, presented in Figure 8. This shows that ageing in the Netherlands is in line with that in other OECD countries.

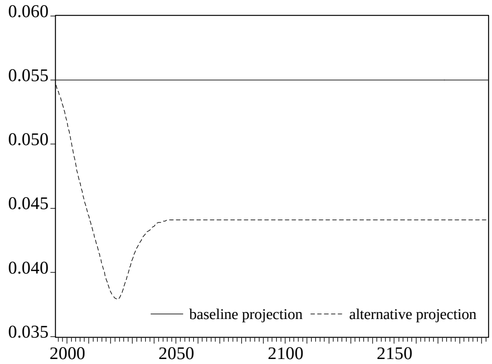

Figure 5
Interest rate projections

The declining interest rate path is implemented as a pre-announced shock in 1994. Figures 26-31 show that the news has a substantial effect on impact, even though the decline sets in gradually. To explain these effects, three main channels may be distinguished, *viz.* the effect on wealth and saving behaviour of households, the effect on investment and the market value of firms in the tradables sector, and the effect on supplementary pension contribution rates. The macro-economic effect on the consumption-saving decision is given in Figure 26 and 27. A lower future interest rate has an immediate impact on consumption and labour supply, through the intertemporal substitution effect. Consumption profiles are flattened out, and households shift their consumption of goods and leisure to the present. The result is a lower saving rate and lower initial participation rates (Figure 28). This causes a deterioration of the current account in comparison with the base path. This decline compensates the surplus on the benchmark path to a large extent.

A low interest rate boosts investment. This gradually raises labour productivity and increases the gross wage rate, despite the increase in labour supply. Since domestic saving falls, most of the extra capital is supplied by foreigners. The investment boom increases the growth rate of GDP per capita in the first two decades (Figure 29). However, this does not raise tax revenues, as the extra factor income is transferred abroad. Obviously, lower interest rates must decrease national income, given the large national saving surplus on the benchmark growth path.[17] As a result, the decline in income of the private sector causes an increase in income taxes, to finance the increase in government expenditure.

Figure 19 show the effects of the new expected interest path on the pension contribution rate. The projected pension liabilities rise sharply on impact, by 32%, both because of the decline in the interest rate, that lowers the capital income on the investment of the pension fund, and because of the rise in the gross wage. The latter effect is particularly pronounced in a final pay pension system, such as is in operation in the Netherlands. The increase in liabilities necessitates a dramatic increase in initial contribution rates. Clearly, such a sharp increase would not occur in reality, but some degree of contribution rate smoothing would be applied instead.

[17] And the negative initial net asset position of foreigners.

However, this requires temporarily abandoning the full coverage requirement.[18]

The decline in the interest rate boosts investment (Figure 20). This gradually raises labour productivity and increases the wage rate, despite the increase in labour supply (Figure 21). Since domestic saving falls, most of the extra capital is supplied by foreigners. The market value of firms falls because of the increase in the income tax rate, even though marginal *q* rises.

The basic PAYG pension system is hardly affected by the interest rate change (see Figure 25). This shows an important difference between a pay-as-you-go system and a funded system, a tax base that is defined for a large part in terms of human capital (labour income). The gross return to human capital rises at the same time as the return on physical capital falls. In addition, PAYG benefits are linked to after-tax wages, and these fall initially. In the long run too, PAYG benefits increase only slightly. The contribution rate rises by 0.6%-point, because of the decline in the capital income component of the PAYG tax base.

The effects of the interest rate change on the health care sector are also modest. The costs of health care increase, as a result of the increase in the wage rate. This drives up health care insurance premiums, but the net change is limited, both because the consumption volume of health care decreases in line with that of other goods and services, and because the contribution base widens because of the increase in labour supply. The net effect is an increase of about 0.4%-point in the ABWZ contribution rate, and an initial increase of 0.3%-points in the public health care contribution rate, that falls back to the benchmark in about a decade.

For households the substitution effect has both an intertemporal and an intratemporal aspect. The interest rate decline induces intertemporal substitution by “flattening” the life cycle consumption profile for households. As a result, young households supply less labour initially, and save less. This intertemporal substitution effect on leisure is further reinforced by the expected future increase in the wage rate, to be discussed below. The overall income effect is negative as a result of the considerable net claims of domestic sectors on foreigners. On impact the present value of the loss in income is some 5% of national wealth. Older households in particular suffer a substantial loss in capital income, both on account of a decline in interest payments and because of a fall in the market value of equity. In addition, intertemporal tradeoffs are less important to them. They respond to the interest shock by decreasing their consumption and, initially, also their labour supply as a result of a substantial drop in the after-tax wage, especially for households above the supplementary pension franchise.

In later years the labour supply response changes sign. The initial boost in the pension contribution rate has levelled off, and the intertemporal substitution effect that caused the initial fall in supply now works the other way, causing labour supply to rise because of lower wealth. The change in labour supply over time, and also the shift in the participation rate from the young to the old, can be read from Figure 22. Figure 23 show the decline in the share of consumption in GDP, and Figure 24 the change in the savings ratio and the current account as a fraction of GDP. The slump in savings and the current account precede the trough in the rate of interest by

[18] In the books, this problem can be easily avoided because pension funds apply an accounting rate of interest that may temporarily deviate from the market rate. The obvious way to achieve contribution rate smoothing is then to gradually change the accounting rate in response to a change in views about the time path of market interest rates.

about a decade, in anticipation of its subsequent rise. Government tax receipts fall as a result of the shock. Both the capital income tax base and the consumption tax base decrease. Labour supply increases however by about 1% on average, which offers a partial compensation.

4. Social Security Reform

The analysis of the effects of the demographic shock identifies several problems. In the baseline projection the main problem is the sharp rise in the tax burden, which causes generational imbalance, as shown in Figure 4. Figures 9-12 identify the source of this problem in terms of the rise in PAYG social security contributions and health care contributions. In addition, the increasing tax rates boost the excess burden starting from an initial situation that is already characterized by high marginal rates. It is therefore attractive to try to correct both problems at once by a suitable reform of social security. Judging from the baseline projection, the obvious candidate for reform seems to be the PAYG social security system, as it contributes most to the increase in the tax burden.

To investigate the benefits of this reform, I compute the effects of three reform measures, *viz.*

- an immediate reduction in PAYG benefits, compensated for by a reduction in income taxes;
- an immediate reduction in PAYG benefits, compensated for by a sustainable permanent reduction in indirect taxes;
- a gradual phasing out of PAYG benefits, compensated for by a sustainable permanent reduction in indirect taxes.

4.1 A balanced-budget reduction in PAYG benefits

A reduction in PAYG benefits aims at a decrease in the distortionary impact of the PAYG contributions on labour and capital income. The cut implies a smaller deficit of the PAYG fund, and consequently a smaller PAYG subsidy from the government. In the present scenario, incomes tax rates are cut to maintain a constant debt-GDP ratio. Existing old generations in the Netherlands are to some extent sheltered from the income effects of a reduction in PAYG benefits, if they are eligible to a supplementary pension. The pension fund supplements PAYG benefits to a maximum of 70% of the final wage before retirement, provided that a household has contributed to the fund during his entire working life. Households with a wage higher than the franchise threshold implied by this arrangement therefore receive a higher supplementary pension if PAYG benefits are cut.[19] All households benefit from the cut in income taxes. Table 1 below presents a summary of the macroeconomic effects of this policy measure. The welfare effects for generations and productivity types are given in Figure 32.

Equity and Efficiency

Overall, the reform is efficiency-improving. The present value of the aggregate of compensating variations is -*ƒ*40 milliards, 6% of GDP. Compared with the reduction in PAYG benefits of

[19] This legal obligation is subject to the restriction that the pension fund have sufficient financial resources.

f 148 milliards, the efficiency gain is 27 cents per guilder. The efficiency gain results from the decrease in distortionary income taxes and an implicit lump-sum tax on the elderly. Table 1 shows that the benefit cut allows for a gradually falling income tax rate (t_y), to an eventual -1.2% points. The income tax is to some extent replaced by a higher contribution rate (*w*) from the funded supplementary pension system, at least in the first two decades after the reform. However, this contribution is less distortionary, since it is linked to pension benefits. Efficiency also increases due to the lump-sum component in the reform. Old low productivity households are not included in the supplementary pension scheme. Following the cut in PAYG benefits, they therefore receive no compensation from the supplementary pension fund, so that for them the reform operates as a lump-sum tax. Young generations profit in the form of lower income taxes. Figure 32 shows that old generations of low-productivity households are indeed much worse off than households of the same age, but higher productivity. Nonetheless, most retired households lose from the reform. Supplementary pensions are indexed on the gross wage rate, which falls as a result of the increase in labour supply of working-age generations. Also, the income tax rises to compensate for the loss in tax revenues due to the decrease in consumption. Compared with younger generations, retired generations profit less from the simultaneous decrease in the income tax rate, since they do not supply labour.

Macroeconomic Effects

Labour supply increases because of the lower burden. Initially, the labour supply response is dampened by the increase in the pension contribution rate (*w*), that rises because the pension fund has to compensate most retired households for the fall in PAYG benefits. However, this contribution rate is less distortionary, as pension benefits are linked to hours worked. Over time, this rate declines again as the pension fund succeeds in regaining its desired coverage of future obligations. The increase in labour supply boosts investment as well, which gradually restores labour productivity and wages. The reform also stimulates savings, as the PAYG contribution also bears on capital income. This implies that consumption of young households falls initially. Consumption of retired households also falls, as a result of lower lifetime income. Since part of the increase in saving is invested abroad, this implies an initial decrease in the domestic tax base. As a result, the income tax rate initially falls by only 0.3%, less than corresponds to the *ex ante* saving on PAYG subsidies.

The results of this analysis lead to the conclusion that a reform of old-age social security through a balanced-budget reduction in the basic PAYG pension benefits must hurt poor households. They cannot profit from the shelter offered by the funded pension scheme, because their income is already near the minimum level defined by the current PAYG scheme. A straightforward cut in PAYG benefits also hurts old rich generations, however. The compensation offered by the FC pension fund is incomplete, because it does not provide shelter against the general-equilibrium effects of the reform, notably the fall of gross wages. These conclusions are similar to those obtained by Fehr (1999), Chapter 8, for a reform of the German pension system (even though that system does not provide a compensation through an FC scheme).

It is therefore improbable that the reform would enjoy sufficient political support to be feasible. Table 3 shows that only 35% of the electorate would benefit from the reform. A reform that makes current generations better off must compensate these generations for any implied income transfer to future generations. This can be achieved in a generic fashion through the use of debt financing.

4.2 **A debt-financed cut in PAYG benefits**

A simple way to implement a debt-financed cut in PAYG benefits is to combine the cut in PAYG benefits with a cut in indirect taxes that is larger than what compatible with a balanced-budget tax cut. The room for such an "excess compensation" exists, because Section 4.1 showed that the full beneficial effects materialize only in the long run. Table 2 presents the effects of the same 10% cut in PAYG benefits, now compensated for by a maximal sustainable cut in the indirect tax rate. The income tax rate now remains at the level of the benchmark path. This cut causes an increase in government debt and thereby transfers part of the welfare gain to current generations.

Equity and Efficiency

The present value of compensating variations is -50 milliards, 8% of current GDP. The present value of the cut in PAYG benefits in *ƒ*151 milliards, so that the efficiency gain is *ƒ*0.33 per guilder. This is slightly larger than the efficiency gain of the reform with balanced-budget income tax compensation. As in the previous case, the efficiency gain is causes by a decrease in distortionary taxes. The indirect tax rate falls by 1.9%-points. This reduces the consumption-leisure wedge in the long term by nearly the same amount as the fall in income taxes in the preceding case. In the short-term the reduction is considerably greater, as a result of the tax smoothing. This provides a better stimulus to labour supply and generates a larger inflow of foreign capital, to finance investment. Indeed, both the capital stock and employment are larger in the long run. The larger tax base allows for lower tax rates and a smaller efficiency loss.

The reform has much more equitable intergenerational distribution effects than a balanced-budget cut in PAYG benefits. Figure 33shows that for most productivity types, almost all generations gain. Only for generations born around 1930 the majority loses. The more equitable welfare distribution results because the cut in indirect taxes operates in part as a lump-sum subsidy to old households, who finance a large part of their consumption from financial wealth. This compensates for the likewise lump-sum cut in PAYG benefits. Only low-productive households still suffer a substantial welfare loss. They finance most of their consumption from current income so that for them the reduction in indirect taxes does not imply a substantial lump-sum subsidy. In addition they are the only type without any compensation from the FC pension fund.

The welfare loss of low-productivity households is difficult to solve if the social security system must provide a basic income to all old households, independent of past contributions. A possible way out would be to make the PAYG benefit means-tested. This would increase the progressivity of the tax system and is beyond the present paper. Still, even for poor households the welfare losses associated with the reform are considerably less than the redistribution caused by the ageing itself. A comparison of Figures 4 and 33 shows that the combined effect of ageing and the reform is beneficial for *all* current generations. From an equity point of view, it may be argued that the effects of the shock, ageing, and the policy reform that addresses the shock should be evaluated together. Politically, the reference point is more plausibly the status quo, which includes ageing. This implies that current generations will compare their utility in the benchmark case with that under a proposed policy reform to determine how to vote. Table 3 gives the percentage of voters that benefit from the proposal to reduce PAYG benefits, subdivided by productivity type. Not surprisingly, all high-productivity households gains from the reform. All low-productivity households lose. Most intermediate types gain. Adding up all the votes, it appears that 62% of the electorate is in favour of the PAYG reform, if accompanied by an appropriate debt policy, so that it is politically feasible.

Macroeconomic Effects

The macro-economic effects of the tax-smoothed reform resemble those of the balanced-budget reform discussed in the previous section with respect to their effect on labour supply. Labour supply increases more than in the previous case because the tax wedge is lower. Consumption is stimulated as a result of the tax cut. At first, this is financed through the balance of payments. In later years production increases. However, savings are lower than in the alternative case, and the surplus on the trade balance remains small. As a result, income effects on labour supply in later years are also limited, and the labour supply response stays positive in the new steady state. Government debt increases by 10% of GDP, as a consequence of the transfer of welfare between generations. Though marginal tax rates fall, the average tax burden as a percentage of GDP increases by 1.5%, as a result of the increased debt service and the increased share of non-GDP related government expenditures.[20]

4.3 **Phasing Out the PAYG Pension System**

In Section 4.2, we saw that a reduction in PAYG benefits is welfare increasing for most current and future generations, provided that part of the welfare gain is transferred to the present through an appropriate debt policy. Even so, the reform has a number of disadvantages. All low-productivity households lose from the reform, and it requires a substantial increase in FC pension contribution rates on impact, to cover the sudden increase in projected benefit obligations. This curbs labour supply in the first few periods. A possible remedy to these side effects is to reduce PAYG benefits gradually. Such a policy is more in line with both the gradual expected increase in PAYG benefits and with stable FC contribution rates. This policy also resembles the actual development of PAYG benefits in the Netherlands over the past decade, where PAYG benefits were linked to contractual wage increases. PAYG beneficiaries therefore missed out on the wage drift, which amounted to about half a percent per year over that period. Since a continuing decline of PAYG benefits is incompatible with a final steady state, I

[20] However, since indirect tax rates fall by 2%, the tax burden does not increase if GDP is evaluated against factor costs.

implement the policy as a reduction with half a percent per year for the next 50 years.

Equity and Efficiency

The cut results in a reduction in the present value of PAYG benefits of ƒ210 milliards. The present value of compensating variations is -ƒ86 milliards, 14% of current GDP. The efficiency gain is therefore ƒ0.41 per guilder, considerably more than with the immediate cut discussed the preceding sections. Table 3 shows that the contribution rate to the FC pension fund rises less on impact than in the previous cases, despite the larger present value of the cut. This explains most of the extra efficiency gain. The fact that the cut in PAYG benefits is now pre-announced does not generate distortions, because the benefits are lump-sum. The fall in the consumption tax again serves to transfer part of the future efficiency gains to current generations. The substantial increase in the debt-GDP ratio results from the gradual implementation of the cut. This implies that the efficiency gains will be postponed as well, and more debt is required to bridge the transition. Figure 34 shows that the policy succeeds better in transferring welfare gains to current generations than an immediate cut of PAYG pension benefits. As a result, the political support for the reform is also larger, with 83% of the electorate being in favour of the reform.. On the other hand, the negative welfare effects for future low-productive generations are also larger. Figure 3 shows that type 0.24 breaks almost even in the long run. This implies that slightly more that 24% of the population eventually loses from 0 to about 1.5% of lifetime wealth from the reform.

Macroeconomic Effects

Labour supply is boosted more on impact than in the previous cases. The cut in consumption taxes is larger and the FC contribution rate rises less. As a result the tax wedge on labour supply is reduced substantially. The increase in labour also stimulates investment and GDP against factor costs. GDP against market prices falls, however, which explains the initial jump in the debt ratio. Consumption is boosted more than before on impact, because the adverse consequences of the PAYG cut for the income of pensioners do not materialize right away. As a result, the trade balance turns negative initially. The increase in foreign debt is however limited, as the extra consumption is paid for from the increase in domestic production once the expansion of the capital stock has been completed.

5. **Conclusion**

This paper has studies the effects of the imminent ageing of the population on economic growth and the distribution of welfare in the Netherlands. It shows that a slowdown in economic growth per capita may be expected as a result of the decrease in the participation rate and the increase in the tax wedge on labour. The increase in the tax burden is in large part due to the PAYG nature of the basic pension scheme. Occupational pensions are not very sensitive to an increase in the old-age dependency ratio, but are vulnerable in case of a fall in interest rates. Such a fall appears likely in view of the large surpluses on the balance of payments that are predicted to occur otherwise. A lower interest rate would also add to the future increase of the wedge.

The paper measures the distributional impact of the social security system on future generations in terms of a comparison of their lifetime utility. The paper shows that the main redistributive effect of ageing is not between current young generations and future generations, but between current young generations and current middle-aged and old generations. Future generations suffer the equivalent of only some 4% loss in lifetime wealth, compared to generations that currently enter the labour force. However, current young generations suffer some 30% loss in wealth in comparison with current old generations, if evaluated at the same point of their life. This is because current old generations escape the larger part of the future rise in taxes and social security contributions, in contrast to current young generations. In addition, low- and mid-income groups are hit somewhat harder than high-income groups.

The paper identifies the PAYG social security system as the largest single distortionary influence on economic growth. PAYG benefits raise the tax burden by some 6%-points of GDP. This gives rise to large potential efficiency gains from a reform of social security. A cut in PAYG social security of 10% leads to an aggregate discounted welfare gain of 6% of current GDP, and a redistribution of welfare towards future generations. Losses of most current generations are fairly small, as they are sheltered to some extent from the PAYG cut by the existing supplementary occupational pension schemes. Low-income groups are hit particularly hard, however, as they face not only the full size of the cut, but also an initial fall in wages, to which their social security benefits are indexed.

The burden of the reform can be shifted to future generations by an appropriate use of government debt. A cut in PAYG benefits that is combined with a maximal sustainable cut in indirect taxes largely succeeds in synchronizing welfare gains and losses over generations. 62% of current generations benefit from the reform. This percentage can be raised further by implementing the cut gradually. However, low-productivity households still suffer a welfare loss. To solve this problem, the PAYG benefit should be made means-tested.

Table 1: Effects of a decrease of 10% in PAYG benefits, compensated for by a reduction in income taxes[21]

	year	1	10	20	30	40	50	200
L	%	0.04	0.25	0.35	0.36	0.32	0.20	0.01
K	%	0	0.42	0.65	0.67	0.56	0.21	-0.33
c	%	-0.44	-0.24	0.01	0.32	0.63	0.90	1.80
S/GDP	D%	0.16	0.36	0.52	0.61	0.69	0.69	0.46
I/GDP	D%	0.11	0.06	0.02	-0.02	-0.08	-0.15	-0.23
TB/GDP	D%	0.03	0.21	0.23	0.15	0.07	-0.09	-0.72
A_e	%	0	-0.74	-1.87	-2.98	-4.12	-5.83	-10.4
t_y	D%	-0.27	-0.41	-0.58	-0.76	-0.95	-1.05	-1.19
w	D%	1.18	0.40	0.09	-0.05	-0.10	-0.14	-0.14
p_l	%	-0.11	-0.02	0.05	0.06	0.02	-0.09	-0.21

Table 2: Effects of a decrease of 10% in PAYG pension benefits compensated for by a sustained reduction in indirect taxes

	year	1	10	20	30	40	50	200
L	%	0.13	0.31	0.37	0.34	0.27	0.23	0.21
K	%	0	0.45	0.61	0.61	0.54	0.47	0.39
c	%	0.23	0.33	0.43	0.56	0.67	0.76	0.97
S/GDP	D%	0.16	0.32	0.42	0.45	0.41	0.37	0.31
I/GDP	D%	0.22	0.17	0.13	0.10	0.09	0.09	0.07
TB/GDP	D%	-0.13	0.08	0.13	0.06	-0.05	-0.14	-0.21
D/GDP	D%	0.62	3.28	5.43	7.86	8.83	9.18	9.89
A_e	%	0	0.17	-0.42	-0.99	-1.44	-1.90	-2.34
t_c	D%	-1.87	-1.87	-1.87	-1.87	-1.87	-1.87	-1.87
w	D%	1.17	0.40	0.10	-0.03	-0.08	-0.14	-0.15
p_l	%	-0.25	-0.11	-0.05	-0.01	0.01	0.02	-0.00

[21] All variables are given either as percentage deviations from the baseline solution (%), or as absolute deviations (D%). The definition of the symbols is given in Appendix 3.

Table 3: Effects of a phasing out of PAYG pension benefits by 0.5% per year, compensated for by a sustained reduction in indirect taxes

	year	1	10	20	30	40	50	200
L	%	0.36	0.61	0.70	0.70	0.65	0.64	0.70
K	%	0	0.80	1.12	1.21	1.24	1.31	1.31
c	%	1.09	1.11	1.07	1.01	0.97	0.96	1.14
S/GDP	D%	-0.03	0.13	0.22	0.26	0.23	0.18	0.23
I/GDP	D%	0.35	0.29	0.26	0.24	0.25	0.30	0.26
TB/GDP	D%	-0.47	-0.07	0.08	0.11	0.05	-0.02	0.07
D/GDP	D%	0.91	8.80	19.4	29.7	38.4	42.5	43.6
A_e	%	0	1.61	1.63	1.38	1.23	1.48	1.43
t_c	D%	-2.96	-2.96	-2.96	-2.96	-2.96	-2.96	-2.96
w	D%	0.64	0.57	0.57	0.53	0.41	0.11	-0.34
p_l	%	-0.57	-0.21	-0.09	-0.04	-0.01	0.06	-0.00

Table 4: Percentage of current generations that benefit from a pension reform

reform measure	Productivity type						
	0	0.24	0.48	0.71	0.95	0.99	all
a balanced-budget cut of PAYG benefits	0%	19%	32%	44%	68%	71%	35%
a tax smoothed cut of PAYG benefits	0%	42%	68%	80%	100%	100%	62%
a tax smoothed phasing out of PAYG benefits	12%	74%	100%	100%	100%	100%	83%

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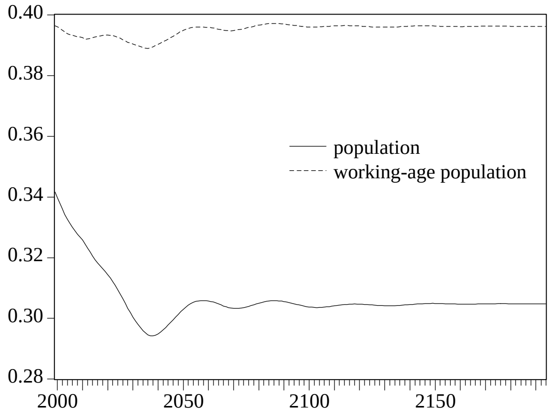

Figure 6
Participation Rates

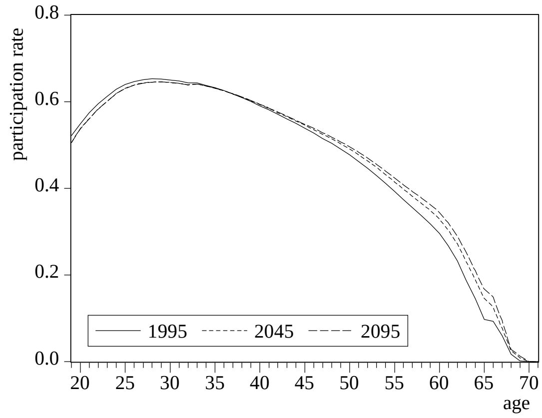

Figure 7
Participation rates by age for selected years

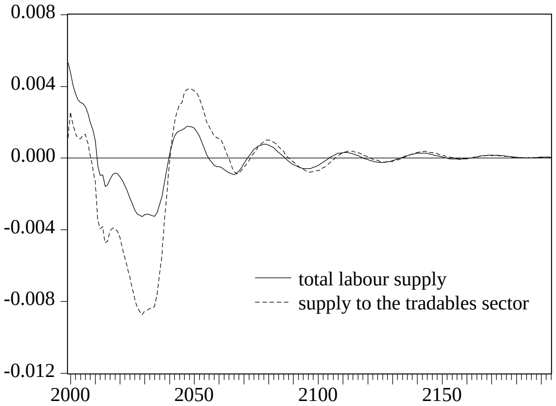

Figure 8
Growth of Labour Supply

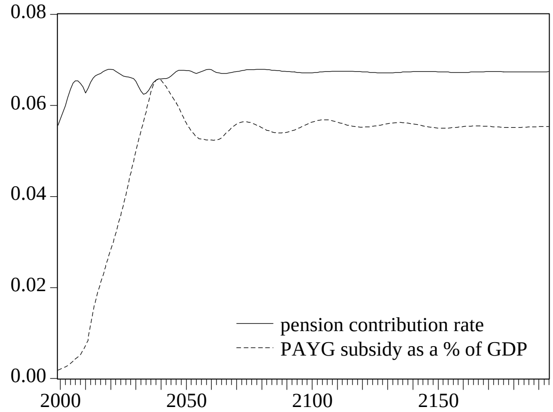

Figure 9
Old-age social security contribution rates

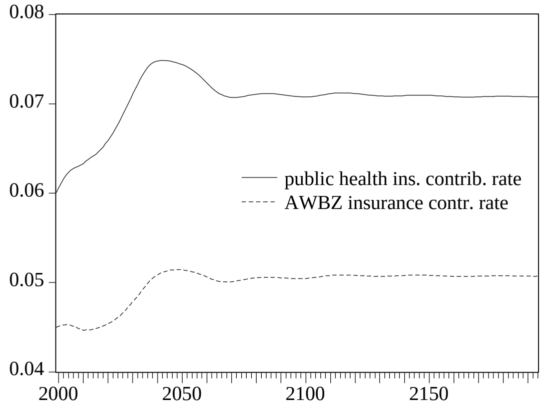

Figure 10
Health insurance contribution rates

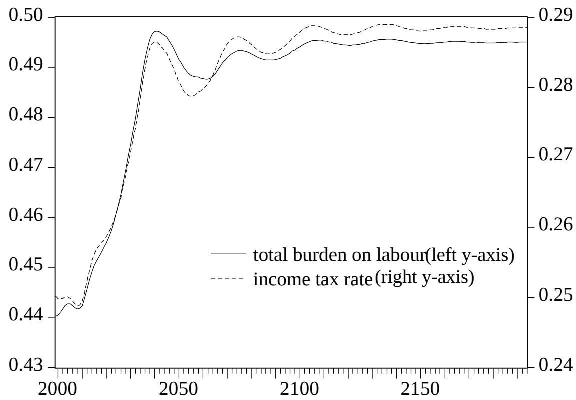

Figure 11
Income tax rates and total burden on labour

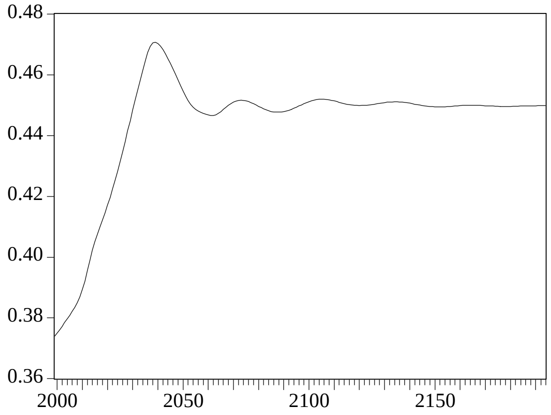

Figure 12
Total tax burden as a fraction of GDP

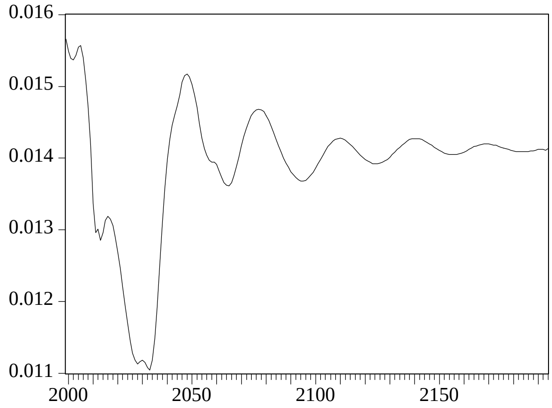

Figure 13
Government deficit-GDP ratio

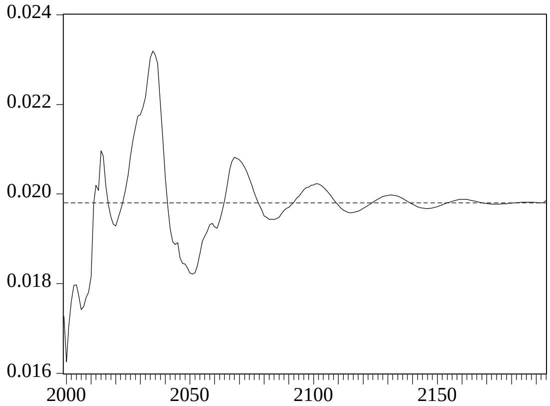

Figure 14
Market wage growth

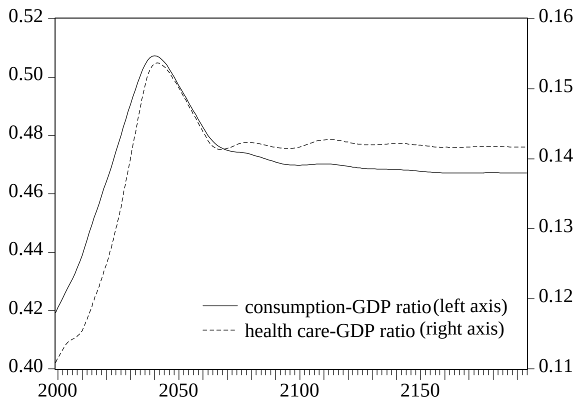

Figure 15
Consumption- output ratios

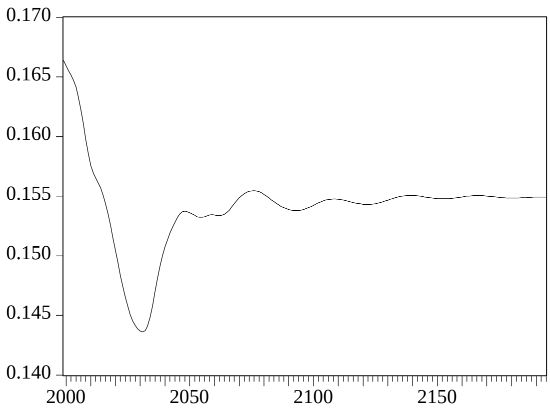

Figure 16
Investment-output ratio

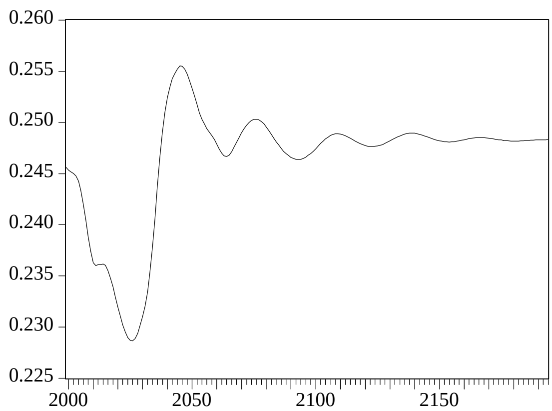

Figure 17
Investment-output ratio
in the tradable goods sector

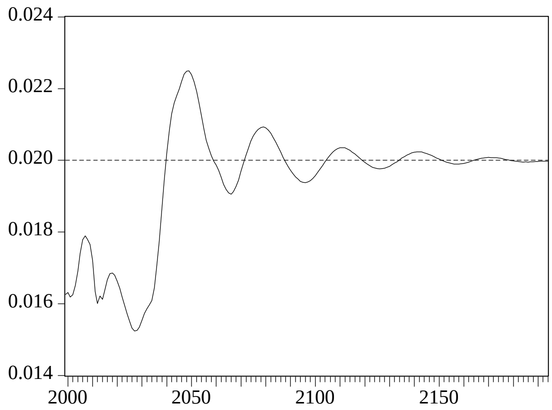

Figure 18
Growth rate of GDP per capita

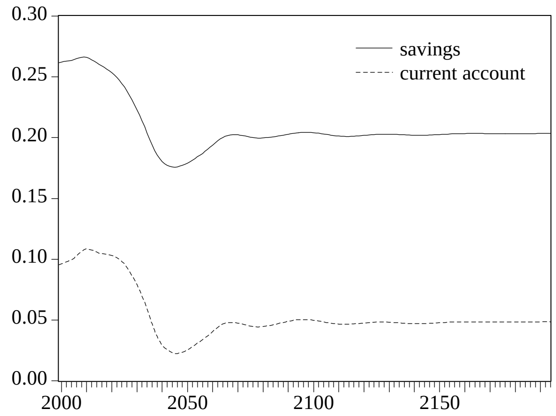

Figure 19
Current account surplus and savings
as a fraction of GDP

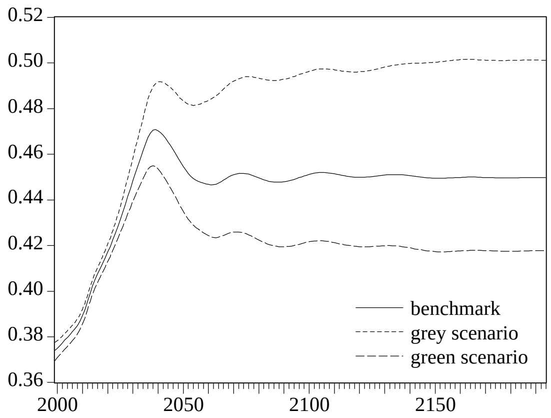

Figure 20
Ageing uncertainty:
Tax burden as a fraction of GDP

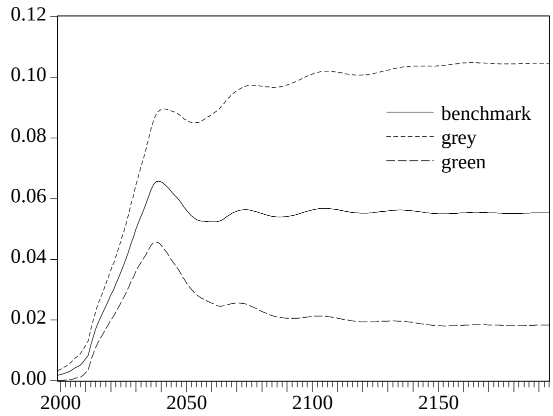

Figure 21
Ageing uncertainty:
PAYG subsidy as a fraction of GDP

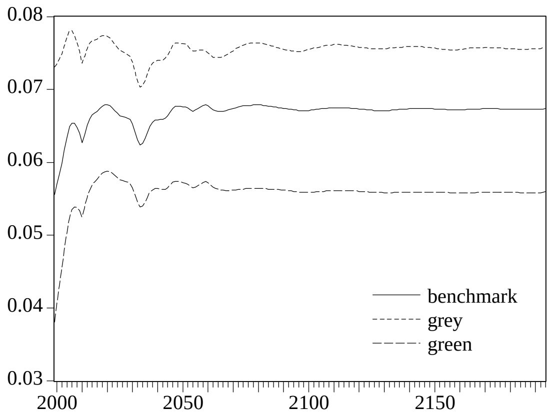

Figure 22
Ageing uncertainty:
FC pension contribution rates

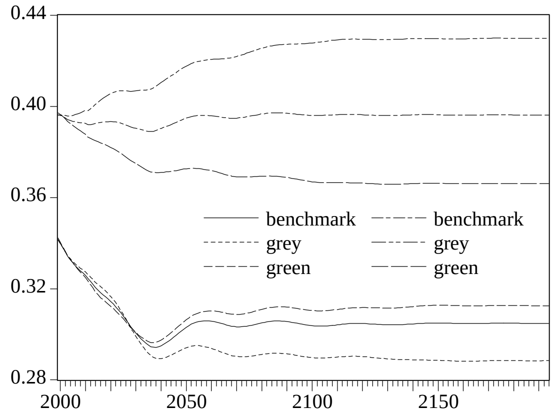

Figure 23
Ageing uncertainty:
Labour participation rates

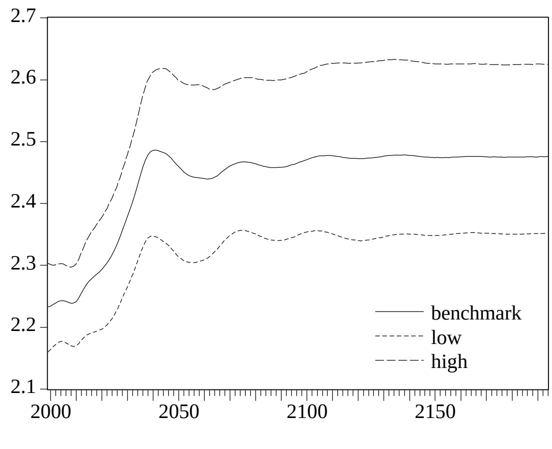

Figure 24
Population growth uncertainty:
the wedge

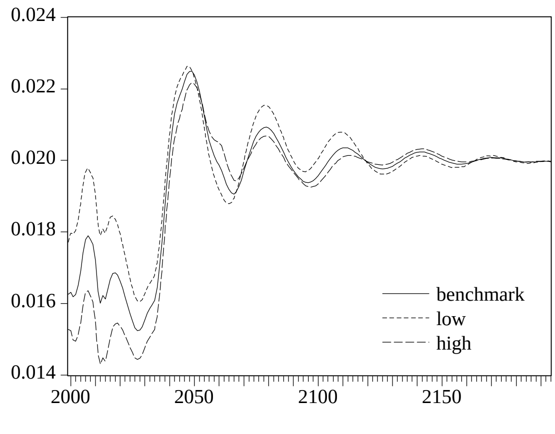

Figure 25
Population growth uncertainty:
per capita growth of GDP

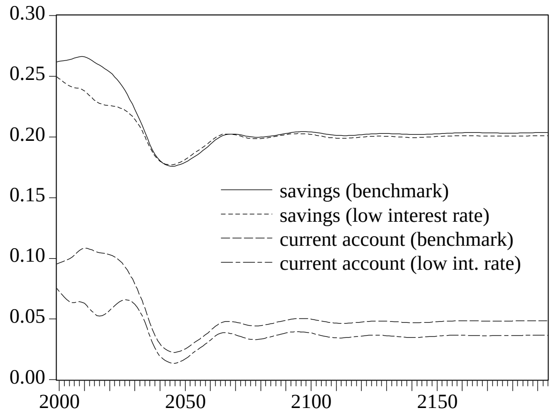

Figure 26
Interest rate uncertainty:
saving and current account as a fraction of GDP

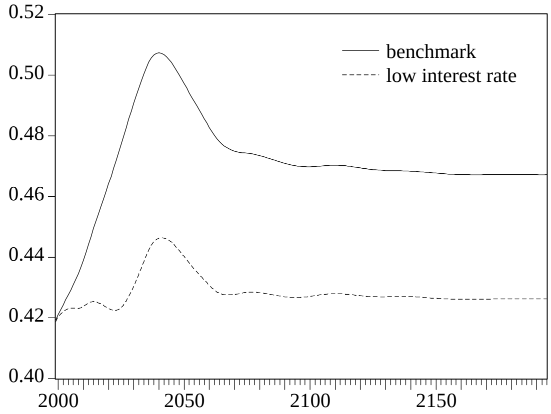

Figure 27
Interest rate uncertainty:
Private consumption as a fraction of GDP

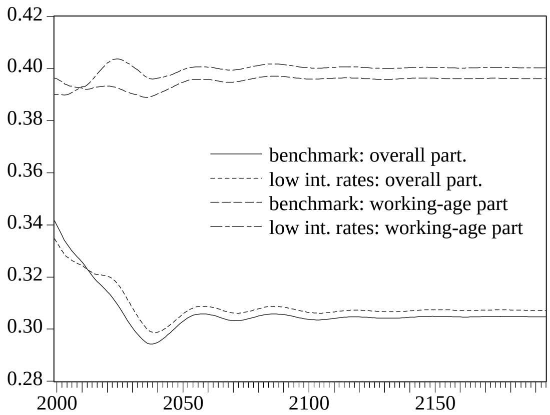

Figure 28
Interest rate uncertainty:
Labour market participation rates

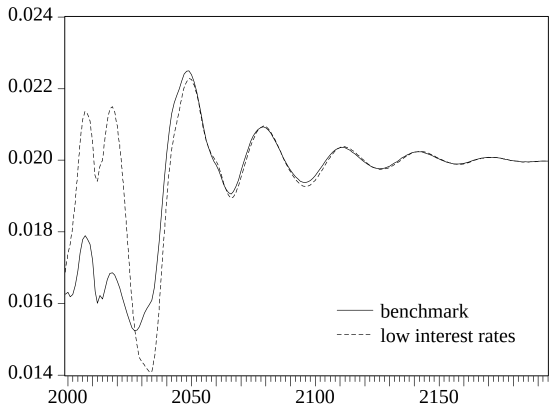

Figure 29
Interest rate uncertainty:
Growth rate of GDP per capita

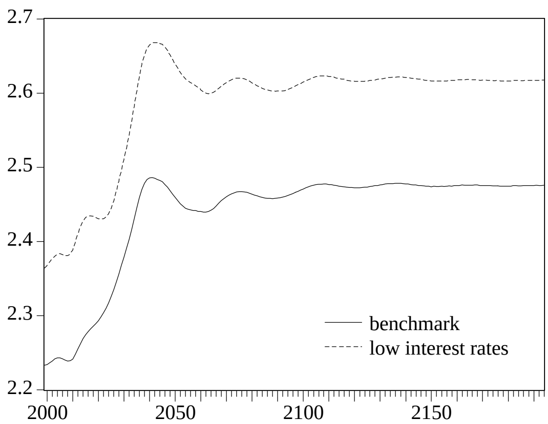

Figure 30
Interest rate uncertainty
Labour tax wedge

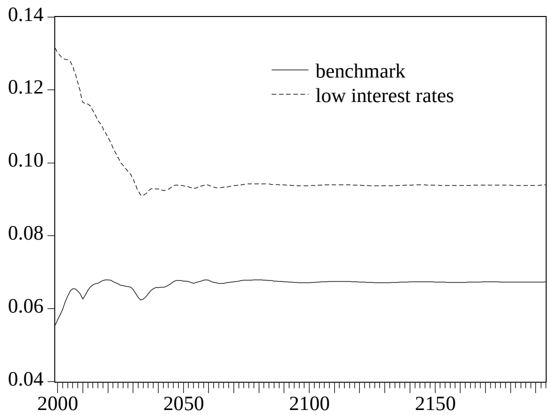

Figure 31
Interest rate uncertainty
FC pension contribution rates

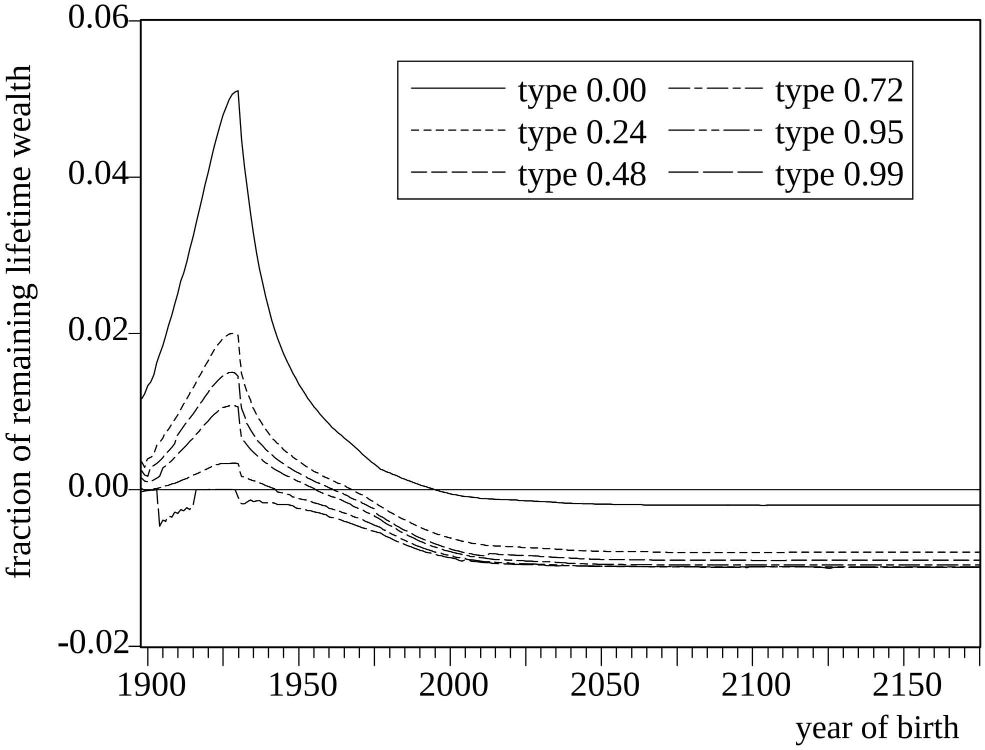

Figure 32
Compensating variations for a 10% reduction in PAYG benefits

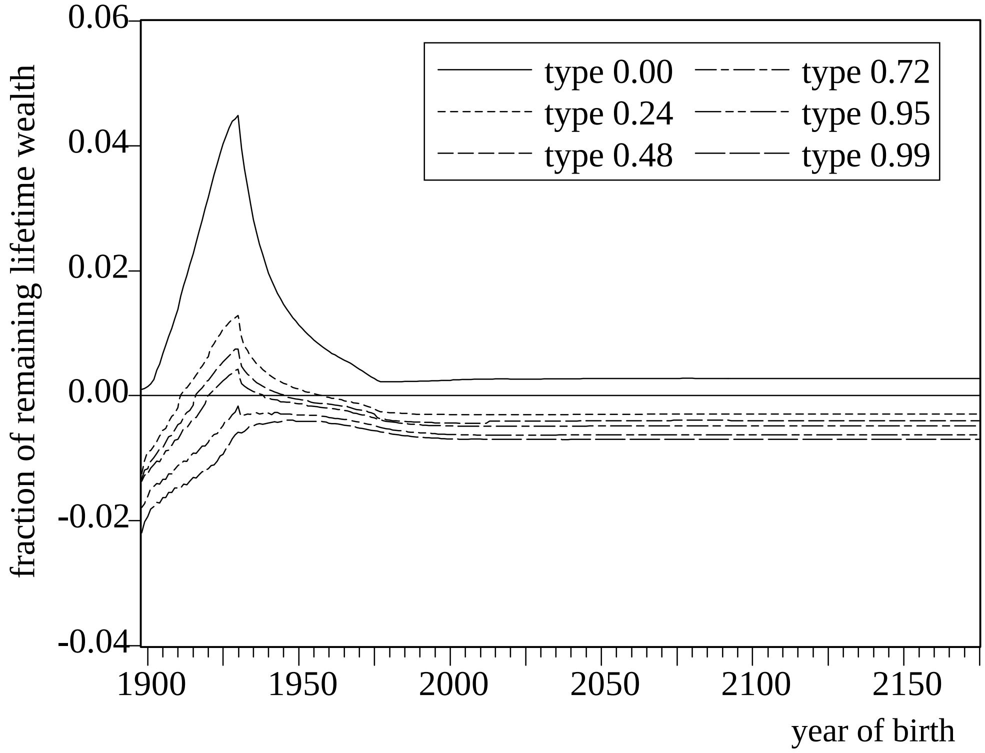

Figure 33
Compensating variations for a 10% reduction in PAYG benefits,
compensated by a 2% reduction in the consumption tax rate

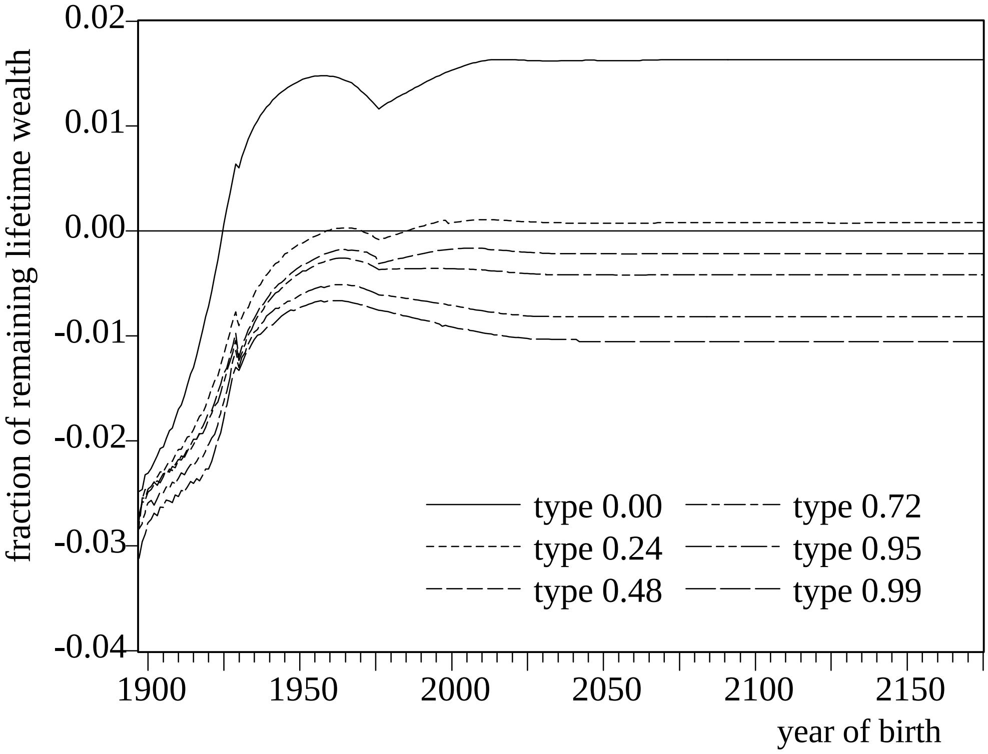

Figure 34
Compensating variations for a phasing out of PAYG benefits by 0.5% per year, compensated for by a 3% reduction of consumption taxes

Appendix 1

Description of the individual model equations

1. The Tradable Goods Sector

Firms in the tradable goods sector use capital, labour, and raw materials to produce output. Production is subject to (internal) adjustment costs in capital formation. Technical change is purely labour augmenting, at rate α. Labour and raw materials are variable inputs. Labour is heterogeneous by age and skill type, but workers of all types are perfectly substitutable. Let the productivity of labour of type *i* be equal to $h(i)$, then the production function reads as follows

$$y(t) = \mathrm{F}[M(t),H(t)] - \tfrac{1}{2} c_I \frac{I^2(t)}{K(t)} \tag{1}$$

$$F[M,H] = \left[\zeta_M M^{-\rho_y} + \zeta_H H^{-\rho_y}\right]^{-1/\rho_y}$$

$$H(t) = \left[\zeta_K K(t)^{-\rho_H} + \zeta_L \left(L_{eff}(t)(1+\alpha)^t\right)^{-\rho_H}\right]^{-1/\rho_H} \tag{2}$$

$$L_{eff}(t) = \sum_{\tau=t-n_T+1}^{t} \int_0^1 h(i,t-\tau) L(t,\tau,i)\, \mathrm{d}i \tag{3}$$

Here *M* denotes the use of raw materials, *K* denotes the beginning-of-period capital stock, and L_{eff} denotes the labour input in efficiency units. The integral in **(3)** is computed by numerical integration. For this, the interval [0,1) is split in [0,0.95] and (0.95,1). On the first interval the integral is approximated by Simpson's rule, using 5 points. On the second interval, the integral is improper, since labour productivity is not bounded above. It appears that the upper tail of the Dutch productivity distribution is approximately Pareto, with density $p(h) \propto h^{\alpha-1}$, where $\alpha \approx -3.1$ (see Figure 5 below). The inverse distribution over types is then $p(i) \propto (1-i)^{1/\alpha}$. This suggests the transformation $j = (1-i)^{1+1/\alpha}$. I use a two-point Gauss quadrature for the thus transformed integrand of **(3)** to evaluate the integral over the second interval.

I define the real market wage as the marginal product of efficiency labour. The normalization of productivity is chosen so that in the base year (t_0) $L(t_0)/L_{eff}(t_0) = 1$. As a result, the market wage equals the average wage rate in the base year

$$p_l(t_0,\tau,i) = \mathrm{F_L}[K(t_0),L_{eff}(t_0),M(t_0)]\; h(i,t_0-\tau) \quad \Rightarrow$$

$$p_l(t_0) = \sum_{\tau=t_0-n_T+1}^{t_0} \int_0^1 p_l(t_0,\tau,i) L(t_0,\tau,i)\, \mathrm{d}i \Big/ \sum_{\tau=t_0-n_T+1}^{t_0} \int_0^1 L(t_0,\tau,i)\, \mathrm{d}i \tag{4}$$

Investment goods can be either imported or produced domestically. They are combined into a single capital good during installation by means of a production function $I(t) = G[I_1(t),I_2(t)]$. The price of the composite investment good is given as the minimal cost per unit of *I*:

$$p_I(t) = \left[\gamma_1^{-\sigma_I} p_{I_1}(t)^{1-\sigma_I} + \gamma_2^{-\sigma_I} p_{I_2}(t)^{1-\sigma_I}\right]^{1/(1-\sigma_I)} \tag{5}$$

Demand for each individual investment good is then derived from Shephard's lemma as $I_i(t) = I(t)\, \partial p_I(t)/\partial p_i(t)$. Profits before taxes are given by

$$\Pi(t) = y(t) - p_M(t)M(t) - p_l(t)L(t) - r(t)B(t) \tag{6}$$

where *r* denotes the rate of interest, and *B* the amount of debt. Dividends can be financed out of net cash flow or out of debt issues:

$$Div(t) = \Pi(t) - T_b(t) - p_I(t)I(t) + B(t+1) - B(t) \quad \textbf{(7)}$$

Dividends must be nonnegative to prevent shareholders from avoiding the dividend tax

$$Div(t) \geq 0 \quad \textbf{(8)}$$

Corporate taxes are levied on profits net of depreciation and a possible investment tax credit:

$$T_b(t) = t_b(t)\left(\Pi(t) - cr(t)p_I(t)I(t) - \sum_{\tau=t-T_D+1}^{t} \Delta(t-\tau)p_I(\tau)I(\tau) \right) \quad \textbf{(9)}$$

where T_D denotes the tax life of capital goods. It is assumed that the amount of debt issued is proportional to the capital stock

$$B(t) = \beta_K p_I(t)K(t) \quad \textbf{(10)}$$

The market value of the firm follows from the portfolio decisions of investors. It is assumed that the marginal investor is a working-age domestic household. Investment is financed through retained earnings and debt, according to **(7)** and **(10)**. With perfect capital markets, the arbitrage equation reads as

$$\frac{V(t+1)-V(t)}{V(t)} + \frac{1-t_d(t)-\pi_k^y(t)-\pi_{AWBZ}(t)}{1-t_v(t)}\frac{Div(t)}{V(t)} = \frac{1-t_k(t)-\pi_k^y(t)-\pi_{AWBZ}(t)}{1-t_v(t)}r(t) \quad \textbf{(11)}$$

where t_d is the dividend tax rate, π_y^k is the basic pension premium on capital income, π_{AWBZ} is the part of the health care premium that is levied on income, and t_v is the capital gains tax. The right-hand side of the equation represents the alternative return on bonds for young households. Integrating **(11)** backwards gives the expression for the market value of firms

$$V(t) = \sum_{\tau=t}^{\infty} R_f(\tau,t) \frac{1-t_d(\tau)-\pi_k^y(\tau)-\pi_{AWBZ}(\tau)}{1-t_v(\tau)} Div(\tau) \quad \textbf{(12)}$$

where the compound discount rate is given by

$$R_f(\tau,t) = \prod_{s=t}^{\tau}\left[1 + (1-t_k(s)-\pi_k^y(s)-\pi_{AWBZ}(s))r(s)/(1-t_v(s))\right]^{-1} \quad \textbf{(13)}$$

Capital accumulation is given by

$$K(t+1) = I(t) + (1-\delta)K(t) \quad \textbf{(14)}$$

Let q denote the shadow price of investment (equation **(14)**), let λ_B denote the shadow price of the cash flow restriction **(7)** and λ_D denotes the shadow price of the dividend restriction **(8)**. The first-order conditions for investment can be derived as

$$q(t) = \lambda_B(\tau)\left((1-t_b(t))c_I\frac{I(t)}{K(t)} + p_I(t)(1 - t_b(t)cr(t) - depr(t)) \right) \quad \textbf{(15)}$$

$$depr(t) = \sum_{\tau=t}^{t+T_D-1} t_b(\tau)\frac{\lambda_B(\tau)}{\lambda_B(t)}\Delta(\tau-t)R_f(\tau,t) \quad \textbf{(16)}$$

$$(1-t_b(\tau))\lambda_B(\tau)\left(\frac{\partial F(\tau)}{\partial K(\tau)} + \tfrac{1}{2}c_I\left(\frac{I(\tau)}{K(\tau)}\right)^2 - p_I(\tau)\,\beta_K\, r(\tau)\right)$$

$$- p_I(\tau)\,\beta_K\lambda_B(\tau) + (1-\delta)\,q(\tau) = \left(q(\tau-1) - p_I(\tau)\,\beta_K\lambda_B(\tau-1)\right)\frac{R_f(\tau-1,t)}{R_f(\tau,t)} \qquad \textbf{(17)}$$

where

$$\lambda_B(t) = (1 - t_d(t) - \pi_k^y(t) - \pi_{AWBZ}(t))/(1 - t_v(t)) + \lambda_D(t) \qquad \textbf{(18)}$$

$$\lambda_D(t)\,Div(t) = 0; \qquad \lambda_D(t) \geq 0 \qquad \textbf{(19)}$$

λ_D satisfies the usual Kuhn-Tucker condition. If the dividend restriction is binding, $\lambda_D > 0$, and the marginal cost of funds λ_B increases to the point where investment is cut back sufficiently to maintain nonnegative dividends. The first-order conditions for the variable production factors are

$$\frac{\partial F(t)}{\partial M(t)} = p_M(t) \qquad \textbf{(20)}$$

$$\frac{\partial F(t)}{\partial L(t)} = p_l(t) \qquad \textbf{(21)}$$

2. **Households**

Households derive utility from the consumption of tradable goods, health care, and leisure over their remaining life. Households are distinguished by their year of birth (generation) t_0, and by their *relative* productivity h, $h \in (0,\infty)$. Productivity is exogenous to households but may vary with age. The productivity distribution function is denoted by $P(h,\tau)$, where τ denotes age. It is assumed that the productivity ranking of households is age-invariant (*i.e.* no cross-overs), so that productivity defines a household type i, $i \in (0,1)$, according to $i = P(h,\tau)$. The relative productivity of a household of type i at age τ is then $h = h(i,\tau)$ and its wage rate is given by $h(i,\tau)\, p_l(t)$ as a consequence of perfect substitution between types in the production of tradables (see Section 1). The wage profiles for 1995, on which this distribution is calibrated, are given in Figure 5 below.

Denote the survival function of a household of generation τ at time t by $\Lambda(t,\tau)$. Households maximize their expected utility, given by

$$\mathrm{E}(U(t,t_0,i)\,|\,t) = (1-1/\gamma)^{-1} \sum_{\tau=t}^{t_0+n_T-1} (1+\beta)^{t-\tau}\, \frac{\Lambda(\tau-t_0+1,t_0)}{\Lambda(t-t_0+1,t_0)}\; u(\tau,t_0,i)^{1-1/\gamma} \qquad \textbf{(22)}$$

The flow of utility, u, is specified as

$$u(t,t_0,i) = \left[c_v(t,t_0,i)^{(\sigma_u-1)/\sigma_u} + c(t,t_0,i)^{(\sigma_u-1)/\sigma_u}\right]^{\sigma_u/(\sigma_u-1)}$$

$$c_v(t,t_0,i) = \left[(\theta_v(t,t_0,i)\,v(t,t_0,i))^{(\sigma_v-1)/\sigma_v} + (\theta_z(t,t_0,i)\,c_z(t,t_0,i))^{(\sigma_v-1)/\sigma_v}\right]^{\sigma_v/(\sigma_v-1)} \qquad \textbf{(23)}$$

where c denotes consumption of tradables, v denotes leisure, and c_z denotes consumption of health care. Preference coefficients depend both on the state of knowledge, reflected in the rate labour productivity growth α, on the productivity type i, to represent the idea that human capital does not affect the labour-leisure choice,[1] and on age t-t_0

$$\theta_v(t,t_0,i) = \theta_0\, h(i,t-t_0+1)^{\eta_h}\,(1+\alpha)^{t_0}\;(1+\theta)^{t_0-t} \qquad\qquad (\eta_h > 0)$$

$$\theta_z(t,t_0,i) = \theta_1\, h(i,t-t_0+1)^{\eta_h}\,(1+\alpha)^{t_0}\;\theta_t(t-t_0) \qquad\qquad \textbf{(24)}$$

$$\theta_t(t+1-t_0,t_0) = \theta_t(t-t_0,t_0)\left((1+\theta)^{-0.1}\;\frac{0.21\,\lambda(\tau-t_0,t_0)+0.0026}{0.21\,\lambda(\tau+1-t_0,t_0)+0.0026}\right)^{1/(1-\sigma_v)}$$

here θ and θ_t represent the effect of age on leisure and health care, respectively, and h^{η_h} the effect of productivity (see the calibration section). The effect of age on health care is linked to the mortality rate, $\lambda(\tau,t_0) = 1 - \Lambda(\tau+1,t_0)/\Lambda(\tau,t_0)$. The coefficients have been determined by regression. Households can divide their time between leisure v, labour l, and health care c_z

$$l = l_{\max} - v - c_z \geq 0 \qquad\qquad \textbf{(25)}$$

An important consequence of this formulation is that health care takes time that cannot be used for leisure or labour.[2]

To write down the budget constraint of a household, we need to consider the consequences of heterogeneity with respect to age and productivity. The death hazard at time t of generation τ is

$$\lambda(t,\tau) = (\Lambda(t,\tau) - \Lambda(t+1,\tau))/\Lambda(t,\tau)$$

$$\lambda_h(t,\tau) = [1-\varphi_\lambda(t_k(t)+\pi_k^y(t)+\pi_{AWBZ}(t))]\;\lambda(t,\tau) \qquad \tau \leq t-n_y \qquad\qquad \textbf{(26)}$$

$$\lambda_h(t,\tau) = [1-\varphi_\lambda(t_k(t)+\pi_{AWBZ}(t))]\;\lambda(t,\tau) \qquad \tau > t-n_y$$

The death hazard of households rises with age (independent of type). Following Yaari (1965), households can insure their death risk at an actuarially fair rate, leaving their remaining assets $A(t+1,t_0)$ to an insurance company against a return $\lambda(t,\tau)$ in case of survival. If $\varphi_\lambda = 1$, the government levies a capital income tax and social security contributions on the return.

Capital income of a household is subject to a uniform capital income tax t_k and to a health care premium (AWBZ), π_{AWBZ}. Capital income of working-age generations is also subject to pay-as-you-go (PAYG) premiums on the basic old-age social security system, π_k^y. The net rate of interest for households is therefore age-dependent:

$$r_h(t,\tau) = [1-t_k(t)-\pi_k^y(t)-\pi_{AWBZ}(t)]\;r(t) \qquad (t_0 > t-n_y) \qquad\qquad \textbf{(27)}$$

$$r_h(t,\tau) = [1-t_k(t)-\pi_{AWBZ}(t)]\;r(t) \qquad (t_0 \leq t-n_y)$$

Labour income is taxed at the same uniform rate as capital income, using a labour income tax rate t_l (= t_k), the AWBZ premium π_{AWBZ}, and PAYG pension premiums for working-age households. In addition, households with a wage below a threshold g_{ZF} are compulsorily insured at the national health insurance, which levies a proportional premium π_{ZF} on labour income, as well as a lump-sum contribution π_{NZF}. A threshold (franchise) f also exists for the supplementary pension scheme. Households with a wage above this franchise pay a proportional premium w on

[1] In contrast to wages (see Rebelo (1991) for an explicit formulation of this idea)

[2] This overstates the time costs of health care for employees. These are usually shifted to the employer.

their labour income in excess of the threshold. In practice, this second threshold is substantially below the national health insurance one.

Hence, labour income taxes depend both on age and productivity. The budget restriction of old households (generation index $t_0 < t\text{-}n_y$) with a past productivity below the health insurance threshold g_{ZF} is

$$\begin{aligned} A(t+1,t_0,i) \;=\; & (1+r_h(t,\tau))A(t,t_0,i) \;+\; \lambda_h(t,t_0)A(t+1,t_0,i) \;+\; (1-\pi_{ZF}(t))\,T(t,t_0) \\ & -\; \pi_{NZF}(t) \;-\; \pi_a(t)\,p_z(t)\,c_a(t,t_0,i) \;-\; \pi_b(t)y_{FC}(t,t_0,i) \;-\; (1+t_c(t))\,c(t,t_0,i) \\ & +\; (1-t_l(t)-\pi_{ZF}(t)-\pi_{AWBZ}(t))\,(p_l(t,t_0,i)\,l(t,t_0,i) + y_{PAYG}(t) + y_{FC}(t,t_0,i)) \end{aligned} \qquad \textbf{(28)}$$

here T denotes transfers per capita,[3] p_z is the price of health care, t_c denotes the consumption tax, and π_b is the PAYG contribution rate on pension benefits. c_a denotes the consumption of AWBZ health services. It is assumed that c_a is complementary with c_z in utility, so that its consumption is proportional with c_z,

$$c_a(t,t_0,i) \;=\; \chi_{AWBZ}\,c_z(t,t_0,i) \qquad \textbf{(29)}$$

π_a denotes the own contribution rate of the household to AWBZ consumption. Note that supplementary pension benefits, y_{FC}, are zero if the working-age wage of the household is below the pension franchise f. For households above the health insurance threshold the budget restriction is

$$\begin{aligned} A(t+1,t_0,i) \;=\; & (1+r_h(t,\tau))A(t,t_0,i) \;+\; \lambda_h(t,t_0)A(t+1,t_0,i) \;+\; T(t,t_0) \\ & +\; (1-t_l(t)-\pi_{AWBZ}(t))\,(p_l(t,t_0,i)\,l(t,t_0,i) \;+\; y_{PAYG}(t) \;+\; y_{FC}(t,t_0,i)) \\ & -\; \pi_a(t)p_z(t)\,c_a(t,t_0,i) \;-\; (1-\pi_z(t))p_z(t)c_z(t,t_0,i) \;-\; \pi_b(t)y_{FC}(t,t_0,i) \\ & -\; \pi_P(t) \;-\; (1+t_c(t))\,c(t,t_0,i) \end{aligned} \qquad \textbf{(30)}$$

where π_z is the private insurance coverage,[4] and π_P is the private health insurance premium per household. This premium includes a contribution of privately insured households to the collective health insurance fund (MOOZ).

Working-age households below the health insurance threshold obey a budget restriction

$$\begin{aligned} A(t+1,t_0,i) \;=\; & (1+r_h(t,\tau))A(t,t_0,i) \;+\; \lambda_h(t,t_0)A(t+1,t_0,i) \;+\; (1-\pi_{ZF}(t))\,T(t,t_0) \\ & -\; \pi_{NZF}(t) \;-\; \pi_a(t)\,p_z(t)\,c_a(t,t_0,i) \;-\; (1+t_c(t))\,c(t,t_0,i) \\ & +\; (1-t_l(t)-\pi_l^y(t)-\pi_{ZF}(t)-\pi_{AWBZ}(t))\,\{p_l(t,t_0,i)-w(t)\max[p_l(t,t_0,i)-f(t),0]\}\,l(t,t_0,i) \end{aligned} \qquad \textbf{(31)}$$

and young households above this threshold take into account that

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[3] In the model, the age-dependency of transfers represents the effect of the Occupational Disability Insurance Act (WAO).

[4] In the calibration, the coverage is 84%. In reality, insurance usually takes the form of full reimbursement of health expenditures above a threshold. This implies that the price of health care depends on the amount consumed. Nonlinear pricing is a feature that the present model cannot handle.

$$A(t+1,t_0,i) = (1+r_h(t,\tau))A(t,t_0,i) + \lambda_h(t,t_0)A(t+1,t_0,i) + T(t,t_0)$$
$$- \pi_a(t)p_z(t)c_a(t,t_0,i) - (1-\pi_z(t))p_z(t)c_z(t,t_0,i) - \pi_P(t) - (1+t_c(t))c(t,t_0,i) \quad \textbf{(32)}$$
$$+ (1-t_l(t) - \pi_l^y(t) - \pi_{AWBZ}(t))\{p_l(t,t_0,i) - w(t)\max[p_l(t,t_0,i) - f(t),0]\}l(t,t_0,i)$$

Households with a wage p_l below the franchise f do not pay any supplementary pension benefits. Neither do they accumulate pension rights.[5] The franchise threshold is determined by the requirement that households eligible for the supplementary pension receive a total pension equal to a fraction φ_0 of their last earnings, provided they have been working full-time for n_y years. The franchise is given by

$$f(t) = y_{PAYG}(t)/\varphi_0 \qquad \textbf{(33)}$$

PAYG benefits net of taxes are linked to the after-tax average wage

$$y_{PAYG}(t) = \varepsilon(t)\, \frac{1-\pi_{AWBZ}(t) - t_l(t) - \pi_l^y(t)}{1-\pi_{AWBZ}(t) - t_l(t)}\, p_l(t) \qquad \textbf{(34)}$$

$\varepsilon(t)$ defines the social security replacement ratio. Benefits paid by the pension fund are given by

$$y_{FC}(t,t_0,i) = \max\left[p_l(t_0+n_y,t_0,i)\frac{p_l(t)}{p_l(t_0+n_y)} - f(t), 0\right] ac \sum_{\tau=t_0}^{t_0+n_y-1} l(\tau,t_0,i) \qquad \textbf{(35)}$$

Here $p_l(t_0+n_y,t_0,i)$ is the wage rate of the household at the time of retirement, and ac is the accumulation rate of pension rights, $ac = \varphi_0/n_y$. The accumulation rule in **(35)** results in opportunity costs of leisure for working-age generations that are larger than the after-tax wage rate, because of the implied loss of pension rights. The price of leisure is given by

$$p_v(t,t_0,i) = ac \sum_{\tau=t_0+n_y}^{t_0+n_T-1} R_h(\tau,t,t_0)[1-t_l(\tau) - \pi_b(\tau) - \pi_{AWBZ}(\tau)] \max\left[\frac{p_l(t_0+n_y,t_0,i)p_l(\tau)}{p_l(t_0+n_y)} - f(\tau), 0\right]$$
$$+ [1-t_l(t) - \delta_i\pi_{ZF}(t) - \pi_{AWBZ}(t) - \pi_l^y(t)]\{p_l(t,t_0,i) - w(t)\max[p_l(t,t_0,i) - f(t),0]\} \quad \textbf{(36)}$$
$$(t_0 > t - n_y)$$
$$p_v(t,t_0,i) = (1-t_l(t) - \delta_i\pi_{ZF}(t) - \pi_{AWBZ}(t))p_l(t,t_0,i) \qquad (t_0 \le t - n_y)$$

Here δ_i is a dummy variable, indicating whether household i carries ZF health insurance:

$$\delta_i = \begin{cases} 1 \text{ if } p_l(t,t_0,i) < g_{ZF}(t) \\ 0 \text{ if } p_l(t,t_0,i) > g_{ZF}(t) \end{cases} \qquad \textbf{(37)}$$

The intertemporal budget restriction may now be formulated as

$$\sum_{\tau=t}^{t_0+n_T-1} R_h(\tau,t,t_0)\Big[p_v(\tau,t_0,i)v(\tau,t_0,i) + p_{cz}(\tau)c_z(\tau,t_0,i) + (1+t_c(\tau))c(\tau,t_0,i)\Big] \le W(t,t_0,i) \qquad \textbf{(38)}$$

$R_h(\tau,t,t_0)$ is the discount factor, given by

[5] It is possible for households to accumulate pension rights over part of their working life, as a result of a rising wage profile.

$$R_h(\tau,t,t_0) = \frac{1}{1+r_h(\tau,t_0)} \prod_{s=t}^{\tau-1} \frac{1-\lambda_h(s,t_0)}{1+r_h(s,t_0)} \tag{39}$$

p_{cz} denote the opportunity costs of health care. These consist of the net costs of health care plus the opportunity costs of the time required to consume health care

$$p_{cz}(t,t_0,i) = \big((1-\delta_i)(1-\pi_z(t)) + \chi_{AWBZ}\pi_a(t)\big)p_z(t) + p_v(t,t_0,i) \tag{40}$$

$W(t,t_0,i)$ denotes lifetime wealth, given by

$$\begin{aligned} W(t,t_0,i) &= A(t,t_0,i)) + \sum_{\tau=t}^{t_0+n_T-1} R_h(\tau,t,t_0)\big[p_v(\tau,t_0,i)l_{\max} + (1-\delta_i\pi_{ZF}(\tau))\,T(\tau,t_0)\big] \\ &+ P_R(t,t_0,i) + \sum_{\tau=\max(t,t_0+n_y)}^{t_0+n_T-1} R_h(\tau,t,t_0)\,[1-t_l(\tau)-\delta_i\pi_{ZF}(\tau)-\pi_{AWBZ}(\tau)]\,y_{PAYG}(\tau) \end{aligned} \tag{41}$$

In this expression, wealth consists of financial assets A, human capital, the present value of net future transfers, the present value of accumulated supplementary pension rights (P_R) and PAYG pension benefits. Supplementary pension rights are given by

$$\begin{aligned} P_R(t,t_0,i) &= \sum_{\tau=\max(t,t_0+n_y)}^{t_0+n_T-1} R_h(\tau,t,t_0)[1-t_l(\tau)-\delta_i\pi_{ZF}(\tau)-\pi_b(\tau)-\pi_{AWBZ}(\tau)] \\ &\cdot\ \max\left[\frac{p_l(t_0+n_y,t_0,i)\,p_l(\tau)}{p_l(t_0+n_y)} - f(\tau),0\right] ac \sum_{s=t_0}^{\min(t_0+n_y-1,t-1)} l(s,t_0,i)\ d_{s,t_0,i} \end{aligned} \tag{42}$$

Here $d_{t,t_0,i}$ denotes a dummy variable indicating whether the household contributed to the FC pension plan in period t

$$d_{t,t_0,i} = \begin{cases} 1 \text{ if } p_l(t,t_0,i) > f(t) \\ 0 \text{ if } p_l(t,t_0,i) < f(t) \end{cases} \tag{43}$$

The consumption plan of a household of generation t_0 and type i at time t is now given by maximizing **(22)** subject to **(25)** and **(37)**. This yields a standard CES-type demand system, apart from the effect of the time constraint **(25)**. This time constraint operates directly on the consumption of leisure and health care, and indirectly on the consumption of other goods and services. Because of the separability structure chosen, leisure and health care are both substitutes with other goods. Mutually, they may be complementary.

$$\mu(t,t_0,i)(l_{\max} - v(t,t_0,i) - c_z(t,t_0,i)) = 0 \tag{44}$$

$$p_v^*(\tau,t_0,i) = (p_v(\tau,t,i) + \mu(\tau,t_0,i))/\theta_v(\tau,t_0,i) \tag{45}$$

$$p_{c_z}^*(\tau,t_0,i) = (p_{c_z}(\tau) + \mu(\tau,t_0,i))/\theta_z(\tau,t_0,i) \tag{46}$$

$$p_{c_v}(\tau,t_0,i) = \left[p_v^*(\tau,t_0,i)^{1-\sigma_v} + p_{c_z}^*(\tau,t_0,i)^{1-\sigma_v}\right]^{1/(1-\sigma_v)} \tag{47}$$

$$p_u(\tau,t_0,i) = \left[p_{c_v}(\tau,t_0,i)^{1-\sigma_u} + (1+t_c(\tau))^{1-\sigma_u}\right]^{1/(1-\sigma_u)} \tag{48}$$

$$p_W(\tau,t_0,i) = \left(\sum_{s=\tau}^{t_0+n_T-1} \left((1+\beta)^{\tau-s} \frac{\Lambda(\tau-t_0+1)}{\Lambda(s-t_0+1)} \right)^{\gamma} \left(p_u(s,t_0,i) R_h(s,\tau,t_0) \right)^{1-\gamma} \right)^{1/(1-\gamma)} \quad \textbf{(49)}$$

$$u^*(\tau,t,t_0,i) = \left(\frac{p_u(\tau,t_0,i) R_h(\tau,t,t_0) / \left((1+\beta)^{t-\tau} \Lambda(\tau-t_0+1)/\Lambda(t-t_0+1) \right)}{p_W(t,t_0,i)} \right)^{-\gamma} \frac{W^*(t,t_0,i)}{p_W(t,t_0,i)} \quad \textbf{(50)}$$

$$W^*(t,t_0,i) = W(t,t_0,i) + \sum_{s=t}^{t_0+n_T-1} R_h(s,t,t_0)\, \mu(s,t_0,i)\, l_{\max} \quad \textbf{(51)}$$

$$c(\tau,t_0,i) = u^*(\tau,t,t_0,i) \left(\frac{1+t_c(\tau)}{p_u(\tau,t_0,i)} \right)^{-\sigma_u} \quad \textbf{(52)}$$

$$c_v(\tau,t_0,i) = u^*(\tau,t,t_0,i) \left(\frac{p_{c_v}(\tau,t_0,i)}{p_u(\tau,t_0,i)} \right)^{-\sigma_u} \quad \textbf{(53)}$$

$$v(\tau,t_0,i) = \frac{c_v(\tau,t_0,i)}{\theta_v(\tau,t_0,i)} \left(\frac{p_v^*(\tau,t_0,i)}{p_{c_v}(\tau,t_0,i)} \right)^{-\sigma_v} \quad \textbf{(54)}$$

$$c_z(\tau,t_0,i) = \frac{c_v(\tau,t_0,i)}{\theta_z(\tau,t_0,i)} \left(\frac{p_{c_z}^*(\tau,t_0,i)}{p_{c_v}(\tau,t_0,i)} \right)^{-\sigma_v} \quad \textbf{(55)}$$

To obtain macro quantities, the individual households are aggregated over generations and types.

$$L_s(t) = \sum_{t_0=t-n_T+1}^{t} \int_0^1 l(t,t_0,i)\,\mathrm{d}i \;\; gen(t_0)\, \Lambda(t-t_0) \quad \textbf{(56)}$$

$$L_{s_{eff}}(t) = \sum_{t_0=t-n_T+1}^{t} \int_0^1 h(i,t-t_0)\, l(t,t_0,i)\,\mathrm{d}i \;\; gen(t_0)\, \Lambda(t-t_0) \quad \textbf{(57)}$$

$$N^o(t) = \sum_{t_0=t-n_T+1}^{t-n_y} gen(t_0)\, \Lambda(t-t_0) \quad \textbf{(58)}$$

$$T(t) = \sum_{t_0=t-n_T+1}^{t} T(t,t_0)\, gen(t_0)\, \Lambda(t-t_0) \quad \textbf{(59)}$$

$$c(t) = \sum_{t_0=t-n_T+1}^{t} \int_0^1 c(t,t_0,i)\,\mathrm{d}i \;\; gen(t_0)\, \Lambda(t-t_0) \quad \textbf{(60)}$$

$$A(t) = \sum_{t_0=t-n_T+1}^{t} \int_0^1 A(t,t_0,i)\,\mathrm{d}i \;\; gen(t_0)\, \Lambda(t-t_0) \quad \textbf{(61)}$$

Labour supply in hours is given in **(56)**. Note however that the economically relevant supply variable is efficiency-corrected labour supply, given in **(57)**. N^o is the number of people entitled to the basic old-age pension.

3. **The Health Sector**

The health sector produces health services using as a sole input labour of different skill types in fixed proportions. Let y_z denote production of health services, then

$$y_z(t) = \min_i L_z(t,i)/\zeta_z(i) \qquad \textbf{(62)}$$

Skill types with $\zeta_z(i) = 0$ are not employed in the health sector. Because of perfect labour mobility, the wage rate of labour in the health sector equals that of the private sector for each individual skill class. Hence, labour demand in efficiency units and production costs in the health sector are

$$\begin{aligned} L_z(t) &= y_z(t) \int_0^1 \zeta_z(t,i)\, h(i)\, \mathrm{d}i \\ &\doteq y_z(t)\, \bar{\zeta}_z(t) \end{aligned} \qquad \textbf{(63)}$$

$$\begin{aligned} p_z(t) &= \int_0^1 p_l(t,i) L_z(t,i)\, \mathrm{d}i \;/\; y_z(t) \\ &= p_l(t)\, \bar{\zeta}_z(t) \end{aligned} \qquad \textbf{(64)}$$

$\bar{\zeta}_z$ is the aggregate number of hours of productivity-weighted labour input required to produce one hour of health care. In the calibration, $\bar{\zeta}_z = 2.1$, pointing to the high costs of health care. Equilibrium on the health care market requires that

$$y_z(t) = c_z(t) + c_a(t) \qquad \textbf{(65)}$$

where c_a denotes the consumption of AWBZ care (see section 6 below).

4. Private Health Insurance Firms

Households that are privately insured enjoy a wage rate above the health insurance threshold g_{ZF}. This threshold defines a productivity $h_z(t) = g_{ZF}(t)/p_l(t)$ and a marginal "health" type $i_z(t,t_0) = P(h_z(t), t-t_0)$.[6] Private health consumption is then given by

$$c_{ZP}(t) = \sum_{t_0=t-n_T+1}^{t} \int_{i_z}^{1} c_z(t,t_0,i)\ \mathrm{d}i\ gen(t_0)\ \Lambda(t-t_0) \qquad \textbf{(66)}$$

It is assumed that insurance firms use only labour to provide their services, analogous to the production structure of the health sector

$$L_{ZP}(t) = \zeta_{ZP}(t)\, c_{ZP}(t) \qquad \textbf{(67)}$$

in which L_{ZP} denotes labour demand in efficiency units. Health insurance firms operate on a PAYG basis. Therefore the budget restriction of health insurance firms determines the fixed insurance premium per household, π_P

$$p_z(t)\Big(\pi_z(t)\, c_{ZP}(t) + \chi_{MOOZ}(t) c_{ZF}(t)\Big) + p_l(t) L_{ZP}(t) = \pi_P(t) \sum_{t_0=t-n_T+1}^{t} (1 - i_z(t,t_0))\, gen(t_0)\, \Lambda(t-t_0) \qquad \textbf{(68)}$$

In this equation χ_{MOOZ} denotes the contribution rate of privately insured households to publicly insured households.[7]

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[6] In the calibration, 61% of the households carries public health insurance. The marginal productivity level is h_z = ??

[7] The so-called MOOZ contribution, which intends to compensate public health insurance for the relatively high share of elderly people in the public health scheme. In the model, this over-representation does not occur, and the contribution rate is fixed exogenously.

5. **The Public Health Insurance Fund**

Households with a wage below the health insurance threshold g_{ZF} are compulsory insured at the Public Health Insurance Fund. Public health consumption is given by

$$c_{ZF}(t) \;=\; \sum_{t_0=t-n_T+1}^{t} \int_0^{i_z} c_z(t,t_0,i)\;\mathrm{d}i\;\; gen(t_0)\;\;\Lambda(t-t_0) \tag{69}$$

Analogous to the private insurance companies, labour demand in efficiency units is given by

$$L_{ZF}(t) \;=\; \zeta_{ZF}(t)\,c_{ZF}(t) \tag{70}$$

Total income is composed of insurance premiums on the wages of insured households, a nominally fixed contribution of insured households (π_{NZF}), a statutory contribution of private health insurance firms (MOOZ), and a government subsidy T_{ZF}

$$\begin{aligned}\Pi_{ZF}(t) \;=\; \pi_{ZF}(t)\Bigg\{ \sum_{t_0=t-n_T+1}^{t} \Bigg(&\int_0^{i_z}\Big(p_l(t,t_0,i)\,l(t,t_0,i) \;+\; y_{FC}(t,t_0,i)\Big)\mathrm{d}i \\ &+\; i_z(t,t_0)\;y_{PAYG}(t)\,N^{\,o}(t) \;+\; i_z(t,t_0)\,T(t,t_0)\Bigg)\;\; gen(t_0)\;\;\Lambda(t-t_0)\Bigg\} \\ +\; \chi_{MOOZ}(t)\,p_z(t)\,c_{ZF}(t) \;+\; \pi_{NZF}(t) &\sum_{t_0=t-n_T+1}^{t} i_z(t,t_0)\;\; gen(t_0)\,\Lambda(t-t_0) \;+\; T_{ZF}(t)\end{aligned} \tag{71}$$

Budgetary equilibrium requires that the income-related premium $\pi_{ZF}(t)$ be set so that

$$p_z(t)\,c_{ZF}(t) \;+\; p_l(t)\,L_{ZF}(t) \;=\; \Pi_{ZF}(t) \tag{72}$$

6. **AWBZ Insurance**

AWBZ insurance entails coverage of special health care expenditures, that have to be approved before the expense can be made. It is therefore reasonable to assume that these expenditures are complementary with the consumption of other health services

$$c_a(t) \;=\; \chi_{AWBZ}(t)(c_{ZF}(t) \;+\; c_{ZP}(t)) \tag{73}$$

The price of AWBZ health services is taken to be equal to the price of health care. The tax base of the AWBZ premiums coincides with that of the income tax:

$$\begin{aligned}\Pi_{AWBZ}(t) \;=\; \pi_{AWBZ}(t)\Big(&p_l(t)\,L_{eff}(t) \;+\; r(t)(A(t)-V(t)) \;+\; Div(t) \;+\; (y_{FC}(t)+y_{PAYG}(t))\,N^{\,o}(t) \\ &-\; w(t)\sum_{t_0=t-n_y+1}^{t}\int_0^1 \max[p_l(t,t_0,i)-f(t),0]\,l(t,t_0,i)\;\mathrm{d}i\;\; gen(t_0)\;\;\Lambda(t-t_0)\Big)\end{aligned} \tag{74}$$

AWBZ operating costs equal labour costs. AWBZ labour demand is

$$L_a(t) \;=\; \zeta_a\,c_a(t) \tag{75}$$

Budgetary equilibrium requires that π_{AWBZ} be chosen to equalize

$$p_z(t)\,c_a(t) \;+\; p_l(t)\,L_a(t) \;=\; \Pi_{AWBZ}(t) \tag{76}$$

7. **Pension Funds**

The PAYG pension fund offers a basic pension to all households above 65. The pension is not means tested. Premiums are levied both on labour income and on capital income of young households. Net benefits are related to net wages according to **(34)**. Budgetary balance requires that

$$
\begin{aligned}
y_{PAYG}(t)N^{o}(t) \;=\; & \pi_l^y(t)\,[p_l(t)L_{eff}^y(t) \;-\; \Pi_{FC}(t)] \;+\; \pi_k^y(t)\,[r(t)(A^{y}(t) - V(t)) \;+\; Div(t)] \\
& + \pi_b(t) \sum_{t_0=t-n_T+1}^{t-n_y} y_{FC}(t,t_0)\,gen(t_0)\,\Lambda(t-t_0) \;+\; \pi_p(t)\,r(t)\,A_p(t) \;+\; T_{PAYG}(t)
\end{aligned} \qquad \textbf{(77)}
$$

Here L_{eff}^y denotes labour supply of young workers, and Π_{FC} denotes supplementary pension premiums paid by young workers, that are deductible before income taxes. T_{PAYG} is a government subsidy to the PAYG fund. Supplementary pensions and the capital income of the pension fund are not taxed either at present ($\pi_b = 0$, $\pi_p = 0$). At present, the PAYG fund maintains a constant contribution rate π_l^y and the government adjusts the subsidy to close the PAYG fund's budget.

Supplementary pension premiums are given by

$$
\Pi_{FC}(t) \;=\; w(t) \sum_{t_0=t-n_y+1}^{t} \int_0^1 \max\Big[p_l(t,t_0,i) \;-\; f(t), 0\Big]\; l(t,t_0,i)\,\mathrm{d}i\;\; gen(t_0)\;\; \Lambda(t-t_0) \qquad \textbf{(78)}
$$

Observe that in this setup low productivity households do not pay supplementary pension premiums because their wage is below the franchise $f(t)$ (given in **(33)**). Total FC pensions paid are found by summing **(35)** over generations. Asset accumulation of the FC fund is then

$$
A_P(t+1) \;=\; (1 \;+\; (1 - \pi_p(t) - t_p(t))\,r(t))\,A_P(t) \;+\; \Pi_{FC}(t) \;-\; y_{FC}(t) \qquad \textbf{(79)}
$$

where t_P denotes the tax rate on FC interest income. Pension fund regulations in the Netherlands require funding to be sufficient to cover the projected benefit obligation accumulated thus far (see also Davis (1995)). Projected benefit obligations at the beginning of period t are defined by

$$
\begin{aligned}
PBO(t) \;=\; & \int_0^1 \sum_{t_0=t-n_T+1}^{t} \; \sum_{\tau=\max[t,t_0+n_y]}^{t_0+n_T-1} R_p(\tau,t)\;\max\left[\frac{p_l(t_{\text{last}},t_0,i)}{p_l(t_{\text{last}})}\,p_l(\tau) - f(\tau), 0\right] \\
& ac \sum_{s=t_0}^{\min[t_0+n_y-1,t-1]} d_{s,t_0,i}\;\; l(s,t_0,i)\;\; gen(t_0)\;\; \Lambda(\tau-t_0)\;\; \mathrm{d}i \\
t_{\text{last}} \;=\; & \min[t-1, t_0+n_y-1]
\end{aligned} \qquad \textbf{(80)}
$$

In this expression, the summation is over all generations t_0 and types i. The summation over τ defines the present value of the pension payments to a household that it is entitled to on the basis of its contributions so far (summation over s). t_{last} specifies the last contribution period so far. Any discrepancy between PBO and A_P must be closed at a prescribed rate $\lambda_P \le 1$ by means of an adjustment in the pension premium $w(t)$

$$
A_P(t+1) \;=\; A_P(t)\;\frac{PBO(t+1)}{PBO(t)}\left(\frac{PBO(t)}{A_P(t)}\right)^{\lambda_P} \qquad \textbf{(81)}
$$

8. **The Government**

Productive activities of the government sector consists of education, $p_{l_o}(t)L_o(t)$, and general government $p_{l_g}(t)L_g(t)$. Both activities use only labour as input, in fixed proportions per skill type.. Labour input for education is linked to the age structure of the population,

$$L_o(t) = \sum_{t_0=t-n_T+1}^{t} gen(t_0)S(t-t_0) \qquad \textbf{(82)}$$

$S(t)$ denotes the age-schooling profile. The cost of education depend on the productivity of the education sector. Let $\zeta_o(t)$ denote the aggregate number of productivity-weighted labour hours required to produce one hour of schooling, then the average wage in the education sector is $p_{l_o}(t) = \zeta_o(t)p_l(t)$. Labour input for general government is proportional to the population. It has a similar efficiency index, that results in an average wage $p_{l_g}(t) = \zeta_g(t)p_l(t)$. Apart from the expenditures for these two categories, the government consumes goods and services from the private sector, $g(t)$, in proportion to the size of GDP

$$g(t) = g_0(t)\ GDP(t) \qquad \textbf{(83)}$$

Other expenditure categories are interest payments on debt, disability insurance payments ($T_{WAO}(t)$), transfers to households ($T(t)$), transfers to foreigners ($Tf(t)$), and a public health insurance subsidy ($T_{ZF}(t)$). Disability insurance payments are linked to the size and age composition of the population

$$T_{WAO}(t) = p_l(t)\sum_{t_0=t-n_T+1}^{t} gen(t_0)\Omega(t-t_0) \qquad \textbf{(84)}$$

where Ω denotes the age-disability profile. The public health insurance subsidy is proportional to public health insurance payments,

$$T_{ZF}(t) = \chi_{ZF}(t)p_z(t)c_{ZF}(t) \qquad \textbf{(85)}$$

Transfers to households are linked to population size and net wages:

$$T(t) = (1-t_l(t)-\pi_{AWBZ}(t)-\pi_l^y(t))p_l(t)\,N(t) \qquad \textbf{(86)}$$

while foreign transfers are proportional with population size and productivity growth, $Tf(t) \propto N(t)(1+\alpha)^t$.

Tax receipts consist of income taxes, indirect taxes, and corporate taxes. The income tax base consists of labour income, interest income, and dividend income. The dynamic budget constraint is

$$\begin{aligned} D(t+1) = {} & (1+r(t))D(t) + g(t) + p_{l_o}(t)L_o(t) + p_{l_g}(t)L_g(t) + T(t) + Tf(t) + T_{ZF}(t) \\ & + T_{PAYG}(t) + T_{WAO}(t) - T_L(t) - T_K(t) - T_D(t) - T_b(t) - T_C(t) \end{aligned} \qquad \textbf{(87)}$$

where T_L denotes tax receipts from labour, T_K from capital, T_D from dividends, T_b denotes the corporate taxes, and T_C indirect taxes:

$$T_L(t) = t_l(t)(p_l(t)L_{eff}(t) - \Pi_{FC}(t) + T_{WAO}(t) + y_{PAYG}(t)N^o(t) + y_{FC}(t)) \qquad \textbf{(88)}$$

$$T_K(t) = t_k(t)(A(t)-V(t)) \qquad \textbf{(89)}$$

$$T_D(t) = t_d(t)Div(t) \qquad \textbf{(90)}$$

$$T_C(t) = t_c(t)c(t) \qquad \textbf{(91)}$$

and $t_l(t) = t_k(t) = t_d(t)$ is the income tax rate. The intertemporal budget restriction is given by the no-Ponzi game condition

$$\lim_{t\to\infty} D(t)\prod_{\tau=1}^{t}(1+r(\tau))^{-1} = 0 \qquad \textbf{(92)}$$

9. **The Foreign Sector**

The economy imports consumption goods, investment goods, and raw materials from abroad. The foreign good is a perfect substitute for the domestic commodity. The only non-traded good is labour. By assumption, equity claims are not traded internationally either. Private and government bonds are perfect substitutes for foreign bonds. Foreign debt, A_e, is related to net exports $b(t)$ and net foreign transfers Tf:

$$A_e(t) = \sum_{\tau=t}^{\infty} \prod_{s=t}^{\tau} (1+r(s))^{-1} \; [b(\tau) - Tf(\tau)] \qquad \textbf{(93)}$$

10. **Equilibrium**

All markets clear through price adjustment. The goods market and asset markets are characterised by perfectly elastic demand, so that prices are effectively exogenous. Equilibrium on the labour market requires that demand and supply match in efficiency units. The other equations relate to the goods market, the asset market and the foreign asset market. One of the equations **(94)**-**(96)** is redundant.

$$L_{s_{eff}}(t) = \zeta_g(t)L_g(t) + \zeta_o(t)L_o(t) + L_{b_{eff}}(t) + L_z(t) + L_{ZF}(t) + L_{ZP}(t) + L_a(t) \qquad \textbf{(94)}$$

$$y(t) = c(t) + I(t) + g(t) + b(t) \qquad \textbf{(95)}$$

$$A(t) + A_e(t) + A_P(t) = D(t) + B(t) + V(t) \qquad \textbf{(96)}$$

$$r(t) = r_e(t) \qquad \textbf{(97)}$$

11. Calibration of the Model

The calibration of the model is based on the National Accounts of 1994. Appendix 2 presents the condensed format used in the present model. To match this format with that of the National Accounts, a number of specific additions has been performed.

- The sector social insurance funds has been integrated with the sector government. Social insurance premiums are not separately distinguished, except for old-age PAYG insurance, and supplementary pension premiums.
- The sector financial enterprises has been combined with the tradables sector
- The sector health care has been separated from the sector other business
- Government consumption is taken to include government investment
- Government transfers are *net* of taxes, but *gross* of PAYG premiums
- Investment of the tradable goods sector is inclusive of inventories and land
- It is assumed that households hold all equity and bonds of domestic firms, and the residual part of government debt. Pension funds hold only government bonds, while the net claims of the foreign sector are in government bonds. However, only the *net* interest payments of each sector can be matched to the national accounts.

The calibration uses a steady-state growth path for the values of all exogenous variables for the period after 1994, except for population growth, that is based on the so-called “mid-range” demographic projection of the Dutch Central Statistical Office. This projection runs till 2050 and is presented in Figure 1 in the main text.

The calibration for the tradable goods sector is based on the following assumptions

$$\rho_y = 1,\; \rho_H = 1,\; \sigma_I = 0.5,\; \alpha = 0.02,\; c_I = 10,\; \delta = 0.115$$

These parameter values imply that all substitution elasticities are set at 0.5. The rate of labour saving technical progress α determines the long-run growth rate per capita of the economy. At a steady-state investment-capital ratio of $\alpha+\delta$, this implies that adjustment costs are 7% of the value of gross investment. The other production parameters, ζ_M, ζ_H, ζ_K, ζ_L, γ_1, γ_2, are determined so as to give a cost share in gross production of 24.7% for raw materials, 35.5% for capital, and 39.8% for labour. Investment is for 65% of domestic origin. The steady-state user cost of capital is used to generate an estimate of the capital stock in 1994 based on the given cost share of capital. The implied capital-output ratio at factor costs for the tradable goods sector is 1.9, and the capital-labour ratio is 205 K*f* per employee. Fiscal depreciation is assumed to be straight-line, and to extend over 13 years at 5.5% per year. The percentage is chosen to capture the distortionary effect of fiscal depreciation at historic purchase prices without actually introducing inflation into the model. The debt-capital ratio is assumed to be 0.5.

Table 1 below presents the long-term partial equilibrium elasticities of the tradable goods sector. Note that the factor demand response contains the effect of the increase in the firm's own price (p_1). This implies that the real price elasticities are higher, *e.g.* the own price elasticity of labour is -0.65 and the own price elasticity of capital is -0.35. These elasticities are somewhat higher than available econometric estimates for the Netherlands suggest (see CPB 1997).

The calibration of the other production sectors in the model is based on the assumption that these do not use any capital. The value added and employment of the health care sector thus determine the wage rate and the productivity index $\bar{\zeta}_z$. This generates a value of $\bar{\zeta}_z \approx 2.1$. The same procedure is followed to determine the technical coefficients for the health insurance sectors, ζ_P, ζ_{ZF}, and ζ_a. The wage rate below which households are compulsory insured at the public health insurance fund is determined from the average wage distribution, using that 61.5% of the households are publicly insured.

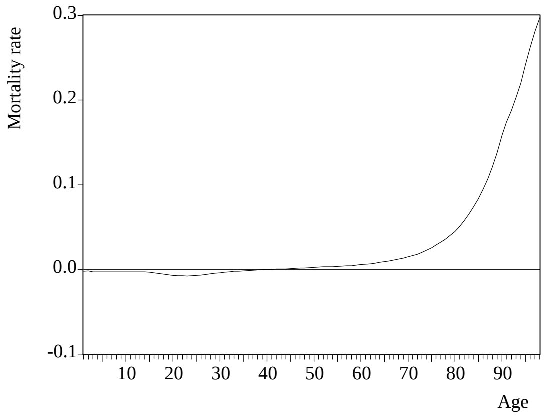

Figure 1
Projected mortality rates for the 1994 generation

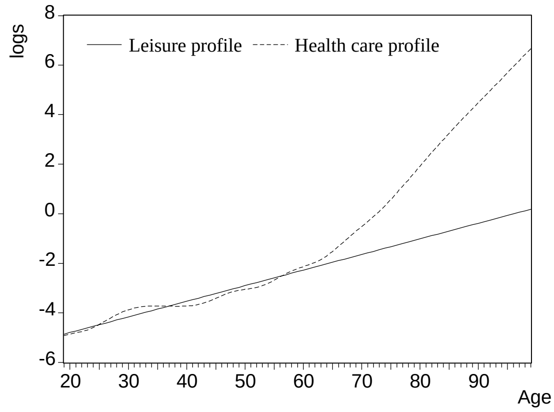

Figure 2
Preference profiles for leisure and health care

The calibration of the household model uses the following parameter values for the rate of time preference, the intertemporal elasticity of substitution, the elasticity of substitution between health care and leisure, and the effect of productivity on the preference for leisure, respectively:
$\beta = 0.02$, $\gamma = 0.25$, $\sigma_v = 0.65$, $\eta_h = 0.25$
The survival rates Λ are derived from the demographic projections of the CSO, as explained above. Figure 1 displays the mortality rates for the 1994 generation. Note that the rates are initially negative. Figure 2 displays the calibrated leisure and health care preference profiles $\ln\theta_v^{-1}$ and $\ln\theta_z^{-1}$ in **(24)** above. Note that the health care profile runs similar to that of the mortality rate. This shows the effect of the observed health care consumption profile, which has been used for θ_t in **(24)** above.
The match between the observed health care consumption profile of publicly insured households in 1994 and the computed profile for the same year is shown in Figure 3. The demand for health care by minors is not endogenous in the model.

The elasticity of the preference for non-labour hours, η_h, has been chosen to compensate for

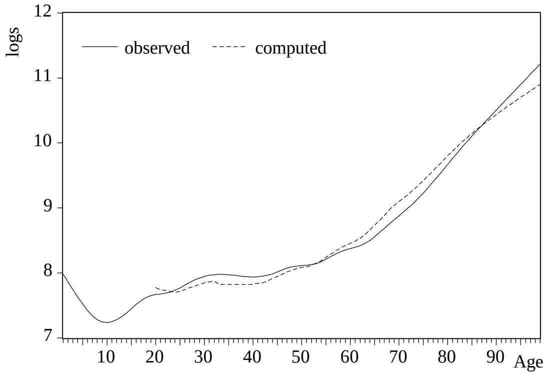

Figure 3
Demand for health care by age

the income effect of higher productivity on demand for leisure. Given that the elasticity of substitution between hours and goods is smaller than one in the calibration, the labour supply curve would be backward bending in the productivity type, as the income effect dominates the substitution effect for large incomes (see *e.g.* Stern (1986)). The elasticity η_h compensates for that and in fact generates a labour supply profile that slightly increases with productivity.

Figure 4 shows the wage profiles for productivity types in the interval (0,0.95), spaced at 5% intervals, i.e. each successive curve represents a productivity type 5% higher on the distribution. Note that wages increase more steeply from one interval to the next both at the lower end and at the upper end of the productivity distribution. Also, for high-productivity households the fall in wages at the end of the working life is less severe.

The nature of the wage distribution over types can be seen more clearly by looking at the average wage. Figure 5 depicts ln(1-P) against ln(p_l), where P denotes the cumulative probability. By choosing this unit of measurement for the y-axis, it appears that the distribution fits the Pareto distribution very well in the upper tail. The Pareto coefficient is -3.5, pointing to a very egalitarian distribution (Bronfenbrenner (1971), Ch. 3.2).

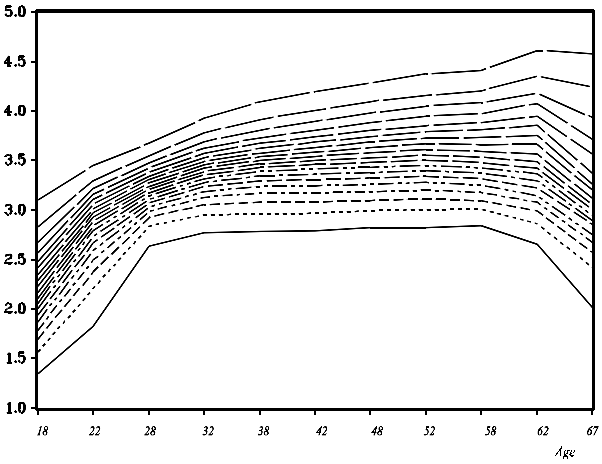

Figure 4 Wage profiles (logs) for different productivity types

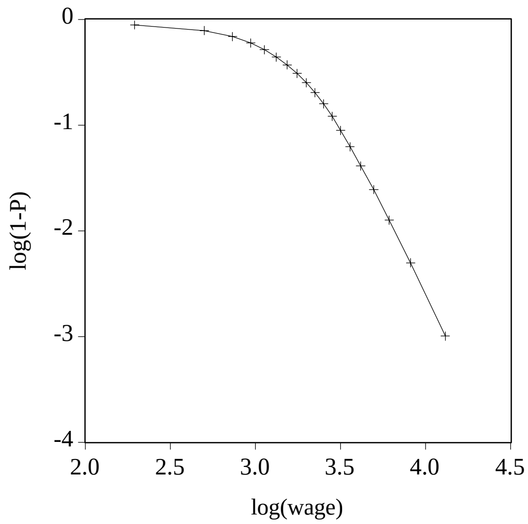

Figure 5

Table 1: Partial Demand Elasticities for the Household Sector

	c	c_{zf}	c_{zp}	c_a	L_{s_eff}	W
p_l	0.747	0.096	0.179	0.125	0.016	1.69
p_1	-0.912	-0.076	-0.082	-0.077	0.095	-0.645
p_z	-0.005	-0.340	-0.296	-0.325	0.007	0.031
t_l	-1.213	-0.211	-0.296	-0.240	0.060	-3.818
t_{zf}	-0.710	-0.232	-0.088	-0.183	-0.041	-2.01
w	-0.428	-0.042	-0.116	-0.067	0.009	-1.215
T	0.112	0.070	0.035	0.058	-0.082	0.298
r	2.700	0.789	1.418	1.00	-0.119	22.20

Note: The dependent variables are given in the columns, the independent variables in the rows. The meaning of the symbols is given in Appendix 3. The effects of taxes (t_l, t_{zf}, w) and the interest rate, r, are given as half-elasticities

Table 2: Partial Demand elasticities for Firms in the Tradable Goods Sector

	p_1	L_d	k	I_1	I_2	m
p_l	0.551	-0.103	0.179	0.084	0.359	0.393
p_2	0.108	0.066	-0.083	0.071	-0.374	0.066
p_m	0.342	0.052	-0.083	-0.142	0.029	-0.448
y	0.000	1.000	1.000	1.000	1.000	1.000
r	3.411	1.840	-2.849	-3.440	-1.734	1.840

Note: p_1 is the output price of domestic firms, p_2 is the price of imported investment goods.

Appendix 2
Calibrated National Accounts for 1994

Expenditure Account

value added comp. sector	441.1	consumption goods	281.9
value added health sector	57.1	consumption med. serv.	57.1
value added government	59.2	cons. gov. services	59.2
value added health ins.	2.3	cons. health ins.	2.3
imports goods	45.1	mat. cons. gov.	38.7
imports raw mat.	149.0	exports	248.9
imports inv. goods	35.4	investment	101.0

Income distribution Government

interest to households	23.6	indirect taxes	56.4
interest to pension fund	33.0		
interest to foreigners	-34.6		
Transfers	44.7	wage tax + soc.premiums	109.3
ZF subsidy	5.6	corporate taxes	21.5
disability insurance	32.6	dividend tax	2.7
Foreign Transf.	8.0	cap.income tax	10.9
disposable income	88.0	capital gains tax	0.0
		pension fund tax	0.0

Savings Government

wages edu. sect.	20.9	disposable income	88.0
wages gen. gov.	38.3		
goods and services	38.7		
savings	-9.9		

Income distribution households

wage tax + soc.premiums	109.3	wages firms	239.8
		wages government	59.2
Nom. ZF contribution	1.6	wages health sector	57.1
ZF contribution	14.0	adm. costs Pu. Health care	0.9
Private Health Contrib.	10.5	adm. costs Pr. health care	1.0
AWBZ Contribution	23.0	adm. costs AWBZ	0.4
cap.income tax	10.9	interest govn.	23.6
		interest firms	20.2
dividend tax	2.7	dividends	10.7
capital gains tax	0.0	reimb. priv. health ins	9.0
PAYG Contribution	36.1	PAYG benefits	36.1
Pension Contributions	14.5	pension benefits	24.8
own contrib. AWBZ	2.9	ABWZ reimbursements	25.5
		ZF reimbursements	20.8
disposable income	380.7	transfers	44.7
		disability insurance	32.6

Savings households

consumption goods	281.9	disposable income	380.7
consumption med. serv.	57.1		
savings	41.8		

Income Distribution Firms

wage bill	239.8	gross value added	441.1
Dividends	10.7		
corporate taxes	21.5		
indirect taxes	56.4		
interest payments	20.2		
disposable income	92.5		

Capital Transactions Firms

net investment	37.7	disposable income	92.5
depreciation	63.3	new equity issues	0.0
		debt issues	8.5

Income distribution health sector

wage costs	57.1	value added	57.1

Foreign Sector

exports	248.9	imports cons. goods	45.1
savings	-46.2	imports investment good	35.4
		imports raw materials	149.0
		interest receipts	-34.6
		transfers	8.0

Pension Sector

pension	24.8	Pension Contributions	14.5
tax on interest income	0.0	interest income	33.0
savings	22.7		

PAYG Sector

PAYG benefits	36.1	PAYG contribution	36.1
interest payments	0.0		

Public Health Insurance Sector

cons. ZF	0.9	value added	0.9
health insurance payments	20.8	ZF insurance contrib.	14.0
admin. costs	0.9	nom. ZF contributions	1.6
		MOOZ contribution	0.4
		subsidy	5.6

AWBZ Health Insurance Sector

cons. AWBZ	0.4	value added	0.4
ABWZ expenses	25.5	AWBZ contribution	23.0
admin. costs	0.4	own contribution	2.9

Private Health Insurance Sector

cons. Priv. health ins.	1.0	value added	1.0
health insurance payments	9.0	contributions	10.5
admin. costs	1.0		
MOOZ contribution	0.4		

Asset holdings of households

gov. bonds	429.0	Wealth	1400.1
Firm bonds	366.4		
equity	604.7		

Asset holdings of government

gov. debt	400.0	dom. bonds	429.0
		For. bonds	-630.0
		Pens. bonds	600.0

Appendix 3
List of Symbols

Parameters and Calibrated Values

α	0.02	labour saving technical progress
β	0.02	rate of time preference
β_K	0.5	debt-capital ratio
γ	0.25	intertemporal elasticity of substitution
δ	0.115	technical depreciation of capital
Δ	0.055	fiscal depreciation of capital
ε	0.298	net replacement rate of PAYG pension as a fraction of the average wage rate
ζ_K	0.333	cost share of capital in the tradable goods sector
ζ_L	0.393	cost share of labour in the tradable goods secto
ζ_M	0.274	cost share of raw materials in the tradable goods sector
ζ_P	0.2047	labour-output ratio of private health insurance
ζ_{ZF}	0.0947	labour-output ratio of public health insurance
ζ_a	0.0375	labour-output ratio of AWBZ insurance
η_H	0.25	elasticity of productivity in the time preference of households
θ	0.062	preference drift of leisure of a household
θ_0		weight of leisure in utility
θ_1		weight of health care in utility
σ_h	0.5	elasticity of substitution between labour and capital in the tradable goods sector
σ_v	0.65	intratemporal elasticity of substitution between leisure and health care
σ_u	0.71	intratemporal elasticity of substitution between consumption of goods and the leisure-care group
σ_y	0.5	elasticity of substitution between raw materials and value added in the tradable goods sector
φ_0	0.7	supplementary pensions as a fraction of the final wage at full pension build-up
χ_{AWBZ}	0.805	AWBZ expenses as a fraction of health consumption
ac	0.015	accumulation rate of supplementary pensions
c_I	10	investment adjustment costs
l_{max}	1	available time per period
n_T	80	maximal life span of an adult
n_y	43	life span of an adult from entering the labour force till entitlement to basic pension.
T_D	13	length of fiscal life of capital goods

Variables[8]

$A(t,\tau,i)$	assets of households of generation τ and type i at time t
$c(t,t_0,i)$	consumption of tradables of a household of generation t_0 and type i in period t.
$c_a(t,t_0,i)$	AWBZ consumption of a household of generation t_0 and type i in period t.
$c_v(t,t_0,i)$	consumption of leisure of a household of generation t_0 and type i in period t.
$c_z(t,t_0,i)$	consumption of health care of a household of generation t_0 and type i in period t.
$c_{zf}(t)$	aggregated consumption of health care by publicly insured households.
$c_{zp}(t)$	aggregated consumption of health care by privately insured households.
$f(t)$	franchise threshold for supplementary pension benefits.
$g(t)$	government consumption of goods
$g_0(t)$	share of government consumption of goods in GDP (exogenous)
$h(i)$	productivity of household type i.
i_z	fraction of households that is publicly insured against health care expenses.
$K(t)$	capital stock of tradable goods sector.
$l(t,t_0,i)$	labour supply of a household of generation t_0 and type i in period t.

[8] For variables that are constant in the baseline projection the benchmark value is added in parentheses.

$L_a(t)$	employment in AWBZ insurance institutions.
$L_O(t)$	employment in education sector.
$L_G(t)$	other government employment.
$L_{ZP}(t)$	employment in private health insurance firms.
$L_{ZF}(t)$	employment in public health insurance firms.
$L(t)$	employment in the tradable goods sector in efficiency units.
$L(t,i)$	total labour supply of household type i.
$L_s(t)$	labour supply in full-time equivalence units.
$L_{s\_eff}(t)$	labour supply in efficiency units.
$M(t)$	use of raw materials by the tradable goods sector.
$N^o(t)$	number of elderly.
$p_{cz}(t,t_0,i)$	opportunity costs of health care of a household of generation t_0 and type i in period t.
$p_l(t,i)$	wage rate of household type i.
$p_l(t)$	wage rate of an average household (with $h(i) = 1$).
$p_v(t,t_0,i)$	opportunity costs of leisure of a household of generation t_0 and type i in period t.
$p_z(t)$	price of health care.
$P(h)$	cumulative distribution function of productivity.
$R_h(\tau,t,t_0)$	discount rate of households of generation t_0 in period t to period τ.
$r_h(t,\tau)$	net interest rate of households of generation τ in period t.
$r(t)$	domestic interest rate (0.055).
$S(t)$	Savings of the domestic sectors
$TB(t)$	trade balance surplus
$t_c(t)$	consumption tax rate (0.25).
$t_k(t)$	tax rate on interest income of households (0.25).
$t_l(t)$	tax rate on labour income (0.25).
$T(t,t_0)$	transfers of the government to generation t_0 at time t.
$T_{ZF}(t)$	government transfer to the public health insurance fund.
$T_{PAYG}(t)$	government transfer to the PAYG fund.
$v(t,t_0,i)$	leisure of a household of generation t_0 and type i in period t.
$w(t)$	contribution rate of supplementary pension scheme
$W(t,t_0,i)$	life-time wealth of generation t_0 and type i in period t.
$WAO(t)$	occupational disability insurance payments.
$y(t)$	value added against factor costs of the tradable goods sector.
$y_{FC}(t,t_0,i)$	supplementary pension benefits of generation t_0 and type i in period t.
$y_{PAYG}(t)$	PAYG pension benefits per household.
$\theta_v(t,t_0,i)$	efficiency index of the consumption of leisure.
$\theta_z(t,t_0,i)$	efficiency index of the consumption of health care.
λ_B	marginal cost of funds
λ_D	contribution of the dividend restriction to the marginal cost of funds.
$\lambda_h(t,t_0)$	annuity of life insurance companies to households of generation t_0 at time t.
$\pi_{AWBZ}(t)$	AWBZ contribution rate.
$\Pi_{AWBZ}(t)$	AWBZ contributions.
$\pi_a(t)$	fraction of AWBZ consumption that is not reimbursed (exogenous).
$\pi_b(t)$	PAYG contribution rate levied on supplementary pension benefits (0.0).
$\pi_l^y(t)$	PAYG contribution rate levied on labour income of young households (0.085)
$\pi_k^y(t)$	PAYG contribution rate levied on capital income of young households (0.085)
$\pi_{NZF}(t)$	nominal public health insurance contribution (exogenous).
$\pi_P(t)$	private health insurance premium per household.
$\pi_z(t)$	fraction of health care expenses reimbursed by private health insurance funds (exogenous).
$\pi_{ZF}(t)$	public health insurance contribution rate.
$\Pi_{ZF}(t)$	public health insurance contributions.
$\chi_{MOOZ}(t)$	contribution rate of private health insurance funds to the public health insurance fund (exogenous).