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The Impact of Ageing on Demand, Factor Markets and Growth

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ABSTRACT/RESUMÉ

This paper examines the channels through which ageing will shape the main economic factors that in turn affect potential growth; identifies current policy settings that may in fact amplify the adverse impact of demographic trends; and sets out policy reforms that will work to temper the effects of ageing on growth. The paper begins with a brief discussion of demographic issues. The analysis first focuses on the impact of these trends on the future level and structure of consumption, which may affect aggregate saving and the structure of the economy, respectively. Then, it explores the main channels through which ageing affects the supply side of the economy following a production function approach: capital markets, labour markets and productivity. The empirical analysis focuses on a subset of large OECD countries with differing ageing patterns and generosity of pension systems. Using a simple general equilibrium overlapping generations model and considering alternative reform scenarios, some illustrative simulations are presented decomposing the effects of ageing on potential GDP *per capita* growth and economic convergence within OECD countries.

JEL Classification: C68, D91, G10, J11, J26
Key words: Ageing populations, longevity, overlapping generation model, pension reforms, employability, old workers, economic convergence.

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Cette étude examine les canaux par lesquels le vieillissement de la population est susceptible d'affecter l'économie et la croissance potentielle. Elle identifie les dispositifs actuels qui pourraient amplifier les effets négatifs induits par les tendances démographiques et analyse les réformes pouvant limiter ces effets. L'étude commence par une brève discussion relative aux évolutions démographiques. Leur effet sur le niveau et la structure de la consommation est ensuite analysé, ainsi que leur impact sur le niveau d'épargne agrégé et la structure de l'économie. L'effet sur l'offre est analysé suivant une approche de type fonction de production: marchés des capitaux, du travail et productivité. L'analyse empirique se concentre sur un sous-ensemble de grands pays de l'OCDE qui diffèrent par leurs profils de vieillissement et par la générosité de leurs systèmes de pension. Utilisant un modèle simple d'équilibre général avec des générations imbriquées et des scénarios alternatifs de réforme, l'étude présente des simulations illustrant l'impact du vieillissement sur le PIB potentiel par tête et la convergence économique entre pays de l'OCDE.

Classification JEL : C68, D91, G10, J11, J26
Mots Clés : Vieillissement des populations, longévité, modèle à générations imbriquées, reforme des système de pensions, travailleurs agés, convergence économique.

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THE IMPACT OF AGEING ON DEMAND, FACTOR MARKETS AND GROWTH

By Joaquim Oliveira Martins, Frédéric Gonand, Pablo Antolin,
Christine de la Maisonneuve and Kwang-Yeol Yoo[1]

1. Introduction

1.1 Scope of the study

1. Ageing is likely to slow per capita GDP growth in OECD countries. This paper examines the channels through which ageing will shape the main factors that in turn affect growth; identifies current policy settings that may in fact amplify the adverse impact of demographic trends; and sets out policy reforms that will work to temper the effects of ageing on growth.

2. The report shows that the two main sources of ageing, the decrease in fertility rates from baby-boom levels and the steady increase in longevity, tend to depress growth relative to a scenario with a stable population, especially in countries where pension and labour market policies discourage private saving and employment of older workers. Thus, by magnifying the welfare losses implied by these policy institutional arrangements, ageing will make the cost of delaying reforms even stronger. Where policies are inappropriate to start with, corrective measures can contribute to offset some of the drag on growth due to ageing.

3. The paper begins with a brief discussion of demographic issues (Section 2). The analysis then turns to the impact of these trends on the future level and structure of consumption, which may affect saving and the structure of the economy, respectively (Section 3). The next two sections explore the main channels through which ageing affects the supply side of the economy: capital markets (Section 4), labour markets and productivity (Section 5) focusing on a subset of large OECD countries with differing ageing patterns and generosity of pension systems. A final section presents some illustrative simulations showing the aggregate impact of the different channels through which ageing affects potential GDP *per capita* growth.

1.2 Main findings and policy implications

4. With a rising share of inactive population, GDP *per capita* growth will tend to slow in most OECD economies in this century. Keeping in mind the illustrative nature of the simulation exercises implemented in the report, the analysis suggests that with unchanged social security and labour market policies the following outcomes could be expected:

- While demographic developments will continue to sustain growth in the United States, ageing will tend to slow the expansion of GDP *per capita* in Japan, France and Germany. Relative to a

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situation with a stable age-structure of the population, the ageing-induced drag on GDP *per capita* in these countries will be on average -0.2 to -0.3 percentage points of growth *per annum* during the next half century. As a result, ageing will tend to widen GDP *per capita* gaps relative to the United States from around 25% currently to over 30% by 2050.

- The slowdown in GDP *per capita* growth will be driven by the decline in labour supply, whose negative contribution to growth will range on average from -0.2 and -0.5 percentage points *per annum* in France and Germany, respectively, to -0.8 percentage points *per annum* in Japan. The decline in the number of workers will be partially compensated by an increase in the quality of labour, as more educated cohorts of workers join employment. However, this is an effect that wears off over time due to a technical assumption in the projections; future improvements in human capital of new cohorts of workers could indeed materialise in the future.

- As in the past, growth over the next decades will still be largely driven by multifactor productivity developments, which may be influenced by ageing in conflicting ways. One concern is that changes in the structure of consumption may twist the supply mix towards service industries having low productivity growth (*e.g.* long-term care). However, while increased health spending will create tensions on public finances, the report finds that no sizeable effects of changes in consumption habits on aggregate productivity growth can be expected under reasonable assumptions concerning spending propensities of different age groups.

5. In several countries, growth prospects will depend to a large extent on the interaction of demographic developments with policies that generate disincentives for private saving and, especially, labour force participation of older workers. For instance, welfare systems that provide incentives for early retirement and fail to account for the increase in longevity are more harmful to growth the faster is the ageing process. In other words, lack of reforms in these systems may make their costs for society unsustainable in the context of rapid ageing. By simulating the alternative growth trajectories that would be obtained in the presence of pension and labour market reforms, the report attempts to identify how less distortionary outcomes could be achieved.

6. Notably, pursuing policies that encourage at the same time the development of pension savings, the increase in the effective age of retirement and a stronger participation of old-age workers in the labour force might largely eliminate the potential ageing-related growth costs of current pension and labour market arrangements:

- Under this combination of policies, GDP *per capita* growth would be boosted on average (2001-2050) by around 0.4-0.6 percentage points in Japan, France and Germany, and by 0.3 percentage points in the United States relative to a no-reform ageing scenario in which the burden of adjustment is put only on increased contribution rates. This is because strengthening incentives to save and participate in the labour market would sustain both capital deepening and labour supply in efficiency units. Most of these growth gains would be recorded before 2040.

- Such a policy package would also help stabilise the divergence of income per capita *vis-à-vis* the United States, containing the tendency of GDP *per capita* gaps to increase in Japan and France and maintaining the gap at the current level in Germany.

7. The report also suggests that the policies just mentioned can only be fully successful if they are flanked by measures that increase the employability of old workers and the efficiency of capital markets:

- The employability of old-aged workers depends critically on their level of human capital and on whether wage-productivity gaps emerge at old age. By bringing reservation wages of older workers more in line with their productivity, policies that eliminate incentives for early retirement may also help increase the employability of these workers. Concerning human capital investments, encouraging or facilitating longer working lives would make training a more attractive option for older workers. Overall, more flexible wage determination systems and proper training incentives would also fit with the increased heterogeneity of the labour force at higher ages.

- In a context where policies encourage pension savings, it is important that the structure of financial markets be such that investments are allocated to their best use. For example, deepening the market for annuities could reduce any tendency to over-save for precautionary motives and developing reverse mortgage schemes would make it easier to turn illiquid assets, such as real estate, to other possibly more efficient uses.

2. Demographic issues: disentangling the effects of fertility and longevity

8. The main exogenous factors driving the analysis in this paper are demographic projections (2005-50),[1] mostly drawn from national sources. As illustrated in Table 2.1, the underlying assumptions on fertility and life expectancy differ somewhat across countries, even at the end of the projection period. Notably, assumed longevity gains for women range from 1.6 years in Iceland to 8.2 years in Korea, and differ significantly even among European countries. As discussed below, this heterogeneity of assumptions and lack of cross-country convergence in the long-run can only partly be explained by the controversial nature of the fertility and longevity phenomena.

[Table 2.1 Underlying assumptions of population projections]

2.1. Can fertility be predicted?

9. On the issue of fertility rates, some studies continue to support the idea of a fertility cycle (*e.g.* Van Wissen, 2004), whereby fertility rates alternate periods of booms and busts. In this context, the current extended decline in fertility would be partly explained by a 'postponement effect', *i.e.* a shift over time of the date a woman has her first child.[2] A certain increase in fertility rates can then be expected in countries or regions, such as Southern Europe, where currently a significant gap is recorded between the surveyed number of desired children and actual fertility rates. However, this increase in fertility is likely to be limited, among other factors, by the increasing participation of women in the labour force.

10. By contrast, other research has concluded that fertility rates do not follow cyclical patterns but seem to be subject to sudden changes (Bonneuil, 2003). This view, supported by the evolution since 1930 of net reproduction rates[3] given in Figure 2.1, suggests that future developments would be largely unpredictable.

[Figure 2.1 Shifts in fertility regimes in selected European countries]

2.2 The impact of longevity gains on dependency ratios

11. Longevity trends and the underlying mortality hypotheses are also controversial.[4] Currently, there is no evidence of a deceleration in longevity. Over the past century and a half, female longevity has increased almost linearly by 2.4 years per decade (Figure 2.2). Moreover, conditional life expectancy at higher ages has recently accelerated, though with a wide cross-country dispersion (Table 2.2). Hence, the regular increase in longevity seems to be a *permanent* effect.

[Figure 2.2 Historical trends in female life expectancy, 1840-2000]
[Table 2.2 Increases in life expectancy for different age groups]

12. On average, current national population projections, on which this paper is based, assume longevity gains of around 1.2 years per decade over the next fifty years (Table 2.3). This implies a significant slowdown in life expectancy gains. This 'pessimistic' view on longevity gains is at odds with the past trends referred to above. The lack of convergence in life expectancy across countries, either in levels or in differences, is also problematic. Higher projected longevity gains would naturally induce an increase in dependency ratios, conditional on assuming a fixed old-age threshold (usually the population of 65+ over the 15-64 year age group).[5] But, there is no *a priori* reason why the old-age threshold should remain constant in the presence of longevity gains.

[Table 2.3 Comparison of past with projected gains in life expectancy]

13. To investigate this point, the dependency ratios were re-calculated by indexing the old-age threshold (currently at 65 years) on each underlying country-specific longevity assumption. Rather strikingly, gradually increasing the old-age threshold in line with longevity appears to be sufficient to stabilise, or even reverse, the upward trends in dependency ratios in many OECD countries (Figure 2.3).

[Figure 2.3 Simulations of the impact of longevity indexation on dependency ratios]

2.3 Do gains in longevity translate into healthy ageing?

14. Moving the old-age threshold in line with longevity gains would only affect old-age dependency if aged workers participate in the labour force, are employed and remain in good health. Labour force participation and employability of older workers will be discussed in Section 5. With regard to healthy ageing, the evidence is scattered and points to many unknowns. No clear pattern emerges from the comparison of trends in life expectancy (LE) and disability-free life expectancy (DFLE) based on available cross-country data (Table 2.4). In some countries, there is a balanced increase, in others the DFLE progresses faster than LE and in a few the reverse is observed.

[Table 2.4 Gains in life expectancy versus disability-free life expectancy]

15. Several, sometimes conflicting, factors can explain these patterns, such as control of chronic diseases, extended life of sick persons, better health habits and the emergence of very old, frail individuals (Michel and Robine, 2004). Depending on the relative weights of each of these factors at various times, countries can move around regimes of compressed, expanded or balanced morbidity/disability *vis-à-vis* longevity. This makes health expectancy hard to project. The access to new drugs counteracting a decline in cognitive and physical capabilities with age could also be another factor explaining differences in DFLE across countries (Lichtenberg and Virabhak, 2002; Lichtenberg, 2003).

16. Disentangling the effects of the decline in fertility and the increase in longevity is important for policy. For instance, increasing effective retirement age mainly makes sense in a context of increased longevity without incapacity, though it could also smooth over time the impact of the baby-boom shock. Conversely, increasing youth and female participation or other policies increasing employment can help dealing with the baby-boom shock but would address the longevity issue only over a transition period.

3. How will ageing affect consumption?

17. If, as is likely, the level and structure of individual consumption behaviour are influenced by ageing, the potential growth rate of the economy would be attested. Two channels can be envisaged. First, according to the life-cycle hypothesis, older people tend to have a higher propensity to consume out of income. Hence, a lower aggregate saving would be expected as a smaller rate of capital accumulation would be needed to equip a dwindling labour force.[6] Second, changes in the structure of consumption could induce sectoral shifts in the economy. Even though these shifts are a reflection of changes in

preferences and, therefore, do not call for policy action, depending on the type of goods and services most in demand, those shifts may affect aggregate productivity gains. For example, certain types of services demanded by older people, such as long-term care, are often seen as having low potential for productivity gains compared with manufactured goods. Investigating the extent of changes in the structure of consumption implied by ageing may, therefore, provide useful information about future growth trends. Accordingly, this section assesses by means of regression analysis and a 'thought experiment' how future demographic changes can be reflected in aggregate consumption, saving and the broad structure of consumption.

3.1 Ageing, aggregate consumption and saving

18. Household survey data suggest that total consumption displays a hump-shaped profile across age-groups[7] (Figure 3.1). These profiles are subject to uncertainties and are not equivalent to saying that the consumption profile is hump-shaped over the life cycle, mainly due to the existence of cohort and time effects.[8] Nonetheless, they would suggest that the pure consumption-smoothing hypothesis is only partly supported by the micro data.[9] In the absence of strong life-cycle effects the impact of ageing on consumption and savings would then be hard to predict.

[Figure 3.1: Relationship between consumption and age groups]

19. In fact, when the age-income profile is more hump-shaped than consumption, the above observed age-consumption patterns are still compatible with some consumption smoothing over the life cycle, as illustrated in Figure 3.2. Evidence for the more pronounced hump-shaped income profile is found in the household survey data across age groups, *e.g.* in the United States and in Japan (Figure 3.3).

[Figure 3.2 Consumption smoothing over the life cycle: an illustration]
[Figure 3.3 Consumption smoothing: evidence from household surveys]

20. Under the assumption of partial consumption smoothing, aggregate saving rates should be positively correlated with the proportion of prime-age working individuals in the total population and negatively correlated with the proportion of retired individuals in the total population. A simple test of this relationship was performed by running a panel regression (countries x time) of the household saving rate (one minus the propensity to consume out of income) on age-structure effects and a number of controls (Table 3.1). The relative impact of age structure is likely to depend on the generosity and coverage of pension and health care systems. The latter are proxied by aggregate variables, such as average replacement rates and the share of public spending in total health care. Another important demographic variable is the increase in life expectancy, which can lead to higher saving (lower consumption) rates at every age. This is due to the fact that higher life expectancy may increase the need for additional precautionary savings, despite the effect of improved health care on the length of desired working life (see Bloom *et al.* 2003; Sheshinski, 2004).

[Table 3.1 Econometric estimates of the impact of population structure on the household saving rate]

21. All the estimated coefficients are significant and have the expected sign, except for life expectancy (Table 3.1).[10] The results suggest that an increase in the share of the old-age population (60-99 years) has a strong negative impact on the saving rate – more than five times greater than the positive impact of increasing the share of prime-age population (25-59 years). The estimates also show that the characteristics of social protection systems interact with the population structure. A relatively generous public pension system and a higher old-age population share contribute to increase the saving rate. The opposite effect is obtained for the interaction between the replacement rate and the prime-age population,

given that a generous pension system creates a disincentive to save for retirement. A larger share of public provision of health care in total health consumption is also found to contribute negatively to the savings rate.

22. The period of analysis (1970-2003) is characterised by a low share of the old-age population in OECD countries, hence the estimates are not well suited to make an extrapolation on the impact of ageing over the next 50 years. Moreover, the size of the coefficients on age composition variables may not be estimated precisely enough to be used in projections.[11] Nonetheless, estimation results suggest that the potential magnitude of this effect can be large given that the share of the people above 60 years in the total population is projected to roughly double in most OECD countries between 2000 and 2050. This partial evaluation does not take into account other countervailing factors of the impact of ageing on saving and will be completed in the next section by a general equilibrium analysis.

23. At this stage, the conclusion is that the evolving population structure could have a strong negative impact on household saving, the extent of which partly depends on the generosity and coverage of social systems. *Ceteris paribus*, lower savings would imply a lower capital deepening and, at unchanged policies, a lower growth rate of labour productivity and GDP *per capita* growth during the demographic transition.

3.2 Ageing and the structure of consumption

24. Household survey data also allow an assessment of the age-group specific composition of consumption expenditure by broad categories of goods and services (Figure 3.4). Among the items covered by the data, the shares of housing, energy and health care spending tend to increase with age. The increase in the share of health care is particularly pronounced in the United States.[12] By contrast, the expenditure share on motor vehicles and related services falls with age, as older people tend to drive less. As could be expected, the elderly also tend to spend relatively less on entertainment and education.

[Figure 3.4: Relationship between age and consumption by expenditure items]

25. These expenditure shares by age groups can be used to project the mechanical impact of demographic trends on the structure of consumption. Assuming a constant propensity to consume by age group, the mechanical effect of ageing on the structure of consumption was calculated by keeping also the share of any given consumption item in total consumption by age group constant during the projection period (at 2000 levels or an average of recent years).[13] In all countries, the strongest rise in demand shares is projected for health care, followed by energy consumption and housing expenditure (except in the United States and Japan).[14] Education is the item that slows down the most relative to average. Aggregate demand for owned vehicles is also projected to grow at a below-average rate, as well as clothing, entertainment, transport services and communication.[15]

[Figure 3.5 Relative changes in consumption structure, 2005-2050]

26. However, despite the large demographic shocks, changes in projected consumption shares are relatively moderate at most a +/-17% change to compare, for example, with the doubling of health expenditures in many OECD countries over the past 30 years. This is due to the fact that changes in the consumption shares of age-sensitive products tend to offset each other across age groups, as illustrated by some examples in Figure 3.6. For instance, in Japan, France and Italy, the shrinking young-age group spends less on health care, whereas the expanding older-age group spends more, but the share of the large group of prime-age households does not change much. As a result, the aggregate expenditure share of health services is little affected. In the case of the United States, the changes in population structure are simply not large enough to generate sizeable changes in the composition of consumption. With these

orders of magnitude, ageing-induced changes in consumption shares are not expected to generate major structural changes in the economy.

[Figure 3.6 Consumption and population shares]

27. It should be stressed that these results depend on the assumption that propensities to consume on the various items will remain at their current levels over the projection period. However, if participation of old-age people in the labour force were to increase, their consumption patterns could come closer to those of prime-age workers. Also, with the development of information and communication technologies (ICT) some of the products that are less consumed by older people could become more old-age friendly.

4. Ageing and financial markets

28. Changes in the age structure of the population will translate into movements in aggregate saving rates and the supply of capital, with potential implications for growth. In this context, actions taken to make pay-as-you-go (PAYG) pension regimes sustainable during the demographic transition and developments in private pension schemes will interact with ageing trends to shape capital accumulation in OECD countries. Assessing the relative magnitude of these effects can be carried out using an approach that takes general equilibrium interactions into account. In this section, a simple overlapping generations' model is applied to derive the implications of alternative pension policy scenarios for capital accumulation. The model was built and calibrated to fit the characteristics of the four largest OECD countries: the United States (slow ageing), Japan and Germany (fast ageing), and France (intermediate ageing). The extent of saving and capital accumulation will also have implications for the structure of capital markets, in particular concerning the development of new financial products, which will also be addressed in this section.

Box 1. Main features of the overlapping generations model

The general equilibrium model with overlapping generations embodies 79 cohorts, thus capturing in a detailed way changes in the population structure. Each cohort has a maximum life span of 20 to 99 years and a specific mortality profile. The national demographic projections, based on five-year periods by age groups, were transformed in order to obtain coherent yearly profiles, as well as survival probabilities for each cohort.

The specification of the model draws mainly on Miles (1999) and Börsch-Supan *et al.* (2002). To simplify, each country is viewed as a closed economy and the labour market is exogenous. The latter assumption implies that there is no intertemporal trade-off between consumption and leisure. An extended version of the model, endogenising this intertemporal choice is also available (see Annex 2), but results do not change qualitatively for any reasonable choice of parameters. The closed economy assumption may have a greater impact on the results, as international capital flows would probably help to smooth out the impact of ageing. Nevertheless, to fit with observed patterns of capital flows, a much heavier calibration procedure would be required and the specification would be less robust.

In order to isolate the pure effect of ageing, unemployment rates are frozen at their level of 2000, as are participation rates for each age group, except for the scenarios incorporating an increase in the age of retirement. All variables are expressed in real terms. The production function has constant returns to scale, involving capital, labour and a labour-augmenting total factor productivity (TFP).

Individuals optimise their consumption path over their lifetimes and do not have any bequest motives. They are either employed, unemployed, retired or none of these (in which case they do neither contribute nor get a pension). The base year is 1989 and the model reaches its steady-state after 2080. The solution equalizes the demand of capital (for production) and the supply of capital (from household savings).

The model was parameterized using a capital share in output of 0.3, a relatively large elasticity of substitution between capital and labour of 1.25, in line with the long-term characteristics of the model, and TFP gains were assumed to be at 1.5% per year. The households' discount rate is fixed at 3%. This choice of parameters results from recent behavioral and econometric studies (see Annex 2 for details) and is the same for all countries. In this way, the pure effect of ageing trends on the equilibrium of financial markets can be identified. Replacement rates, a proxy for the generosity of the pension system, are country-specific and calculated as the ratio between average pension payments and average earnings.

The model was calibrated on an interest rate of 4.5% in the base year (corresponding to the sum of TFP gains and the discount rate), as suggested by the life-cycle theory. This assumption yields realistic contribution rates and capital/income ratios but has no impact on the profile of macroeconomic variables over time. Contrary to some studies, the model was not calibrated on the households' risk aversion parameter, in order to reproduce observed variations in the stock of capital around the base year. It turns out that this calibration procedure can generate rather high levels of risk aversion, resulting in a very inelastic reaction of households to interest rate movements. In order to avoid such a drawback, the risk aversion parameter was set at 1.33, this value being in accordance with econometric studies (cf. Annex 2). Several sensitivity tests were carried out, suggesting that the model is reasonably robust to the calibration procedure and parameter choices.

4.1. A quantitative assessment of the impact of ageing on capital markets

29. In applying the model (see Box 1 for detail), three different scenarios were considered. They mainly aim at illustrating the impact of different policy channels in a stylised way, without necessarily capturing the future impact of the already implemented policy packages in each country.

- In the *"rising contribution rate"* scenario, pension regimes are balanced over time by increasing contribution rates, while leaving replacement rates and retirement ages unchanged. For illustrative purposes, this may be considered as the "no-reform" scenario.

- In the *"gradually increasing age of retirement"* scenario, reforms increase the legal age at which an individual can receive a full pension. The rise in the official age of retirement was set to 1¼ years per decade, roughly in line with the average increase in longevity underlying national demographic projections (cf. Section 2). The residual imbalances of the PAYG regime are covered by changes in contribution rates. Access to a full pension is conditional on a minimum amount of working years during which contributions have been paid. When this condition is not met, replacement rates are lowered by using a penalty rate (taken arbitrarily here to be 6 per cent per year).[16] As the labour market is exogenous, it was assumed that age-specific participation rates of workers above 50 years of age increase in line with the changes in the age of retirement. For instance, in 2045 participation rates of 60 year old workers are the same as those of 55 year old workers in 2005, and so on.

- In the *"pension saving"* scenario, contribution rates are frozen after 2005 and the system is balanced by gradually decreasing replacement rates for *new* retirees. This motivates agents to increase savings (in the form of pension fund assets or other financial instruments) to sustain consumption levels upon retirement.

30. In the two reform scenarios, policy changes are implemented from 2005 onwards. After the reform is announced, households revise their optimal saving paths in order to smooth future consumption levels. This implies that before 2005 consumption for each cohort remains equal to its level in the no-reform 'rising contribution rate' scenario. The economies return to a stable population level and structure by 2080, when a steady state equilibrium is reached. In this situation, GDP *per capita* growth is exclusively determined by the (exogenous) growth in total factor productivity (TFP) and capital deepening grows in line with TFP, at 0.45% *per annum*.[17] By contrast, during the demographic transition, the dynamic equilibrium is driven by ageing trends and pension reforms.

31. The simulation results are relatively robust to parametric changes in the model (for details see Annex 2). They show a substantial impact of demographic changes on capital accumulation. Consider first the implications of ageing in the "no-reform" scenario, with rising contribution rates. The main

characteristics of the implied growth path during the demographic transition are the following (Figure 4.1 and detailed country figures in Annex 1):

- As would be expected, balancing PAYG systems in the context of ageing requires a sizeable increase in contribution rates. These would double from current levels in France and Japan, increase substantially in Germany and, more moderately in the United States, reflecting differences in the speed of ageing and the generosity of pension systems.

- Movements in the capital-labour ratio reflect the relative speed of the decline in saving and labour supply over the simulation period. They are bell-shaped in France and, especially, the United States, where savings are higher than elsewhere during the first phase of the demographic transition, due to lower taxes and a younger population. In Germany and, especially, Japan they rise above their initial levels, reflecting increasing scarcity of labour.

- Accordingly, the contribution of capital deepening (changes in the capital-labour ratio) to growth is U-shaped in all countries. It falls below the steady state rate (0.45 per cent) for most of the projection period in France and the United States, it stays close to this rate in Germany and it remains above this rate in Japan.

- Movements in the real interest rate mirror the evolutions of capital-labour ratios, with a tendency to decline during the first half of the simulation period and to rise afterwards, except in Japan where it declines steadily. Noteworthy, however, the amplitude of these variations remains modest (from -70 basis points to +30 basis points).

32. The differential implications of ageing in the alternative policy reform scenarios can then be interpreted as deviations from the outcomes of the rising contribution rate scenario. Two main features spring out of the "gradually increasing age of retirement scenario" (Figure 4.2 and detailed country figures in Annex 1):

- As already pointed out in Section 2, increasing retirement age in line with projected longevity gains significantly slows down the increase in old-age dependency ratios due to ageing. Thus, except in Japan, the increase in contribution rates required to balance PAYG systems is much smaller than in the previous scenario. This of course implies gains in overall economic efficiency that are not accounted for in the simple model used in simulations.

- The profiles of capital-labour ratios remain similar to those observed in the previous scenario. In this scenario, the tendency of individuals to reduce saving in line with a shorter retirement span is compensated by the longer working life period during which they save. The capital-labour ratio profiles tend, however, to be flatter especially in Germany and France, partly reflecting a wider scope for increasing labour force participation of old-age workers in these countries.

33. Unsurprisingly, the capital accumulation outcomes of the "pension saving scenario" tend to depart more significantly from the previous two scenarios (Figure 4.3 and detailed country figures in Annex 1):

- With replacement rates declining to 25-35% by 2050, there are strong incentives for prime-age households to save more in order to avoid a sharp reduction of their revenues and consumption after retirement. As a result, capital-labour ratios increase significantly in all countries and remain bell-shaped only in the United States, reflecting the differential evolution of labour supply in this country.

- Accordingly, the contribution of capital deepening to growth remains above its steady state level for most of the simulation period in all countries except the United States. In comparison with the previous scenario, the contribution of capital deepening to labour productivity increases on average by 0.2 to 0.3% percentage points *per annum*.

- Reflecting the amplitude of movements in capital-labour ratios, the decline in interest rates is more pronounced over the simulation period (up to 100 basis points in the United States and 150 basis points in Japan).

[Figure 4.1: The ‘rising contribution rate’ scenario]
[Figure 4.2: The ‘gradually increasing age of retirement’ scenario]
[Figure 4.3: The ‘pension saving’ scenario]

34. The results give little support to the so-called "asset meltdown hypothesis", according to which the massive pension withdrawals during the second phase of the ageing process could induce a large decline in asset prices (see Box 2). Other quantitative studies using general equilibrium models also tend to reject this hypothesis. This is because the asset meltdown hypothesis reflects a partial equilibrium view where changes in economic agents’ behaviour spurred by interest rates movements are not taken into account. Also, the hypothesis may also be based on an exclusive focus on the impacts of ageing on savings, ignoring the impacts via labour supply on investment. In a general equilibrium setting, accounting for these mechanisms largely offsets the asset meltdown effect.[18]

Box 2. The asset meltdown hypothesis

An increase of pension savings, especially in countries with dominant PAYG schemes, would entail a positive net demand for financial assets at the beginning of the ageing process. This holds as long as the sum of all contributions to saving accounts and the flows of interest and dividends received from assets outpace the amount of pensions to be paid. The decline in the labour force, together with the rise in the retired population, creates a concern as to whether these conditions will be met in the future. If so, pension funds might become structural net sellers of financial assets on a very wide scale, creating downward pressures on asset prices and pushing up interest rates. This “asset-meltdown” phenomenon could trigger detrimental side-effects on the cost of capital for businesses (Schieber and Shoven, 1994) and affect growth prospects.

International diversification of capital investment could counteract these effects, as rapidly-ageing countries could use capital investments in relatively younger countries to push up their average rate of return on capital (McMorrow and Roeger, 2003). However, the scope for these international saving flows is unclear. The positive effect of international diversification on asset returns can be hindered by the detrimental impact of exchange rate risks on capital investment and, more generally, of a “home bias’’ in international capital allocation. Moreover, experiences with capital account liberalisation in emerging markets have been mixed. It requires a better institutional environment, which will take time to build (Blair and Lorentzen, 2003). The demographic transition in emerging and developing countries is also taking place at a much faster pace than in the OECD.

Some authors have advocated a reverse meltdown effect arising not from saving but investment due to a severe capital shortage after 2025-30 entailing a strong upswing in the rate of return on capital (Fehr *et al.*, 2003). Nevertheless, their result stems from strong assumptions, according to which all the financial distress of the current PAYG pension regimes will have to be covered by tax hikes.

35. A related issue is whether downward pressure on asset prices during the second phase of the ageing process (after 2025-30) could induce households to shift their portfolios from stocks to bonds. However, with the limited impact of ageing trends on interest rates, as suggested by the simulations described above, this reallocation effect might not be large. Expected fluctuations in asset prices could have an impact on households’ portfolio strategies. However, there is little consensus around this issue (Box 3). Depending on whether risk aversion varies with age, the share of risky assets (*e.g.* stocks) in

individual portfolios could decline, remain roughly constant or even increase with a higher proportion of old individuals in the population.

4.2. Implications of capital accumulation for the structure of financial markets

36. Policies that enhance saving incentives, such as in the "pension saving" scenario are likely to lead to an increase in *individual* accumulation of capital. Similarly, in the "gradually increasing age of retirement" scenario, lifetime accumulation of wealth increases because lifetime labour income is higher and individuals, therefore, wish to have a greater retirement income (Figure 4.4). However, greater reliance on private saving for resources in retirement is likely to require structural changes in financial markets to allow households to insure themselves against the risks related to longevity at a reasonable price.

[Figure 4.4: Accumulated wealth of an individual under different scenarios]

Box 3. Ageing and household portfolio strategies

An ongoing debate concerns the impact of age on individual portfolio strategies. Ageing could have a major impact on financial markets if the average individual in a population modifies his/her arbitrage between stocks and bonds just because he/she gets older. Samuelson's seminal lifetime asset allocation model (Samuelson, 1969) suggests that age does not have any impact on portfolio decisions. However, this result relies on strong assumptions. Specifically, taking into account accumulated labour income (or "non financial capital") in total wealth significantly alters Samuelson's result (Jagannathan and Kocherlakota, 1996). Non-financial capital, computed as the discounted value of future labour income, decreases mechanically with age, while accumulated financial wealth increases. But, assuming that risk-aversion remains constant over time, the optimal fraction of *total* wealth invested in risky assets would also have to remain constant. In consequence, the fraction of *financial* wealth invested in stocks has to decline over time. This would imply that individuals' portfolio strategies would gradually switch with age from stocks to bonds. However, this effect could be mitigated if risk aversion were to decrease with age (Gollier and Zeckhauser, 2002; Bommier, 2004; Bommier and Rochet, 2004). Retirees would be willing to take on more risk because they no longer have to face uncertainty about labour income. To sum up, there is no consensus on the likely impact of age on portfolio strategies.

Empirical research is not conclusive either. Among other factors, the share of financial wealth held in equities by an individual in a given year may depend on age, cohort and time-specific market performance. These three factors being interdependent, a strong identification problem can emerge (Poterba, 2004). Using data for the United States, Ameriks and Zeldes (2002) conclude that the fraction of financial wealth held in equities might remain fairly constant with age. This result has also been obtained for other countries (*e.g.* Sanroman, 2002). It is likely that the impact of ageing on the arbitrage between bonds and stocks will also depend upon institutional factors, but this remains a relatively unexplored area.

Longevity risk, capital accumulation and the demand for annuities

37. Having accumulated a certain amount of financial wealth for retirement, uncertainties about asset prices, rates of return on capital and individual longevity create a specific risk for older individuals. In addition, older persons may be concerned about increased, but uncertain, personal care expenditures with age. As a result, individuals increase precautionary saving,[19] which not only has implications for capital accumulation but also lowers overall welfare since households would tend to consume too little during their lifetime. Shifting the uncertainty away from households through insurance markets could improve efficiency. In theory, this improvement could be achieved if individuals were allowed to exchange all or part of their accumulated wealth for annuities (see Yaari, 1965 and Box 4).

38. The welfare gains of buying an annuity can be substantial. Calculations provided in Annex 3 show that a retired individual would be 25 and 45% better off (depending on the countries)[20] if he or she had bought an actuarially fair annuity upon retirement. Even with a non-fair annuity this favourable effect on welfare would remain significant. Structural policies could be aimed at diminishing the imperfections of

annuities markets. Different policies can be envisaged, depending on whether they would foster developments in insurers' supply or households' demand for annuities.

39. Governments could support the development of annuities by allowing some market segmentation. Indeed, annuities prices are often computed on the basis of uniform – notably, undifferentiated by gender – and compulsory tables defined by regulators or governments. For instance, allowing for specific contractual clauses in annuity contracts would enable insurers to extract information from annuitants about their survival probabilities. A guaranteed period clause would ensure that if the annuitant dies before this period is over, periodic payments over the remaining number of years to fulfil this period are paid to heirs. This clause would introduce a kind of bequest mechanism. A capital protection clause would ensure that the discounted value of periodic payments paid by the insurers to the annuitant would have to be at least equal to the amount of capital sold at the beginning of the contract. These clauses are costly but reveal information about survival expectations by annuitants. Insurers can then adjust annuity prices accordingly,

Box 4. Annuity markets

An annuity is an insurance contract where the insurer pays out a periodic sum to an annuitant for the rest of his/her life in exchange for a premium. Thus, it shifts the individual's longevity risk away from households to the insurer, which can pool the risks. An annuity can take many forms: immediate or deferred, fixed or variable (escalating or inflation-indexed), with or without options for conditional payments to heirs in the event of premature death of an annuitant. For illustrative reasons, this box focuses on the standard annuity, *i.e.* a single-premium immediate fixed annuity.

Let *A* stand for the fixed sum paid by the insurer on a yearly basis, p_t the average survival probability over the whole population (conditional on the age of the annuitant at the date of purchase of the annuity, noted *a*), r_t the risk-free long-run real interest rate, *S* the premium paid by the annuitant and *D* the age of the annuitant at death. If the discounted value of the stream of future payments associated with the purchase of this annuity is equal to the premium, then the annuity is actuarially fair for the average individual:

$$S = \sum_{t=a}^{D} \left(A.\, p_t \,/ \prod_{1}^{t} (1 + r_t)^t \right).$$

There are several reasons why an annuity could entail a net cost, compared with a standard risk-free investment: administrative and marketing costs levied by insurers, corporate taxation and especially asymmetries of information in the insurance market. The persistence of asymmetries concerning the survival probabilities of individuals willing to purchase an annuity is related to the sizeable costs implied by the acquisition of this information by insurance companies. Thus, insurers price their annuities using relatively limited information, *e.g.* by age and gender.

Rothschild and Stiglitz (1976) show that the optimal strategy for insurers consists in offering different types of contracts so that individuals would self-select the type of contract fitting their private information. Individuals with high survival prospects are then assumed to select contracts offering features that, at a given price, are more valuable to them than to individuals with reduced life expectancy. Insurers know that individuals choosing high-risk contracts have relatively high life expectancy and adjust upwardly the survival probabilities when computing the premium for these contracts. Annuities will be sold at a higher price than if average population survival probabilities had been used – a price that is more or less fair for the average annuitant but unfair for the average individual. The average difference between the price of the annuity and the fair price (*i.e.* the present value of periodic payments) has been calculated in one study at 13.5 % of the price paid for a 65-year old male in the United Kingdom (Finkelstein and Poterba (2002). On US data, Mitchell *et al.* (1999) obtain a figure of 18.6%.

Mitchell *et al.* (1999) noted that these differences cannot fully explain the small size that voluntary annuity markets have in most countries. Indeed, annuities provide a valuable service by insuring households against longevity risk, which would justify a lower rate of return than on other financial instruments. A possible, but not entirely convincing explanation is related to bequest motives (Friedman and Warshawsky, 1988 and 1990) (see Annex 3 for details).

segmenting the market and lowering the level of asymmetries of information (Finkelstein and Poterba, 2002). However, relatively high pricing of these clauses could also depress annuities purchases by individuals with low survival expectancy.

40. On the demand side, a compulsion approach may appear interesting especially in the context of the development of pre-funded pension schemes. This compulsion policy would require that part of the accumulated capital in pre-funded regimes must be transformed into an annuity at retirement. This would diminish asymmetries of information since annuities would be priced on the basis of the average survival probability in the total population (Finkelstein and Poterba, 2002). However, it would also create a cross-subsidisation from shorter-lived (often poorer) individuals to (often richer) individuals with longer survival prospects (Dushi and Webb, 2004). Where pension funds are organised along occupational lines and provide annuities such concerns may be lower.

Capital liquidity and reverse mortgages

41. The liquidity of assets is also crucial to ensure an efficient use of accumulated capital. Retired individuals are relatively "house rich, cash poor". The development of new financial products, such as reverse mortgages, could make it possible for older individuals to turn a significant fraction of their illiquid real state assets into cash, without selling them. Contrary to standard annuities, it could also be possible to leave bequests out of these assets.

42. A reverse mortgage is a financial contract where the owner of a house receives regular payments by a lender until death (Box 5). Overall, new issues of reverse mortgages have been limited, reflecting the fact that these loans are perhaps best suited to financially literate individuals. Nonetheless, recourse to this financial instrument has developed in some OECD countries, such as the United States and the United Kingdom. Encouraging the development of reverse mortgages would broaden the supply of financial products, helping households to cope with longevity risk. In this context, governments could provide insurance for bankers against the risk associated with the non-recourse limit (see Box 5), thereby diminishing the cost of reverse mortgages for households, provided the market is competitive. When the borrower dies, the loan becomes payable and is usually reimbursed by selling the house.

Box 5. Reverse mortgages in the United States

A reverse mortgage is a loan against the borrower's home that has not to be paid back as long as the borrower lives. To be eligible for most reverse mortgages, the borrower must currently be at least 62 years old. It is called "reverse" since it reverses the scheme of a traditional ("forward") mortgage. With a standard mortgage, remaining debt diminishes gradually and home equity rises along with regular payments from the borrower to the bank. When the debt is reimbursed in full, home equity equals the home value. With a reverse mortgage, debt rises (because interest compounds) and home equity shrinks along with regular payments from the bank to the borrower. When the borrower dies, the reverse mortgage becomes payable. The reimbursement is usually financed by selling the house. Legislation imposes that the lender, when seeking repayment of the loan, does not have legal recourse to anything other than the home value. Banks fix the amounts of periodic payments taking into account this "non-recourse limit", the market interest rates, the survival probability of the borrower and the home value. If positive, the difference between the value of the home sold and the amount of debt to be reimbursed at the time of death can be transmitted to the heirs.

5. Ageing, labour markets and productivity

43. With unchanged policies, ageing is expected to induce a slowdown or a decline in labour supply relative to current levels. The implied drag on growth could be compensated by higher productivity, labour quality or increased participation in the labour force. This section evaluates by means of numerical simulations the likely impact of ageing on the average level of education and the average level of productivity of the labour force. It also looks at the impact on labour supply of policies aimed at

eliminating disincentives to participate in the labour force, especially for older workers. Since such policies can only work as long as labour demand adjusts, factors that may impinge on the employability of old workers will also be discussed.

5.1 Ageing and labour supply

44. Following a production function with capital (K), quality-adjusted labour (L_q) and labour-augmenting technical progress (A), output (GDP) is given by:

$$GDP = f(K, A \cdot L_q) \qquad where \quad L_q = a_p \cdot Edu \cdot L$$

45. Labour supply is decomposed into a productivity parameter (a_p) related to the age composition of the labour force, an index of education of the labour force (Edu) and the number of workers (L). With unchanged migration trends and policies affecting retirement incentives, ageing will be exerting a slight downward pressure on the number of workers (L) in the OECD at large after 2020 (Figure 5.1). But this trend is not uniform across OECD countries. While labour supply would decline in Europe and especially in Japan, it would continue to grow in North America during the next half-century.[21]

[Figure 5.1 Impact of ageing on labour supply]

5.2 Mechanical impact of ageing on education and individual productivity

46. As illustrated in the formula above, the decline in labour supply can be compensated (or aggravated) by several factors. In the first place, aggregate productivity may change depending on how *individual* productivity evolves with age (Figure 5.2). It is commonly assumed that individual productivity follows a (quadratic) inverted U-shaped age profile (*e.g.* Miles, 1999). However, in more optimistic age-productivity profiles, productivity would stabilise after a certain age up to retirement, or follow an intermediate path. The impact of each of these hypothetical age productivity profiles on aggregate productivity can be derived by applying them to each of the cohorts considered in the previous section (cf. Box 1) and summing-up across living cohorts at each point in time.

[Figure 5.2 Different age-productivity profiles]

47. In the most optimistic scenario, assuming a flat productivity profile for old-age workers, the resulting aggregate productivity levels would increase over the next two decades and stabilise thereafter (Figure 5.3). In the other two scenarios, productivity would uniformly decrease. However, in all three scenarios the order of magnitude of the change is small (+/-2.5%) and this level effect would stabilise after a certain time. This result is related to the evolution of the average age of the labour force (Figure 5.4), which is increasing but will stabilise over the next decades if retirement patterns remain unchanged. This explains why, despite contrasting assumptions about individual age-productivity profiles, ageing *per se* does not have a major impact on the aggregate productivity *level*. In this context, concerns about the current "greying" of the labour force have to be seen as a rebound from a previous sharp decrease in the average age of the labour force, the "rejuvenating" shock that took place during the 1970s, from which OECD economies are just recovering.[22] In fact, in the 1990s Japan already experienced the average age of the labour force that is projected to occur in Europe and in North America by 2050.

[Figure 5.3 Mechanical impact of ageing on productivity levels]
[Figure 5.4 Average age of the labour force, 1960-2050]

48. A second factor affecting the quality-adjusted labour inputs is the level of education. Younger cohorts tend to be better educated than retiring cohorts; hence, large flows into retirement could increase

the average level of education of the labour force. To capture this effect, four levels of education were considered (primary, lower-secondary, upper-secondary and tertiary). In order to isolate the mechanical impact of ageing, this experiment assumes that the shares of each level of education by age group will remain constant at their 2000 levels. The shares were applied to each cohort in order to generate an aggregate weighted index, with the weights depending on relative wages by level of education.[23] The average level of education projected in this way would tend to increase in most ageing countries, with the exception of Germany,[24] but would flatten out after a certain time (Figure 5.5). In conclusion, the effects of ageing on education and individual productivity, which may counterbalance the decline in labour supply, are limited and tend to dissipate relatively soon over the projection period.

[Figure 5.5 Mechanical impact of ageing on education]

5.3 Impact of increased labour participation

49. To simulate policies that would exert a more persistent counterbalancing effect on the decline in labour supply, the combined effects of education, individual productivity and two alternative scenarios increasing participation are shown in Figure 5.6: one where the age of retirement increases in line with the longevity gains underlying national population projections and another where the labour force projections are drawn from the 'most optimistic' policy scenario put forward by Burniaux *et al.* (2003).[25]

50. While the labour quality effects induce an upward shift in the labour supply curve, the impact of increasing retirement age in line with longevity prevails over the long-run. For countries currently having a low participation rate of older workers, this effect is very large. In France, for instance, it would turn a decline in labour supply (either in levels or quality-adjusted) into a growing labour supply during the whole simulation period. In Japan, the size of the ageing problem is such, that neither the quality adjustments nor the increased participation scenarios considered here are sufficient to prevent an absolute decline in the labour supply by 2050. By contrast, these policy scenarios would push up the growth rate of the labour force in the United States. In Germany, they would compensate for a large part of the decline in the labour supply.

[Figure 5.6 Labour supply including quality adjustments and policy scenarios]

5.4 Employability of older workers

51. A cross-country comparison between employment rates of prime-age and old-age workers suggests that there is ample scope for increasing employment of aged workers in many OECD countries (Figure 5.7).[26] The relatively lower employment rate of old-age workers is likely to reflect both supply and demand factors. On the supply side, there is room for removing policy or institutional distortions encouraging early retirement (Blöndal and Scarpetta, 1998; Dang *et al*., 2001; and Casey *et al*., 2003; and Duval, 2003), which may artificially increase the gap between reservation wages and productivity at older ages. This creates strong work disincentives and hinders the employability of old-age workers, which crucially depends on their labour costs relative to their productivity (Box 6).

[Figure 5.7 Employment ratios by age groups across OECD countries]

Box 6. Age, productivity and wages

There are several reasons why the age profiles of productivity and wages could diverge at the end of the working life. For instance, wages could continue to increase because firms need to establish implicit contracts to avoid shirking and warrant maximum effort from workers (Shapiro and Stiglitz, 1984), to reward seniority, to warrant loyalty to the firm (Lazear, 1979), or to sustain workers' motivation by means of continuous wage increases (Salop, 1979).

However, the human capital accumulation rationale (Becker, 1993; Mincer, 1974) would suggest the opposite conclusion: wages should fall at later ages. Individuals invest in schooling and training at the early stages of their working life, gradually reducing the rate of investment as the time over which they can recoup their investment dwindles with age. As a result, wages should rise with age and experience as the stock of general human capital increases, but they should eventually fall when the loss of general human capital through depreciation exceeds gross investment.

In the general human capital model, wages and productivity move in tandem. In the specific human capital model, bonding considerations may drive wedges between wages and marginal products, thus predictions of declining wages at older ages are less robust. Jean and Nicoletti (2002) report estimates of earning profiles for 12 OECD countries, half of which have wages falling slightly for those aged 55 and over; only in three countries do they increase in old age. OECD (1999) reports age-earnings profiles for 20 OECD countries, all of which plateau around the early 50s, decreasing slightly thereafter. Additionally, if part of the initial training effort is financed by the employer, their workers will be expected to reimburse this extra cost at later stages of his/her working life by accepting wages lower than productivity.

52. Another important dimension of policies aimed at increasing the employability of non-employed old-age workers is the degree to which they upgrade their human capital and skills. These workers are likely to be less attractive to employers than the average old-age worker because job-holders may have more opportunities to upgrade their human capital, while non-employed workers may lose both general human capital and specific skills as their ties with the labour market are loosened. This would put them at a disadvantage relative to younger workers, to the extent that they have limited incentives to re-invest in their human capital given their relatively short residual working life.

53. There are only scattered pieces of evidence that could suggest a link between the level of human capital and employment for older workers. First, the level of education of employed old-age workers is higher than the level of education of the population in the same age group in all but two OECD countries (Figure 5.8). Second, trained workers participate more in the labour market and have lower unemployment rates than their non-trained counterparts (OECD, 2004); training and participation and employment rates are well correlated in OECD countries (Figure 5.9).[27] Third, the empirical research on displaced workers (Fallick, 1996; Farber 1993, 1996) shows that workers with higher skills and education are less at risk of losing their jobs.[28] Under the assumption that these findings apply to older workers as well, they would suggest that the low old-age employment rates could be partly explained by a lower average level of skills among these workers.

[Figure 5.8 Relative level of education of employed workers 55-64 years of age, 2000]
[Figure 5.9 Training and employment rates are correlated]

54. However, the returns on human capital investments tend to diminish with age and level of education (OECD, 2003, 2004). In particular, early retirement reduces incentives to train by shortening the period to recoup the investment costs. In this context, eliminating disincentives to longer working lives could make training a more attractive option for older workers. This endogenous adjustment mechanism could also help coping with the fact that older people are typically much more diverse than younger groups (Dean, 2003; EC, 2003).

55. Finally, policies increasing labour market participation and employability of older workers could also help in softening the competing demands for younger workers in the coming years, especially from the public sector, where the labour force is ageing more rapidly than in the rest of economy. OECD estimates suggest that, at current levels of labour force participation, the employment turnover generated by new hiring in the public sector may create substantial pressures in the labour market (Hoj and Toly, 2005). Given the large shares of public employment in OECD countries and that hiring has been often frozen due to budget consolidation pressures, the accelerated ageing in some public sectors is likely to lead to substantial replacement needs (even considering lower demand for public services). If these needs are to be satisfied by new cohorts entering the labour market, this would risk pre-empting the private sector's access to new labour market entrants, which in the past have been a source of flexibility.

6. Ageing and growth: some illustrative simulations

56. Bearing in mind the illustrative nature of simulation exercises, it is possible to draw on the results established in previous sections to gauge how ageing and policy and institutional arrangements jointly affect economic growth during the demographic transition. To this end, the general equilibrium model presented in Section 4 was modified in order to account for labour quality effects and policies aimed at increasing labour force participation. Simulation results are summarized by means of a growth decomposition of GDP *per capita* growth (Table 6.1) and the implied long-run patterns of GDP *per capita* convergence *vis-à-vis* the United States (Figure 6.1). Four scenarios are displayed: the three policy scenarios discussed in Section 4, and an additional scenario incorporating both 'pension saving' (*i.e.,* replacement rates are adjusted in order to balance the pension system) and the 'optimistic' labour force projections of Burniaux *et al*. (2003). The projections reflect the impact of in-depth reforms raising the retirement age and improving incentives to continue working in old age, as well as enhancing women's and youth participation in the labour force.

[Table 6.1 Breakdown of the GDP *per capita* growth rate
[Figure 6.1: Ageing and GDP *per capita* convergence]

57. In the scenario of increasing contribution rates, the interaction of the ageing trends and the lack of reforms drags down GDP *per capita* growth in all countries up to 2030. This effect is particularly stark in France, Germany and, especially, Japan, where growth continues to stagnate even in the two following decades. For a while, the negative effect of ageing on the growth of labour supply is partially compensated by a growth contribution of capital deepening in excess of its steady-state (stable population) rate. However, the contribution of capital deepening gradually weakens during the first phase of the ageing transition, stabilising rapidly at its steady-state level (0.45%). From 2030 onwards, the population structure starts to stabilise and GDP *per capita* growth tends to converge towards its long-run equilibrium value of around 1.5% *per annum*, *i.e.* the exogenous rate of TFP growth. Overall, labour supply and capital deepening are much more influential drivers of growth than the effects of labour quality, which naturally wear themselves out during the projection period in the absence of steady improvements in the human capital of new cohorts. It should be noted, however, that increased labour quality may have a favourable impact on total factor productivity growth through specific channels (*e.g.* endogenous growth effects), which are not captured in the model.

58. These results imply that, under the no-reform scenario, ageing may translate *ceteris paribus* into diverging GDP *per capita* levels between OECD countries, with widening gaps *vis-à-vis* the United States. As shown in Figure 6.1, the gaps would increase significantly from the current 25-28 to around 35 percentage points in most countries by 2050.

59. The simulations suggest that policies aimed at strengthening incentives to save and eliminating disincentives to early retirement and labour force participation of other segments of the population, can significantly soften the effects of ageing on growth. Pension saving tends to sustain growth by increasing the contribution of capital deepening to labour productivity growth. This effect is stronger in rapidly-ageing countries, due to a shrinking labour force. Therefore, in Japan, Germany and, especially, France, GDP *per capita* gaps relative to the United States would tend to widen less than in the baseline scenario, where the burden of the demographic adjustment falls on contribution rates. Increasing retirement age in line with longevity gains would lead to less capital deepening and also would alleviate (and in the case of France would neutralise) the decline in labour supply. The net effect would be to boost growth relative to the pension saving scenario in France and Germany, which have the widest scope for increasing labour force participation of old-age workers. For this reason, GDP *per capita* gaps relative to the United States also tend to widen less than in the baseline scenario in these countries. None of the policy scenarios, however, would lead to resumed convergence of GDP *per capita* levels *vis-à-vis* the United States.

60. Only in the scenario combining deep labour market reforms (the 'optimistic' scenario of Burniaux *et al.*, 2003) and "pension saving", is the income gap *vis-à-vis* the United States substantially reduced in all countries, and even reversed in Germany. This is due to comparatively stronger growth in this country over the first two decades of the century, as labour force participation increases. Thus, the simulations suggest that implementing piecemeal reforms is not the most efficient way to eliminate the policy-induced growth losses in the context of ageing. Combining pension and labour market reforms is likely to provide the best remedy to such losses and can, in some cases, offset the tendency of differential demographic developments to exacerbate income gaps among OECD countries.

NOTES

1 . These data were gathered in the context of the OECD/DELSA Project "Ageing and Employment Policies".

2 . The average age for the first child increased in Europe from around 23 years in 1960s to above 28 years by 2000, see Van Wissen (2004).

3 . The net reproduction rate is the average number of baby girls that will survive until childbearing age, born to a woman experiencing the age-specific fertility and mortality rates of the year in question. When this rate is equal to one for a sufficiently long period, the population stabilises.

4 . This debate emerged from a massive underestimation of actual longevity gains in most countries (Oeppen and Vaupel, 2002; EC, 2003; and Barbi, 2003). Longevity trends have been mainly driven by environmental, economic and social factors (Vaupel, 2002; Yashin, 2003; Lichtenberg, 2003).

5 . The OECD Secretariat was not in a position carry out its own population projections based on higher and harmonised assumptions across countries.

6 . If saving is invested, capital accumulation is not affected but potential income (as opposed to output) growth still is.

7 . To be precise, the consumption profile is hump-shaped across households headed by individuals belonging to different age groups.

8 . Due to the lack of data, it will be assumed that the snapshot picture of total consumption per household by age-groups approximates the life-time consumption profile of a cohort (*e.g. static* ageing as opposed to *dynamic* ageing). This approach takes an agnostic view on how a combination of various household characteristics in conjunction with institutional factors in each country affects the life-cycle consumption pattern. Fernandez-Villaverde and Krueger (2002) suggest that the bias induced by the use of age-groups instead of cohorts may not be very large for the estimation of the hump-shaped consumption profiles.

9 . Attanasio (1999) provides an overview of competing theories of consumption behaviour over the life cycle.

10 . The estimates were carried out using country fixed-effects.

11. It is worth noting, however, that the estimated coefficients are robust to accounting for the potential endogeneity of some of the regressors by using their lagged values.

12. The increase in housing expenditure is due to the fact that the imputed average market (rental) value of owned housing remains relatively high at the age of 75 years and above. As an aside, this reveals a strong potential for the development of reverse mortgage schemes (see Section 4).

13 . The projected demand (*D*) in composite goods *l* at time *t* is defined by:

$$D_{lt} = \sum_i Inc_{it} \cdot APC_{i.} \cdot NH_{it} \cdot \alpha_{il}$$

Where Inc_{it}, $APC_{i.}$, NH_{it}, α_{il} denote the average household income of age group *i* at time *t*, the propensity to consume by age group *i*, number of households headed by the person belonging to the age group *i*, and the share of composite commodity *l* out of total consumption by the age group *i*. Income is considered to be first split between total consumption and savings, and secondly across the different consumption goods.

14 . To some extent, the lower rise in the share of housing expenditure in the United States and Japan reflects the fact that only mortgage payments and maintenance costs related to owned housing are covered in these countries. For instance, the family income and expenditure survey in Japan does not report the expenses associated with the purchase of house. By contrast, the EU household surveys include imputed rental from owner-occupied housing.

15 . To save space, the following items are not shown in the figures: Food, Clothing, Household durables, Transport services, Communications.

16 . This benchmark was taken from the French pension reform. It corresponds roughly to an actuarially fair penalty rate, assuming a long-run real interest rate at 3%.

17 . For a production function with labour-augmenting autonomous technical progress (Harrod-neutral), the growth of labour productivity growth (*y-l*) can be decomposed as:

$$y - l = (1 - \alpha_k) \cdot tfp + \alpha_k \cdot (k - l)$$

where *y*, *k*, *l* and *tfp* and represent output, capital, labour, total factor productivity, respectively, denoting growth rates with lower case letters; and α_k the share of capital in value added. The contribution to labour productivity of capital deepening (*k-l*) is simply $\alpha_k(k-l)$. Given that the capital to labour defined in efficiency units (*K/TFP.L*) is constant in the long-run, the growth rate of the (*K/L*) ratio is equal to TFP growth. Therefore, in the steady state, the expression $\alpha_k(k-l)$ is equal to 0.45% *per annum* (assuming a capital share equal to 0.3 and TFP growth of 1.5% *per annum*).

18 . Arguments raising doubts about the accuracy of the asset-meltdown argument can also be found in Schich (2004). In particular, rational expectations do not support an asset meltdown. Furthermore, financial assets may be withdrawn at a slower rate than the life-cycle hypothesis would suggest when considering bequest motives and longevity risks.

19 . An analysis of these precautionary savings for the French case can be found in Bernard *et al.* (2002).

20 . Welfare gains from buying annuities are negatively related to life expectancy. For instance, due to longevity differentials, they are lower in Japan, Spain, Sweden or Switzerland than in Poland, Czech Republic, Hungary or Turkey.

21 . These projections were obtained using the cohort methodology proposed by Burniaux *et al.* (2003) applied to the national population projections used in this study.

22 . As an aside, if the relationship between age and productivity is bell-shaped, the rejuvenation of the labour force during the 1970s, which decreased significantly the average age of the labour force, must have had a negative impact on productivity levels (not to be confused with total factor productivity growth) (Feyrer, 2002). An analysis of the relationship between ageing and the average age of the labour force can also be found in Blanchet (2001).

23. These weights correspond to the relative wages by level of education observed in the United States. They are 1, 1.4, 1.7 and 2.6 respectively for primary, lower-secondary, upper-secondary and tertiary education (OECD, *Education at a Glance*, 2004, p.175).

24 . The results for Germany are driven by its specific dual educational system, but they are also affected by the large numbers of unclassified individuals. These factors could explain why in the OECD Education data base, younger groups appear to be less educated than older ones, generating a somewhat counter-intuitive result.

25 . Burniaux *et al.* (2003) simulated three different types of reform to increase labour force participation of older workers: *i)* a removal of early retirement schemes; *ii)* a move towards actuarial neutrality of old-age pension systems; *iii)* a convergence of standard retirement age to 67 (*i.e.* currently the highest age level among OECD countries). This study also simulates different scenarios that could potentially increase the labour force participation of women by modifying their incentives to work part- and full-time. The 'most optimistic' scenario used here combines the effect of these different reforms. This scenario is an upper-bound for labour force projections. For instance, it assumes, somewhat counterfactually, that women's participation in the labour force would progressively converge towards that of men. This would probably require creating a certain number of fiscal incentives with associated costs where feedback effects on participation and economic activity are not taken into account.

26 . Such an increase in labour participation would also have the advantage of preserving living standards amongst the elderly population and avoiding poverty traps in old age, which otherwise would create pressures on public social expenditures despite the introduction of privately-funded pension systems (Pestiau, 2003; McMorrow and Roeger, 2003). An in-depth and country-specific analysis of the policies enhancing the employability of older workers can be found in OECD (2003-2005).

27 . Estimates suggest that the addition of one extra year of average education has been historically associated in OECD countries with an increase of 1.1-1.7 percentage points in both participation and employment rates (OECD, 2004). Unfortunately, these results were based on data covering only people up to age 54.

28 . The literature on displaced workers suggests that displacement does not depend on age but on education, skills and tenure. Therefore, old-age workers are as likely to become displaced as other workers given the same level of education, skills and tenure. However, once old-age workers become displaced they tend to drop out of the labour force, particularly in European countries. The cost of displacement is non-negligible as displaced workers are less likely to find a job than other unemployed workers; they suffer longer spells of unemployment, and they experience a larger reduction in wages once they move back into employment. Farber (2003) finds an average wage loss in the United States close to 8% with a strong cyclical pattern, while Lefranc (2003) finds that wages losses for displaced workers in France are comparable to those in the United States and are in the order of 10-15%. Kuhn (2003) reports wage losses for displaced workers in several European countries. In addition, wage losses vary with previous job tenure and, thus, workers that had longer tenures suffer higher wage losses when re-employed (Farber, 2003; Kuhn, 2003).

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ANNEX 1: LIST OF FIGURES AND TABLES

Tables

Figures

Annex Figures: Detailed simulation results by country

Table 2.1 Underlying assumptions of population projections

	Fertility rate[1] 2000	Fertility rate[1] 2050	Life expectancy Men 2000	Life expectancy Men 2050[2]	Life expectancy Women 2000	Life expectancy Women 2050[2]
Australia	1.72	1.60	77.0	84.2	82.4	87.7
Austria	1.40	1.40	75.8	83.0	81.7	88.0
Belgium	1.62	1.74	75.0	83.9	81.5	88.9
Canada	1.48	1.48	77.2	80.0	81.2	84.0
Czech Republic	1.14	1.62	71.7	78.9	78.4	84.5
Denmark	1.73	1.85	74.9	81.0	79.5	84.0
Finland	1.73	1.73	74.1	79.5	81.0	84.6
France	1.79	1.80	75.0	84.3	82.4	91.0
Germany	1.40	1.40	75.0	81.1	81.0	86.6
Greece	1.27	1.85	75.7	79.7	80.9	84.9
Hungary	1.32	1.60	67.5	76.6	76.0	82.6
Iceland	1.95	2.05	78.7	82.1	82.5	84.1
Ireland	1.90	1.85	74.4	78.9	79.6	84.0
Italy	1.21	1.41	76.2	81.4	82.6	88.1
Japan	1.36	1.39	77.6	81.0	84.6	89.2
Korea	1.56	1.40	71.0	79.9	78.0	86.2
Luxemburg	1.73	1.85	75.1	80.8	81.4	86.5
Mexico	2.50	1.85	70.4	76.5	76.4	82.7
Netherlands	1.73	1.75	75.9	79.5	80.7	82.5
New Zealand	1.97	1.85	76.1	82.5	81.0	86.5
Norway	1.78	1.80	76.2	84.2	81.5	88.1
Poland	1.25	1.20	70.4	77.6	78.8	83.3
Portugal	1.56	1.71	72.9	79.0	79.9	84.7
Slovak Republic	1.15	1.70	69.8	77.1	77.8	85.6
Spain	1.22	1.42	75.5	77.7	82.7	85.5
Sweden	1.76	1.85	77.9	83.6	82.4	86.2
Switzerland	1.27	1.50	76.6	82.5	82.4	87.5
Turkey	2.43	1.85	68.0	76.0	73.2	81.0
United Kingdom	1.67	1.74	76.1	81.0	80.6	85.0
United States	2.05	2.22	74.1	81.2	79.8	86.7
OECD average	1.62	1.68	74.4	80.5	80.4	85.7

1. Children per women aged 15-49.
2. Except for Canada and Spain 2026, for Finland, Italy, Poland and United Kingdom 2030, for Iceland 2040 and for Switzerland 2060.
Source: OECD/DELSA Population Database.

Table 2.2 Increases in life expectancy for different age groups

Change in years over the last 40 years [1]

	Females					Males				
	at birth	at age 40	at age 60	at age 65	at age 80	at birth	at age 40	at age 60	at age 65	at age 80
Australia	8.1	6.5	5.3	4.8	2.8	8.7	6.9	5.2	4.4	2.0
Austria	9.3	6.1	5.3	4.9	2.5	10.0	6.1	5.0	4.2	2.2
Belgium	7.3	5.7	5.1	4.7	2.3	6.9	4.9	3.8	3.1	1.4
Canada	7.7	5.6	4.8	4.4	2.7	8.3	5.5	3.9	3.3	1.6
Czech Republic	5.0	3.4	2.8	2.6	1.4	3.8	1.4	1.4	1.2	0.5
Denmark	4.9	3.3	3.0	3.0	n.a	4.1	2.2	1.8	1.5	n.a
Finland	8.5	7.0	6.1	5.6	2.6	8.7	6.4	4.8	4.0	1.6
France	9.1	6.4	5.8	5.3	3.0	8.2	5.3	4.6	4.0	2.3
Germany	8.3	5.7	4.9	4.6	2.4	7.8	4.5	3.7	3.1	1.6
Greece	8.2	5.7	4.6	4.1	1.2	8.2	3.5	3.2	2.9	1.4
Hungary	5.6	2.3	2.6	2.5	1.5	1.3	-2.6	-0.3	0.3	0.9
Iceland	6.4	4.1	3.3	n.a	1.7	7.3	4.8	3.6	n.a	2.2
Ireland	7.3	5.0	3.8	3.3	n.a	6.1	3.7	2.5	2.0	n.a
Italy	10.1	n.a	n.a	n.a	n.a	9.1	n.a	n.a	n.a	n.a
Japan	14.4	10.6	9.1	8.3	4.7	12.4	8.1	6.6	5.9	3.1
Korea	25.5	n.a	n.a	n.a	n.a	20.6	n.a	n.a	n.a	n.a
Luxembourg	9.1	6.6	5.8	5.3	3.4	8.4	5.0	3.8	3.1	1.5
Mexico	17.3	6.6	4.3	3.7	2.0	15.8	5.2	3.0	2.6	1.6
Netherlands	5.1	4.4	4.1	3.9	2.1	4.0	2.7	1.8	1.4	0.7
New Zealand	6.9	5.1	4.4	4.2	2.8	7.0	5.3	3.9	3.4	1.9
Norway	5.6	4.1	3.8	3.7	1.9	4.7	2.7	2.0	1.5	0.5
Poland	7.3	3.0	2.7	2.4	1.2	4.8	0.1	0.8	0.9	0.9
Portugal	12.9	4.4	3.5	3.0	n.a	11.5	3.2	2.3	1.7	n.a
Slovak Republic	4.7	n.a	2.2	1.9	n.a	0.8	n.a	-0.7	-0.3	n.a
Spain	10.5	6.4	5.3	4.8	2.0	8.1	4.0	3.3	3.0	1.3
Sweden	7.1	5.6	5.0	n.a	2.6	6.2	4.2	3.4	n.a	1.4
Switzerland	8.1	6.6	5.8	n.a	3.0	8.2	5.9	4.7	n.a	1.9
Turkey	20.1	4.2	2.6	2.1	0.8	19.5	3.3	1.7	1.4	0.6
United Kingdom	6.5	4.9	4.1	3.8	2.3	7.5	5.7	4.4	3.7	1.7
United States	6.4	4.5	3.6	3.4	2.3	7.5	5.5	4.1	3.5	1.6
OECD average	9.1	5.3	4.4	4.0	2.3	8.2	4.2	3.2	2.6	1.5

1. 1960 (or 1961) to 2000 (or 1999).
Source: OECD Health Data.

Table 2.3. Comparison of past with projected gains in life expectancy

In number of years per decade

	(A) average gains 1960-2000	(B) projected gains 2000-2050[1]	Difference (B)-(A)
Australia	2.1	1.2	-0.9
Austria	2.4	1.4	-1.1
Belgium	1.8	1.6	-0.2
Canada	2.0	0.9	-1.1
Czech Republic	1.1	1.3	0.2
Denmark	1.1	1.1	-0.1
Finland	2.2	1.5	-0.7
France	2.2	1.8	-0.4
Germany	2.0	1.2	-0.8
Greece	2.1	0.8	-1.3
Hungary	0.9	1.6	0.7
Iceland	1.7	0.6	-1.1
Ireland	1.7	0.9	-0.8
Italy	2.4	1.8	-0.6
Japan	3.4	0.8	-2.6
Korea	5.8	1.7	-4.1
Luxembourg	2.2	1.1	-1.1
Mexico	4.1	1.2	-2.9
Netherlands	1.1	0.5	-0.6
New Zealand	1.7	1.2	-0.5
Norway	1.3	1.5	0.2
Poland	1.5	2.0	0.4
Portugal	3.1	1.1	-2.0
Slovak Republic	0.7	1.5	0.8
Spain	2.3	0.8	-1.5
Sweden	1.7	0.9	-0.7
Switzerland	2.0	0.9	-1.1
Turkey	5.0	1.6	-3.4
United Kingdom	1.8	1.6	-0.2
United States	1.7	1.4	-0.3
Average	*2.2*	*1.2*	*-0.9*

1. Except for Canada and Spain 2026, for Finland, Italy, Poland and United Kingdom 2030, for Iceland 2040 and for Switzerland 2060.

Source: OECD/DELSA Population database and OECD Health Data.

Table 2.4 Gains in Life Expectancy versus Disability-Free Life Expectancy

(In number of years per decade)

	Males				Females			
	At birth		At 65		At birth		At 65	
	LE	DFLE	LE	DFLE	LE	DFLE	LE	DFLE
Australia (1981-1998)	2.5	-0.9	1.3	-0.7	1.7	-0.9	1.1	-0.6
Canada (1986-1996)	2.0	0.1	1.0	0.3	1.2	0.2	0.6	0.6
Denmark (1987-2000)	2.0	n.a	0.8	1.7	1.1	n.a	0.2	0.8
Finland (1978-1994)	2.5	n.a	1.3	1.4	1.5	n.a	1.1	0.6
France (1981-1991)	2.3	2.7	1.5	1.2	2.4	2.4	1.6	2.1
Germany (1986-1995)	2.0	2.6	1.2	1.6	2.0	2.8	1.5	1.9
Japan (1975-1990)	2.6	3.1	1.6	1.6	3.1	2.9	2.1	1.6
Netherlands (1990-2000)	1.5	4.3	0.8	1.8	-0.4	4.2	0.3	3.0
Switzerland (1981-1992)	1.8	1.9	0.9	0.8	1.9	3.7	1.3	2.4
United Kingdom (1981-1999)	2.2	1.2	1.2	0.6	1.6	0.8	0.8	0.7
United States (1970-1990)	2.2	1.1	1.0	0.4	2.0	0.6	0.9	0.3

Source: OECD Health Data.

Table 3.1 **Econometric estimates of the impact of population structure on the household saving rate**

	Coefficients	student-t	Coefficients	student-t
Dependent variable: Household saving rate				
Control variables:				
Budget deficit [1]	-0.632	-7.5	-0.633	-7.5
Real interest rate [2]	0.321	3.4	0.327	3.5
GDP per capita	$8.58\ 10^{-6}$	4.4	$7.97\ 10^{-6}$	3.9
Inflation [3]	0.193	1.9	0.200	1.9
Share of population 25-59 [4]	0.778	2.8	0.558	1.6
Share of population 60-99 [4]	-4.267	-7.0	-4.322	-7.0
Share of public health expenditures [5]	-0.327	-3.9	-0.335	-3.9
Interaction pension replacement rates & prime-age population	-0.015	-4.1	-0.016	-4.2
Interaction pension replacement rates & old-age population	0.053	5.1	0.054	5.1
Life expectancy at birth	-0.400	-0.9	-0.845	-1.4
Time trend	..	..	0.173	1.0
R^2 within (country-fixed effects)	0.52		0.51	
Observations	254		254	
Period	1970-2003		1970-2003	
Countries	30		30	

1. Cyclically adjusted government net lending as a % of potential GDP.
2. Real short-term interest rate.
3. Based on CPI indices.
4. In total population.
5. Public expenditure on health as a % of total expenditure on health.

Source: OECD calculations.

Table 6.1. Breakdown of the GDP per capita growth rate [1]

United States

Participation rates frozen at their 2000 levels except in the gradually increasing age of retirement scenario

Annual percentage changes

	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2001-2050
'Rising contribution rate' scenario						
GDP per capita growth rate	**1.7**	**1.2**	**1.1**	**1.2**	**1.4**	**1.3**
Contribution of the labour apparent productivity	1.9	1.8	1.5	1.3	1.3	1.6
of which: contribution of the stock of capital per unit of labour	0.8	0.7	0.4	0.2	0.3	0.5
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	0.6	0.4	0.3	0.6	0.7	0.5
Contribution of the total population growth rate	-0.9	-0.9	-0.8	-0.8	-0.7	-0.8
'Pension saving' scenario						
GDP per capita growth rate	**1.8**	**1.4**	**1.2**	**1.3**	**1.4**	**1.5**
Contribution of the labour apparent productivity	2.0	1.9	1.6	1.4	1.4	1.7
of which: contribution of the stock of capital per unit of labour	1.0	0.9	0.6	0.3	0.3	0.6
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	0.6	0.4	0.3	0.6	0.7	0.5
Contribution of the total population growth rate	-0.9	-0.9	-0.8	-0.8	-0.7	-0.8
'Gradually increasing age of retirement' scenario						
GDP per capita growth rate	**1.8**	**1.4**	**1.2**	**1.4**	**1.5**	**1.4**
Contribution of the labour apparent productivity	1.9	1.8	1.5	1.2	1.4	1.6
of which: contribution of the stock of capital per unit of labour	0.8	0.7	0.4	0.2	0.3	0.5
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	0.8	0.5	0.5	1.0	0.7	0.7
Contribution of the total population growth rate	-0.9	-0.9	-0.8	-0.8	-0.7	-0.8

'Pension saving' scenario, including effects of past and potential future policies on future participation rates and age of retirement [2]

Annual percentage changes

	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2001-2050
GDP per capita growth rate	**1.9**	**1.6**	**1.4**	**1.4**	**1.5**	**1.6**
Contribution of the labour apparent productivity	1.9	1.8	1.7	1.4	1.4	1.6
of which: contribution of the stock of capital per unit of labour	0.9	0.7	0.6	0.3	0.3	0.6
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	0.7	0.6	0.4	0.7	0.7	0.6
Contribution of the total population growth rate	-0.9	-0.9	-0.8	-0.8	-0.7	-0.8

Table 6.1 (cont.) Breakdown of the GDP per capita growth rate [1]

Japan

Participation rates frozen at their 2000 levels except in the gradually increasing age of retirement scenario

Annual percentage changes

	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2001-2050
'Rising contribution rate' scenario						
GDP per capita growth rate	**1.0**	**1.0**	**1.0**	**1.0**	**1.1**	**1.0**
Contribution of the labour apparent productivity	1.6	1.6	1.5	1.5	1.6	1.6
of which: contribution of the stock of capital per unit of labour	0.6	0.5	0.4	0.5	0.6	0.5
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	-0.4	-0.7	-0.8	-1.0	-1.4	-0.8
Contribution of the total population growth rate	-0.3	0.1	0.4	0.6	0.8	0.3
'Pension saving' scenario						
GDP per capita growth rate	**1.1**	**1.2**	**1.3**	**1.3**	**1.3**	**1.2**
Contribution of the labour apparent productivity	1.8	1.8	1.7	1.8	1.8	1.8
of which: contribution of the stock of capital per unit of labour	0.7	0.7	0.6	0.7	0.7	0.7
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	-0.4	-0.7	-0.8	-1.0	-1.4	-0.8
Contribution of the total population growth rate	-0.3	0.1	0.4	0.6	0.8	0.3
'Gradually increasing age of retirement' scenario						
GDP per capita growth rate	**1.0**	**1.0**	**1.2**	**1.2**	**1.1**	**1.1**
Contribution of the labour apparent productivity	1.6	1.5	1.5	1.6	1.7	1.6
of which: contribution of the stock of capital per unit of labour	0.6	0.5	0.4	0.5	0.7	0.5
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	-0.3	-0.6	-0.4	-0.9	-1.6	-0.7
Contribution of the total population growth rate	-0.3	0.1	0.4	0.6	0.8	0.3

'Pension saving' scenario, including effects of past and potential future policies on future participation rates and age of retirement [2]

Annual percentage changes

GDP per capita growth rate	**1.2**	**1.5**	**1.6**	**1.3**	**1.4**	**1.4**
Contribution of the labour apparent productivity	1.6	1.7	1.8	1.9	1.8	1.7
of which: contribution of the stock of capital per unit of labour	0.5	0.6	0.7	0.8	0.7	0.7
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	-0.2	-0.4	-0.5	-1.1	-1.3	-0.7
Contribution of the total population growth rate	-0.3	0.1	0.4	0.6	0.8	0.3

Table 6.1 (cont.) Breakdown of GDP per capita growth rate [1]

France

Participation rates frozen at their 2000 levels except in the gradually increasing age of retirement scenario

Annual percentage changes

	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2001-2050
'Rising contribution rate' scenario						
GDP per capita growth rate	**1.2**	**0.9**	**0.8**	**0.9**	**1.1**	**1.0**
Contribution of the labour apparent productivity	1.7	1.6	1.4	1.3	1.3	1.5
of which: contribution of the stock of capital per unit of labour	0.6	0.5	0.4	0.2	0.3	0.4
of which: contribution of TFP	1.0	1.0	1.1	1.0	1.0	1.0
Contribution of the labour force growth rate	0.1	-0.3	-0.3	-0.2	-0.3	-0.2
Contribution of the total population growth rate	-0.6	-0.4	-0.3	-0.2	0.0	-0.3
'Pension saving' scenario						
GDP per capita growth rate	**1.4**	**1.1**	**1.1**	**1.1**	**1.3**	**1.2**
Contribution of the labour apparent productivity	1.8	1.8	1.7	1.5	1.6	1.7
of which: contribution of the stock of capital per unit of labour	0.8	0.7	0.6	0.4	0.5	0.6
of which: contribution of TFP	1.0	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	0.1	-0.3	-0.3	-0.2	-0.3	-0.2
Contribution of the total population growth rate	-0.6	-0.4	-0.3	-0.2	0.0	-0.3
'Gradually increasing age of retirement' scenario						
GDP per capita growth rate	**1.3**	**1.1**	**1.1**	**1.3**	**1.4**	**1.2**
Contribution of the labour apparent productivity	1.6	1.5	1.5	1.3	1.5	1.5
of which: contribution of the stock of capital per unit of labour	0.5	0.5	0.4	0.2	0.4	0.4
of which: contribution of TFP	1.0	1.0	1.0	1.0	1.0	1.0
Contribution of the labour force growth rate	0.3	0.1	-0.1	0.2	-0.1	0.1
Contribution of the total population growth rate	-0.6	-0.4	-0.3	-0.2	0.0	-0.3

'Pension saving' scenario, including effects of past and potential future policies on future participation rates and age of retirement[2]

Annual percentage changes

GDP per capita growth rate	**1.6**	**1.5**	**1.4**	**1.2**	**1.4**	**1.4**
Contribution of the labour apparent productivity	1.5	1.7	1.7	1.6	1.6	1.6
of which: contribution of the stock of capital per unit of labour	0.5	0.6	0.6	0.5	0.5	0.6
of which: contribution of TFP	1.0	1.0	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	0.7	0.3	0.0	-0.3	-0.2	0.1
Contribution of the total population growth rate	-0.6	-0.4	-0.3	-0.2	0.0	-0.3

Table 6.1 (cont.) Breakdown of the GDP per capita growth rate [1]

Germany

Participation rates frozen at their 2000 levels except in the gradually increasing age of retirement scenario

Annual percentage changes

	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2001-2050
'Rising contribution rate' scenario						
GDP per capita growth rate	**1.2**	**1.1**	**0.9**	**1.2**	**1.2**	**1.1**
Contribution of the labour apparent productivity	1.6	1.6	1.6	1.4	1.5	1.5
of which: contribution of the stock of capital per unit of labour	0.5	0.5	0.5	0.4	0.4	0.5
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	0.1	-0.4	-0.8	-0.5	-0.6	-0.5
Contribution of the total population growth rate	-0.4	-0.1	0.1	0.3	0.4	0.1
'Pension saving' scenario						
GDP per capita growth rate	**1.3**	**1.3**	**1.1**	**1.4**	**1.4**	**1.3**
Contribution of the labour apparent productivity	1.7	1.7	1.7	1.6	1.6	1.7
of which: contribution of the stock of capital per unit of labour	0.6	0.7	0.6	0.5	0.6	0.6
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	0.1	-0.4	-0.8	-0.5	-0.6	-0.5
Contribution of the total population growth rate	-0.4	-0.1	0.1	0.3	0.4	0.1
'Gradually increasing age of retirement' scenario						
GDP per capita growth rate	**1.3**	**1.4**	**1.0**	**1.6**	**1.3**	**1.3**
Contribution of the labour apparent productivity	1.5	1.5	1.5	1.4	1.6	1.5
of which: contribution of the stock of capital per unit of labour	0.5	0.5	0.5	0.3	0.6	0.5
of which: contribution of TFP	1.1	1.1	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	0.3	0.0	-0.6	0.0	-0.6	-0.2
Contribution of the total population growth rate	-0.4	-0.1	0.1	0.3	0.4	0.1

'Pension saving' scenario, including effects of past and potential future policies on future participation rates and age of retirement [2]

Annual percentage changes

	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2001-2050
GDP per capita growth rate	**1.9**	**1.7**	**1.4**	**1.4**	**1.4**	**1.6**
Contribution of the labour apparent productivity	1.3	1.6	1.8	1.7	1.6	1.6
of which: contribution of the stock of capital per unit of labour	0.3	0.6	0.7	0.6	0.6	0.5
of which: contribution of TFP	1.0	1.0	1.1	1.1	1.1	1.1
Contribution of the labour force growth rate	1.0	0.3	-0.5	-0.6	-0.6	-0.1
Contribution of the total population growth rate	-0.4	-0.1	0.1	0.3	0.4	0.1

1. The GDP per capita growth is decomposed here into three contributions. The contribution of the labour apparent productivity is the sum of the contribution of the growth of the capital per unit of labour and the contribution of the TFP. Since TFP is 1.5% and that it is assumed labour-augmenting, TFP contribution amounts to 0.7*1.5% (0.7 being the share of labour in output). The contribution of the labour force growth is equal to the contribution of the employed population, since unemployment rates are frozen in the model after 2000. The contribution of total population is negative when total population grows.

2. Following Burniaux *et al*. (2003).

Source: OECD calculations.

Figure 2.1 Shifts in fertility regimes in selected European countries

(Net reproduction rates)

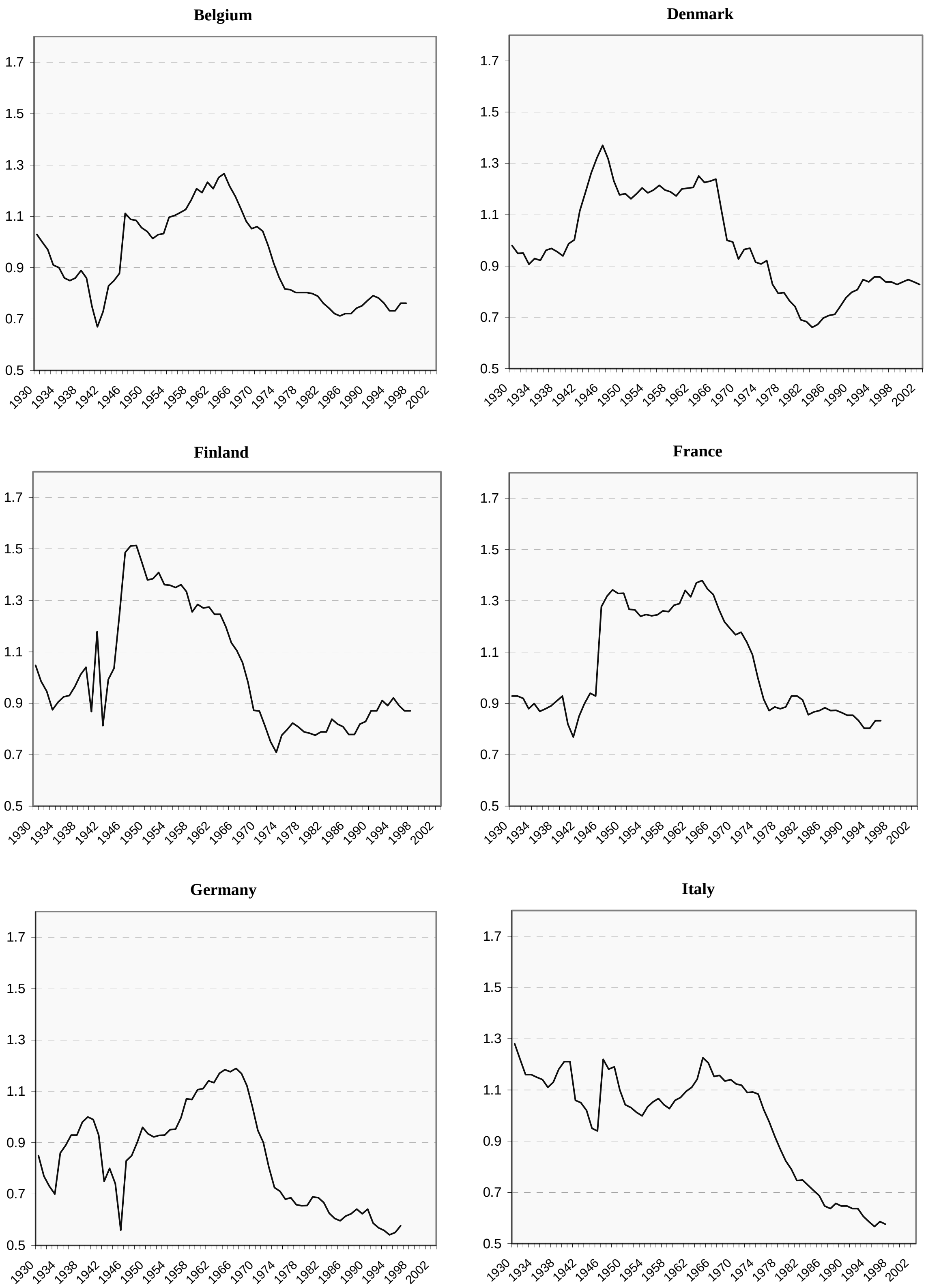
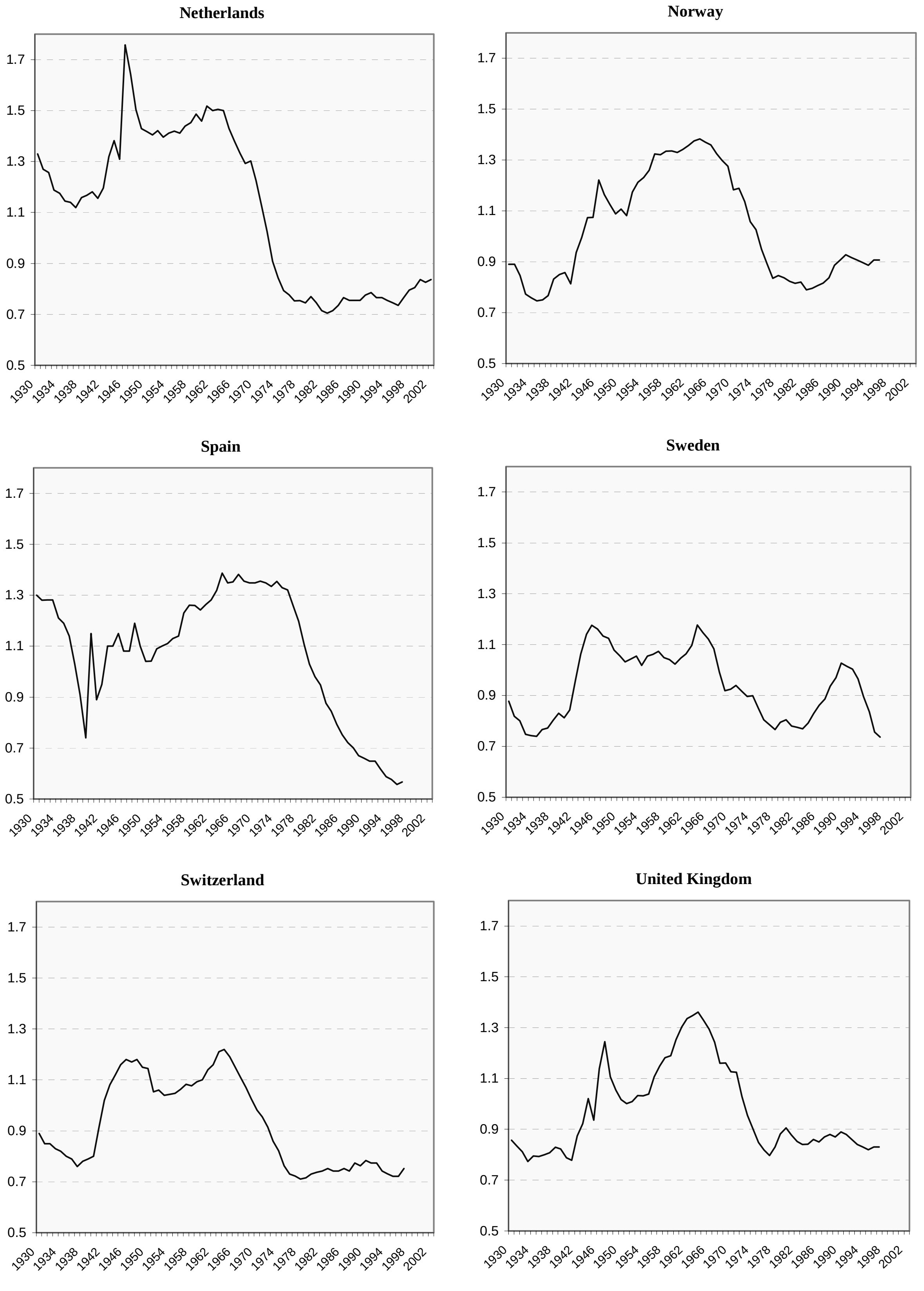


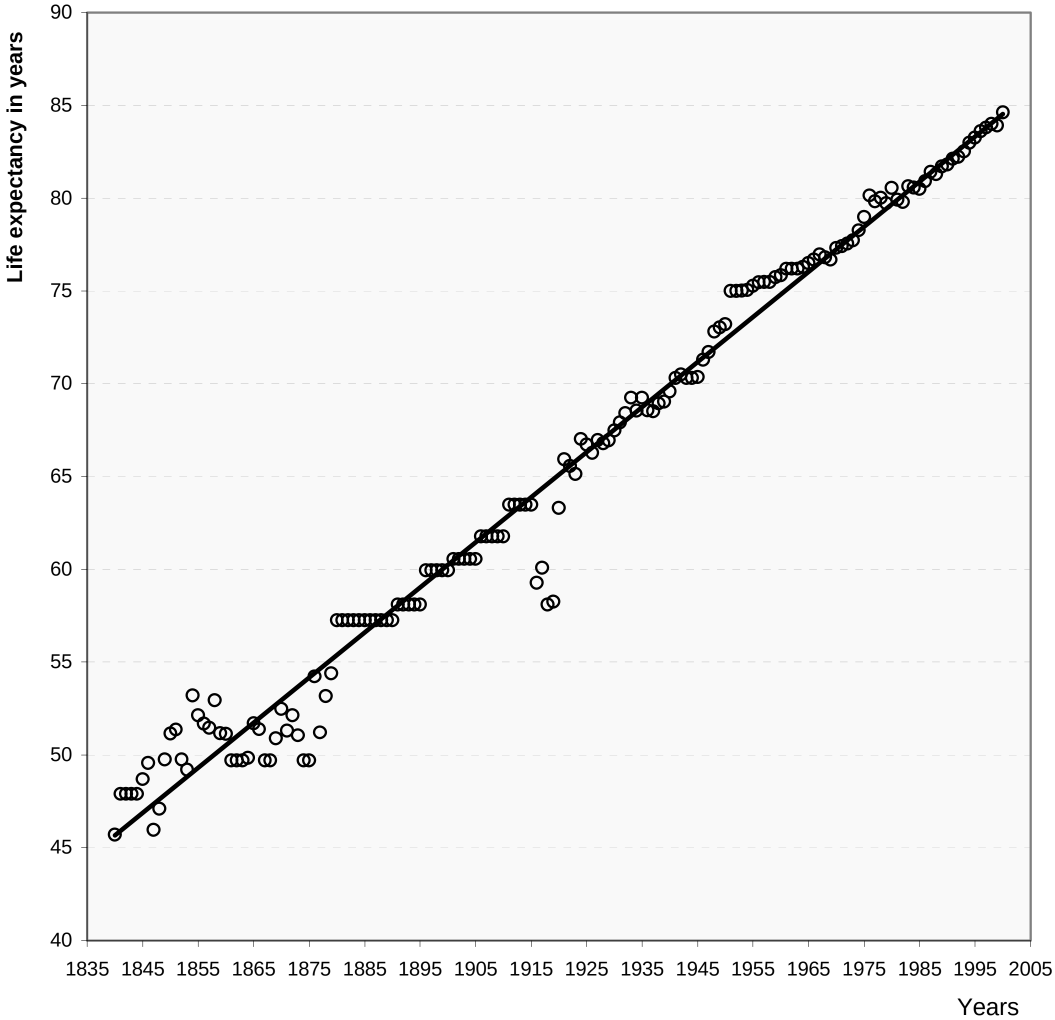
Figure 2.1 (cont'd) Shifts in fertility regimes in selected European countries

(Net reproduction rates)



Source : National Statistical Institutes, Bonneuil (2003) and Eurostat.

Figure 2.2 Historical trends in female life expectancy, 1840-2000 [1]



1. Country with the highest life expectancy. The linear trend: slope=2.43 and R^2=0.98.
Source: Oeppen and Vaupel (2002).

Figure 2.3. **Simulations of the impact of longevity indexation on dependency ratios**

Dependency ratio [1]

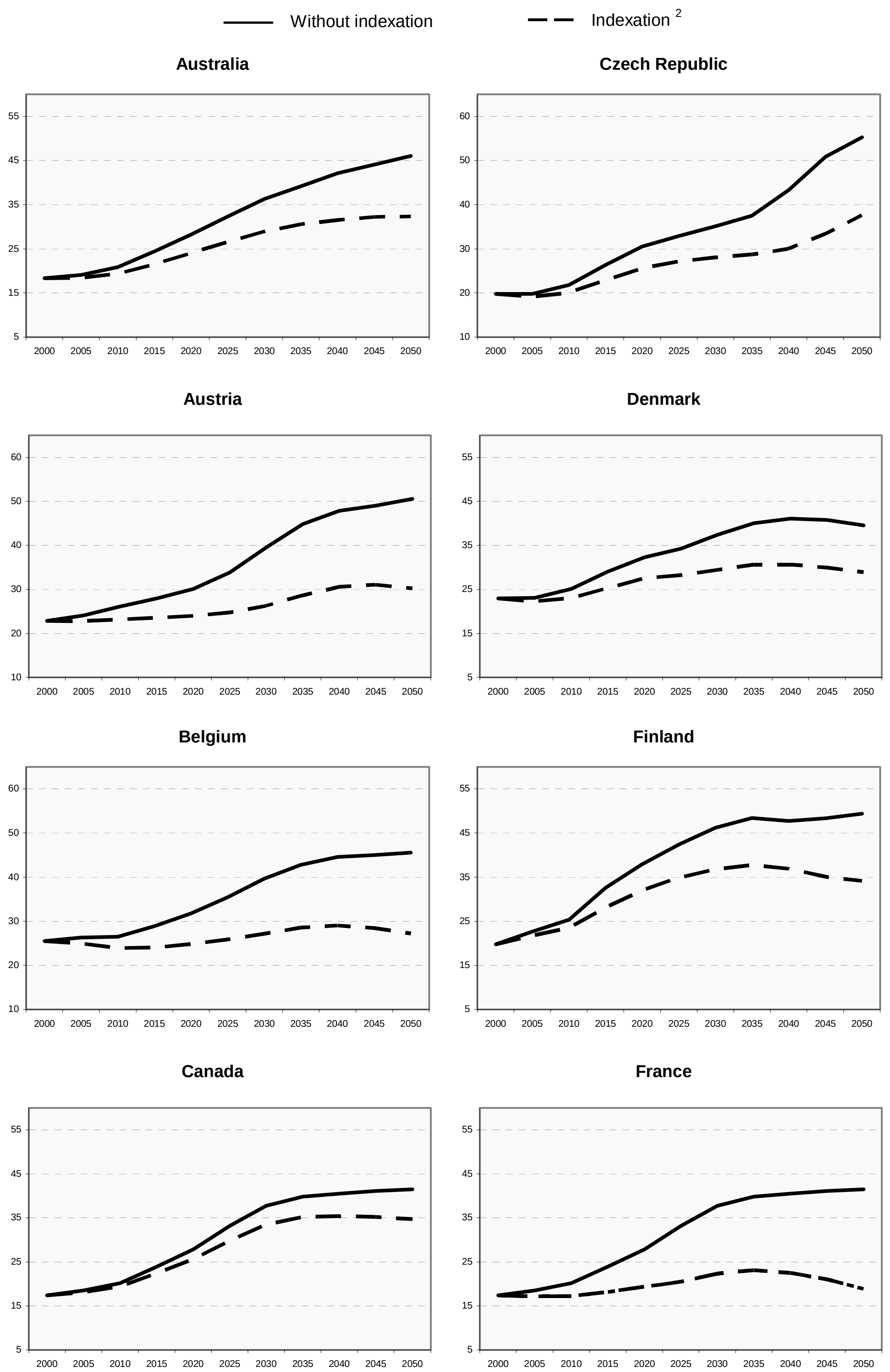


Figure 2.3 (cont'd)**. Simulations of the impact of longevity indexation on dependency ratios**

Dependency ratio [1]

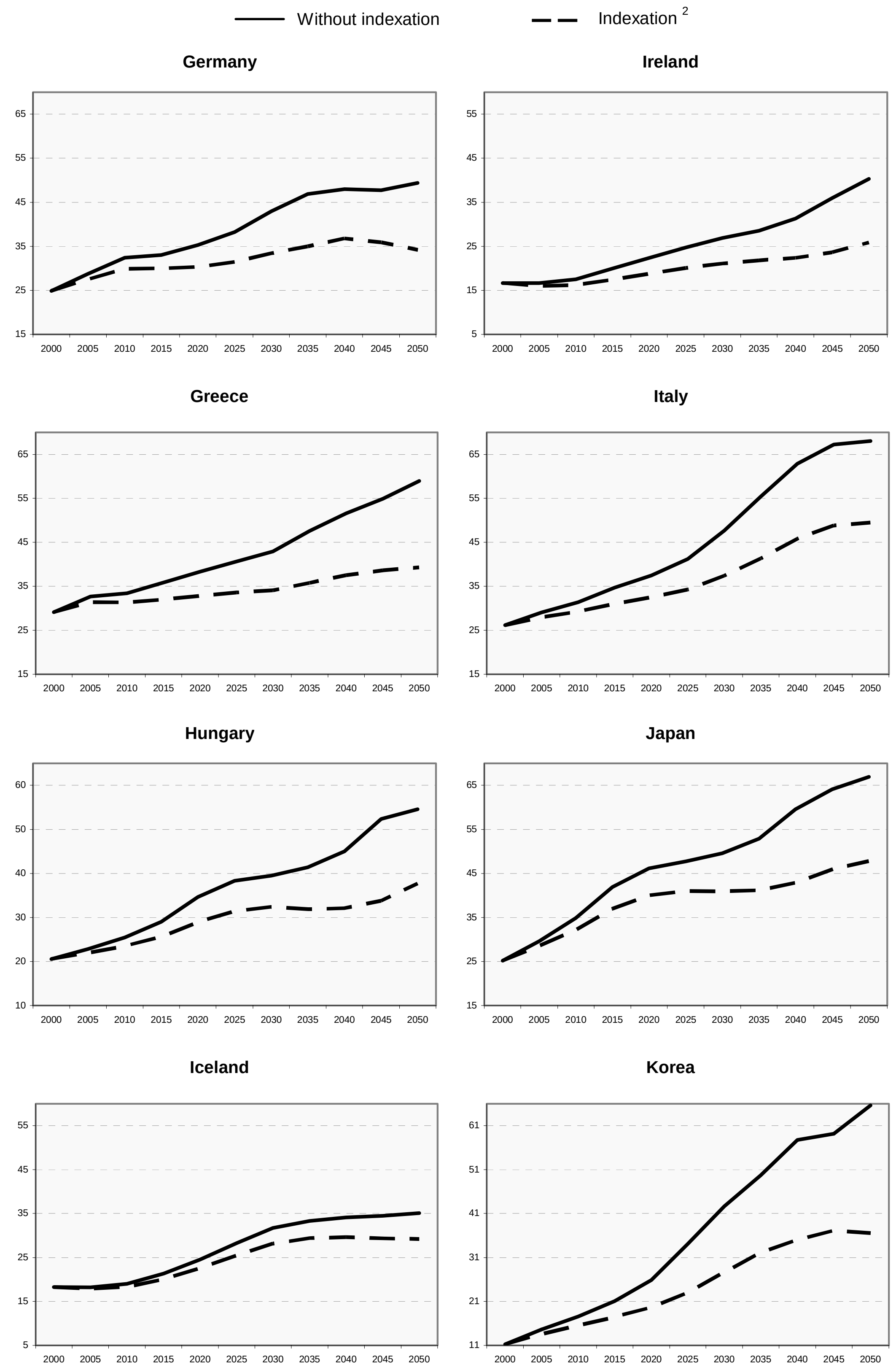


Figure 2.3 (cont'd). **Simulations of the impact of longevity indexation on dependency ratios**

Dependency ratio [1]

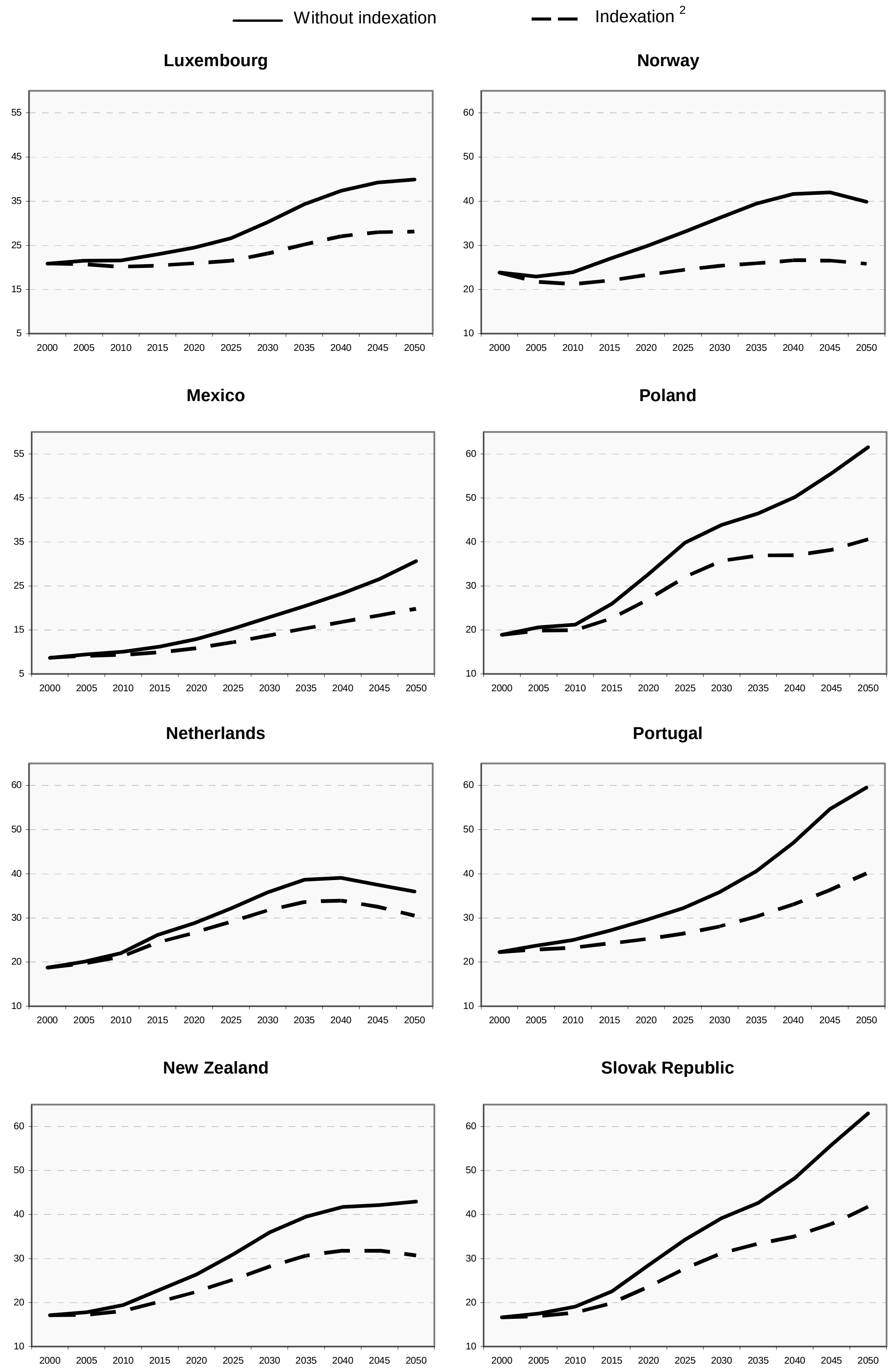
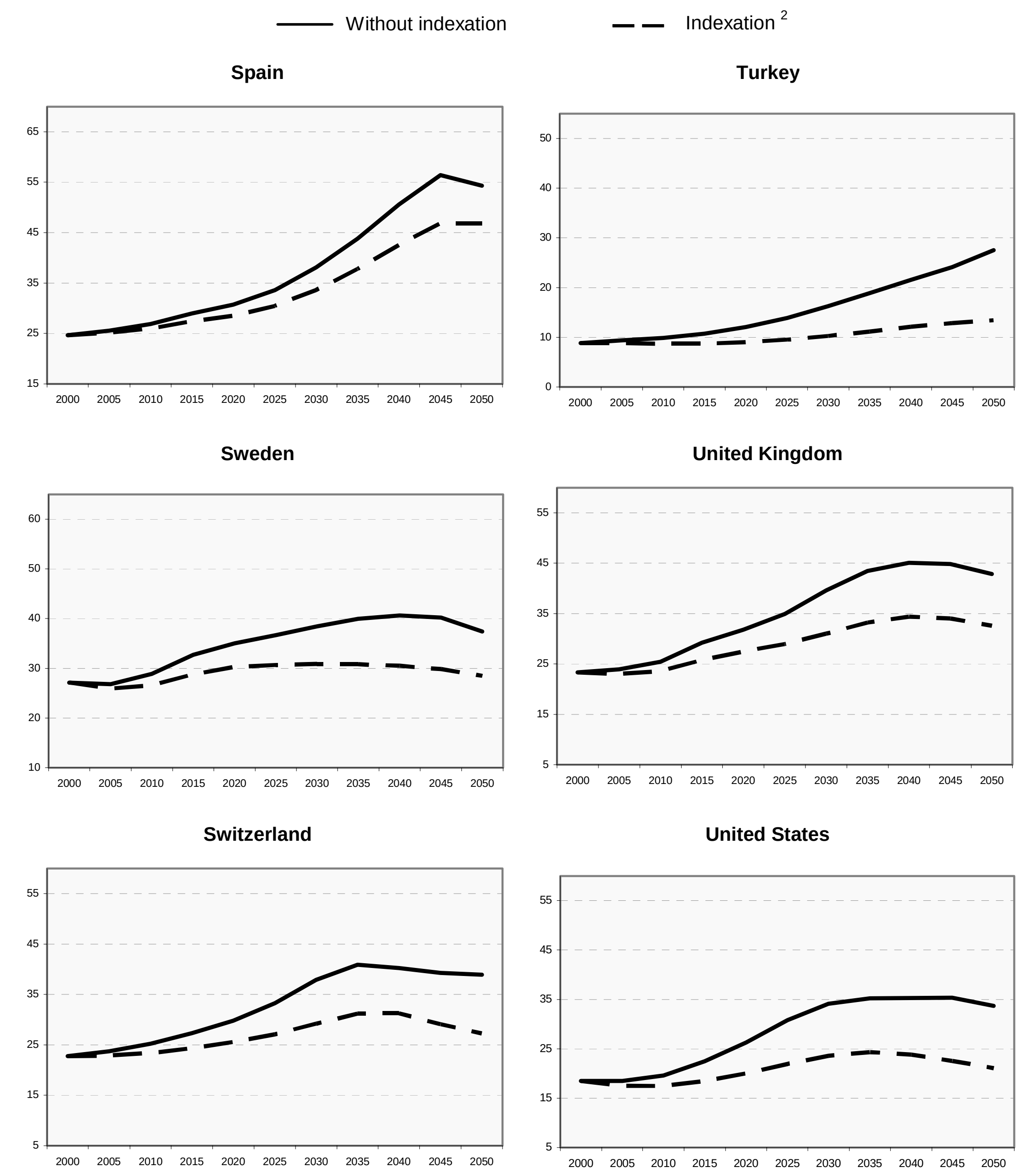


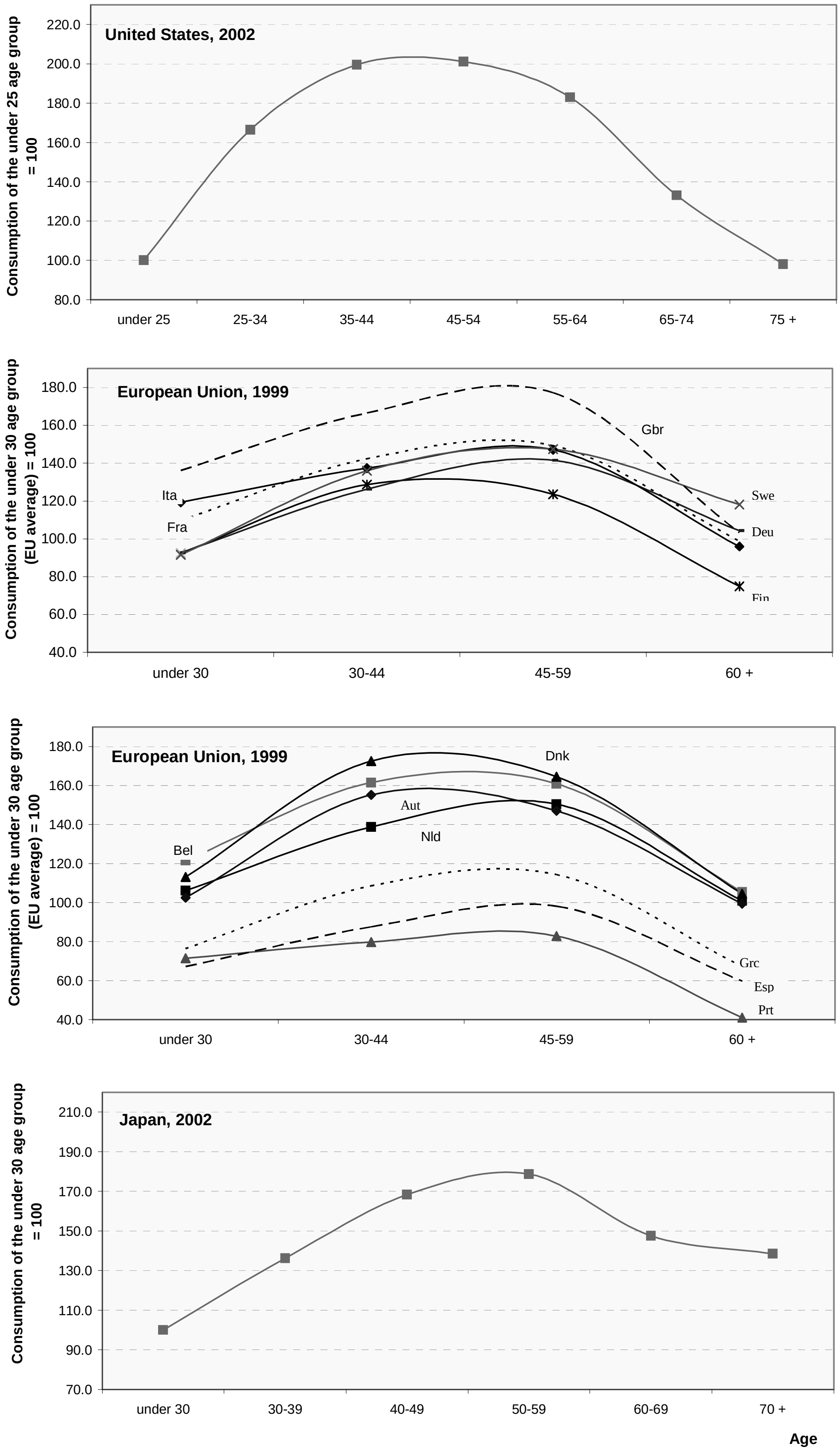
Figure 2.3 (cont'd). **Simulations of the impact of longevity indexation on dependency ratios**

Dependency ratio [1]



1. Defined as the share of the 65+ population over the 15-64 years old.
2. Old-age threshold indexed in line with life expectancy gains underlying national projections (see table 2.3).
Source: OECD/DELSA Population Database.

Figure 3.1 Relationship between consumption and age groups



Source : Consumer Expenditure Survey for the US, Household Budget Survey of Eurostat and Luxembourg Income Study (LIS) for EU countries, and Family Income and Expenditure Survey for Japan.

Figure 3.2 **Consumption smoothing over the life cycle: an illustration**

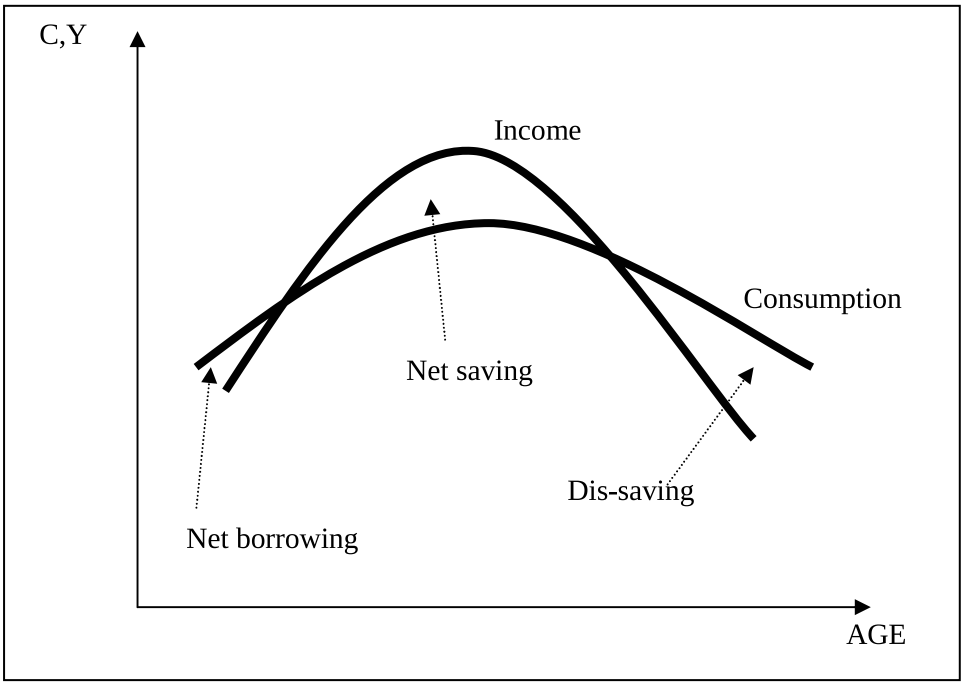
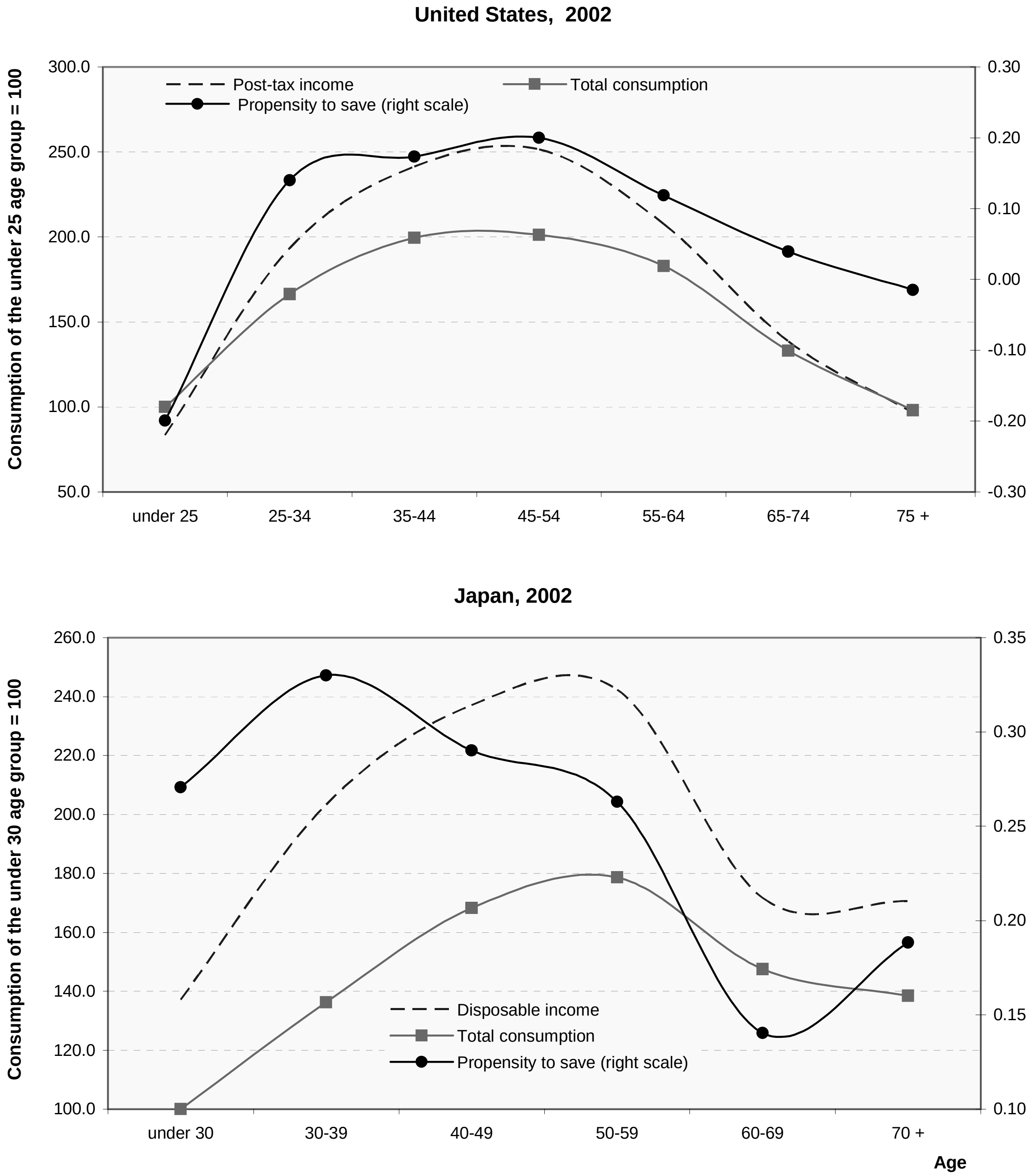


Figure 3.3 Consumption smoothing: evidence from household surveys



Source : Consumer Expenditure Survey for the US, Household Budget Survey of Eurostat and Luxembourg Income Study (LIS) for EU countries, and Family Income and Expenditure Survey for Japan.

Figure 3.4 Relationship between age and consumption by expenditure items
Housing

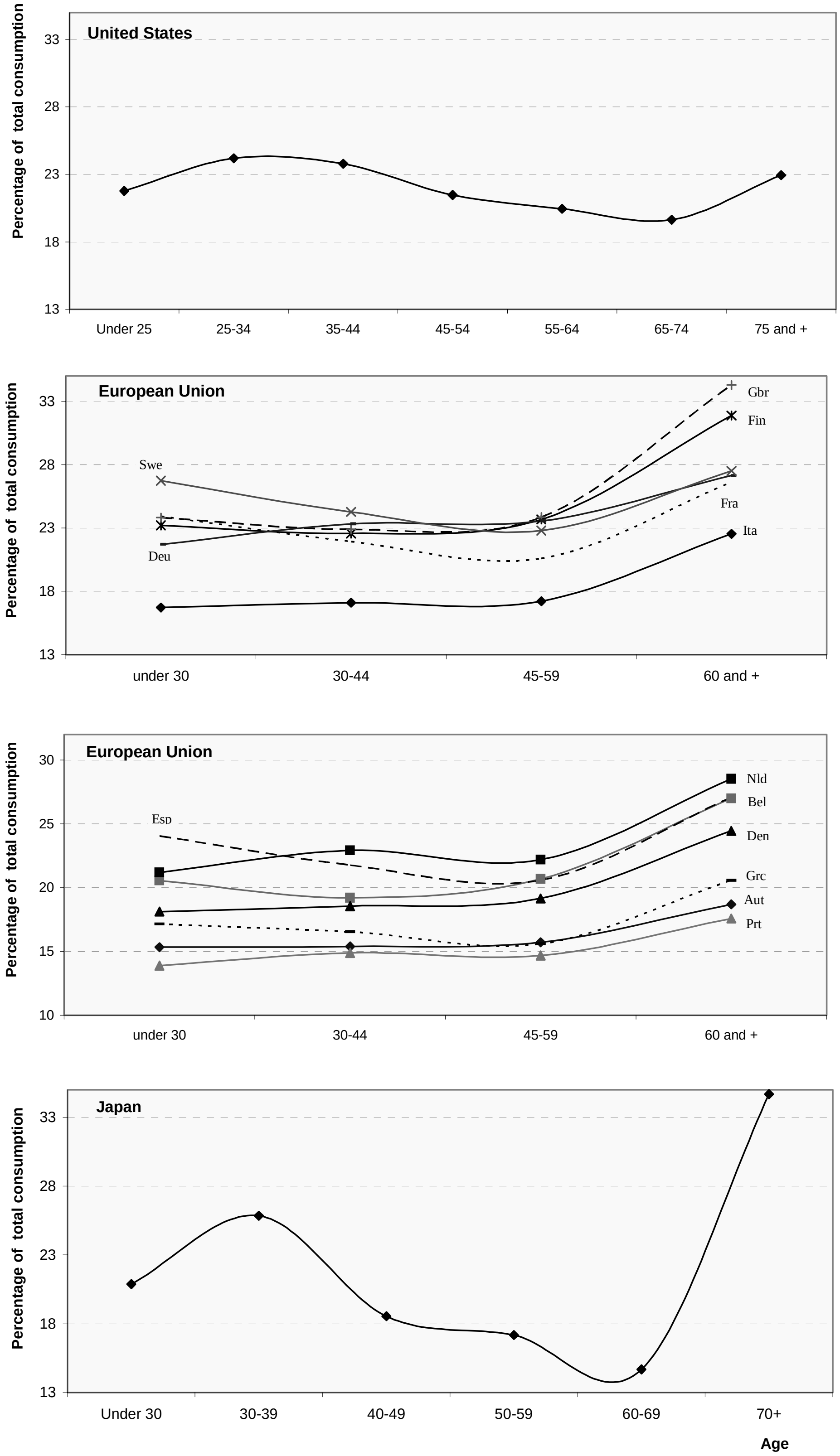


Figure 3.4 (cont.) Relationship between age and consumption by expenditure items
Energy

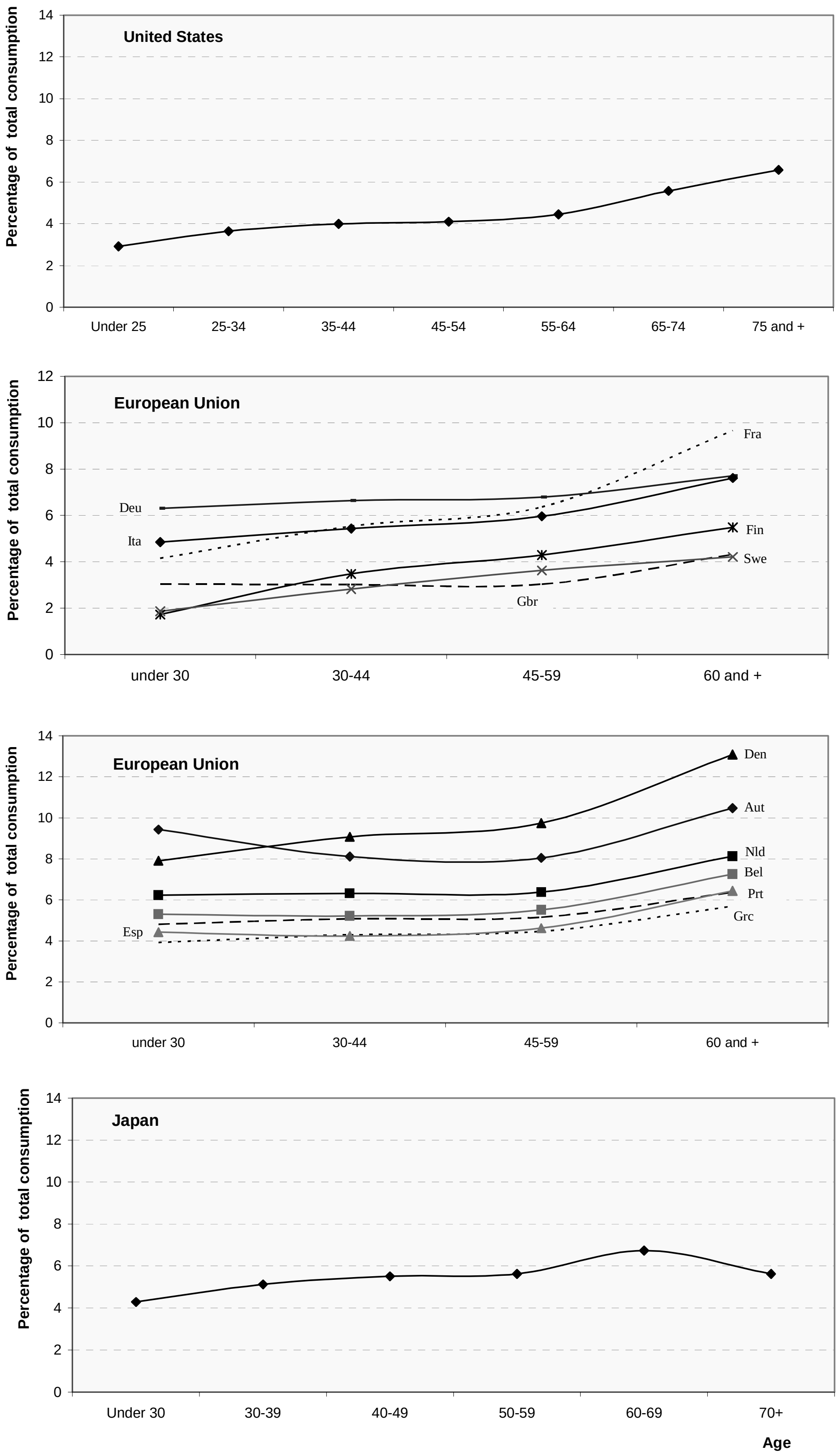


Figure 3.4 (cont.) Relationship between age and consumption by expenditure items
Health

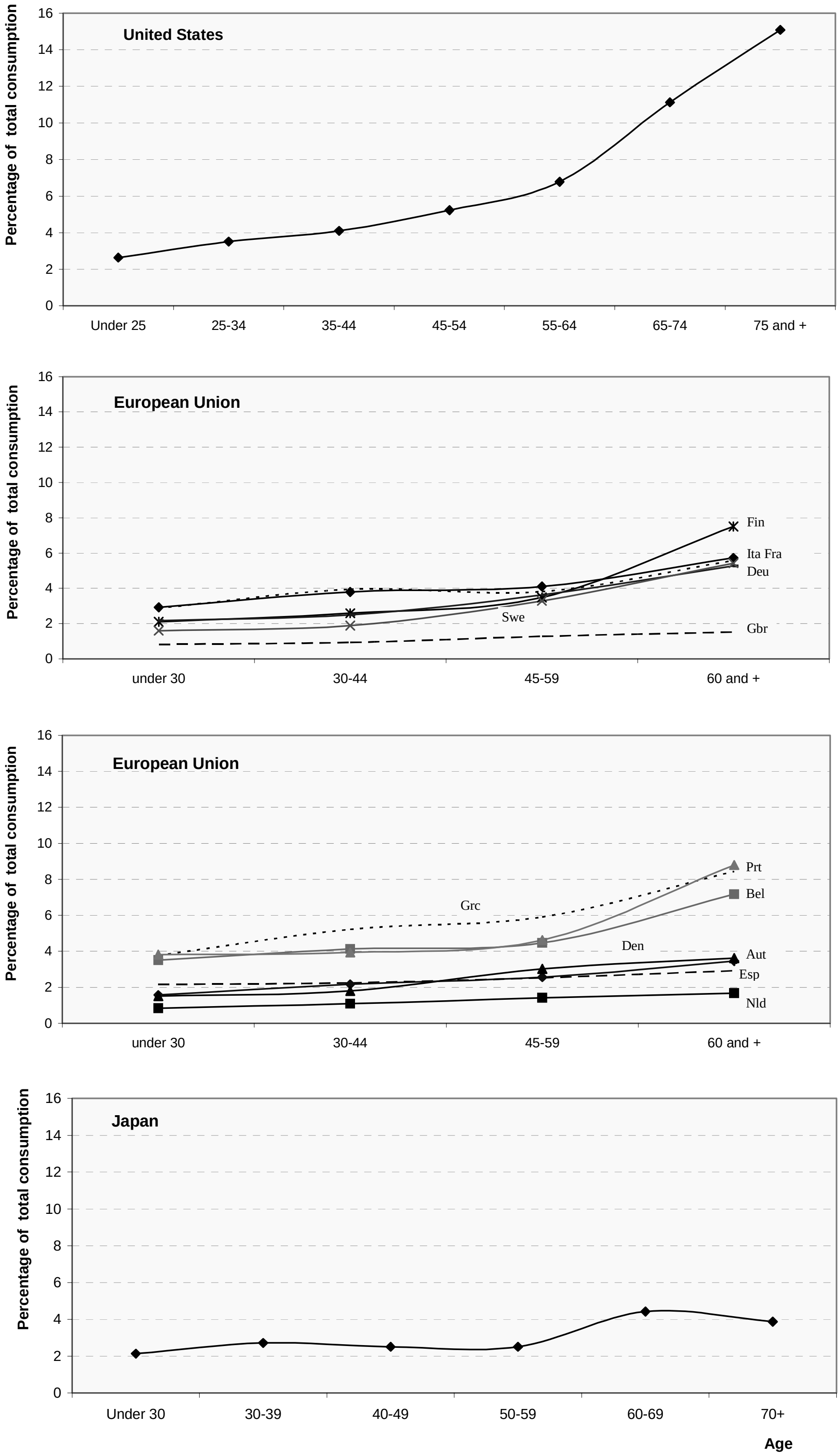


Figure 3.4 (cont.) Relationship between age and consumption by expenditure items
Entertainment

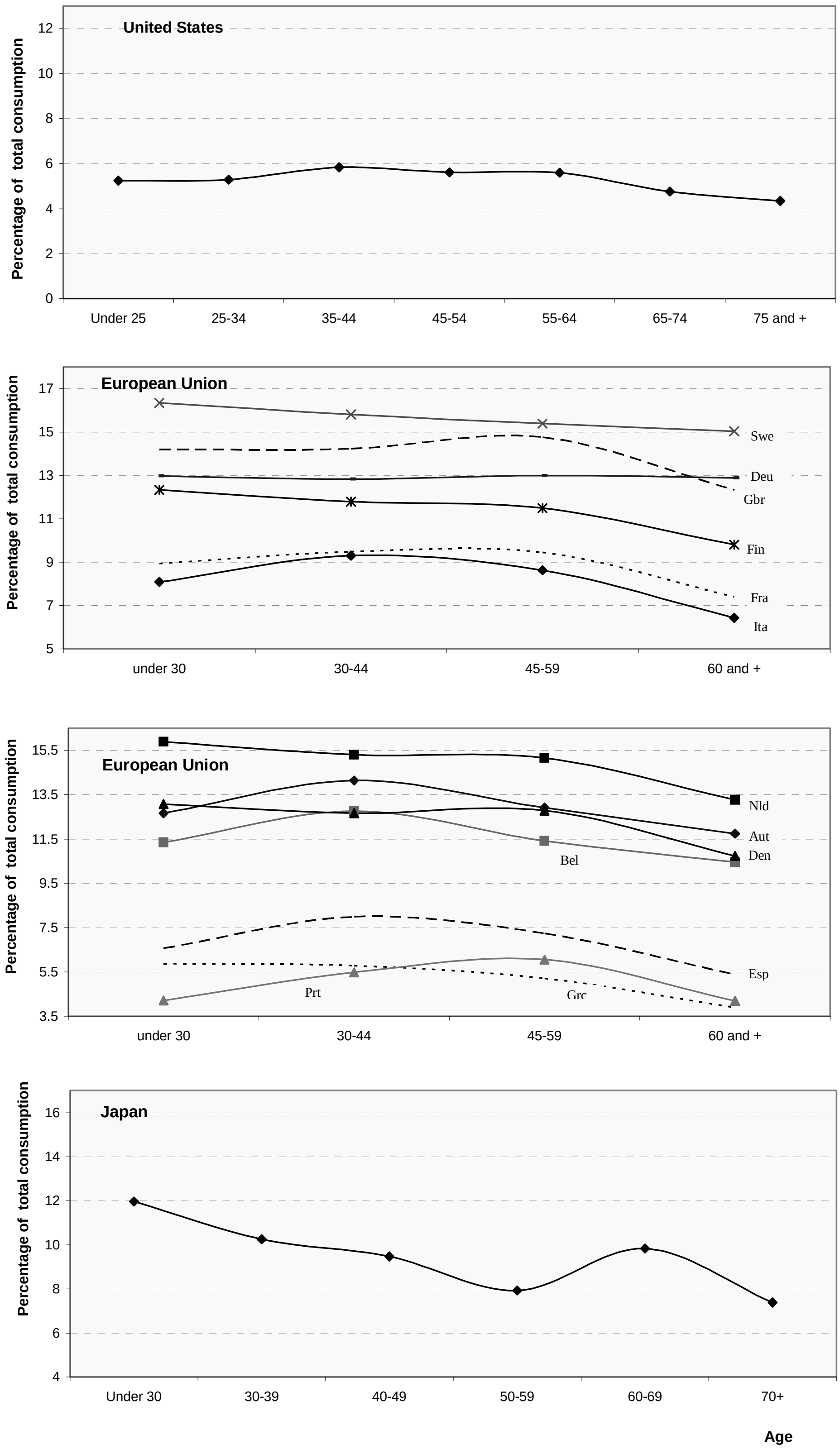


Figure 3.4 (cont.) Relationship between age and consumption by expenditure items
Education

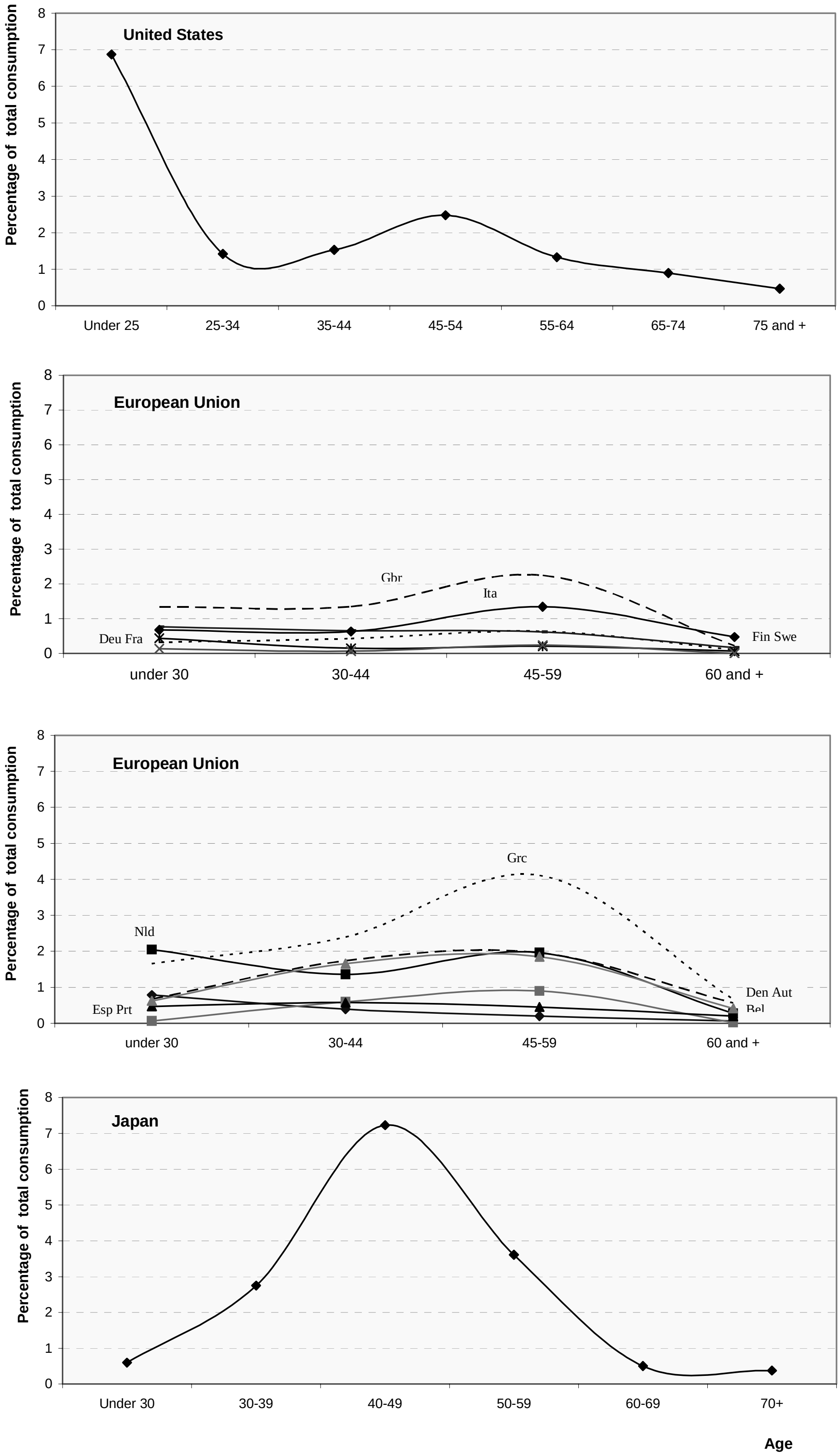


Figure 3.4 (cont.) Relationship between age and consumption by expenditure items
Owned vehicles and services

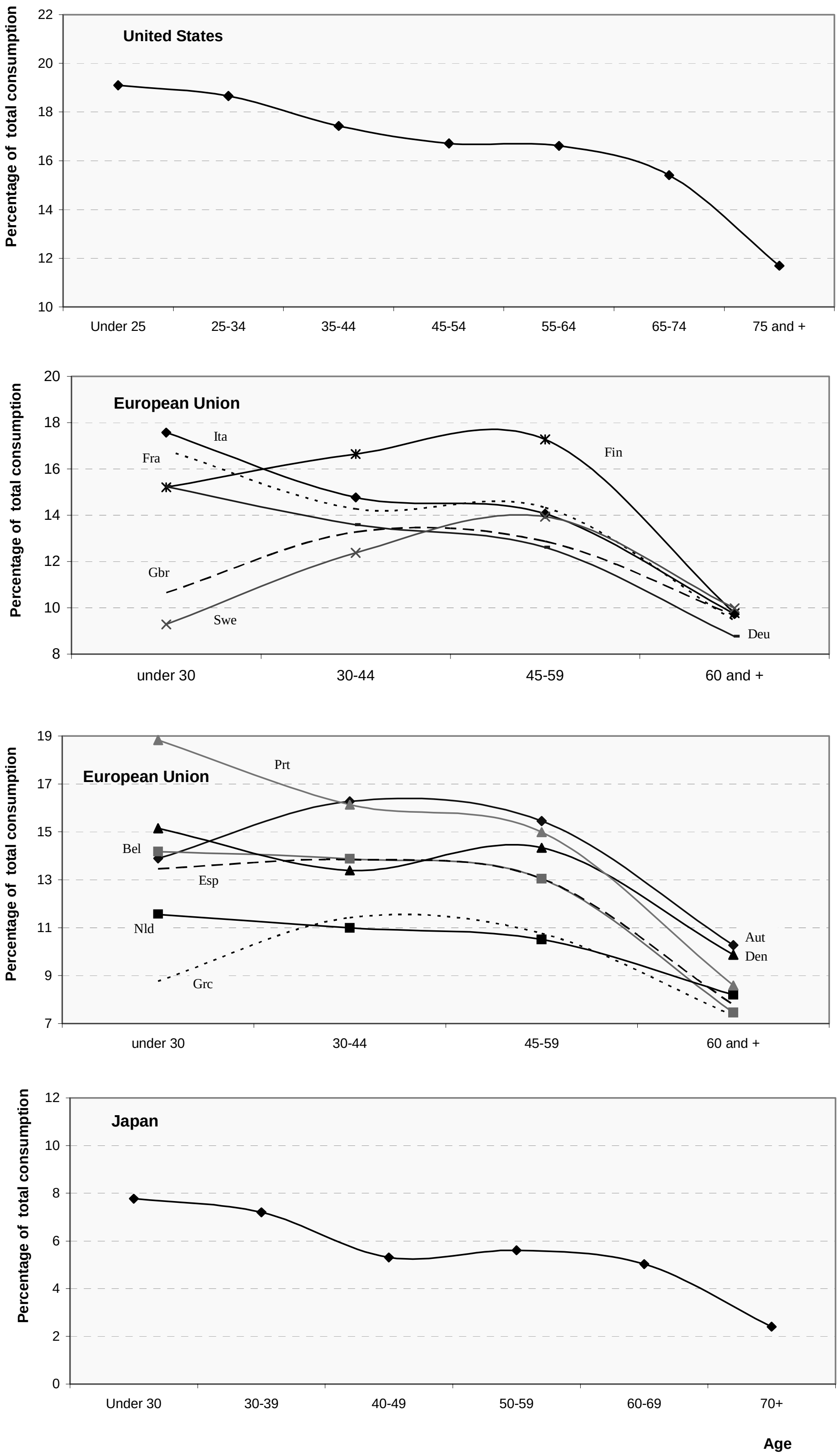
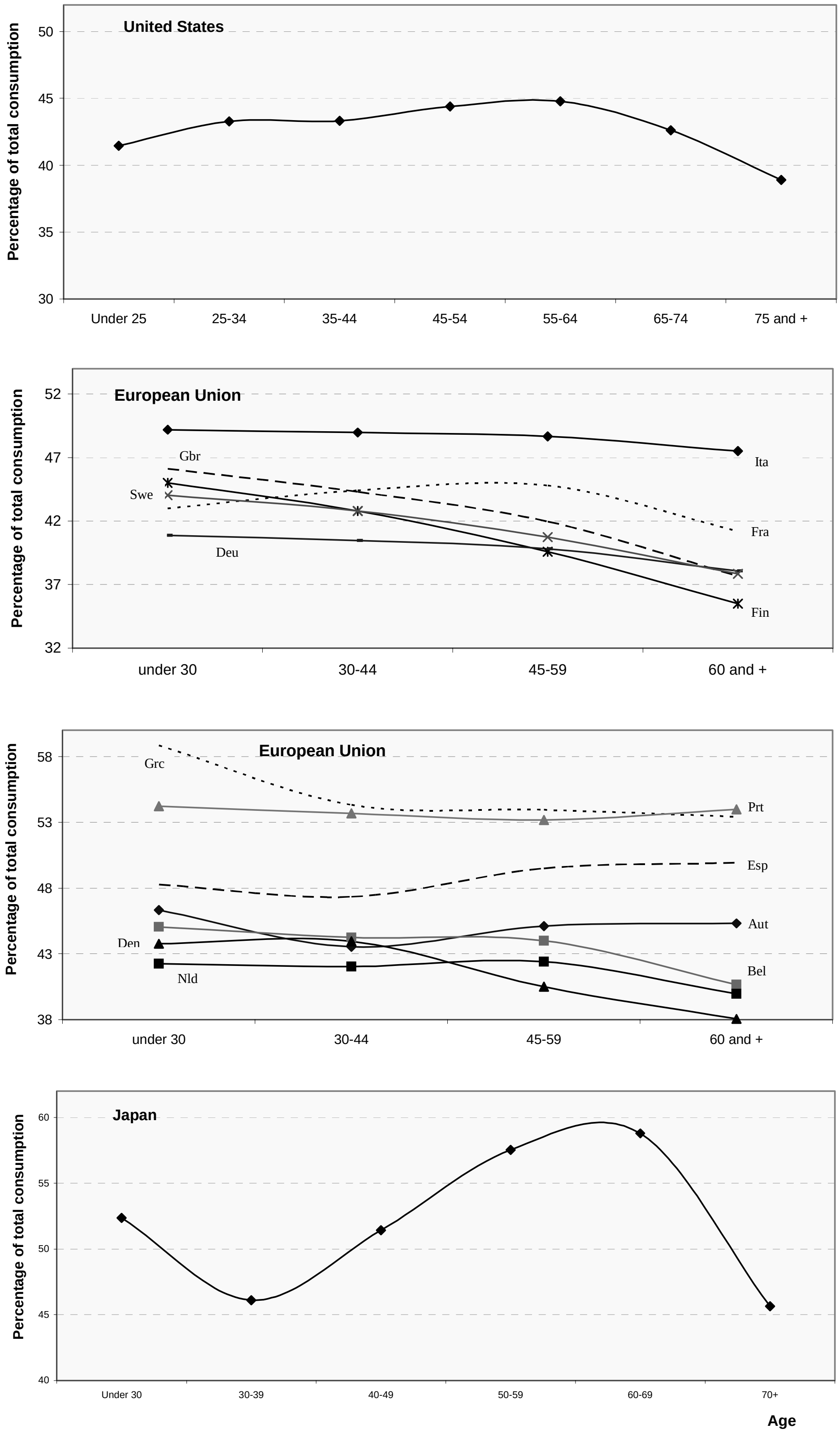


Figure 3.4 (cont.) Relationship between age and consumption by expenditure items
Other



Source : Consumer Expenditure Survey for the US, Household Budget Survey of Eurostat and Luxembourg Income Study (LIS) for EU countries, and Family Income and Expenditure Survey for Japan.

Figure 3.5 Relative changes in consumption structure, 2005-2050

(2005=100)

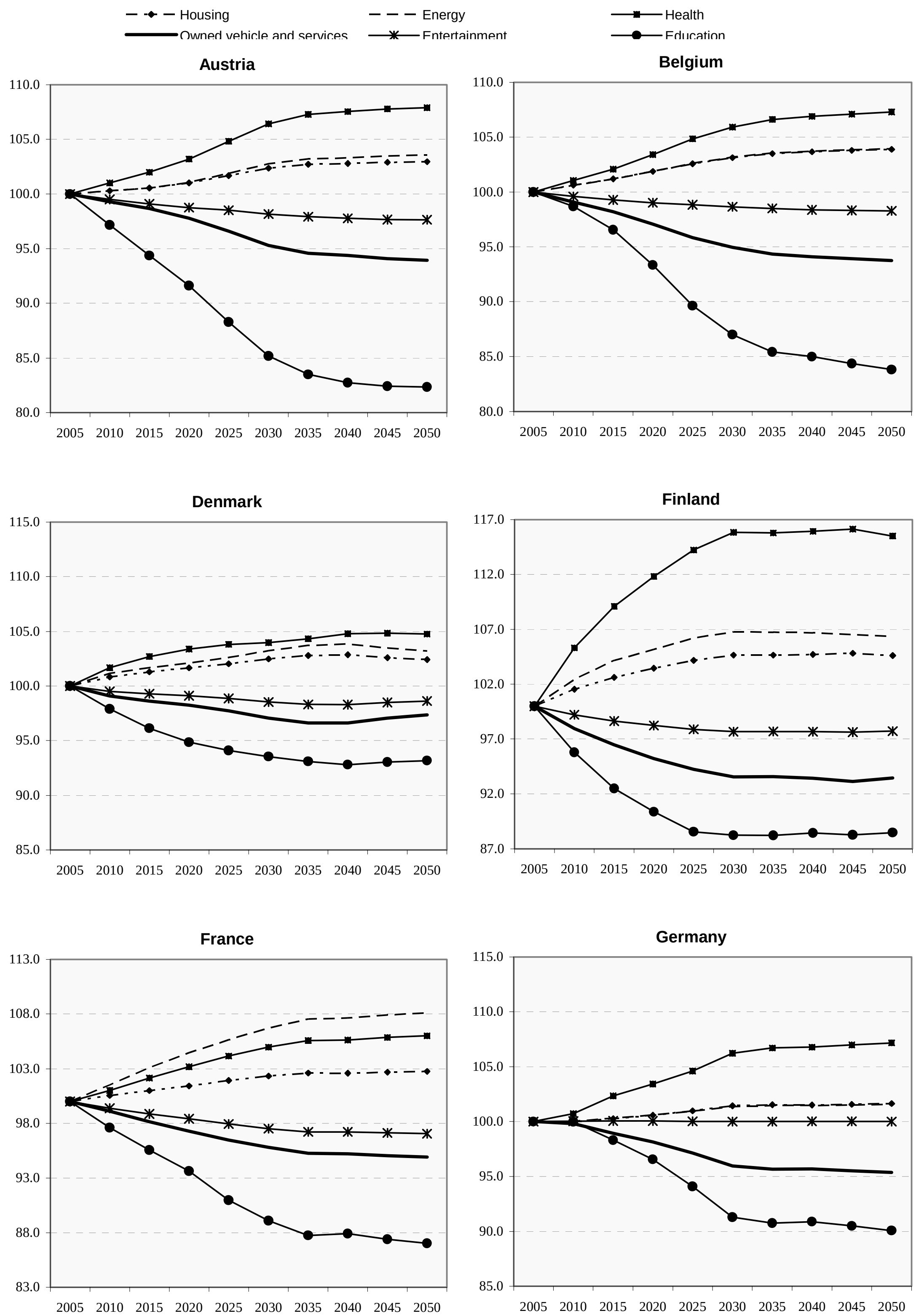


Figure 3.5 (cont'd) Relative changes in consumption structure, 2005-2050

(2005=100)

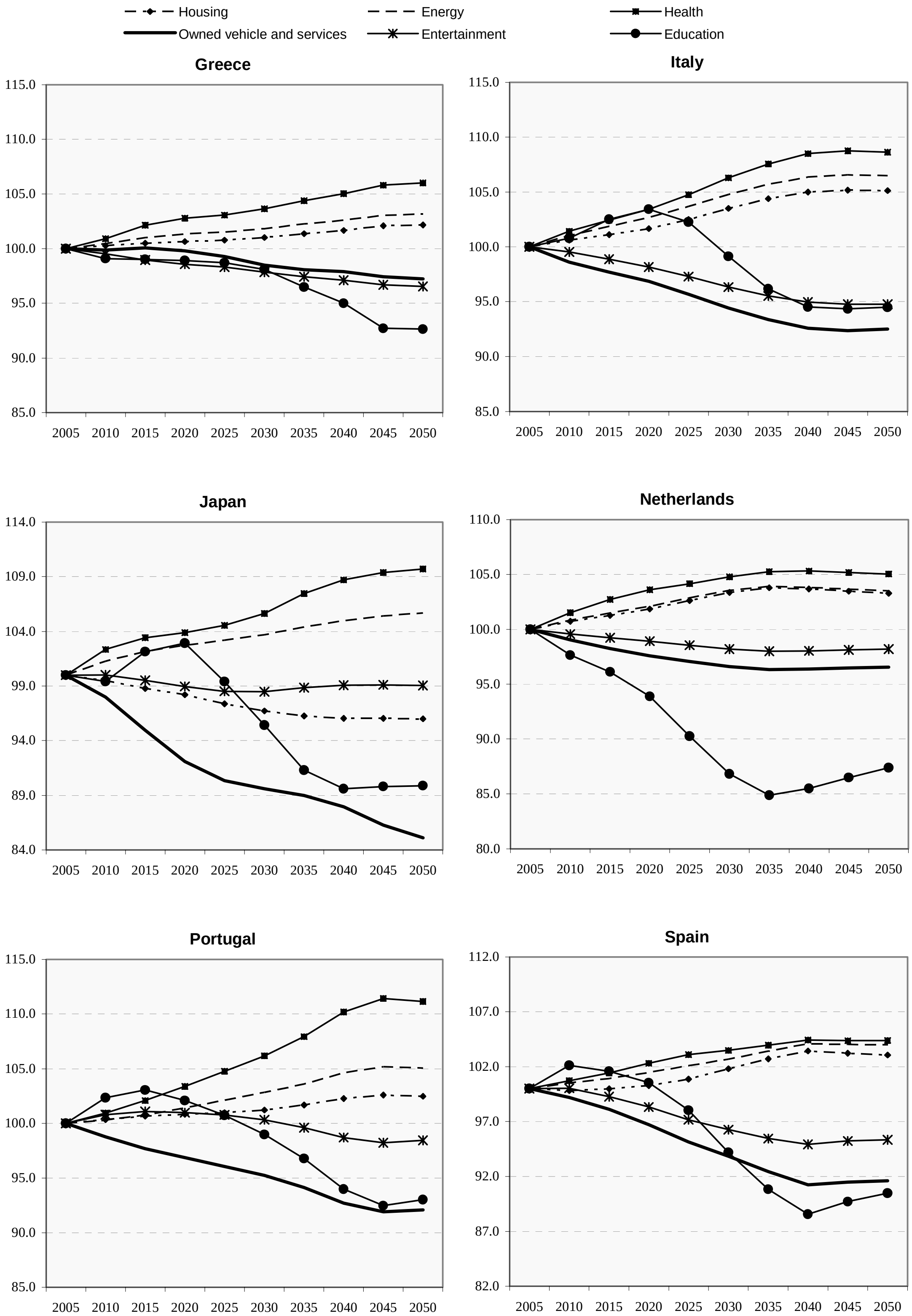
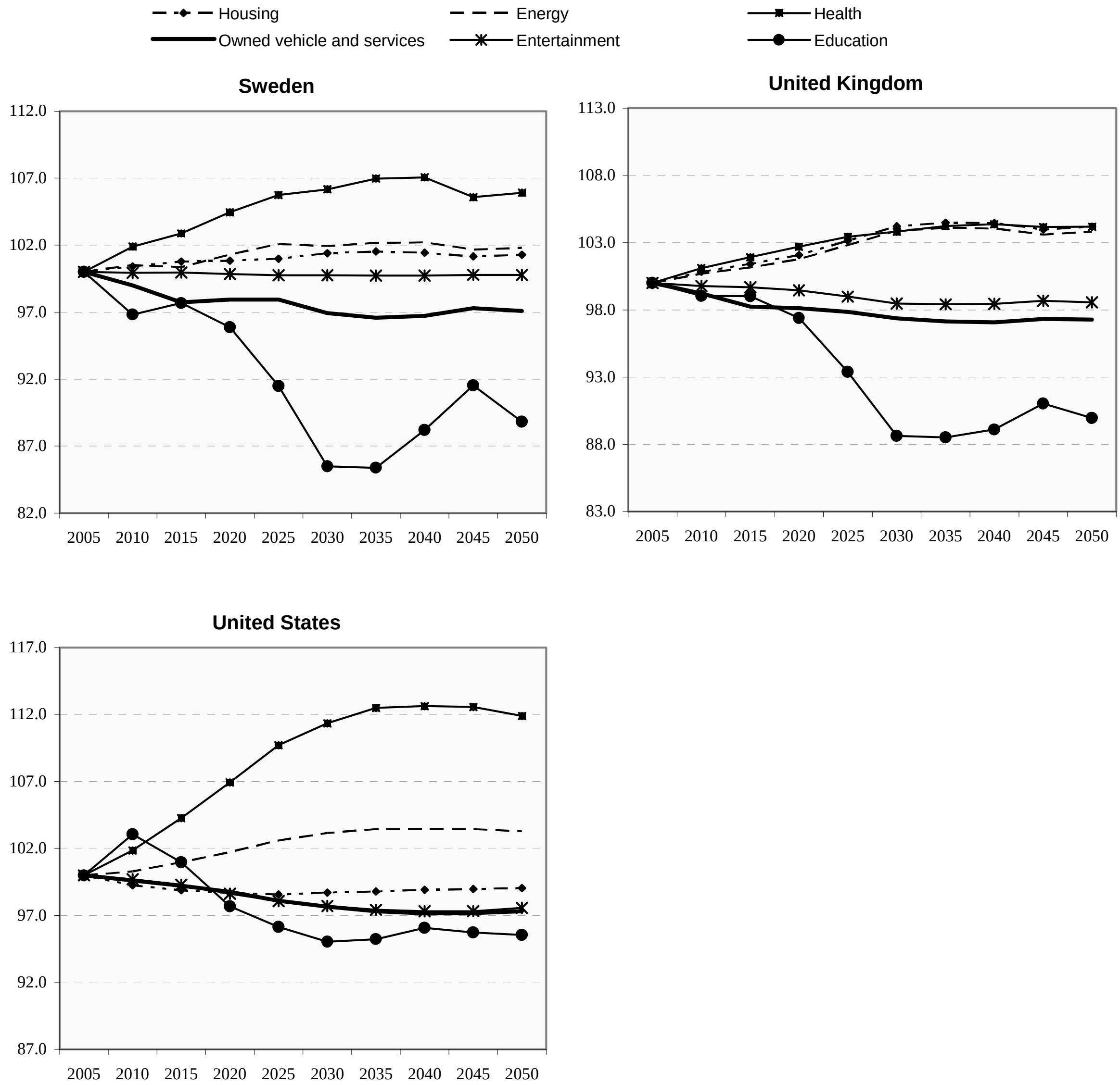


Figure 3.5 (cont'd) Relative changes in consumption structure, 2005-2050

(2005=100)



Source : Consumer Expenditure Survey for the US, Household Budget Survey of Eurostat and Luxembourg Income Study (LIS) for EU countries, and Family Income and Expenditure Survey for Japan.

Figure 3.6. Consumption and population shares

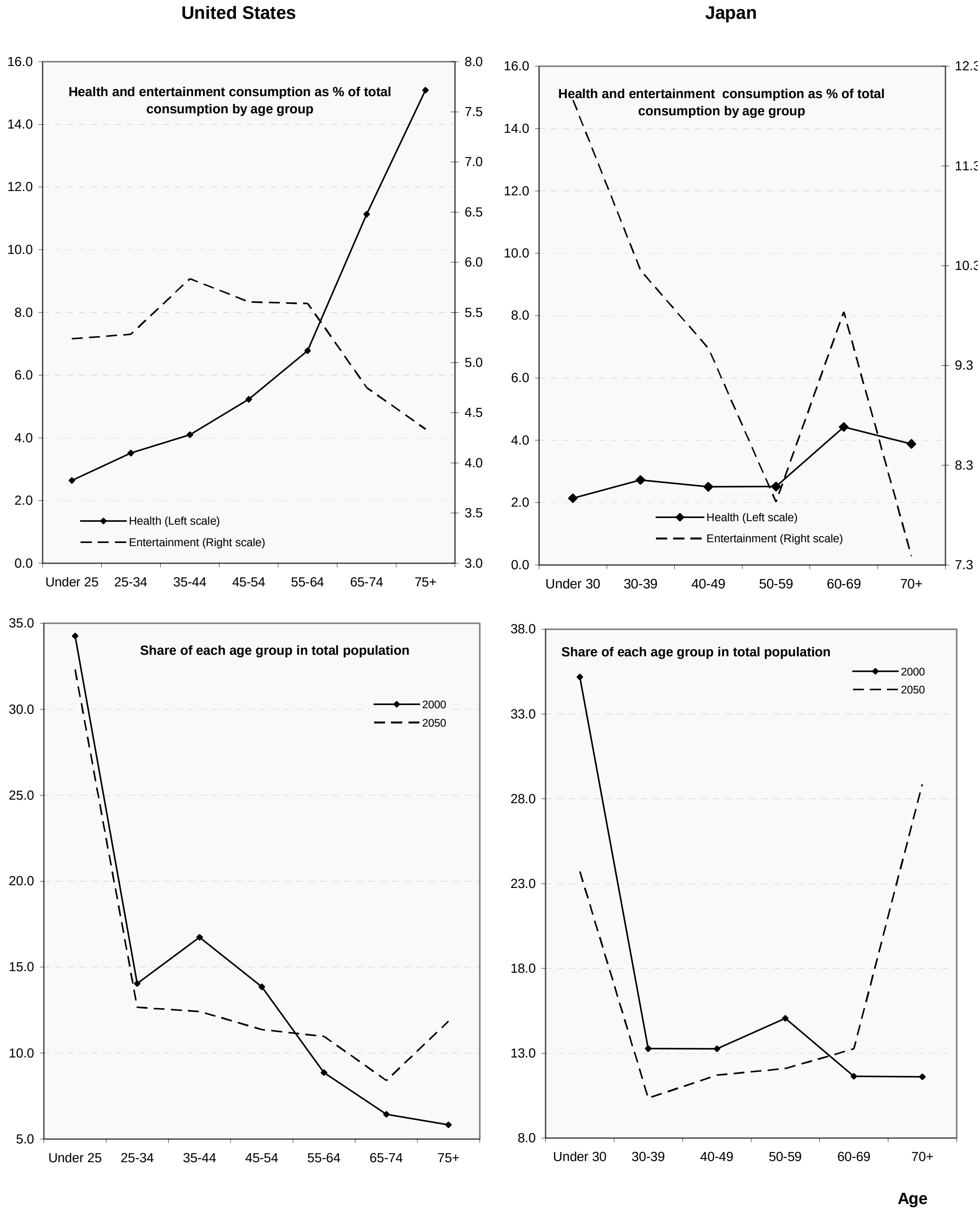
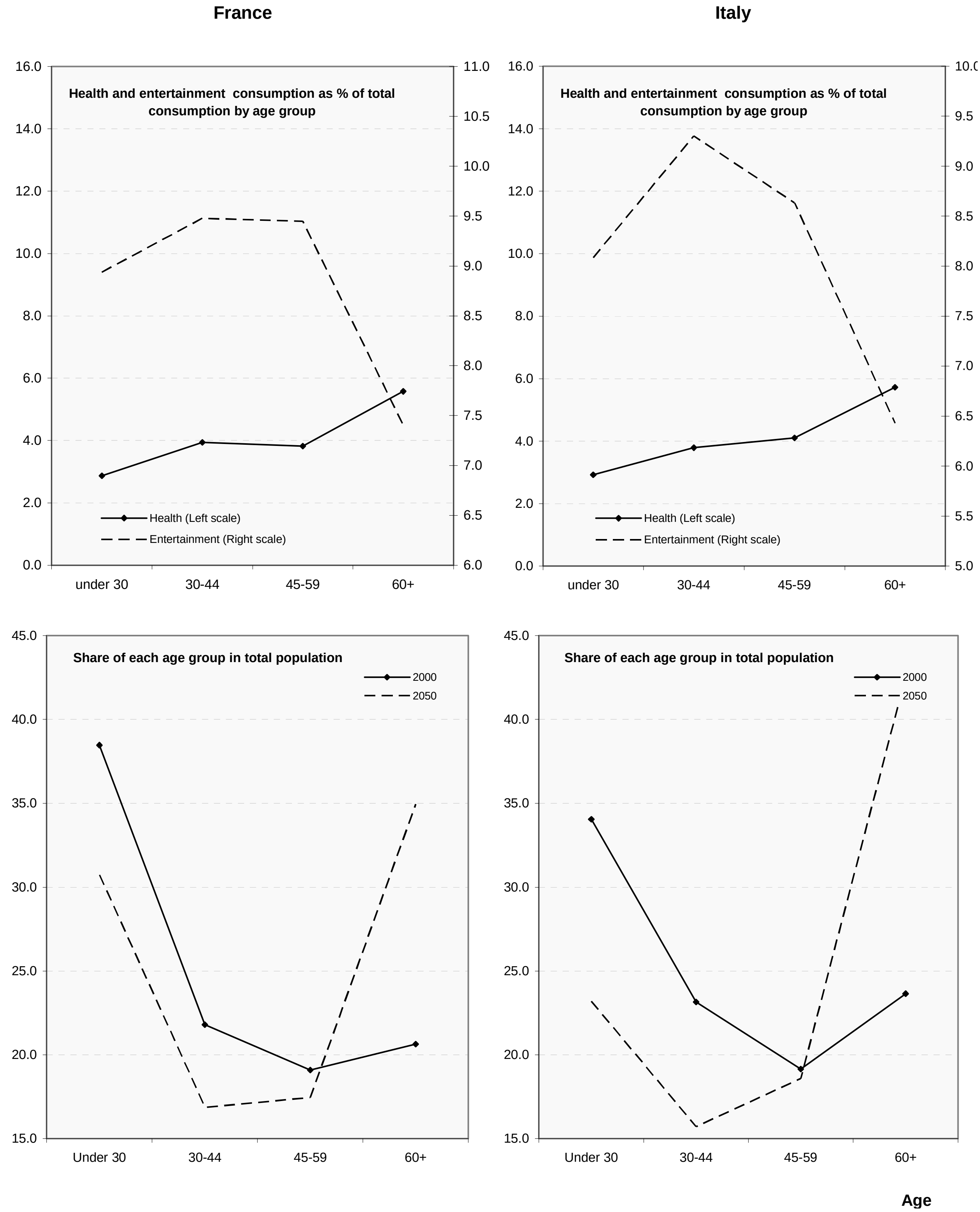
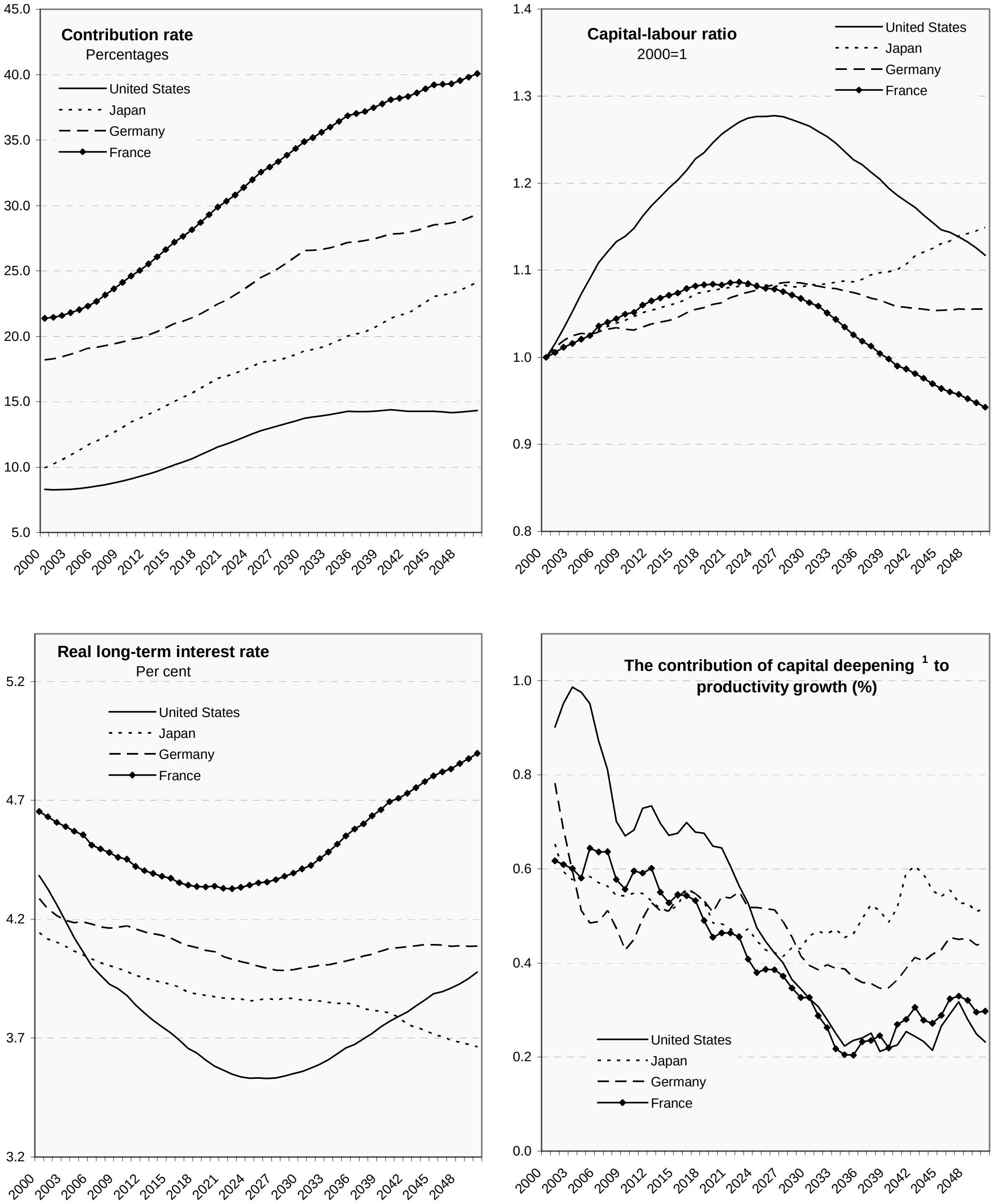


Figure 3.6 (cont.) Consumption and population shares



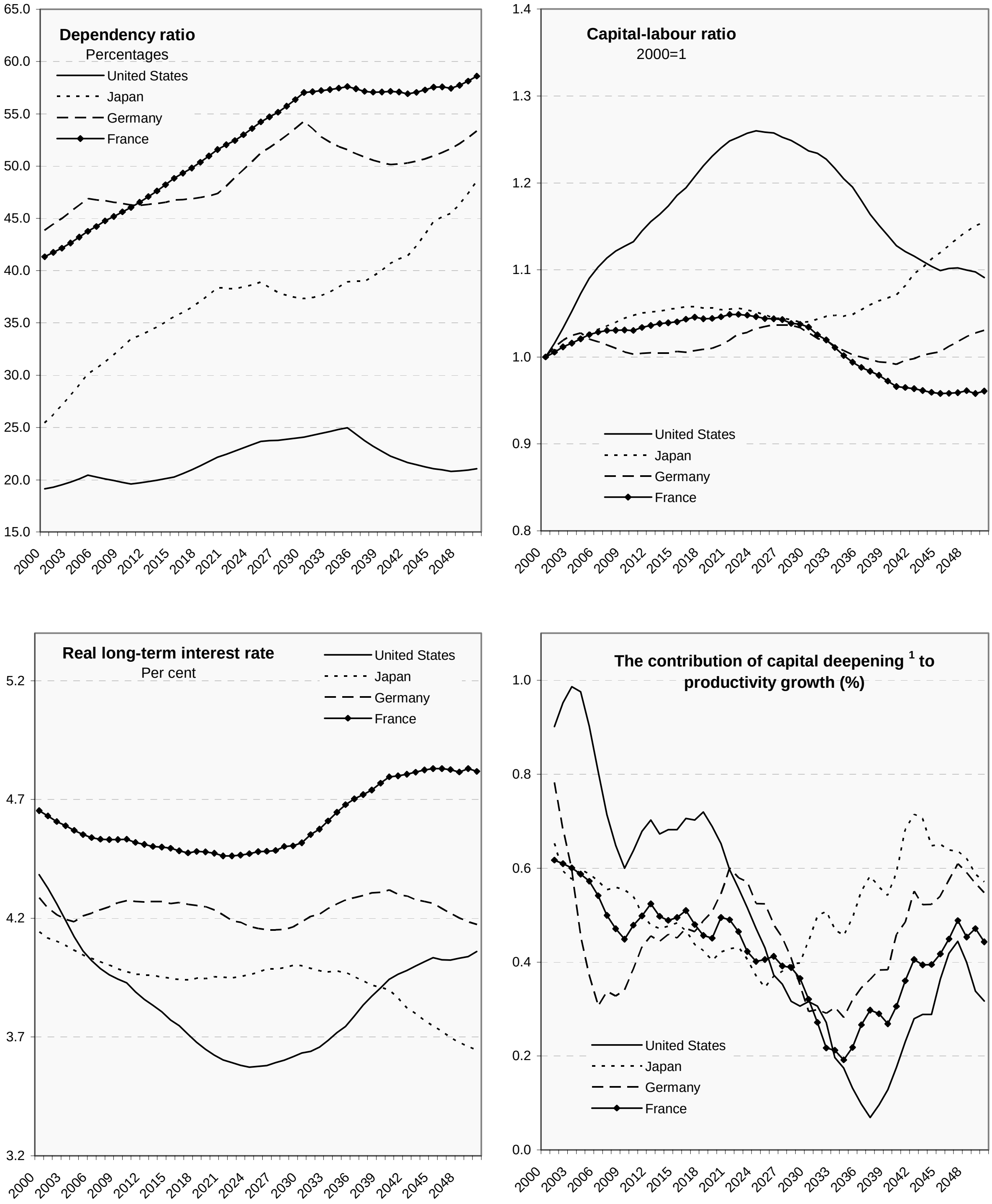
Source : Consumer Expenditure Survey for the US, Household Budget Survey of Eurostat and Luxembourg Income Study (LIS) for EU countries, and Family Income and Expenditure Survey for Japan. OECD/DELSA Population Database.

Figure 4.1 The 'rising contribution rate' scenario



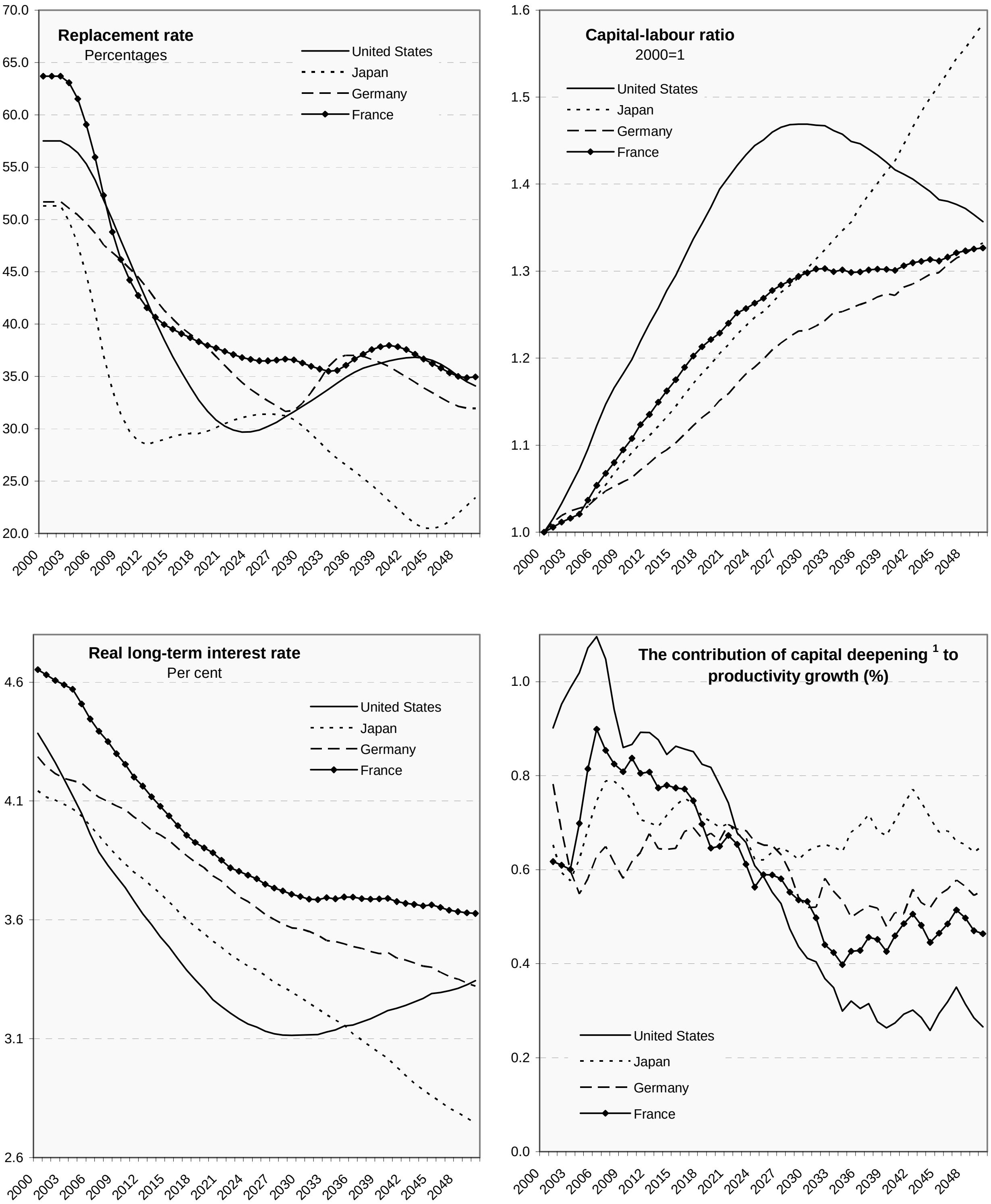
1. Ratio of capital to labour.
Source : OECD calculations.

Figure 4.2 The 'gradually increasing age of retirement' scenario



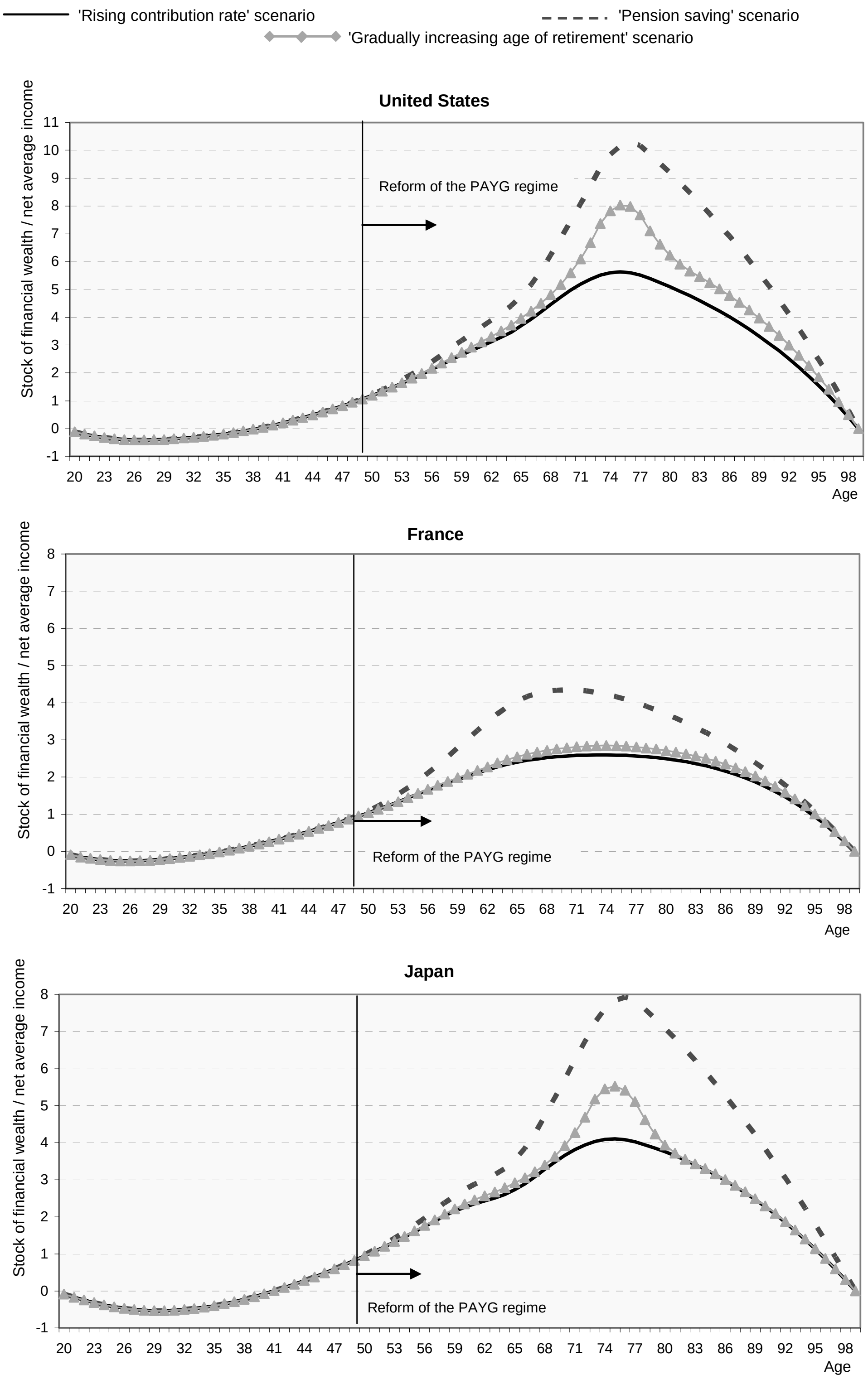
1. Ratio of capital to labour.
Source: OECD calculations.

Figure 4.3 The 'pension saving' scenario



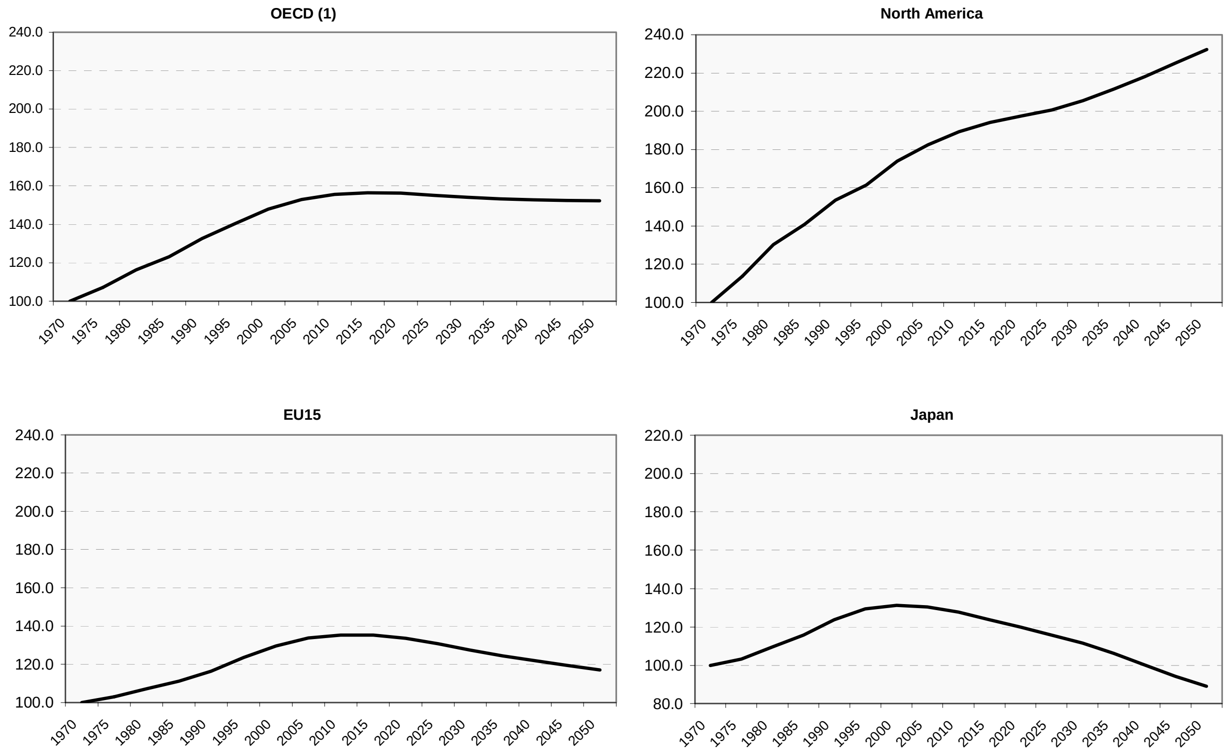
1. Ratio of capital to labour.
Source : OECD calculations.

Figure 4.4 **Accumulated wealth of an individual under different scenarios** [1]



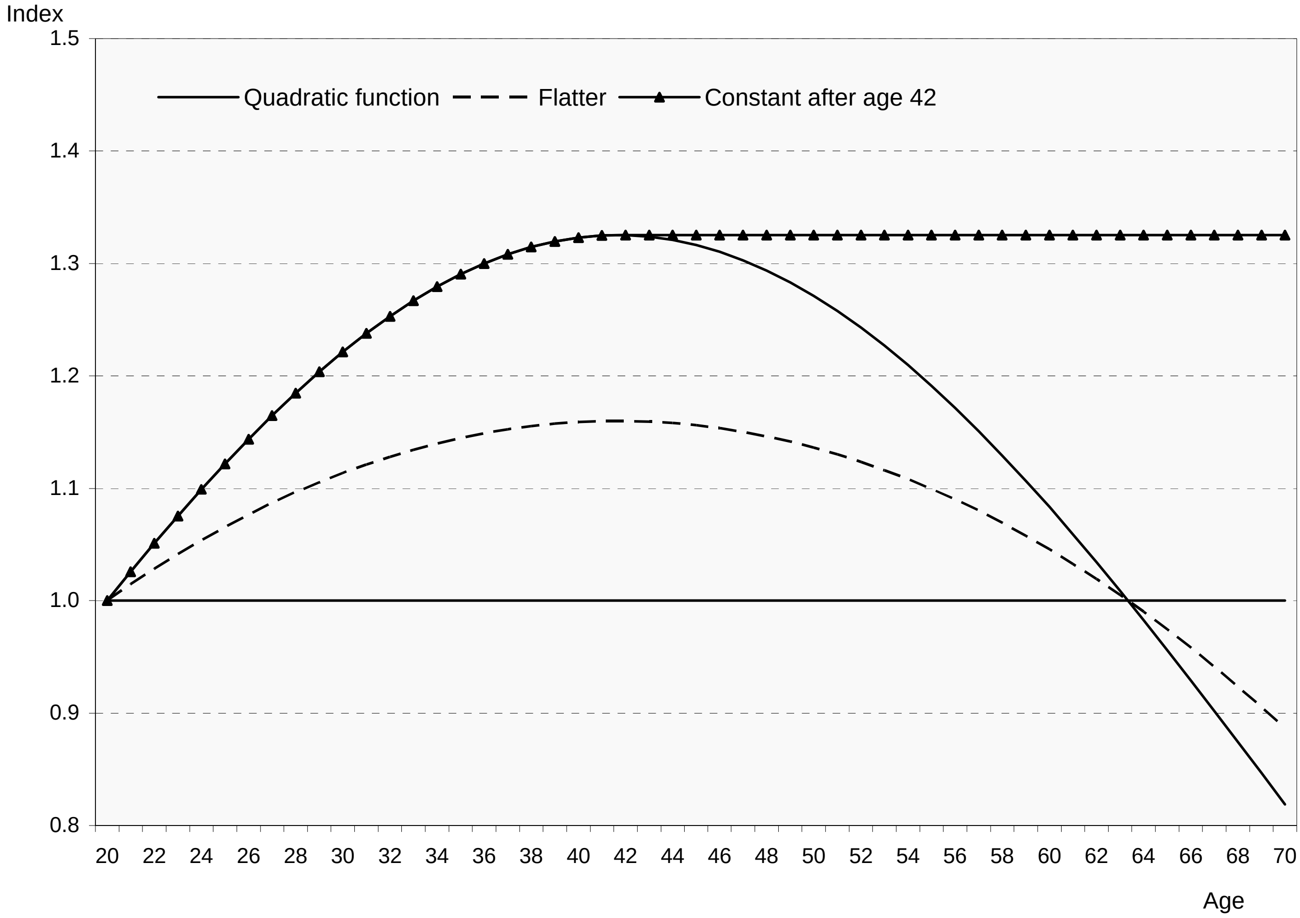
1. Wealth accumulated by an individual joining the labour market in 1975 at the age of 20. The calculations assume that the individual lives until age 99 when assets are run down. Levels of financial wealth may not be comparable to actual levels since households in the model only save for retirement.
Source : OECD calculations.

Figure 5.1 Impact of ageing on labour supply
(Labour supply, 1970=100)



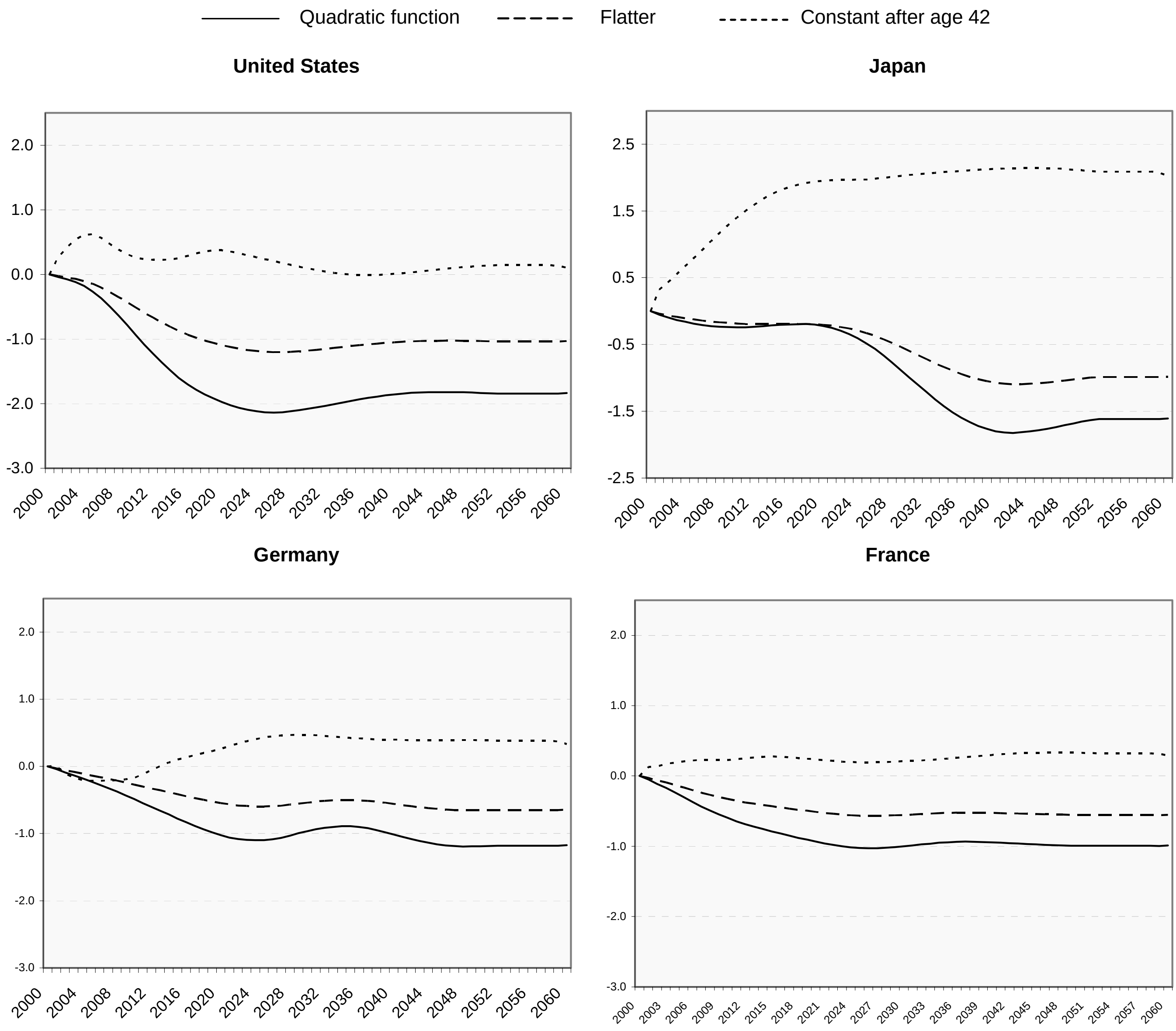
1. Excluding Czech Republic, Hungary, Mexico, Poland, Slovak Republic.
Source: OECD Labour Force Statistics and OECD/DELSA Population Database.

Figure 5.2 Different age-productivity profiles



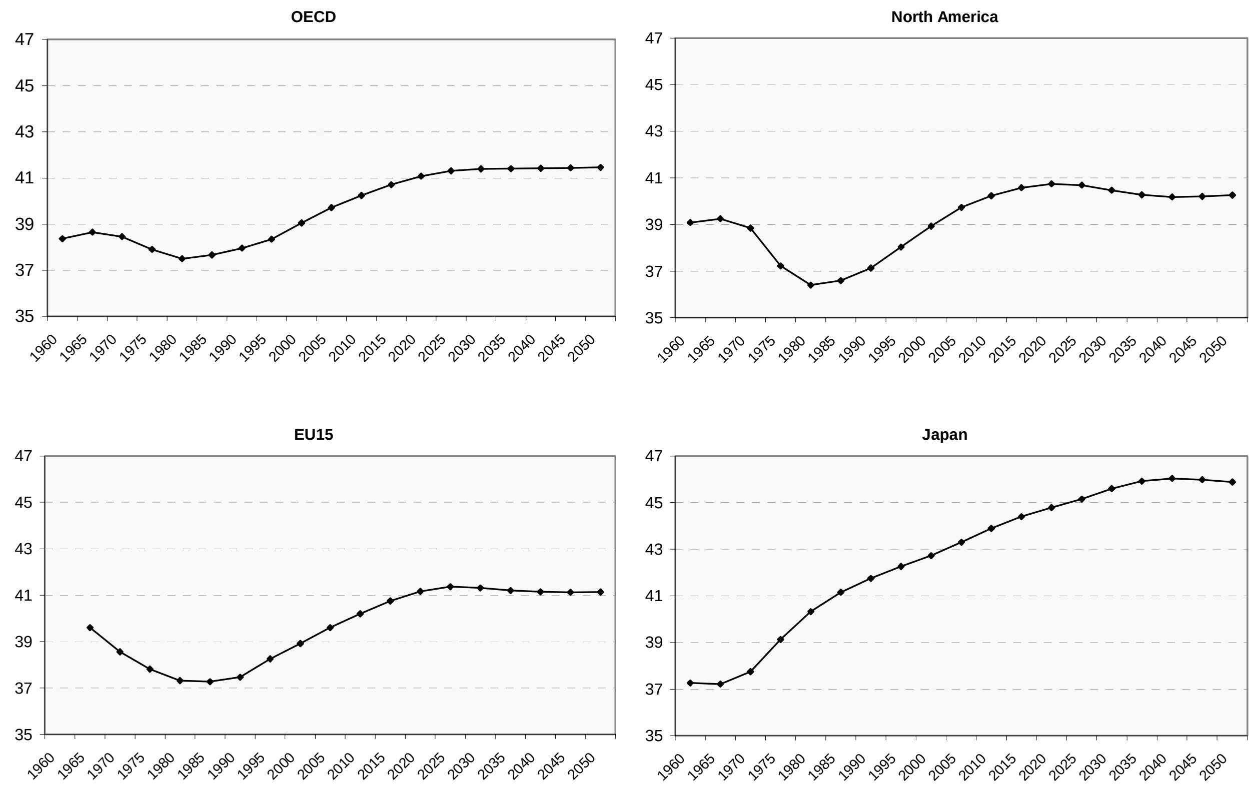
Source : OECD calculations.

Figure 5.3 Mechanical impact of ageing on productivity levels
(Per cent changes relative to 2000 levels)



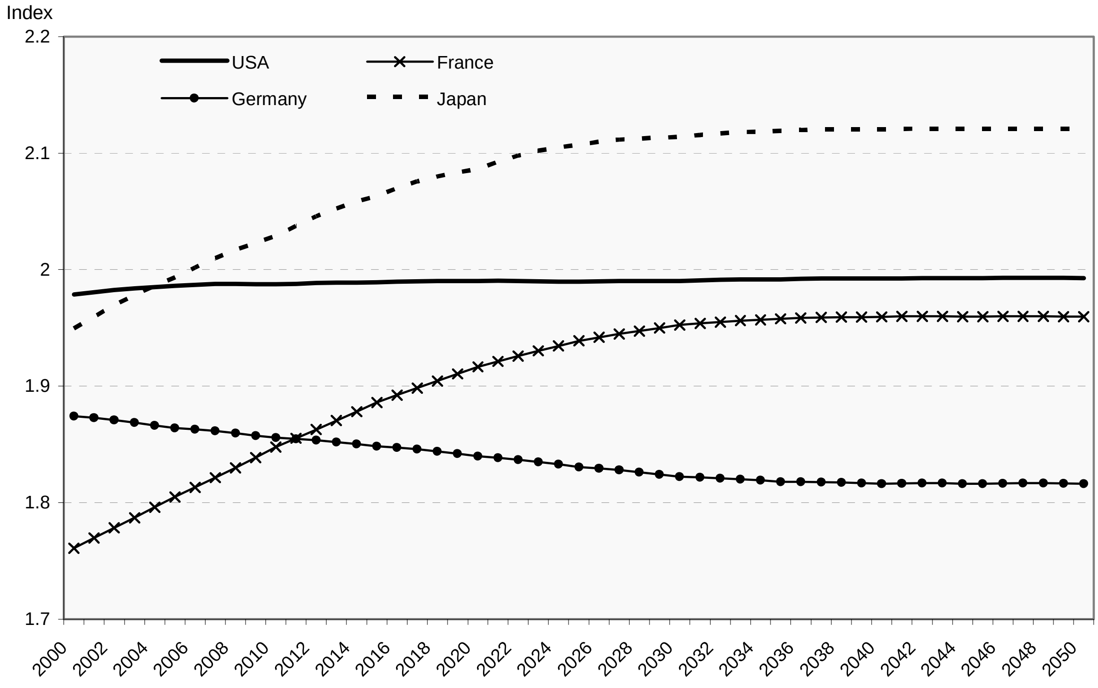
Note : For a description of the productivity-age profiles see main text and figure 5.2.
Source : OECD calculations.

Figure 5.4 Average age of the labour force, 1960-2050
(in years)



Source : OECD/DELSA Population Database.

Figure 5.5 Mechanical impact of ageing on education [1]

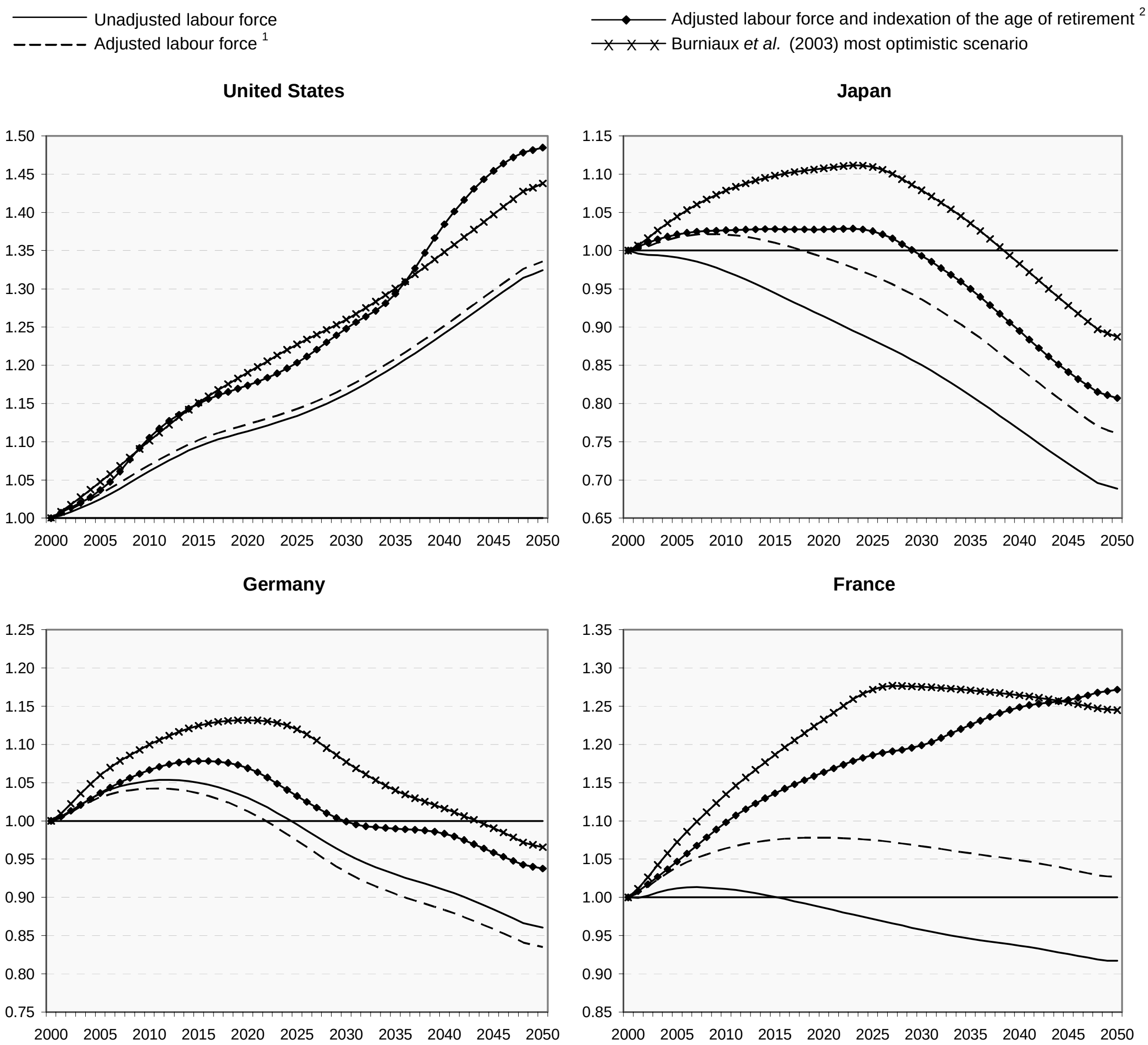


1. The total level of education of the labour force is the weighted average of primary education (weight 1), lower secondary (1.4), upper secondary (1.7) and tertiary (2.6).

Source: OECD Education database, OECD/DELSA Population Database and OECD calculations.

Figure 5.6 Labour supply including quality adjustments and policy scenarios

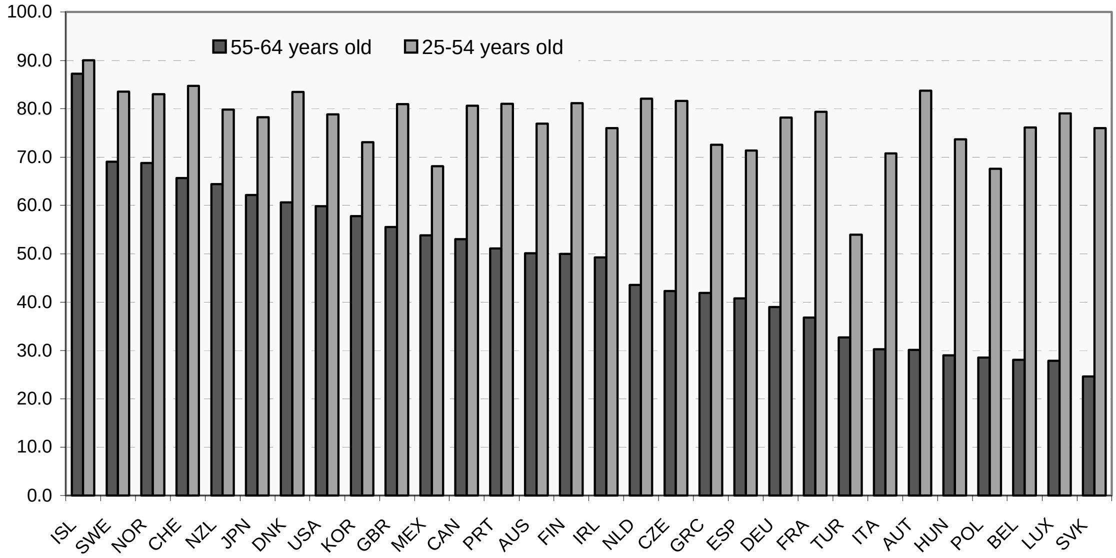
(2000=1)



1. Adjusted for productivity (Increasing until 42 and then flat) and education levels.
2. Indexed in line with life expectancy gains underlying national projections (see table 2.3).
Source : OECD calculations.

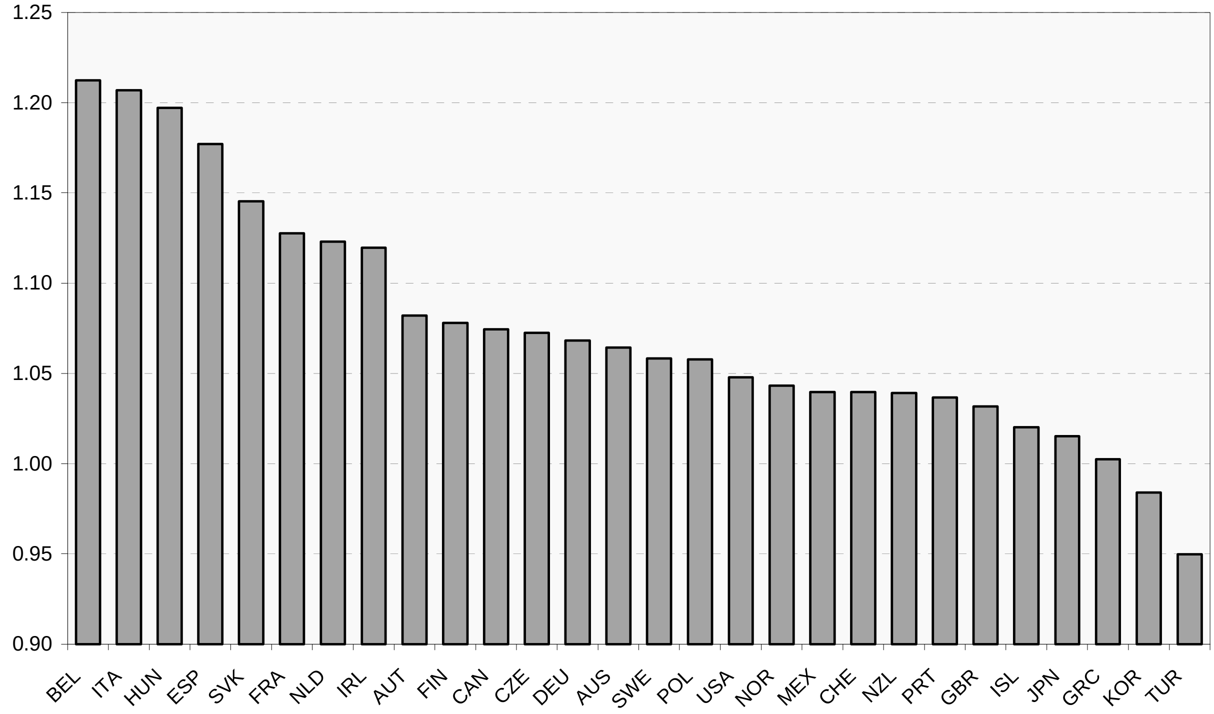
Figure 5.7. Employment ratios by age groups across OECD countries

Latest available year (2003 or 2002)



Source : OECD Labour Force Statistics.

Figure 5.8 Relative level of education of employed workers 55-64 years of age[1], 2000

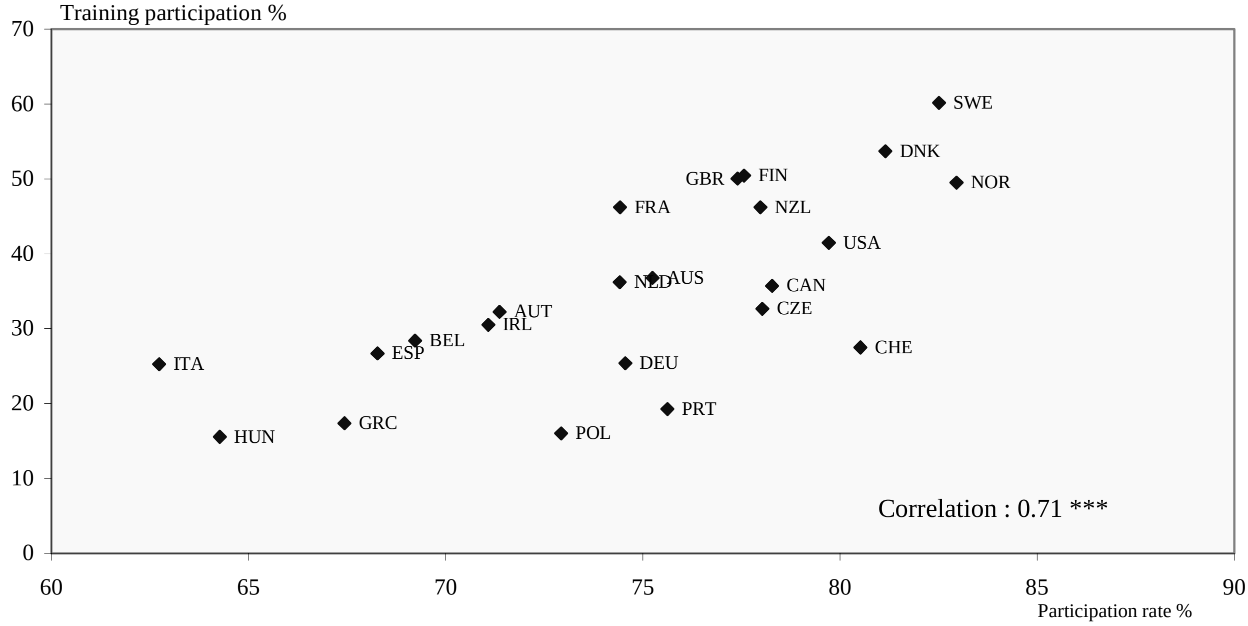


1. Ratio between the average education level of employed workers 55-64 years old and the average level of education of the population in the same age group.
Source: OECD Education database.

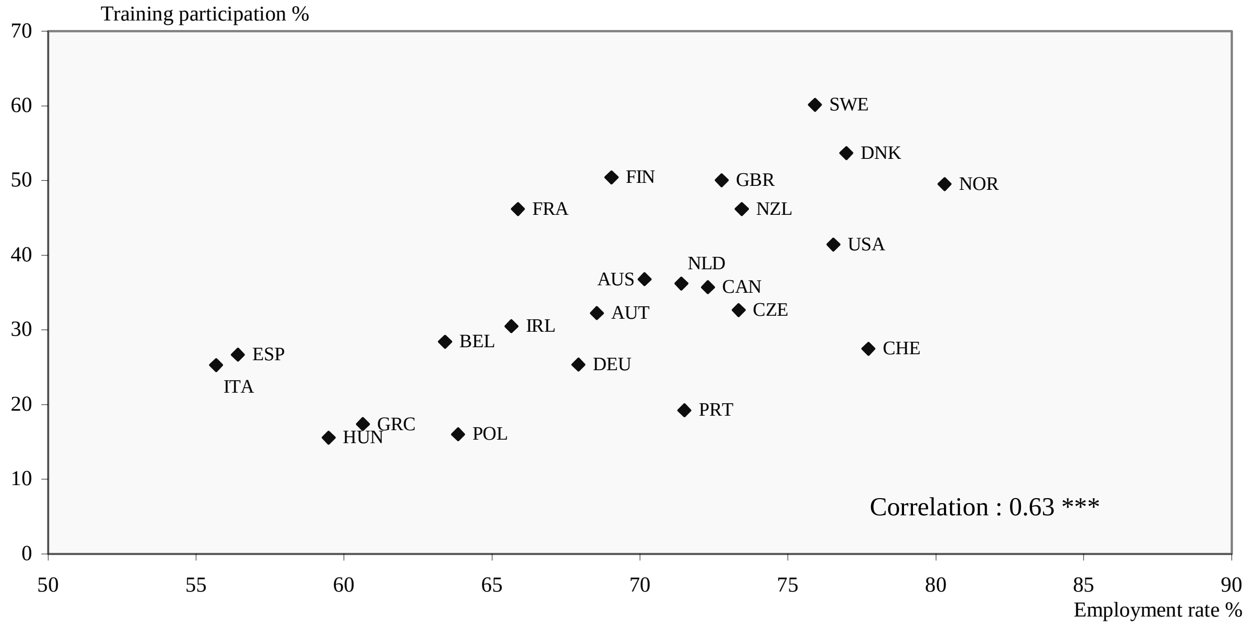
Figure 5.9. **Training and employment rates are correlated**

Training participation [a] and aggregate labour market performance, second half of the 1990's

Panel A. Participation rate



Panel B. Employment rate



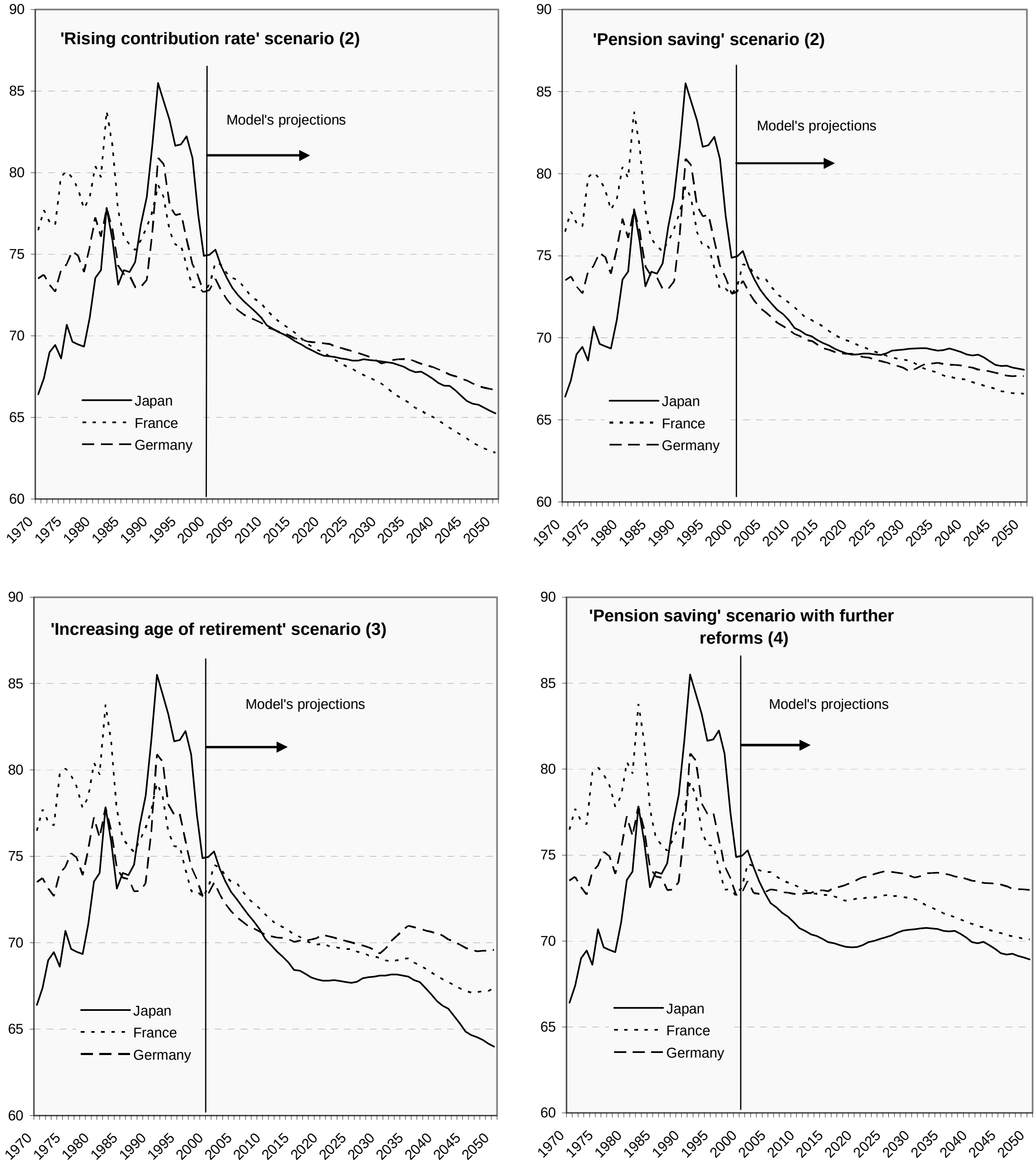
***, **, * Statistically significant at 1% level, 5% level and 10% level, respectively.

a) Ratio of employees receiving training in one year to total employees.

Source: OECD, Employment Outlook, 2004.

Figure 6.1. **Ageing and GDP per capita convergence** [1]

Levels of GDP per capita as a percentage of GDP per capita in the USA



1. Before 2002, GDP per capita is expressed using PPPs. The dynamics after 2002 reflect only demographic factors.
2. Participation rates frozen at their 2000 levels.
3. Increasing participation rates at older ages because of rising age of retirement.
4. Including effects of recent policies and the most optimistic policy scenarios on future participation rates following Burniaux *et al.* (2003).

Source: OECD calculations.

Figure A1.1 United States

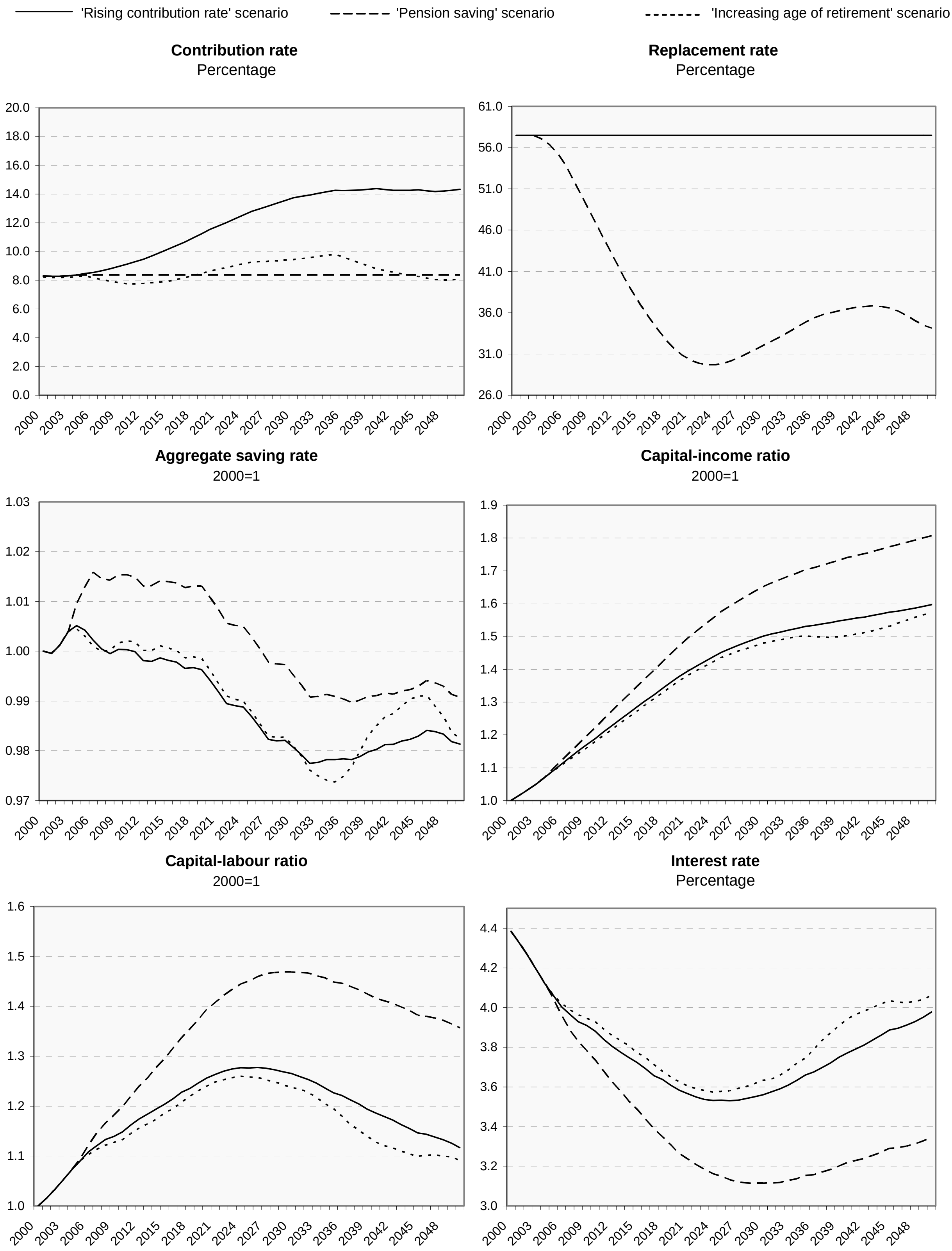
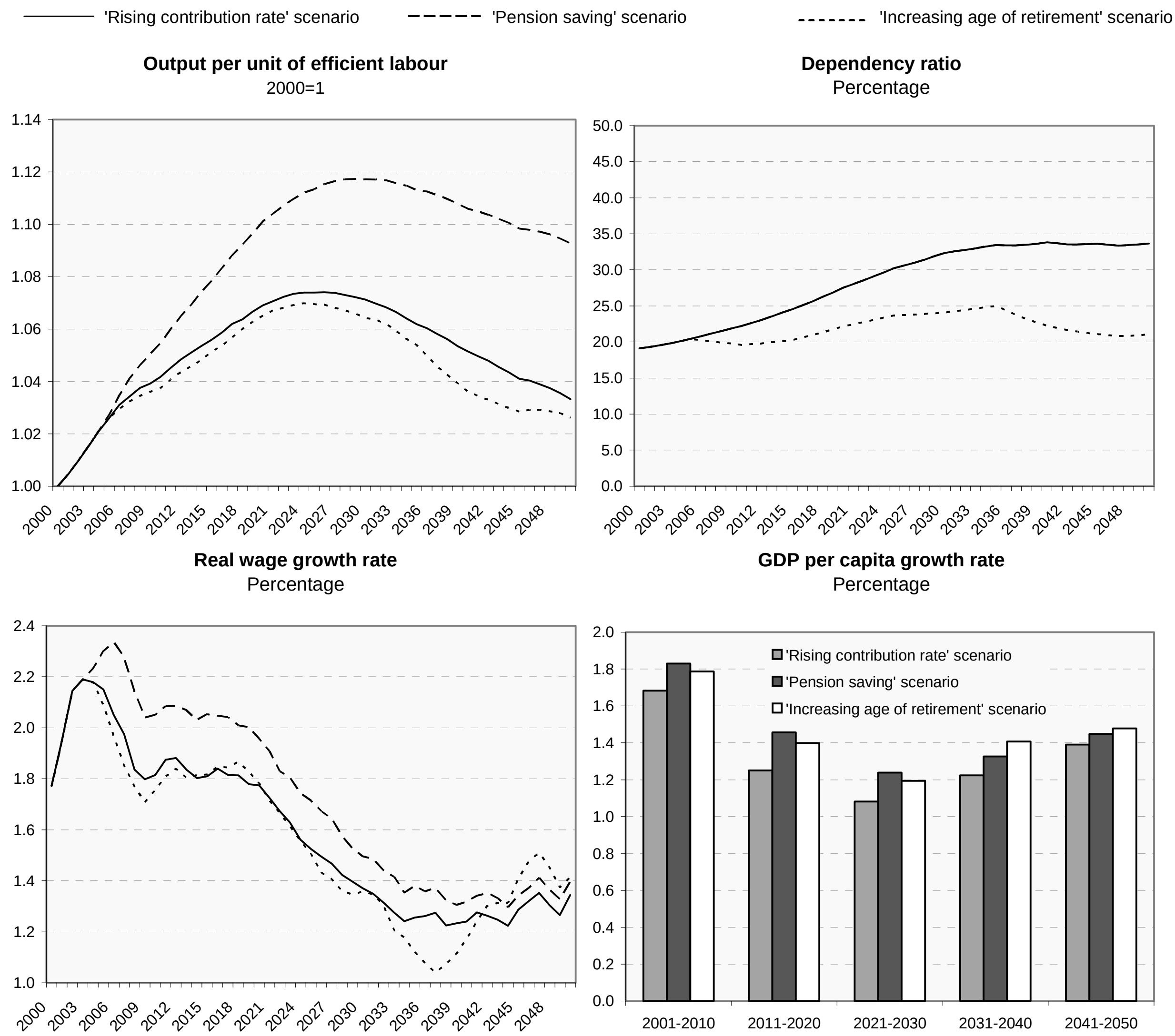


Figure A1.1 (cont.) United States



Note : Participation rates are frozen at their 2000 levels, except for the 'increasing age of retirement' scenario.
Source : OECD calculations.

Figure A1.2 Japan

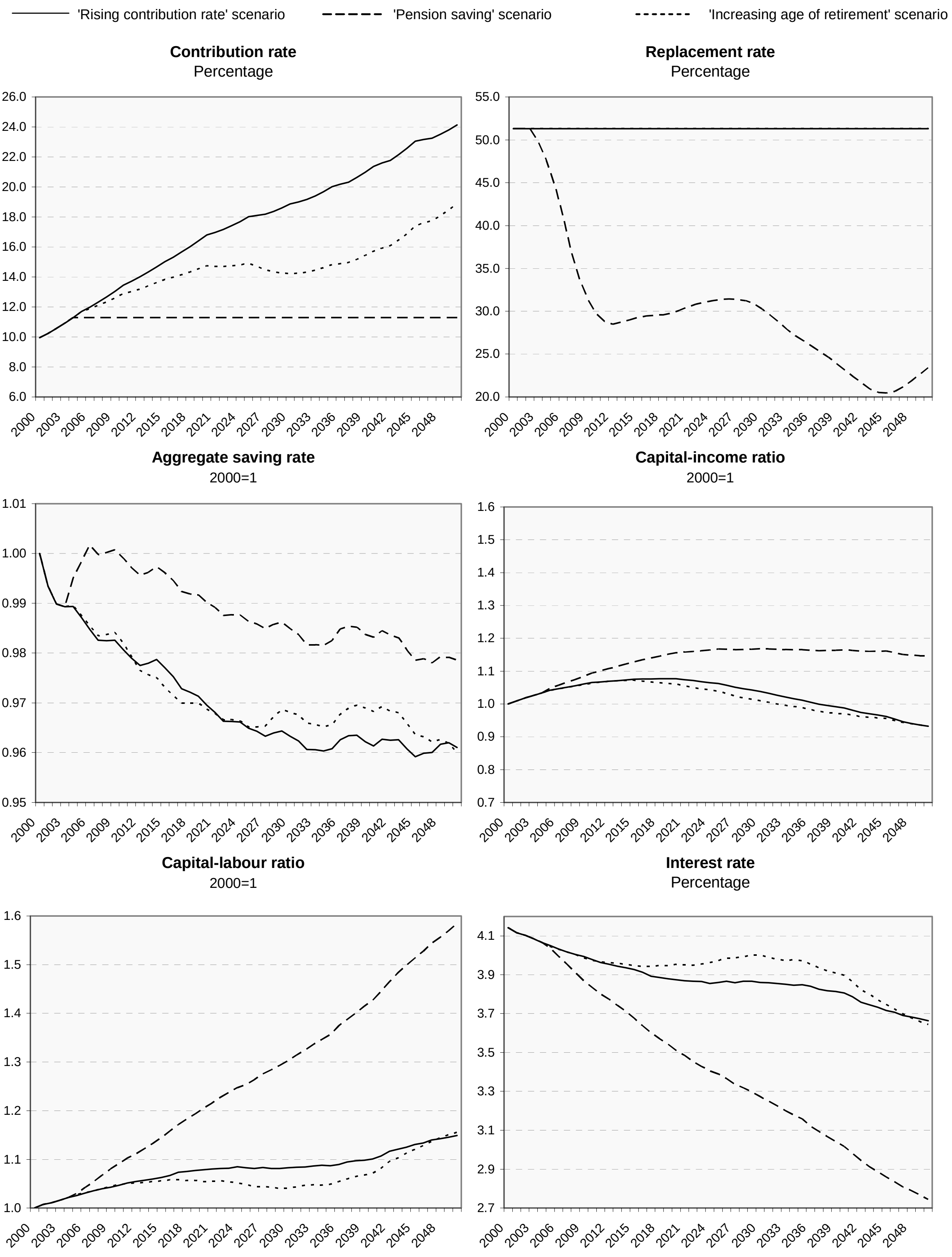
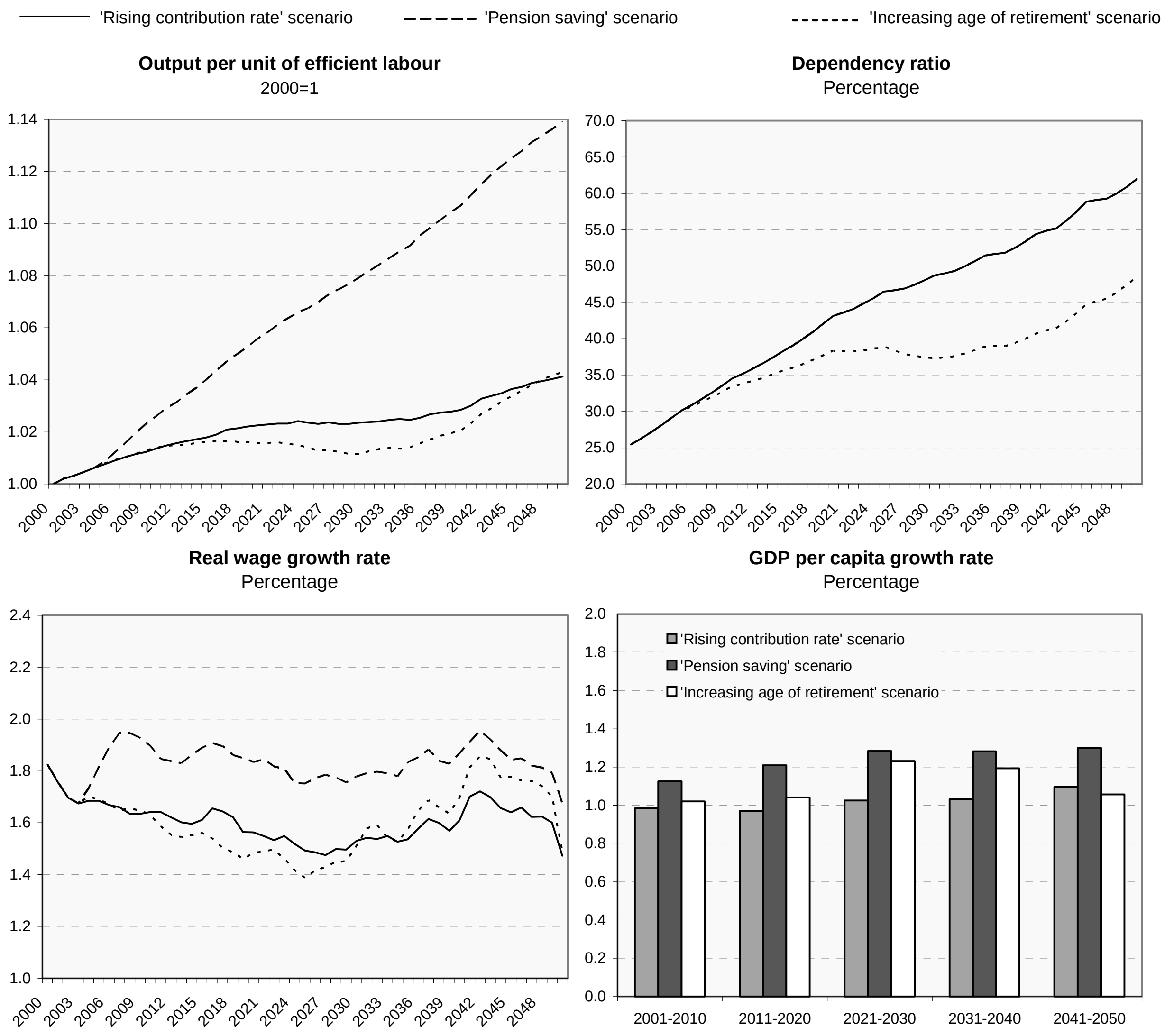


Fig A1.2 (cont.) Japan



Note : Participation rates are frozen at their 2000 levels, except for the 'increasing age of retirement' scenario.
Source : OECD calculations.

Figure A1.3 France

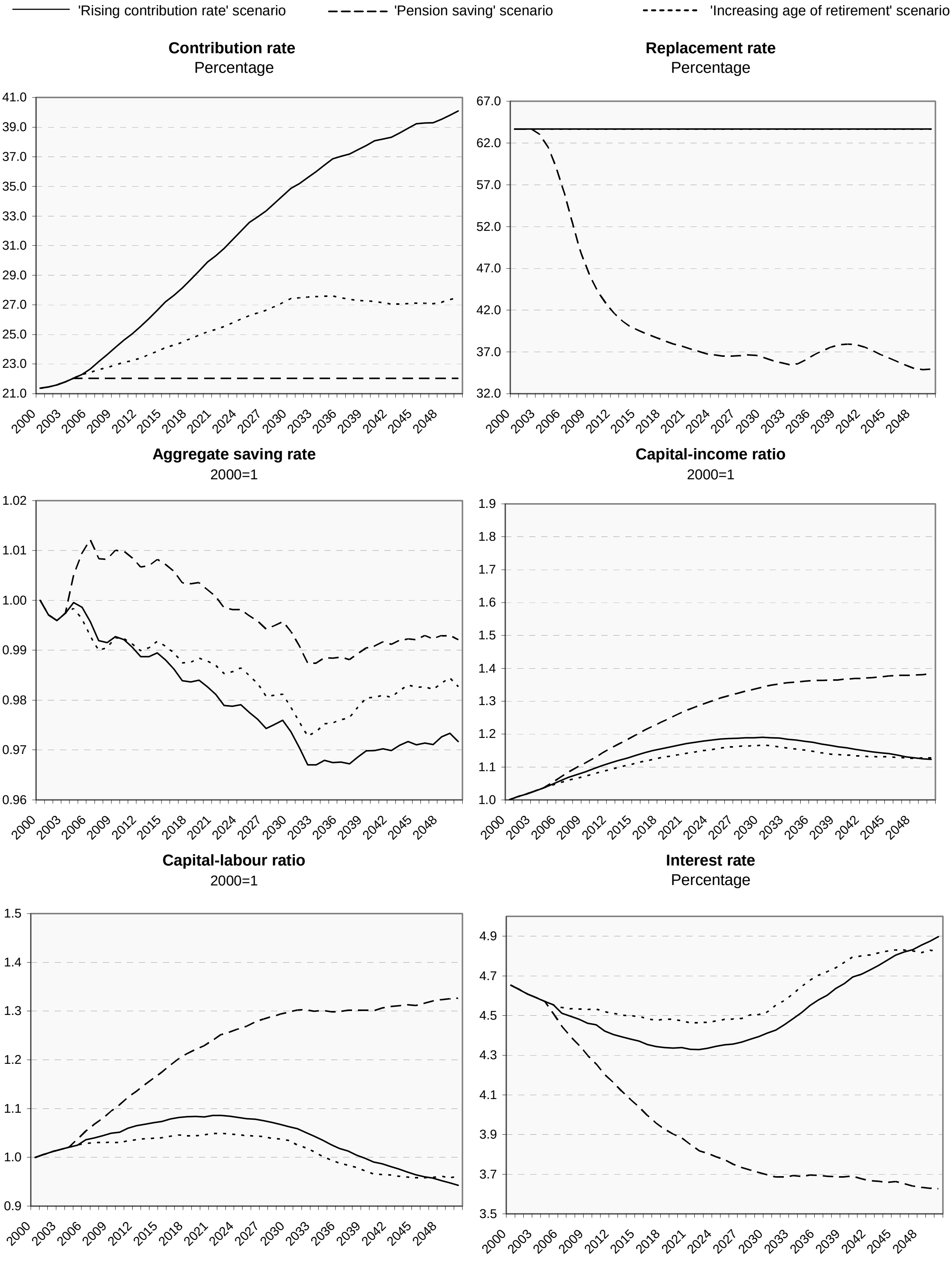
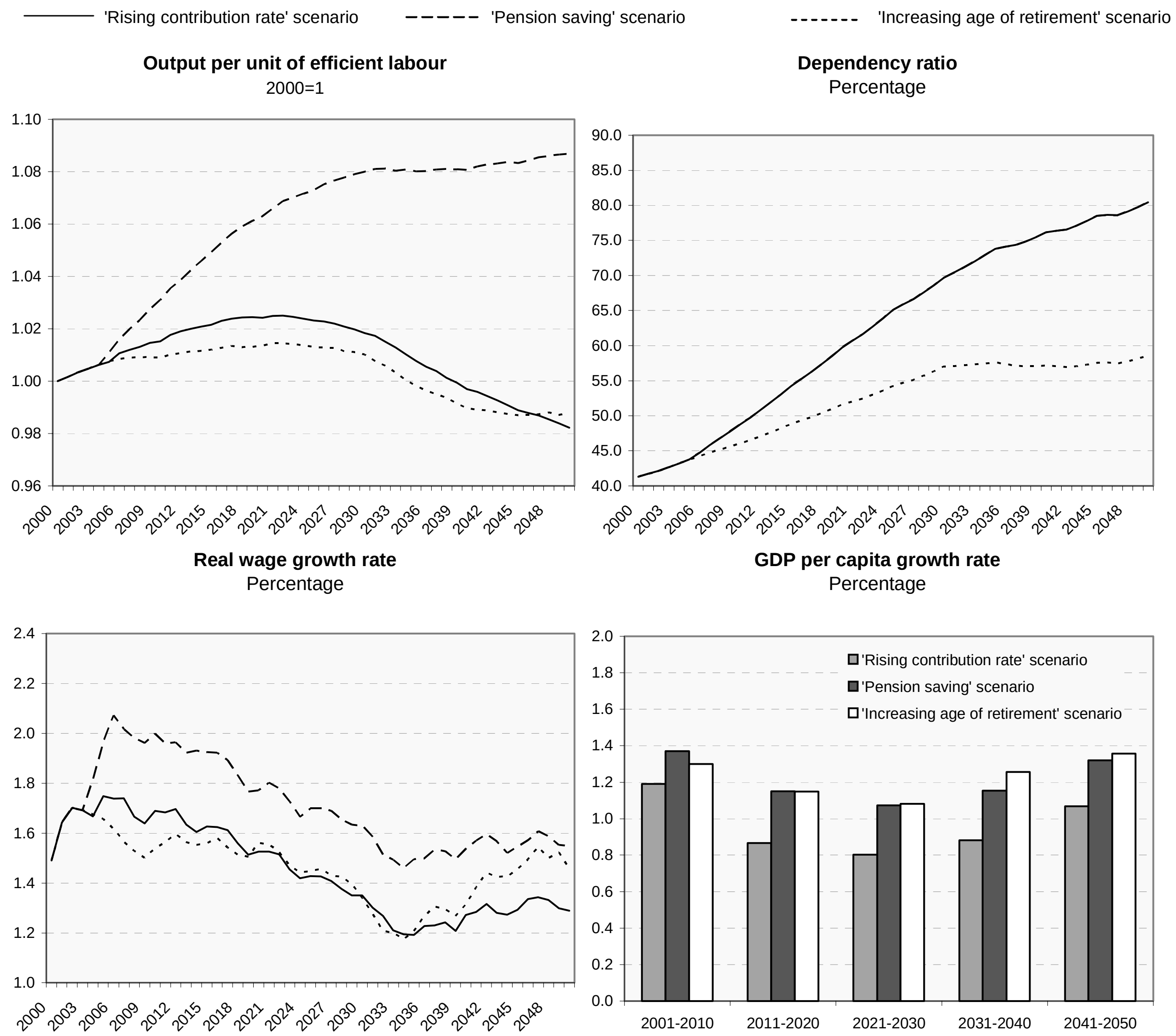


Figure A1.3 (cont.) France



Note : Participation rates are frozen at their 2000 levels, except for the 'increasing age of retirement' scenario.
Source : OECD calculations.

Figure A1.4 Germany

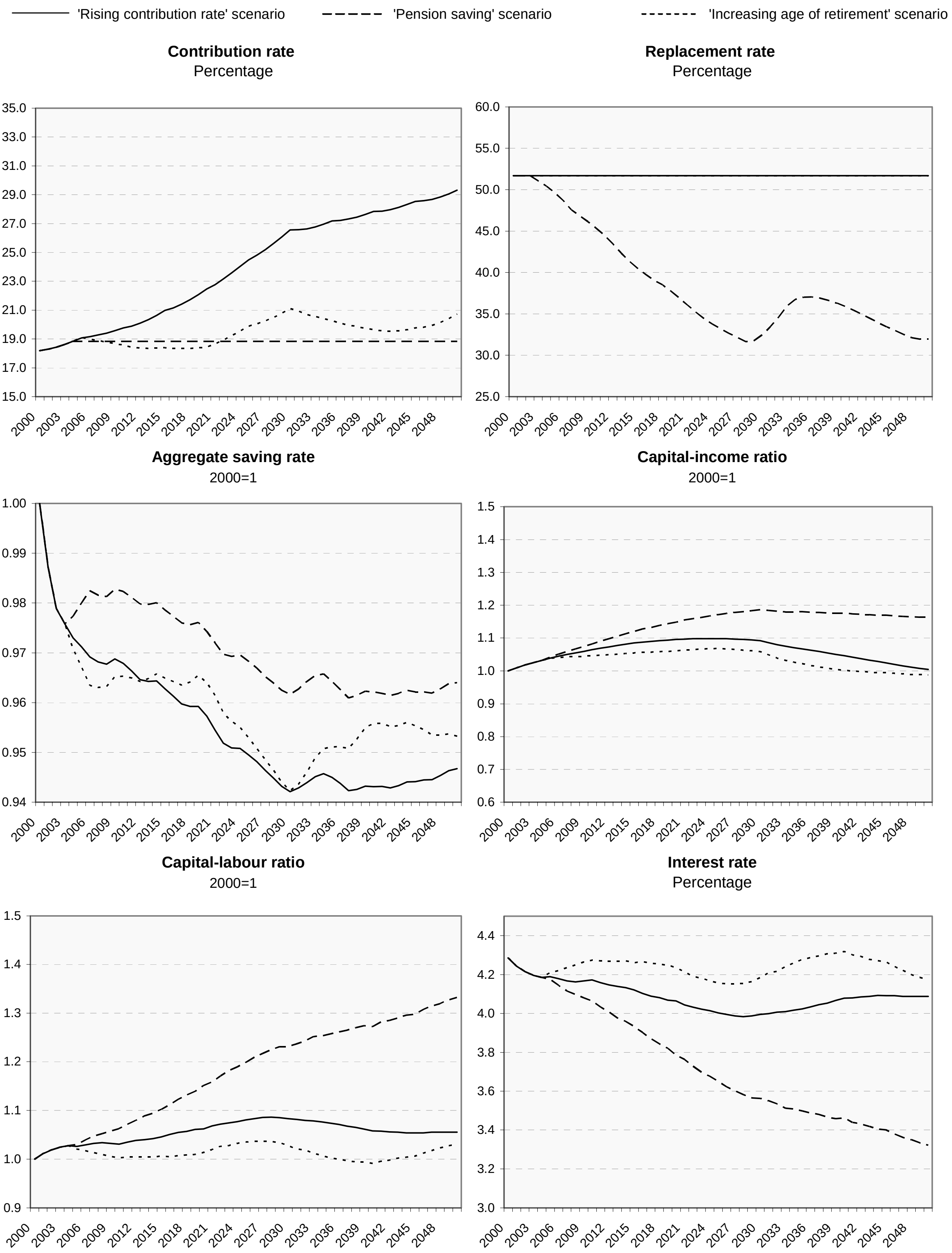
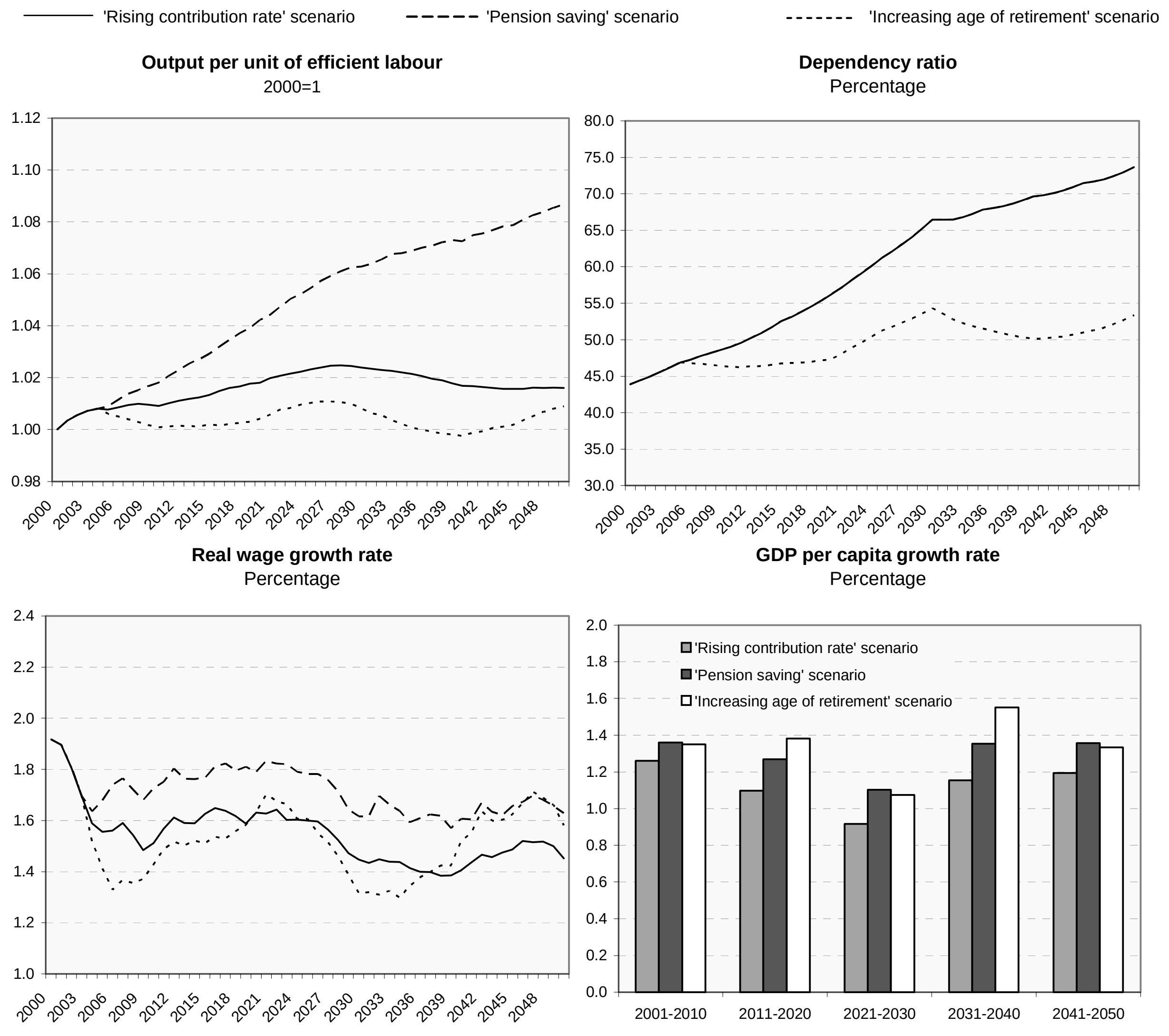


Figure A1.4 (cont.) Germany



Note : Participation rates are frozen at their 2000 levels, except for the 'increasing age of retirement' scenario.
Source : OECD calculations.

ANNEX 2. AN OVERLAPPING GENERATIONS MODEL ASSESSING THE IMPACT OF AGEING AND PENSION REFORMS ON CAPITAL MARKETS AND GROWTH

61. This annex describes the overlapping generations (OLG) model used to assess the impact of ageing on financial markets and growth discussed in the main text. The specification of the model draws mainly on Miles (1999) and Börsch-Supan *et al.* (2002). The model embodies 79 overlapping generations per year. Each cohort has a life span of 20 to 99 years and a specific mortality profile.

62. The structure of the model is the same for each country. However, demographic data and some calibration parameters are country-specific. Each country is a closed economy and the labour market is exogenous. There is perfect information and economic agents are rational. Given the long-term nature of the model, inflation is zero and unemployment rates are assumed to be constant. The impact of some of these assumptions on the simulation results is discussed below.

63. This annex is organised as follows. The first section describes the model's specification. Section two describes the parameterisation and calibration of the model. Section three discusses the robustness of the results to relaxing some of the assumptions, in particular introducing an endogenous choice between leisure and consumption.

1. The model

64. Each cohort at year t and age a has $N_{t,a}$ members. The representative individual is economically active from age 20 until age 99 (i.e. a ranges from 0 to 79). In each cohort, a proportion of $\upsilon_{t,a}$ individuals are working and $\mu_{t,a}$ are unemployed. Among inactive individuals, the proportion of those that will not receive a pension in the future was proxied by the ratio of inactive people aged 40-44 to those inactive aged 65-69 in 2000.[29] The proportion of pensioners in the population $\pi_{t,a}$ was then derived residually. The national population projections described in section 2 of the main text were transformed from five-year periods by age groups to survival probabilities for each cohort, assuming a linear interpolation of the five-year intervals into annual data.

65. The supply-side of the economy is modelled through a standard CES production function, with two inputs (capital and labour):

$$Y_t = \left[\alpha \cdot K_t^{1-\frac{1}{\beta}} + (1-\alpha) \cdot (A_t \cdot L_{q,t})^{1-\frac{1}{\beta}} \right]^{\frac{1}{1-\frac{1}{\beta}}} \qquad [1]$$

66. Where α is the share of capital revenue in the aggregate value-added, $1/\beta$ is the elasticity of substitution between capital and labour, K_t the stock of productive capital in the business sector, A_t is an index associated with a labour augmenting multi-factor productivity. The quality-adjusted labour input (L_q) is equal to:

$$L_{q,t} = \sum_{a=0}^{79} a_{p,a} \cdot Edu_a \cdot (\upsilon_{t,a} N_{t,a})$$

67. For a given cohort a, the parameter $a_{p,a}$ links age to individual productivity and Edu_a is an index of education of the labour force. Following Miles (1999), this age-productivity parameter was assumed to follow a quadratic function peaking at around 42 years old: $a_{p,a} = e^{0.05*(age)-0.0006*(age)^2}$. As discussed in section 5 of the main text, the model results are relatively robust to alternative specifications of this function.[30] The index of education is discussed in section 6 of the main text.

68. The production function [1] can be re-written in a capital-intensive form:

$$y_t = f(k_t) = \left(\alpha k_t^{1-\frac{1}{\beta}} + (1-\alpha) \right)^{\frac{1}{1-\frac{1}{\beta}}}$$

where $k_t = K_t / (A_t \cdot L_{q,t})$.

69. Profit maximisation yields optimal factor prices, as follows:

$$r_t = \alpha \cdot k_t^{-\frac{1}{\beta}} + \left[\alpha \cdot k_t^{1-\frac{1}{\beta}} + (1-\alpha) \right]^{\frac{1}{\beta-1}}$$

$$w_t = A_t \cdot (1-\alpha) \cdot \left[\alpha k_t^{1-\frac{1}{\beta}} + (1-\alpha) \right]^{\frac{1}{\beta-1}}$$

where w_t is the gross real wage, *i.e.* including social contributions paid by households. In the long-run equilibrium, the growth rate of real wages is equal to TFP gains because both total labour force and the capital-labour ratio in efficiency units, *K/(A.L)*, are constant over the long-run. The variable r_t is the marginal productivity of capital, equal to the real interest rate. There is no capital depreciation in the model, but including it would not have changed the dynamics because equilibrium conditions stem from saving behaviour net of depreciation of capital. The price of the produced good is normalized to one (*numéraire*).

70. The household sector is modelled through a standard, separable, time-additive, constant relative-risk aversion (CRRA) utility function and an intertemporal budget constraint encompassing a balanced PAYG pension regime. The objective function over the lifetime for the average representative individual of a cohort of age a at year t is:

$$U_{t,a} = \frac{1}{1-\sigma} \cdot \sum_{j=a}^{79} \left[\frac{1}{(1+\rho)^{j-a}} (c_{t+j-a,j})^{1-\sigma} \right]$$

71. where $c_{t,j}$ stands for the consumption level of the average individual of a cohort of age j in year t, ρ is the psychological discount rate and σ is the relative-risk aversion coefficient. For a CRAA function, this coefficient is equal to the inverse of the intertemporal substitution coefficient.

72. The intertemporal budget constraint for a cohort of age 20 at year t can be written as:

$$y_{t,0} + \sum_{j=1}^{79}\left[y_{t+j,j} \prod_{i=1}^{j}\left(\frac{1}{1+r_{t+i}}\right)\right] = c_{t,0} + \sum_{j=1}^{79}\left[c_{t+j,j} \prod_{i=1}^{j}\left(\frac{1}{1+r_{t+i}}\right)\right]$$

where $y_{t,a}$ corresponds to the after-tax total individual income of the representative individual for each cohort. Given that this individual is supposed to represent the proportion of employed, unemployed and pensioners in a cohort, his or her total income will be equal to:

$y_{t,a} = w^g_{t,a}(1-\tau_{t,U} - \tau_{t,P}) + \xi_{t,a} + \Phi_{t,a}$, where:

- $w^g_{t,a}$ stands for the gross income of the representative individual in a given cohort: $w^g_{t,a} = w_t \cdot a_{p,a} \cdot \upsilon_{t,a}$.
- $\tau_{t,U}$ is the contribution rate on labour income that finances unemployment benefits and balances the unemployment scheme. $\tau_{t,P}$ is the tax on labour income, which enables to balance the pension system every year.
- Unemployment benefits are proportional to the current gross income: $\xi_{t,a} = w^g_{t,a}\mu^g_{t,a}\, u$, where u is an exogenous parameter.
- The pension income $\Phi_{t,a}$ depends on the age of the individual and the age ψ_t at which an individual will be entitled to obtain a full pension. Three cases may occur:

(1) No pension can be received before the age of 50. More precisely:

$$\text{If } \ (a+20) < 50 \ \rightarrow \ \Phi_{t,a} = 0$$

(2) If an individual is above 50 but below the full-right retirement age ψ_t, he or she can receive a pension reduced by a penalty. This penalty was assumed to be equal to 6% by year[31], which corresponds approximately to actuarial neutrality for current PAYG regimes. Thus:

$$\text{If } \ 50 \le (a+20) < \psi_t \ \rightarrow \ \Phi_{t,a} = \max\left(p_t \cdot w_t \cdot a_{p,\psi_t} \cdot \pi_{t,a} \cdot \left(1 - \frac{\psi_t - 20 - a}{100/6}\right) \ ; \ 0 \right)$$

where p_t is the average replacement rate of the regime when retiring at age ψ_t.

(3) Finally, an individual will obtain a full pension if his or her age is above or equal to ψ_t.

$$\text{If } \ (a+20) \ge \psi_t \ \rightarrow \ \Phi_{t,a} = \Phi_{t-1,a-1} \frac{\pi_{t,a}}{\pi_{t-1,a-1}}$$

This implies that the average pension is flat (*i.e.* not wage-indexed), but is adjusted each year by the change in the number of pensioners in each cohort.

73. Knowing the lifetime stream of income, the optimal consumption path can be derived from the usual Euler equation:

$$\frac{c_{t,a}}{c_{t-1,a-1}} = \left(\frac{1+r_t}{1+\rho}\right)^{\kappa}$$

where the intertemporal substitution coefficient is equal to the inverse of the risk aversion $\kappa = \sigma^{-1}$. This relation enables to compute lifetime consumption providing that the initial level of consumption $c_{t,0}$ (*i.e.* the level of consumption of a cohort of age 20 at a year t) is known. The latter can be obtained by replacing the Euler equation into the budget constraint. For a cohort of age 20 at date t, this would yield:

$$c_{t,0} = \frac{y_{t,0} + \sum_{j=1}^{79}\left[y_{t+j,j} \prod_{i=1}^{j}\left(\frac{1}{1+r_{t+i}}\right)\right]}{1 + \sum_{j=1}^{79}\left[\frac{\prod_{i=1}^{j}(1+r_{t+i})^{\kappa-1}}{(1+\rho)^{j\kappa}}\right]}$$

74. Once the optimal consumption path is computed for all the cohorts in the model, average individual's savings can be derived as: $s_{t,a} = y_{t,a} - c_{t,a}$, and individual wealth as: $\Omega_{t,a} = (1+r_t)\cdot\Omega_{t-1,a-1} + s_{t,a}$. The annual saving is invested in the capital market, yielding an interest rate of r_t. The interest payments are capitalised into individual wealth.

75. The market clearing conditions in the capital market derive from the accounting relation stating that the stock of productive capital is equal to total wealth:

$$K_t = \sum_a \Omega_{t,a}\chi_{t,a} = \Omega_t$$

where $\chi_{t,a} = N_{t,a} / \sum_a N_{t,a}$ is the ratio between the number of individuals of age *a* at date *t* over total population at date *t*. In other words, the representative stock of capital of every cohort is weighted by the size of each cohort in total population. This weighting scheme, suggested by Miles (1999), is a decreasing function of the age of the cohort. This allows taking into account cohort-specific mortality profiles without the need to model uncertainty. The latter would require adding a third dimension in the cohort variables, which would reduce significantly the tractability of the model without changing dramatically the results.

76. The model is solved through a standard Gauss-Seidel algorithm equalising the demand K_t and the supply of capital Ω_t. The intertemporal equilibrium is reached when, for any year between 1989 and 2080, the convergence criterion $\max\left|\frac{K_t}{\Omega_t} - 1\right| < \varepsilon$ is satisfied. The parameter $\varepsilon > 0$ denotes an arbitrarily small number (typically lower than 0.005). Walras' law ensures that the labour market is also cleared.

2. Calibration and parameterisation

77. The main exogenous variables in the model are demographic data. Given that the model requires the definition of two long-run steady-states, demographic data had to be constructed for the whole period

1910-2158. Available historical values for the period 1970-2000 were gathered from national sources. For the period 1950 to 1970, the annual growth of total population was assumed to be 1.5 times its average annual growth for the period 1970-2000, in this way capturing the effects of the baby-boom shock. For the period 2000 to 2050 the national population projections described in Section 2 in the main text were used. Finally, from 1910 to 1950, and after 2050, population level and structure by age groups were assumed to be constant.

78. All the production inputs (K_t, L_t and A_t) were normalized to one in 1989 (the base year). The share of remuneration of capital in value-added (α) was set at 0.3 for all countries.[32] The elasticity of substitution between capital and labour was assumed to be equal to 1.25, a relatively high value that is consistent with the long-term characteristics of the model. Sensitivity analysis reported below shows that the results would remain broadly unchanged with an elasticity equal of 0.8. Total factor productivity A_t was assumed to grow at the same 1.5% rate in all countries.[33]

79. In line with recent studies (Gallon and Masse, 2004; and Gourinchard and Parker, 2002), the households' psychological discount rate was set at 3%. The risk-aversion parameter σ in the CRRA utility function was assumed to be equal to 1.33 (implying an intertemporal substitution elasticity of around 0.75). A value of σ greater than one has been indeed suggested by recent financial and behavioural economic literature (cf. Kotlikoff and Spivak, 1981).[34]

80. Unemployment benefits are assumed to replace 50% of the equilibrium wage, but given that the unemployment rates are assumed to remain constant throughout the simulation period, the results are not very sensitive to this parameter. Consistent with the model's specification, the level of the average replacement rate in the base year (p_{89}) was computed as the ratio between pensions received *per capita* and gross wages received *per capita*. This rate is used as a proxy for the generosity of the pension system. The orders of magnitude seem reasonable (57.5% for the United States, 51.2% for Japan, 51.7% for Germany and 63.7% for France).

3. Sensitivity analysis

81. In order to test the robustness of model results to alternative specifications and parameter values, an extensive sensitivity analysis was carried out. Table A2.1 summarizes the results of these tests using the baseline scenario for the United States. Overall, the results appear relatively robust to changes in some key parameters (the capital share in value-added α, the risk-aversion coefficient σ, the age-individual productivity coefficient a_p, the elasticity of substitution between capital and labour $1/\beta$ and the discount rate ρ). Moreover, a higher value for the ratio between unemployment benefits and wages does not modify substantially the results. The variable that seems to be the most affected by changes in parameter specification is the level of equilibrium interest rate, though the dynamic path continues to display the same qualitative shape as in the baseline.

82. A sensitivity test was also carried out with respect to the assumptions underlying demographic projections by assuming that fertility rates would increase by +0.2 children per woman after 2005. As it could be expected, this change does not affect much the results before 2030-40.

83. A more significant change in the model specification is the endogeneisation of the labour market, by introducing the fraction of available time devoted to leisure in the households' instantaneous utility function. In this way, households arbitrage in each period between leisure and consumption and inter-temporally between current and future consumption. As the Euler equation is modified and labour force redefined in terms of total hours worked, the convergence process becomes more complex.

84. In this version of the model there are two additional general equilibrium interactions. As capital deepening tends to increase wages, the opportunity cost of leisure (equal by definition to the net wage) also increases. This tends to push up labour inputs, *ceteris paribus*. At the same time, an increase in the contribution rate, especially in the "rising contribution rate" scenario, has a downward effect on the opportunity cost of leisure and thus on labour inputs. Depending on the country, the balance between these two effects will be different. In a country with relatively strong capital deepening and limited increases in the contribution rate, such as the United States, the first effect tends to dominate and, overall, working time increases and capital deepening declines vis-à-vis the baseline. In a country with relatively limited capital deepening but sizeable increases in the contribution rate, such as France, the second effect is dominant translating into a decline in the working hours and a somewhat higher capital deepening. Overall, with an endogenous labour market, the dynamic path of most macroeconomic variables is smoothed out and the basic results of the model are not substantially modified (Table A2.2).

NOTES

29 . In other words, it was assumed that the individuals that are not in the labour force at the age of 40-44 years will not be entitled to receive a pension at the age after 65 years of age.

30 . INGENUE (2001) uses the same function. Recent econometric studies (Aubert and Crepon 2003)) do not confirm the decrease of individual productivity at older ages, but numerical simulations discussed in the section 6 of the main text show that the results are not very sensitive to alternative specifications.

31 . This benchmark was taken from the French pension reform. It corresponds roughly to an actuarially fair penalty rate, assuming a long-run real interest rate at 3%.

32 . In models incorporating a depreciation rate (Borsch-Supan, 2002), the value for this parameter is usually higher, *e.g.* 0.4. Assuming α=0.4 and a standard depreciation rate of 15% would yield a net remuneration of capital in value-added around 0.3. Miles (1999) assumes α=0.25.

33 . For a discussion see Acemoglu (2000).

34 . Borsch-Supan (2002) uses a risk aversion parameter of 2.7, but this choice results from the specific calibration of his model and might bias the results if applied in another context. Kotlikoff and Spivak (1981) use a value of 1.33, while Epstein and Zin (1991) suggest values ranging from 0.8 to 1.3. Normandin and Saint-Amour (1998) use a value of 1.5.

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Table A2.1 : Sensitivity analysis

Baseline = Rising contribution rate scenario for the United States	Contribution rate	Interest rate	Capital / income ratio 2000=1	Capital / labour ratio 2000=1	Income / labour ratio 2000=1	Wage growth rate
Baseline						
level in 2005	8.5%	4.1%	1.09	1.09	1.026	2.1%
level in 2015	10.2%	3.7%	1.29	1.20	1.056	1.9%
level in 2040	14.4%	3.8%	1.55	1.19	1.051	1.6%
Baseline with capital share in output (net of depreciation) of 0.25 (instead of 0.3)						
Deviation from the baseline in 2005	-0.1%	-0.2%	0.02	0.02	0.000	0.0%
Deviation from the baseline in 2015	0.0%	-0.3%	0.06	0.05	0.000	0.0%
Deviation from the baseline in 2040	0.0%	-0.3%	0.07	0.06	0.003	0.0%
Baseline with capital share in output (net of depreciation) of 0.35 (instead of 0.3)						
Deviation from the baseline in 2005	0.1%	0.2%	-0.02	-0.01	0.001	0.1%
Deviation from the baseline in 2015	0.1%	0.3%	-0.05	-0.05	-0.004	-0.1%
Deviation from the baseline in 2040	0.1%	0.3%	-0.06	-0.06	-0.008	0.0%
Baseline with relative risk aversion of 2 (instead of 1.33)						
Deviation from the baseline in 2005	0.1%	0.3%	-0.01	-0.01	-0.002	-0.1%
Deviation from the baseline in 2015	0.0%	0.2%	0.00	0.01	0.003	0.1%
Deviation from the baseline in 2040	0.0%	0.1%	0.03	0.04	0.011	0.0%
Baseline with relative risk aversion of 1.05 (instead of 1.33)						
Deviation from the baseline in 2005	0.0%	-0.1%	0.00	0.00	0.000	-0.1%
Deviation from the baseline in 2015	0.0%	-0.1%	-0.01	-0.02	-0.005	-0.1%
Deviation from the baseline in 2040	0.0%	0.0%	-0.03	-0.03	-0.009	0.0%
Baseline with individual age-productivity parameter flat after 42 years (instead of declining after 42) 1/						
Deviation from the baseline in 2005	0.0%	0.0%	0.01	0.00	-0.001	0.0%
Deviation from the baseline in 2015	0.0%	0.0%	0.02	-0.01	-0.003	0.0%
Deviation from the baseline in 2040	0.0%	0.0%	0.02	-0.01	-0.002	0.0%
Baseline with capital / labour elasticity of substitution coefficient in the production function of 0,8 (instead of 1.25)						
Deviation from the baseline in 2005	0.0%	0.1%	0.03	0.02	0.007	-0.2%
Deviation from the baseline in 2015	0.0%	0.1%	0.08	0.05	0.016	-0.1%
Deviation from the baseline in 2040	0.0%	0.1%	0.07	0.04	0.012	0.0%
Baseline with capital / labour elasticity of substitution coefficient in the production function of 0,5 (instead of 1.25)						
Deviation from the baseline in 2005	-0.1%	0.1%	0.06	0.04	0.014	-0.3%
Deviation from the baseline in 2015	0.1%	0.3%	0.15	0.10	0.033	-0.1%
Deviation from the baseline in 2040	0.0%	0.3%	0.13	0.06	0.023	0.0%
Baseline with unemployment benefits equal to 70% of wages (instead of 50%)						
Deviation from the baseline in 2005	0.0%	0.0%	0.00	0.00	0.000	0.0%
Deviation from the baseline in 2015	0.0%	0.0%	0.00	0.00	-0.001	0.0%
Deviation from the baseline in 2040	0.0%	0.0%	0.00	0.00	-0.001	0.0%
Baseline with households' discount rate of 2% (instead of 3%) 2/						
Deviation from the baseline in 2005	0.1%	ns	-0.01	-0.01	-0.004	-0.1%
Deviation from the baseline in 2015	0.1%	ns	-0.04	-0.05	-0.012	-0.1%
Deviation from the baseline in 2040	0.1%	ns	-0.08	-0.09	-0.023	-0.1%
Baseline with slightly higher fertility rate (+0,2 child per woman after 2005)						
Deviation from the baseline in 2005	0.0%	0.0%	0.00	0.00	0.000	0.0%
Deviation from the baseline in 2015	0.0%	0.0%	0.00	0.00	0.000	0.0%
Deviation from the baseline in 2040	-0.3%	0.0%	0.02	-0.02	-0.004	0.0%

1/ In this scenario, the age-productivity parameter follows an inverted U-shape quadratic function as in Miles (1999) but the function remains flat after reaching its peak (at 42 years).

2/ Comparing the interest rates obtained in this scenario with those of the baseline is not meaningful since modifying the households' discount rate in a life-cycle model also modifies the long-run equilibrium interest rate.

Table A2.2 : Impact of endogenising the labour market

Baseline = Rising contribution rate scenario	Contribution rate	Interest rate	Capital / income ratio 2000=1	Capital / labour ratio 2000=1	Income / labour ratio 2000=1	Wage growth rate
United States - Baseline						
level in 2005	8.5%	4.1%	1.09	1.09	1.026	2.1%
level in 2015	10.2%	3.7%	1.29	1.20	1.056	1.8%
level in 2040	14.4%	3.8%	1.55	1.19	1.051	1.2%
United States - Baseline with endogenous labour						
Deviation from the baseline in 2005	1.0%	0.3%	-0.03	-0.04	-0.011	-0.2%
Deviation from the baseline in 2015	0.1%	0.4%	-0.05	-0.07	-0.020	0.0%
Deviation from the baseline in 2040	-1.0%	0.4%	-0.08	-0.09	-0.023	0.1%
France - Baseline						
level in 2005	22.3%	4.6%	1.05	1.02	1.007	1.7%
level in 2015	27.2%	4.4%	1.14	1.07	1.022	1.6%
level in 2040	38.1%	4.7%	1.16	0.99	0.997	1.3%
France - Baseline with endogenous labour						
Deviation from the baseline in 2005	-1.6%	0.0%	0.00	0.00	0.000	0.0%
Deviation from the baseline in 2015	-4.3%	-0.1%	0.01	0.03	0.004	0.0%
Deviation from the baseline in 2040	-7.5%	-0.4%	0.06	0.10	0.029	0.1%

ANNEX 3: WELFARE GAINS OF PURCHASING AN ANNUITY AT RETIREMENT

85. This annex assesses the individual welfare gains of buying an annuity at retirement. It shows that, under reasonable assumptions, these gains could be substantial. Therefore, the underdevelopment of annuity markets in OECD countries is puzzling. A few possible explanations are provided.

86. At the time of retirement, individuals face a certain degree of uncertainty regarding their longevity. As a result, retirees tend to consume out of their accumulated assets less than if they had faced a certain lifetime horizon. These precautionary savings tend to lower welfare during retirement.[35] Insuring against this uncertainty would improve individuals' welfare by removing the precautionary saving motive. This could be achieved by exchanging their accumulated assets for an annuity upon retirement (Yaari, 1965). The welfare gains of buying annuities can be assessed by computing the additional amount of assets required at the time of retirement to leave an individual that does not insure as well off as an individual that buys an annuity (Kotlikoff and Spivak, 1981).

1. Framework

87. An individual's well-being is measured in terms of consumption, *c*. Each individual is assumed to retire at age 65, (*t=0*), and to maximize a standard expected utility function:

$$U_t = \sum_{t=0}^{D} \left[(1+\rho)^{-t} \cdot (1-\sigma)^{-1} \cdot p_t \cdot c_t^{1-\sigma} \right] \qquad [1]$$

where *D* is the maximum life expectancy and p_t is the survival probability after *t* years.[36] The coefficients ρ and σ measure the discount rate and the relative-risk aversion, respectively.

88. Retirement income is generated by the amount of assets accumulated at the time of retirement, W_0. The budget constraint in this maximisation problem depends on whether the individual buys an annuity or not:

- $W_0 = \sum_{t=0}^{D} \left[(1+r)^{-t} \cdot c_t \right]$, when no annuity is bought. [2]

- $\lambda . W_0 = \sum_{t=0}^{D} \left[(1+r)^{-t} \cdot p_t \cdot c_t \right]$, when buying an annuity. [2']

89. Equation [2'] reflects the fact that an annuity scheme is equivalent to a situation where the survival probabilities are perfectly known. In this context, parameter λ measures the difference between the discounted value of future periodic payments and the premium charged by the insurer. When $\lambda=1$ the discounted value of the stream of future payments associated with the annuity is equal to the annuity price, *S*:[37]

$$S = \sum_{t=0}^{D} \left[A.p_t / \prod_{1}^{t} (1+r_t)^t \right] \qquad [3]$$

90. Where A is the fixed sum paid annually by the insurer. In practice, λ is often less than one and annuities are likely to entail a net cost compared to a standard riskless investment. These costs reflect administrative and marketing charges, corporate taxation, and asymmetries of information in insurance markets (*e.g.* adverse selection). Finkelstein and Poterba (2004) found that the average difference between the price of the annuity and the fair price may amount to 13.5% of the price paid for a 65 year old UK male. On US data, Mitchell et al., (1999) obtain a figure of 18.6%. Therefore, some of the results presented below are obtained under the assumption that the difference between the premium and the discounted value of future payments is 15%, with λ fixed at 0.85 for all countries.

91. Solving the maximization problem and defining the optimal consumption path gives the maximum utilities associated with W_0, with and without annuities, as follows:

$$N_0(W_0) = (1-\sigma)^{-1} \cdot W_0^{1-\sigma} \cdot \left[\sum_{t=0}^{D} (1+r)^{t(1-\sigma)/\sigma} \cdot (1+\rho)^{-\frac{t}{\sigma}} \cdot p_t^{\frac{1}{\sigma}} \right]^{\sigma} \text{ (when no annuity is bought)}$$

$$A_0(W_0) = (1-\sigma)^{-1} \cdot (\lambda W_0)^{1-\sigma} \cdot \left[\sum_{t=0}^{D} (1+r)^{t(1-\sigma)/\sigma} \cdot (1+\rho)^{-\frac{t}{\sigma}} \cdot p_t \right]^{\sigma} \text{ (when buying an annuity)} \quad [4]$$

92. These equations make it possible to compute the variation of initial assets, M, required in the no-annuity case to leave a 65 year old individual indifferent between buying and not buying an annuity. This amounts to solving the equation: $A_0(W_0) = N_0(MW_0)$. It is noteworthy that M does not depend on the amount of initial assets W_0.

2. Results

93. Figure A3.1 shows the value of M as a share of initial assets in OECD countries for an actuarially fair annuity ($\lambda=1$), a discount rate equal to the real interest rate at 3% and different degrees of risk aversion.[38] The welfare gains of buying an annuity are substantial: to reach the same level of utility as with an annuity, an individual with no annuity would need between 25% and 45% more assets at age 65. These results are in line with Kotlikoff and Spivak (1981) and Mitchell *et al.* (1999). The latter find a value of 38.6% on US data with a high risk-aversion parameter of 2.

94. Figure A3.2, shows the results of setting the value of λ at 0.85 to take into account the effects of asymmetric information on the pricing of annuities. In all countries, the impact on welfare of purchasing a "non-fair" annuity would still remain sizeable. An individual with no annuity should have accumulated 10% to 30% more assets upon retirement to reach the same level of utility as an individual who bought a "non-fair" annuity.

95. The model implies that in countries with higher life expectancies (*e.g.* Japan, Spain, Sweden and Switzerland) individuals would experience lower welfare gains from buying an annuity, independent of whether the annuity is "fair" or "unfair".[39] Another implication of the model is that welfare gains of buying an annuity are likely to increase with aversion to risk. Higher risk aversion leads to higher saving for precautionary motives, increasing therefore the gains from buying an annuity.

96. In the light of these calculations, the negligible development of voluntary annuity markets in OECD countries is puzzling. The cost of asymmetric information cannot by itself account for this

phenomenon, since welfare gains from buying an annuity would seem to be sizeable even in the case of "unfair" annuities. Friedman & Warshawsky (1988, 1990) have argued that the underdevelopment of these markets may be related to bequest motives. By extending Kotlikoff & Spivak's (1981) model to incorporate bequests in the household's utility function, it is possible to rationalise the lack of purchases of "fair" annuities. Even in the case of "non-fair" annuities, a reasonable degree of bequests may account for the low demand for annuities.[40] Nonetheless, the latter result critically depends on the assumption of a low risk-aversion, which raises doubts about the robustness of these calculations. Hence, it remains unclear whether accounting for a bequest motive in annuity schemes could foster the development of an annuity market. It should be noticed however that, in principle, there is no conflict between the demand for annuities and bequests: by reducing longevity risk, the purchase of annuities reduces the need for precautionary savings and may increase the ability to leave voluntary bequests.

NOTES

35 See for instance Bernard, El Mekkaoui de Freitas, Lavigne, and Mahieu (2002) on French data.

36 The source for survival probabilities is United Nations (2002). They are only available up to 100 years of age. The model assumes that they decline linearly reaching zero at age 110.

37 In this case the annuity is said to be actuarially fair for the individual (Kotlikoff and Spivak, 1981).

38 Alternative calculations with r=3% and ρ=2% yield the same orders of magnitude. In the case of a real interest rate above the discount rate, the value of M would increase in each country only by a few percentage points.

39 This is because the difference between life expectancy and the maximum lifetime horizon (fixed in the model at 110 years old) falls. With the period of uncertainty shrinking, the amount of precautionary saving needed to meet the longevity risk also declines.

40 The "reasonable degree" of bequest results from the assumption of an expected bequest at time of death between two to four times the level of consumption in the last year of life. For different orders of magnitude, see Menchik and David (1982).

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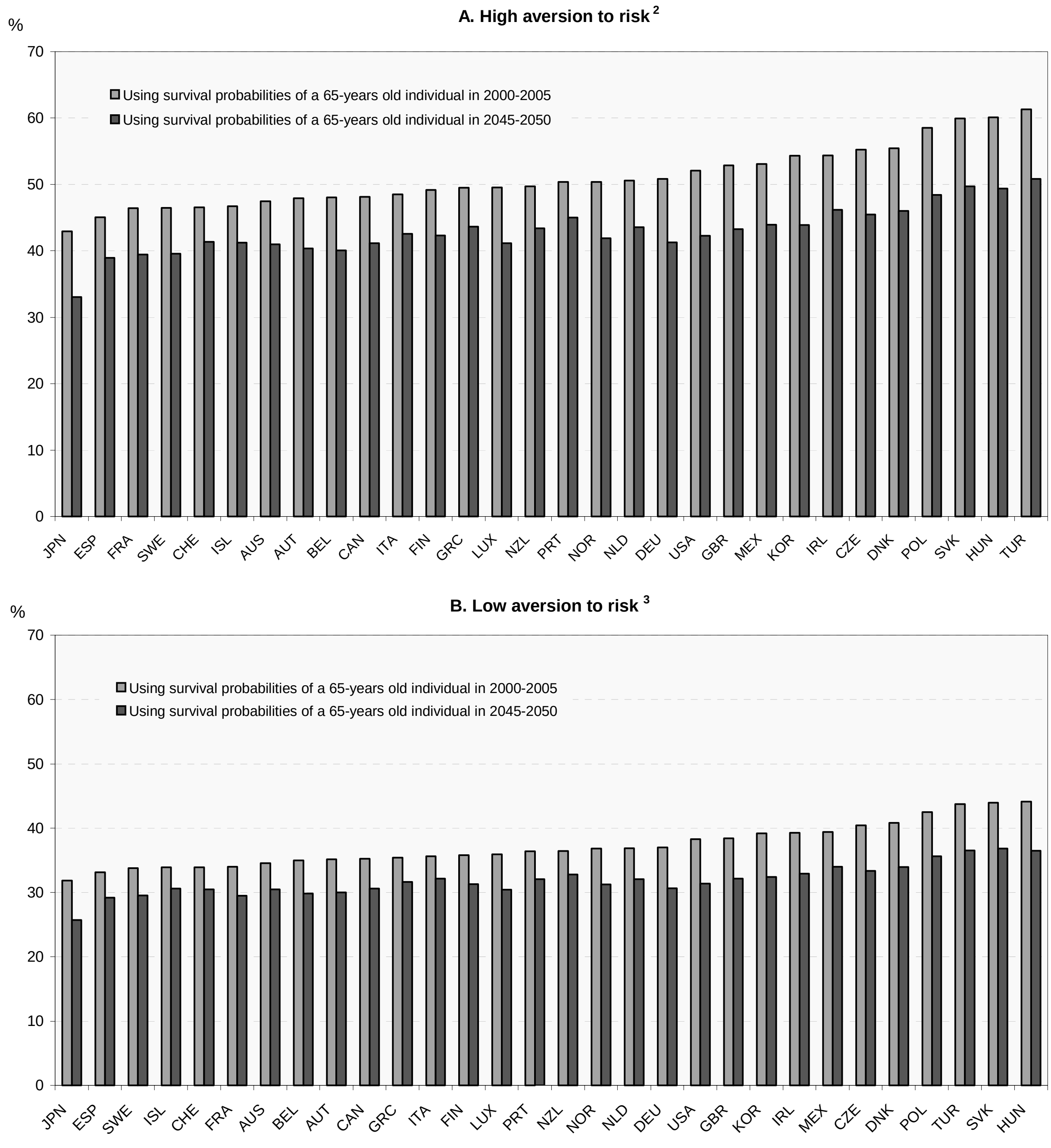
Figure A3.1 Welfare gains from buying an actuarially "fair" annuity [1]

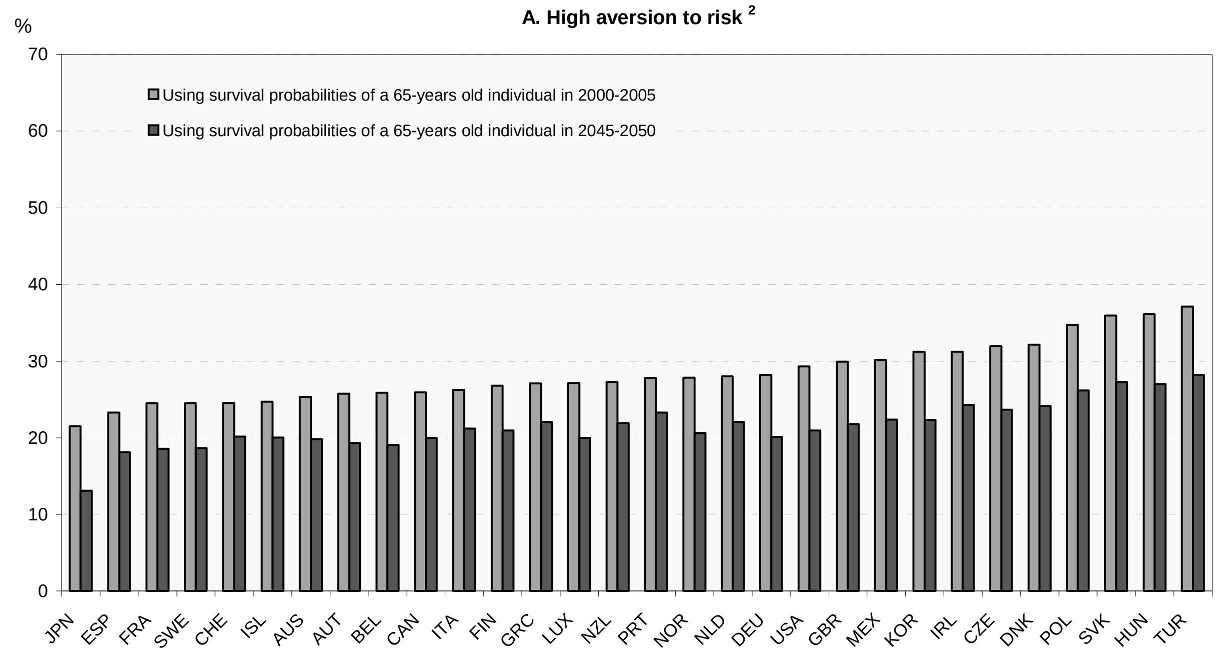
(%)

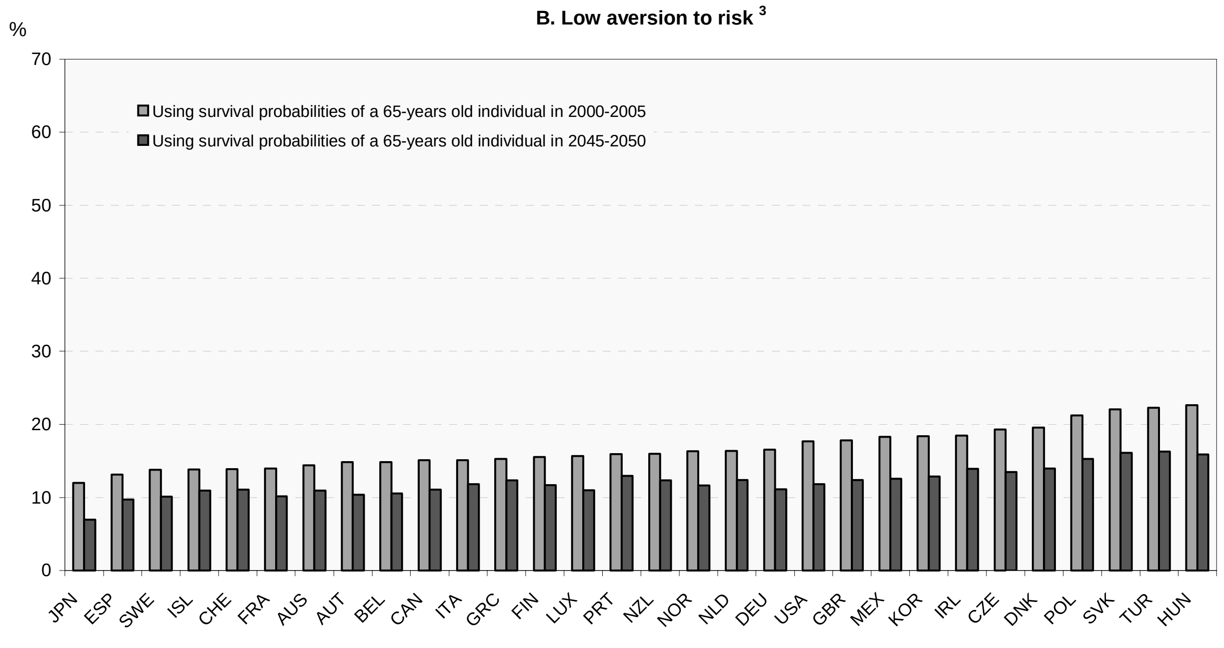


1. Increase in the stock of capital at retirement age needed to remain indifferent between buying an annuity or not. Retirement age is 65 and λ is set at 1. The discount rate is set equal to the real interest rate at 3%.
2. The relative-risk aversion coefficient is set at 2.0.
3. The relative-risk aversion coefficient is set at 0.9.
Source : OECD calculations.

Figure A3.2. Welfare gains from buying an actuarially "unfair" annuity [1]

(%)





1. Increase in the stock of capital at retirement age needed to remain indifferent between buying an annuity or not. Retirement age is 65 and λ is set at 0.85. The discount rate is set equal to the real interest rate at 3%.
2. The relative-risk aversion coefficient is set at 2.0.
3. The relative-risk aversion coefficient is set at 0.9.
Source : OECD calculations.

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