Disparities in Pension Financing in Europe: Economic and Financial Consequences

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Abstract

In recent years, various quantitative tools have been developed in order to study the economic consequences of population ageing and pension reforms. Here, we present a quantitative analysis of the impact of differential ageing and pension reforms across European countries on capital and labour market and, in particular, on intra-European capital flows. To this end, we develop a stylized general equilibrium model with overlapping generations of heterogeneous agents for the three largest European countries: France, Germany and the United-Kingdom (UK). The model presents a structure halfway between, on the one hand, pure general equilibrium models with rigorous microeconomic foundations, and on the other hand, accounting models where the macroeconomic environment remains exogenous. Demographic forecasts are used as an input in this model. Three polar assumptions about economic openness are successively handled. In the first case, the economies are closed and the return to capital adjusts in order to clear the domestic capital market. In the second case, the economies are fully open and the return to capital is taken as a given. In the third case, the economies are integrated in a financial area with perfect capital mobility within the area but no capital mobility toward the rest of the world.

The purpose of this model is to analyze the macroeconomic effects of various pension reforms undertook to insure the sustainability of the main European countries pension systems (rise in social contribution rates, decrease in net replacement ratio, debt policy,...). We show that the dynamics of capital accumulation and pension system sustainability are totally different depending on the assumption concerning economic openness. In a world of closed economies, differential ageing generates differences in rates of return that are likely to be accentuated by implemented reforms. In reality, we do not have closed economies but a global capital market. Population ageing and pension reforms therefore induce large capital flows between countries when it is assumed that each economy always finds financial resources at a fixed interest rate (small open economy). Capital flows are significantly smaller in the intermediate case where capital is perfectly mobile between the three European countries but immobile from the countries to the rest of the world.

In order to underline possible uses of the model, we will also present various kinds

of variants. Two main conclusions may be drawn from the examination of the various prospective scenarios. First of all, the critical assumptions for PAYG systems are the future trend of the global factor productivity and the behavior of agents concerning activity and labour market participation. Secondly, in the long run, resorting to debt financing seems to be a dead end to finance retirement systems. Indeed, public pension systems are unsustainable and generate important public debt which strongly weights on economic growth. A planned fall of the replacement rates presents some virtues with respect to growth but implies a large disequilibrium in the standard of living of retirees compared to active people. A progressive rise in the social contribution rates permits to avoid this but at the cost of a lower growth of resources.

Résumé

Plusieurs outils de prospectives quantitatives ont été élaborés ces dernières années pour répondre aux questions soulevées par l'évolution des systèmes de retraites face au vieillissement démographique. Nous présentons ici une analyse quantitative de ces effets sur le marché du travail et du capital, en portant une attention particulière aux flux de capitaux induits par les différences dans le processus de vieillissement entre les pays ainsi que par les réformes des systèmes de retraites. Dans ce but, nous développons un modèle d'équilibre général calculable à générations imbriquées composés d'agents hétérogènes et appliqué au cas des trois principaux pays européens : la France, l'Allemagne et le Royaume-Uni. La maquette proposée ici se situe à un degré d'intégration démo-économique intermédiaire entre les purs modèles d'équilibre général micro-fondés et les modèles comptables où l'environnement macroéconomique reste exogène. Elle utilise des projections démographiques exogènes pour traiter des conséquences du vieillissement démographique et de l'évolution des systèmes de retraites. Trois hypothèses successives en matière d'ouverture internationale de l'économie sont appréhendées. Dans la première, l'économie est fermée et le taux d'intérêt s'ajuste en fonction de l'équilibre interne du marché financier. Dans la deuxième, l'économie est ouverte et le taux d'intérêt est considéré comme une donnée. Dans la troisième, les économies sont intégrées dans une zone financière caractérisée par la parfaite mobilité des capitaux en son sein mais par l'absence de mobilité vis à vis de l'extérieur.

La finalité de ce modèle est d'analyser les effets sur les principales grandeurs économiques des effets du vieillissement démographique et des réformes envisagées des systèmes de retraites (hausse des cotisations sociales, baisse programmée des pensions, endettement public,...). Nous montrons que la dynamique d'accumulation du capital et la viabilité financière des systèmes de retraites est totalement différente selon l'hypothèse retenue en matière d'ouverture de l'économie. Dans un monde où chaque économie vit en autarcie, les différences de rythme de vieillissement génèrent des différences de taux d'intérêt qui peuvent être accentuées par les réformes mises en place. En réalité, le monde n'est pas composé d'économies fermées mais d'un marché du capital international. Le vieillissement démographique et les réformes des systèmes de retraites peuvent alors conduire à

d'importants flux de capitaux entre les pays lorsque l'on fait l'hypothèse que chaque pays peut toujours trouver les ressources nécessaires au financement de sa dette à un taux d'intérêt fixe (petite économie ouverte). Par contre, les flux de capitaux sont nettement plus faibles dans le cas intermédiaire où le capital est parfaitement mobile entre les trois pays européens mais immobile entre ces trois pays et le reste du monde.

Afin de souligner les vertus prospectives de cet instrument, une série de variantes est ensuite proposée. Deux conclusions principales ressortent de l'examen des différents scénarii de prospectives envisagés. Le premier concerne l'importance des hypothèses effectuées en matière de comportement d'activité et de rythme de croissance du progrès technique pour l'avenir pour la question de la solvabilité financière des régimes de retraite. Le second point concerne les différents modes de gestion de l'équilibre financier des régimes. Le recours à l'emprunt seul paraît au vu des résultats impossible à long terme. La baisse programmée des pensions permet de garantir un équilibre aux vertus macro-économiques indéniables mais reste porteuse de déséquilibres importants de situations individuelles tant entre les générations qu'entre les types d'agents. Finalement, la hausse des taux de cotisation évite cet écueil mais au prix d'une croissance un peu moindre.

1 Introduction

The acceleration of ageing in the coming years and the permanence of this phenomenon over the long term will exert pressure on all pension schemes. While the fact of population ageing is common to all developed countries, extent and timing differ substantially. When considering Europe specifically, the relative drop in the working age population related to the number of pensioners will probably translate into a decrease in the return of pension schemes, be they funded or the pay-as-you-go (PAYG). Against this background, all EU countries have adopted more or less ambitious reforms of their pension systems. Demographic changes, along with changes in the labour market and pension reforms, will deeply impact on saving behaviors and on intra-European capital flows.

In a world of closed economies, differential ageing would generate additional international differences in saving rates, investment and rates of return. These differences are likely to be accentuated when some countries implement pension reforms, such as more pre-funding schemes. In reality, we do not have closed economies but a global capital market. To the extent that capital is internationally mobile, population ageing will therefore induce capital flows between countries, and these capital flows will modify the impact of ageing. More specifically, differences in time profiles of demographic change suggests that capital flows could improve the economic consequences of ageing compared to a situation of economic and financial autarky.

In recent years, various quantitative tools have been developed in order to study the economic consequences of population ageing and pension reforms. Partial equilibrium models rely on mechanical projections of demographics and macroeconomic environment (activity, unemployment, productivity and factor returns). Among these models, some have a purely accounting vocation such as the model of Bac and al. (2003) or more generally the numerous generational accounting studies (see Auerbach and al., 1999, for example). These studies implicitly assume a representative agent and a constant efficiency labour to capital ratio. They aim at analyzing the impact of socio-demographic counterfactual scenarios and of parametric reforms of pension systems on the public budget sustainability. Micro-simulation models, such as Destinie (1999), include macro economic scenarios, in particular concerning production and factor prices, as exogenous variables.

These models analyze all individual paths of a population of agents in relation with changes in contributions and pension benefits. Unlike other methods, micro-simulation techniques provide a simultaneous description of intergenerational and intragenerational transfers.

The second class of models is constituted of general equilibrium models. Most of them have rigorous microeconomic foundations and follow the pioneering work of Auerbach and Kotlikoff (1987). They are based on the overlapping generations framework, as proposed by Samuelson (1958) and amended by Diamond (1965). Assuming exogenous population projections, the economic dynamics is entirely explained by rational choices of optimizing agents and particularly by their life-cycle saving pattern *à la* Modigliani (1986). The main shortcoming of these models consists in their extreme complexity, which limits the possibility of introducing individual heterogeneity in a cohort as in micro-simulation models. Moreover, in most general equilibrium models, contributions to public (PAYG) pension schemes are considered as taxes while benefits are simply obtained through multiplying a replacement rate by an average wage. This replacement rate is generally exogenous (coming from present observations) and simulations are performed with exogenous changes in pension parameters, including a deterministic change in replacement rates. Hence, the links between institutional changes, labour markets, career profiles and unemployment rate are not taken into account.

Another failure of most of general equilibrium models is that the European dimension is not studied. For instance, during the demographic transition, the mix between PAYG and fully funded pensions schemes within European countries will induce different saving behaviors in the different countries. These different saving rates will induce large capital flows between countries in order to equalize the interest rate in the single capital market. Most analyses of pension reforms, whether they use general equilibrium model or not, have been conducted with closed economy models under the assumption of economic and financial autarky.

Here, we present a quantitative analysis of the impact of differential ageing and pension reforms across European countries on capital and labour market and, in particular, on intra-European capital flows. To this end, we develop a stylized general equilibrium model with overlapping generations of heterogeneous agents for the three largest European countries: France, Germany and the United-Kingdom (UK). The model presents a structure halfway between, on the one hand, pure general equilibrium models with rigorous microeconomic foundations, and on the other hand, accounting models where the macroeconomic environment remains exogenous, as in Blanchet (1992). Demographic forecasts are used as an input in this model. In addition to their age, consumers are characterized by their gender and their professional status (executive, non executive or civil servant), in order to replicate the various existing pension schemes in each country. Three polar assumptions about economic openness are successively handled. In the first case, the economies are closed and the return to capital adjusts in order to clear the domestic capital market. In the second case, the economies are fully open and the return to capital is taken as a given. In the third case, the economies are integrated in a financial area with perfect capital mobility within the area but no capital mobility toward the rest of the world.

The purpose of this model is to analyze the macroeconomic impact of various pension reforms undertaken to insure the sustainability of the pension systems. We show that the dynamics of capital accumulation and pension system sustainability are totally different depending on the assumption concerning economic openness. In a world of closed economies, differential ageing generates differences in rates of return that are likely to be accentuated by implemented reforms. Indeed, by raising interest rate, increasing financing needs of pension systems have a negative impact on capital accumulation, hence on growth. On the contrary, the small open economy environment is close to the accounting approach adopted in most public reports since the debt accumulation resulting from successive imbalances does not influence the interest rate. The deficits of pension systems then translate into large capital inflows since it is assumed that each economy always finds financial resources at a fixed interest rate. Capital flows are significantly smaller in the intermediate case where capital is perfectly mobile between the three European countries but immobile from the countries to the rest of the world. Indeed, the three countries cannot simultaneously benefit from positive capital inflows, as in the small open economy case, so as to finance their public debt. Thus, faster ageing countries (Germany and France in a lesser extent) attract capital at the expense of slower ageing one (the UK). Consequently, the consequences of ageing are shared between the three countries through a common interest rate.

In order to underline possible uses of the model, we will also present various kinds of variants. Two main conclusions may be drawn from the examination of the various prospective scenarios. First of all, the critical assumptions for PAYG systems are the future trend of the global factor productivity and the behavior of agents concerning activity and labour market participation. Secondly, in the long run, resorting to debt financing seems to be a dead end to finance retirement systems. Indeed, public pension systems are unsustainable and generate important public debt which strongly weights on economic growth. A planned fall of the replacement rates presents some virtues with respect to growth but implies a large disequilibrium in the standard of living of retirees compared to active people. A progressive rise in the social contribution rates permits to avoid this but at the cost of a lower growth of resources.

The remainder of this study is structured as follows. Section 2 presents the demographic bloc of the model as well as the assumptions made on activity rates. Section 3 introduces the macroeconomic model and the calculation of individual income. Section 4 describes the pension schemes of the three countries. Section 5 discusses the equilibrium conditions of the model and a number of aspects of the calibration process. Section 6 comments our results for several pension policies and capital mobility scenarios. Finally, section 7 provides some concluding remarks.

2 The demographic bloc

At each period of time, different generations coexist and are at different stage of their life cycle. Individuals are characterized by their gender and their professional status. So as to describe in detail the link between the pension and the professional career, we need to depict a complete representation of the past demographic structure for each country. The prospective motivations of the model also justify the need for detailed demographic projections. The temporal horizon of this study is fixed on the period 2000-2050. Thus, the generations concerned by the model are all those born between 1894 and 2049. Indeed, at each date, we consider individuals aged 0 to 105.

In summary, individuals are characterized by

- their date of birth, $g \in [1894, 2049]$
- their gender, $s \in \{H, \text{ for men and } F, \text{ for women}\}$
- their professional status. We consider three professional status: executives (ca), non executives (nc) and civil servants (f), $c \in \{ca, nc, f\}$

The age of each individual is simply defined at date t by: $a(t, g) = t - g$.

2.1 Total population evolution

The size, $Pop(t, g, s)$, of the population of type (g, s) at time t before 2000 is based on historical official statistics. For France, we use historical data of Daguet (2002) for the period 1946-1997 and we complete them with Insee statistics for the period 1998-2000. The German population structure comes from the data of the Federal Statistical Office (Statistisches Bundesamt Deutschland). For the UK, the size and structure of the population between 1960 and 2000 comes from the statistics of the Office for National Statistics (General Register Office). Before 1960, we use the statistics of the United-Nations (2004).

For future decades, the model uses the demographic projections of Bac and Chateau (2003) until 2050 that are based on the method described in Sleiman (2002). The methodology used consists in altering the population cohorts by sex and by age with the three

Table 1: Demographic projections : main assumptions

		Total Fertility Rate	Average age of maternity	Net migratory flows	Men life expectency	Female life expectency
Germany	Initial indicator	1,32	28,1	188 000	75,1	81,0
	Target value	1,35	29,4	150 000	80,0	85,0
France	Initial indicator	1,79	29,3	44 000	75,2	82,7
	Target value	1,77	29,7	50 000	80,0	87,0
United-Kingdom	Initial indicator	1,68	28,4	138 000	74,0	79,8
	Target value	1,70	29,0	70 000	80,0	85,0

Source : Bac and Château (2003)

components of demographic change: fertility, mortality and net migrations. The starting point consists in taking the population structure by age and by sex of a given year (year 2000). By applying survival probabilities, again according to age and sex, it is then possible to provide an estimate of the surviving population of the following year. At the same time, the female fertility rate is applied to calculate the number of births expected during this interval. Lastly, the migratory surplus by sex and by age is added to the number of survivors at the end of the year. These operations are then repeated year after year until the last year of the forecast (the year 2050).

This projection starts with the age pyramid of the three countries in 2000. The values of initial indicators are mainly built on Eurostat data and presented in Table 1. In 2000, the total fertility rate is equal to 1.32 for Germany, 1.79 for France and 1.68 for the UK. The average maternity age in 2000 is equal respectively to 28.1, 29.3 and 28.4 and the annual net migratory flows to 188 000, 44 000 and 148 000. Finally, life expectancy is respectively of 75.1 and 80 for men and women in Germany, 75.2 and 82.7 in France and 74 and 79.8 in the UK. The value retained for the projection (target values in Table 1) are also those of Eurostat assuming a relative stability in the total fertility rate and a progressive rise in life expectancy (see Bac and Chateau, 2003, for more details).

Projection results are given in Table 2. In common with most OECD countries, our three countries have an ageing population. Germany is clearly more affected by ageing than the two other countries. For example, its population quickly decreases and is reduced by over 15% over the next 50 years. The reduction of the working age population begins around 2005 in Germany; 2010 in France and the UK. Ageing is less marked in the UK, as the population aged 65 and over is forecasted to rise from 16% of the total in 2000 to 25% in 2050. In 2050, the same ratio is expected to be 27% in France and 31% in Germany.

Like Germany and France, the UK will nevertheless see a marked shift towards the very old (more than doubling of the number of individuals age over 80 between 2000 and 2050). The old age dependency ratio (i.e. the ratio of people aged 65+ to people aged 20-64) is currently equivalent to 26% in the UK and is expected to be 33% in 2020 and 47% in 2050. Nevertheless, it should be noted that France and Germany are more severely affected by ageing. Indeed, the old age dependency ratio is expected to be almost 50% in 2050. The resulting demographic ageing raises numerous issues for pension schemes since the burden of the retirees will grow spectacularly as the baby-boom generations retire during the next years of the century.

2.2 Working age population

In order to replicate the various existing pension schemes in each country, the workers are characterized by their professional status (c): executives (ca), non executives (nc) and civil servants (f). $rap(t, g, s, c)$ is the share of the class (g, s, c) in the total working age population (i.e. defined in the model as the population aged 16 to 75) in year t. Actually, individuals of class (g, s, c) are represented at each period of time by a representative individual. This representative agent is thus simultaneously employed-unemployed and inactive. The size $N(t, g, s, c)$ of the population of type (g, s, c) at period t is thus given by:

$$N(t, g, c, s) = rap(t, g, s, c) \cdot N(t, g, s) \qquad \text{for } 16 \leq a(t, g) \tag{1}$$

2.2.1 Distribution by professional status

By fixing the shares of population and activity rates by professional status, we try to reproduce the main features of the past and current population of our three countries.

Table 2: Population projection for the period 2000 - 2050

	2 000	2 005	2 010	2 020	2040	2050
Germany						
Total population (thousand)						
	82 160	82 508	82 265	80 645	73 739	69 172
Age repartition (in % of total population)						
<20	21%	20%	19%	17%	16%	16%
20-60	56%	55%	55%	53%	47%	46%
20-65	62%	61%	60%	60%	53%	53%
60+	23%	25%	26%	30%	37%	38%
65+	16%	19%	21%	23%	31%	31%
80+	4%	4%	5%	7%	10%	13%
Old age dependency ratio (in %)						
60+ / 20-59	41%	46%	47%	56%	77%	81%
65+ / 20-64	26%	31%	34%	38%	58%	57%
France						
Total population (thousand)						
	59 219	60 364	61 258	62 437	62 470	61 304
Age repartition (in % of total population)						
<20	26%	25%	24%	22%	21%	20%
20-60	54%	55%	54%	51%	47%	47%
20-65	59%	59%	60%	57%	53%	53%
60+	21%	21%	23%	27%	32%	33%
65+	16%	16%	17%	20%	26%	27%
80+	4%	4%	5%	6%	9%	10%
Old age dependency ratio (in %)						
60+ / 20-59	38%	38%	42%	52%	67%	71%
65+ / 20-64	27%	28%	28%	35%	49%	51%
United-Kingdom						
Total population (thousand)						
	59 615	60 578	61 212	62 272	62 393	61 577
Age repartition (in % of total population)						
<20	25%	25%	23%	22%	21%	20%
20-60	54%	54%	54%	53%	49%	48%
20-65	59%	59%	60%	59%	54%	54%
60+	20%	21%	23%	25%	31%	32%
65+	16%	16%	17%	19%	25%	25%
80+	4%	5%	5%	5%	8%	10%
Old age dependency ratio (in %)						
60+ / 20-59	38%	39%	43%	48%	63%	66%
65+ / 20-64	26%	27%	28%	33%	46%	47%

Source : Bac and Chateau (2003)

For France, our model reproduces a share of executives in the total number of private employment rising from 12.1% in 1971 to 21% in 2000[1] and reaching 24 % in 2040[2] ; a rising share in the proportion of women in the executive population reaching 30% in 2001 (Agirc and Ircantec figures) ; an important recruitment of civil servants between 1975 and 1985 and then a stabilization and even a slight decline (Marchand and al., 2002). In 2000, incumbent civil servants represented 15.6% of total employment, 56.2% of them being women (report of the Ministère de la Fonction Publique, 2002).

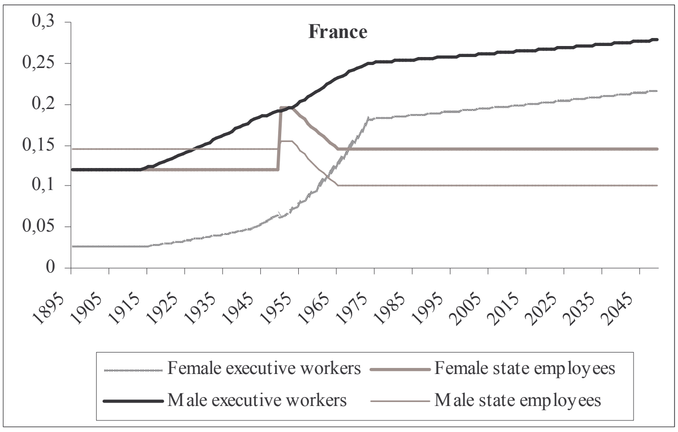
For the UK (respectively Germany), our model reproduces a share of executives in the total number of private employment rising from 23% (resp. 14.4% for Germany) in 1970 to 33.8% (resp. 20.4%) in 2000, a rising share in the proportion of women in the executive population reaching 39.3% (resp. 25.5%) in 2000 (Eurostat). The share of the public sector in public employment is fixed at 21.6% in 1985 and then decreases reaching 12.6% following the statistics of OECD public management service. Note that for the UK, we consider as state employees all those working in the public sector and not only civil servants. Indeed, even if there is a great diversity of pension schemes in the public sector, all state employees are out of the SERPS (State Earnings Related Pension Scheme) coverage. For Germany, this share is fixed at 7 % of total employment at each period, corresponding to those who have their own pension system (Borsch-Supan and Wilke, 2003). At each time, we assume that half of public sector employees are women for Germany and for the UK.

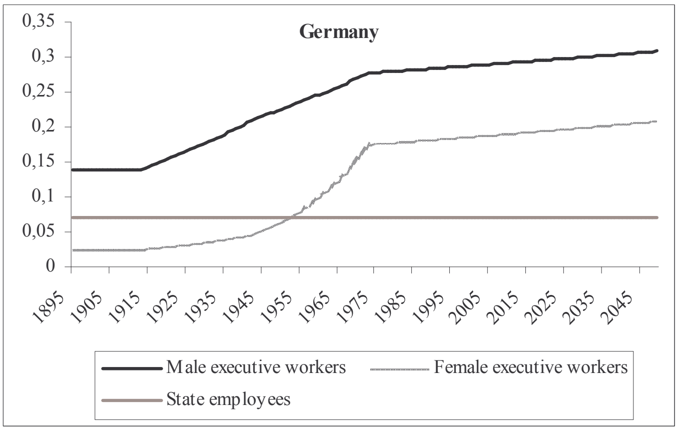
As shown on Figure 1, all these facts are reproduced by calibrating the share of executive and public employment by generation and not directly on the total population. The model then reasonably forecasts the future evolution of executive and public employment given the current observed situation for our three countries.

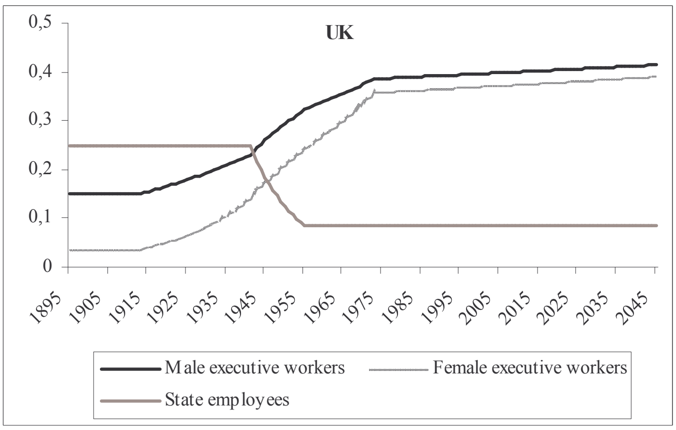
[1] These figures are based on the proportion of contributors to AGIRC (Association Générale des Institutions de Retraite des Cadres) completed by the contributors to the upper limit of other pension plans (Ircantec, ...). See Mesnard (2001) for more precisions.

[2] These prospective assumptions are scaled so as to match the values presented by AGIRC for the Charpin report (1999). In our model, this share is partially endogenous since it is related to the unemployment and activity rates. This share is thus calibrated only in the benchmark scenario.

Figure 1: Share of state employees and executive workers by generation and sex (in %)







2.2.2 Activity of the working age population

We define $\theta_{act}(t,g,s,c)$ as the activity rate of the population of type (g,s,c) at the date t. The size of the population of type (g,s,c) in age of working at the date t is then simply given by:

$$N_{act}(t,g,s,c) = N(t,g,s,c) \cdot \theta_{act}(t,g,s,c) = N(t,g,s) \cdot rap(t,g,s,c) \cdot \theta_{act}(t,g,s,c) \quad (2)$$

$D_2(g,s,c)$ is the average length of education of the population of type (g,s,c) and $D(g,s,c)$ is the average length of working life. Thus, $D_2(g,s,c)+D(g,s,c)$ is defined as the average effective retirement age. For Germany and the UK, estimations of $D_2(g,s,c)$ are based on OECD data for agents working in the private sector (OECD, 2004a) and on the Public Sector Pay and Employment database of the OECD for the age of entry in the public sector. For France, $D_2(g,s,c)$ is scaled on the data of the Destinie model (1999) and the distribution by professional status comes from Assous and al. (2001).

Concerning the age when agents enter or leave the working life, we make some more assumptions:

- nobody works before 16 or after 75, i.e.:

$$\theta_{act}(t,g,s,c) = 0 \quad \text{for} \begin{cases} a(t,g) < 16 \\ a(t,g) > 75 \end{cases} \quad (3)$$

  where $a(t,g)$ denotes the age of generation g at time t $(a(t,g) = t - g)$.

- Agents in the public sector cannot work before the average length of studies, $D_2(g,s,c)$, and after the average effective retirement age, $D_2(g,s,c)+D(g,s,c)$, except in the UK:

$$\theta_{act}(t,g,s,\text{"}f\text{"}) = 0 \quad \text{for} \begin{cases} a(t,g) < D_2(g,s,\text{"}f\text{"}) \\ a(t,g) \geq D_2(g,s,\text{"}f\text{"}) + D(g,s,\text{"}f\text{"}) \text{ and not UK} \end{cases} \quad (4)$$

  Contrasting with French and German ones, UK civil servants can work after the average effective retirement age $D_2(g,s,c)+D(g,s,c)$. Indeed, a large share of civil service employees are still working after the legal public sector retirement age[3]. Note that this average effective retirement age could be different from the legal retirement

[3] http://www.civilservice.gov.uk

age $a_{ret}(g,s)$. Between $D_2(g,s,c)$ and $D_2(g,s,c)+D(g,s,c)$, state employees activity rate is fixed to 1 in the three countries:

$$\theta_{act}(t,g,s,"f") = 1 \qquad \text{for } D_2(g,s,"f") \leq a(t,g) < D_2(g,s,"f") + D(g,s,"f") \quad (5)$$

- before the average length of studies calculated on all individuals, $\overline{D}_2(g,s)$, only non-executive workers participate in the labour market. After $\overline{D}_2(g,s)$, executive workers also start their working life, i.e. $\theta_{act}(t,g,s,"ca") = 0$ for $a(t,g) < \overline{D}_2(g,s)$.

Individual participation in the labour market is not determined directly in the model. We prefer to resort to independent scenarios concerning household activity based on official statistics for each country considered. For private and public sector employees, activity rates by age and professional status are presented in Figures 2 to 4. In every country, the labour market behavior of elder workers have been characterized by a severe fall in participation rates. More precisely, French activity rates start declining around age 55 in a quasi linear fashion until age 60 (Figures 2). At this age, their values are near 25% for men and women. Then, they drop rapidly and only a small part of the population is still at work after 62. Germany shares the rapid decrease of old age labour force participation with France. Figure 3 shows the rapid decline in labour force participation around the age of 58 for both male and women. In the UK, 60% of men in their late 50's are full-time workers. Work participation among women tails off quite rapidly for the 50 year old, falling from about 75% in the late 40's to 50% in the late 50's and 35% at age 60. State pension age is currently five years lower for women than men, but a higher proportion of women work past their state pension age.

Figure 2: French activity rates by sex, age and professionnal status in 2000

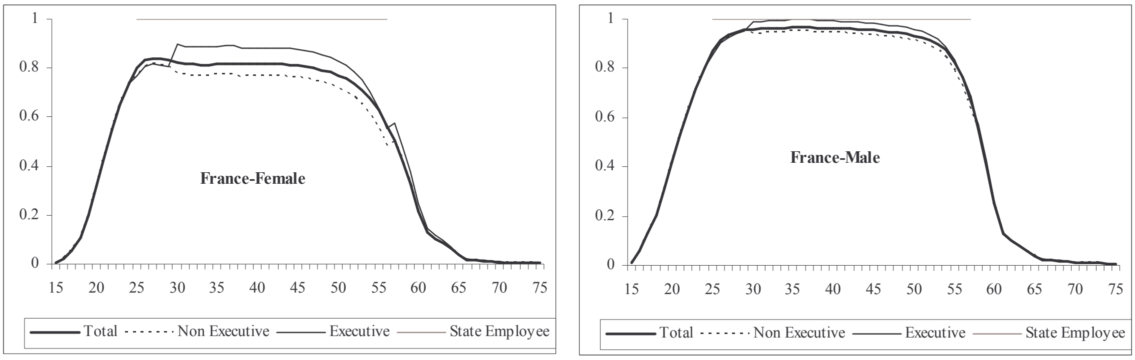


Figure 3: German activity rates by sex, age and professionnal status in 2000

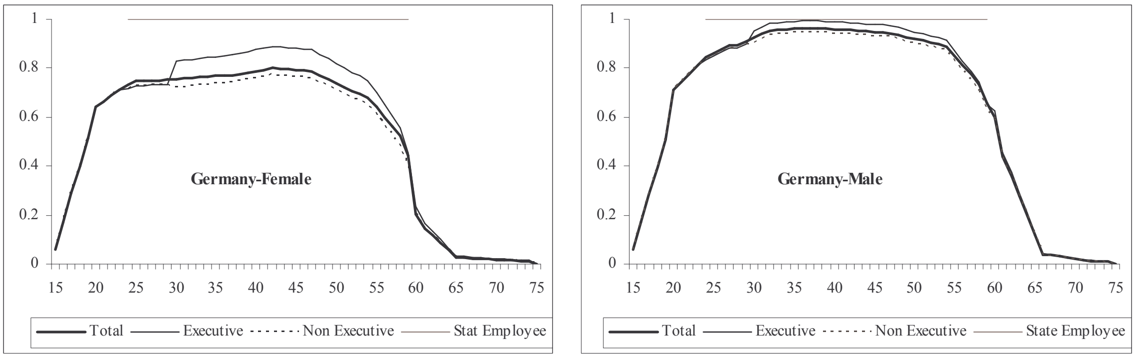
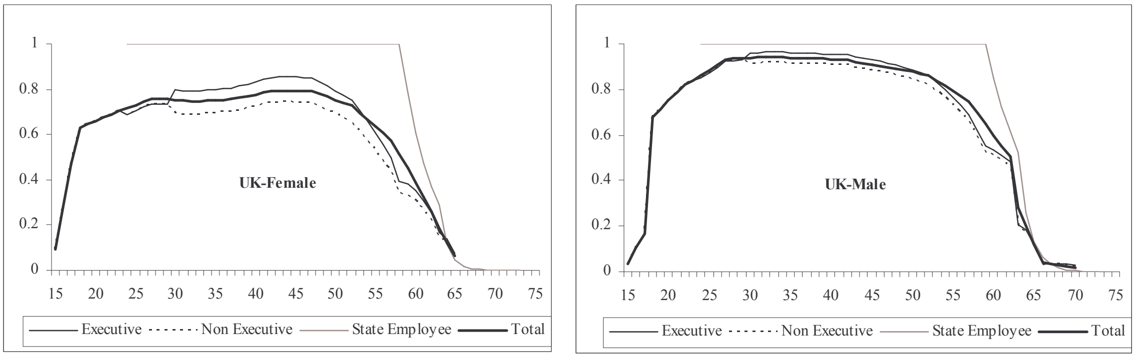


Figure 4: UK activity rates by age, sex and professionnal status in 2000



At each time, activity rates of private sector employees are adjusted so as to catch the historical average activity rate (Insee for France and Labour Force Statistics, OECD for Germany and the UK) and given that public activity rates are fixed to 1 (except for the UK after the effective retirement age). We consider two different scenarios concerning the working age population projections: the first one assumes that activity behaviors remain constant between 2000 and 2050 and the second one (our benchmark) assumes a rise in participation rates of elder workers. In concrete terms, activity rates of those aged between 45 and 65 are progressively shift by three years between 2000 and 2040 for France and the UK and 5 years for Germany[4]. Activity rates of other cohorts remain the same as those observed in 1999. For example, it implies that the activity rate of a French men aged 50 in 2040 is the same as the activity rate of a French men aged 47 in 2000.

2.2.3 Retirees and pre-retirees

Our model considers as pensioners, $N_{ret}(t, g, s, c)$, all those receiving pension benefits, i.e. people aged over 75 and all those inactive after the average effective retirement age $D_2(g, s, c) + D(g, s, c)$. However, many pension benefits as well as other benefits helping to finance anticipated suspension of activity are existing. For example, in the UK, an important number of unwaged (1.7 million in 2000 according to Dupont, 2003) aged

[4] The French aim would be to centered the average age of retirement at around 62 against 59 currently. In the UK, the effective retirement age is currently around 62 and is expected to rise to 65. German authorities hope to shift this age from 60.5 to 65 so as to face to the sharpness of ageing.

between 50 and the legal retirement age receive social benefits, particularly incapacity benefits. These benefits are often used as a vehicle to fund early retirement We thus have assumed that between $\underline{r}^a$ and the effective retirement age, any lowering in activity rates of a cohort between two periods corresponds to early retirement[5]:

$$N_{pre}(t,g,s,c) = \sum_{\underline{r}^a < a(t,g) < D+D_2} (N_{act}(t-1,g,s,c) - N_{act}(t,g,s,c)) \qquad \text{for } c \neq \text{"}f\text{"} \qquad (6)$$

By assuming differential in mortality between the different professional categories (and calibrating this parameter), we could reproduce the current distribution of pensioners. We then fix this differential in mortality for future decades. By simulation, the model provides us the following facts:

- 10.85 million pensioners in France, 16.9 million for Germany and 10.4 million for the UK in 2000 which is close to the official figures (Mesnard, 2001, for France ; Börsch-Supan and Wilke, 2003, for Germany ; Department for Work and Pensions, 2003, for the UK),
- 526 000 million people in early retirement for France (Fournier and Givord, 2001), 850 000 for Germany (Börsch-Supan and Wilke, 2003) and 1,5 million for the UK corresponding to those entitle to receive incapacity benefits (Department for Work and Pensions, 2003),
- 15 % of French pensioners in 2000 worked in the public sector (8% for Germany and 25% for the UK) which roughly corresponds to the share of public sector employment in the 1960's and 1970's,
- 10,1 % of French pensioners in 2000 are former executives (14,3% for Germany and 21% for the UK), of which 20% are women (20% for Germany and 32% for the UK).

In order to calculate the pension of individuals who leave or will leave the labour market in future years, we reconstruct their career with the age structure of activity rates by sex from 1950 to 2000.

[5] $\underline{r}^a$ is equal to 56 for France and equal to 57 for Germany and the UK.

3 The macroeconomic bloc

3.1 The production sector

The production sector is composed of one representative firm. This firm produces a single composite good that may be used for consumption as well as capital accumulation. This good is taken as a *numéraire* and its price is thus normalized to one. The production Y_t of period t comes from the combination of the stock of physical capital K_{t-1} installed at date t and the labour supply N_t. We assume a standard Cobb-Douglas production function with constant returns to scale:

$$Y_t = K_{t-1}^{\alpha} \left(\Gamma_t N_t\right)^{1-\alpha} \tag{7}$$

where α is the share of capital. The level of knowledge in the economy, Γ_t, is assumed to grow at the exogenous rate $\gamma^{\Gamma}(t)$. We calibrate this parameter so as to reproduce the real aggregate economic growth rate in each country until 2004. After this date, $\gamma^{\Gamma}(t)$ is fixed to 1.6% for France, 1.75% for Germany and 1.8% for the UK. These values are close to the long run values suggested by OECD.

The representative firm behaves competitively on factor markets and maximizes profits:

$$PROF_t = Y_t - (r_t + \delta)K_{t-1} - w_t N_t \tag{8}$$

where δ is the depreciation rate of physical capital, r_t the real interest rate and w_t the real wage rate. Profit maximization requires the equality of the marginal productivity of each factor to its rate of return:

$$\frac{\partial Y_t}{\partial K_{t-1}} = r_t + \delta \tag{9a}$$

$$\frac{\partial Y_t}{\partial N_t} = w_t^s \tag{9b}$$

We have to underline here that social contributions paid by employers are not specified: we thus assume that all social contributions are paid by employees and that other types of benefits are not introduced. The capital share parameter, α, is set to 38%. The annual depreciation rate, δ, is assumed to be 5.5% per year. These two parameters are fixed so as to reproduce the accurate share of investment in GDP in 2000[6] as well as a net interest rate around 3.5% for each country.

3.2 Wage and unemployment equilibrium

As in d'Autume and Quinet (2001), we follow a WS-PS (Wage-Setting/Price Setting) approach for the determination of real wage and unemployment level. We assume wage negotiations between the firm and a trade union leading the real wage net of social contributions to be fixed by applying a mark-up on unemployment benefits (see Cahuc and Zylberberg, 1996, for details). More precisely, we simply assume that wage claims consist in applying a mark-up on the reservation wage. The latter increases at the same pace as the total factor productivity, Γ_t, so as to ensure the existence of a structural unemployment rate in the long run. We also assume a decreasing relationship between this mark-up and average unemployment rate that transcripts into an erosion of the negotiation power of the trade union in the case of labour shortage. It may be written:

$$\log(w_t^d) = 0.5 \cdot \log(w_{t-1}) + 0.5 \left[a_u \overline{\theta}_{cho}(t) + \log(\frac{\Gamma_t}{1 - \overline{\tau}_{2000}}) + \Lambda_t \right] \quad (10a)$$

$$w_t^s = w_t^d = w_t \quad (10b)$$

where $\overline{\theta}_{cho}(t)$ is the average unemployment rate of the economy. $\overline{\tau}_t$ is the average contribution rate to the pension schemes referring to a tax wedge effect defined by the pension schemes equilibrium ($\overline{\tau}_t w_t N_t = PensionExpenditures_t$) that would be respected in case of no debt financing. In this study, we fix $\overline{\tau}_t$ to its 2000 value so as to block the tax wage effect that is a much debated empirical question. Λ_t is an adjustment variable calibrated so as to catch the historical unemployment rate of the 2000-2004 period. Then, it is calibrated in such a way that it ensures a convergence of the effective unemployment rate to the equilibrium long term unemployment rate in 2015. The values retained in the long run are 6% in France (as in Bardaji and al., 2003, as well as in the Charpin report, 1999 and the COR report, 2001), 5.6% in Germany (see CES-IFO pension model) and 4% for the UK (see OECD, 2004b). a_u is the long term elasticity of the real gross wage to the unemployment rate and is fixed to -1 (that is slightly lower in absolute term than

[6] Investment, I_t, is simply defined by the standard evolution law: $I_t = K_t - (1-\delta)K_{t-1}$

the value of -1.2 retained by d'Autume and Quinet, 2001). Finally, the past and present average unemployment rates reproduced by the model are those coming from OECD data.

3.3 Individual behaviors

3.3.1 Unemployment profiles of workers

At each date, the representative individual of class (g, s, c) receives an average wage $w_{rep}(t, g, s, c)$ defined as:

$$w_{rep}(t, g, s, c) = w(t, g, s, c) \cdot (1 - \theta_{cho}(t, g, s, c)) \cdot \theta_{act}(t, g, s, c) \tag{11}$$

where $\theta_{cho}(t, g, s, c)$ is the unemployment rate of this type of individual and $w(t, g, s, c)$ is the gross wage rate.

Logically, the observed unemployment rate are highly depending on the age, the sex and the professional status of the individual considered. Thus, we define exogenous profiles of unemployment, $profil_{cho}(t, g, s, c)$, that change with age, sex and professional status:

$$profil_{cho}(t, g, s, c) = a_{cho}(a(t, g)) \cdot b_{cho}(s, c) \tag{12}$$

where $a_{cho}(a(t, g))$ are the relative unemployment rates by age coming from the 1999 Population Census in the case of France and from Labour Force Statistics data of OECD in the case of Germany and the UK. $b_{cho}(s, c)$ refers to the relative unemployment rate by sex and professional status and is evaluated on Eurostat data. At each date, the actual unemployment rate $\theta_{cho}(t, g, s, c)$ is thus given by:

$$\theta_{cho}(t, g, s, c) = aj_{cho}(t) \cdot \overline{\theta}_{cho}(t) \cdot profil_{cho}(t, g, s, c) \qquad \forall (t, g, s, c) \tag{13}$$

and

$$\overline{\theta}_{cho}(t) = \sum_{g,s,c} \theta_{cho}(t, g, s, c) \frac{N_{Act}(t, g, s, c)}{N_{act}(t)} \qquad \forall (t) \tag{14}$$

The second equation gives at each date the uniform adjustment parameter, $aj_{cho}(t)$, ensuring that the average unemployment rate arising from the confrontation between WS and PS is equal to the weighted average of unemployment rates of the different population classes considered.

3.3.2 Wage profiles

The wage profiles are simply given by the product of the experience premium by age, $a_w(a(t,g))$,[7] by the skill premium by sex, $b_w(s,c)$:

$$profil_w(t,g,s,c) = a_w(a(t,g)) \cdot b_w(s,c) \tag{15}$$

As for the unemployment rate, the actual wage rate, $w(t,g,s,c)$, is given by:

$$w(t,g,s,c) = aj_w(t) \cdot w(t) \cdot profil_w(t,g,s,c) \qquad \forall (t,g,s,c) \tag{16}$$

and

$$w(t) = \frac{\sum_{(g,s,c)} w(t,g,s,c)(1-\theta_{cho}(t,g,s,c)) \cdot N_{Act}(t,g,s,c)}{\sum_{(g,s,c)} (1-\theta_{cho}(t,g,s,c)) \cdot N_{Act}(t,g,s,c)} \tag{17}$$

Once again, equation [17] determines, at each date, the uniform adjustment factor of actual wage, $aj_w(t)$, ensuring that the average wage rate of the economy is equal to the weighted average of wage rates of the different population classes considered. The experience premium, $a_w(a(t,g))$, and the skill premium, $b_w(s,c)$, are built on INSEE statistics and on Caussat (1996) for France and on the Eurostat database for Germany and the UK. Figures 5 to 7 present the wage profiles for each country based on equation [15].

[7] We do not explicitly assume here any productivity profile by age.

Figure 5: Wage profiles by age, sex and professional status in France ($profil_w(t, g, s, c)$)

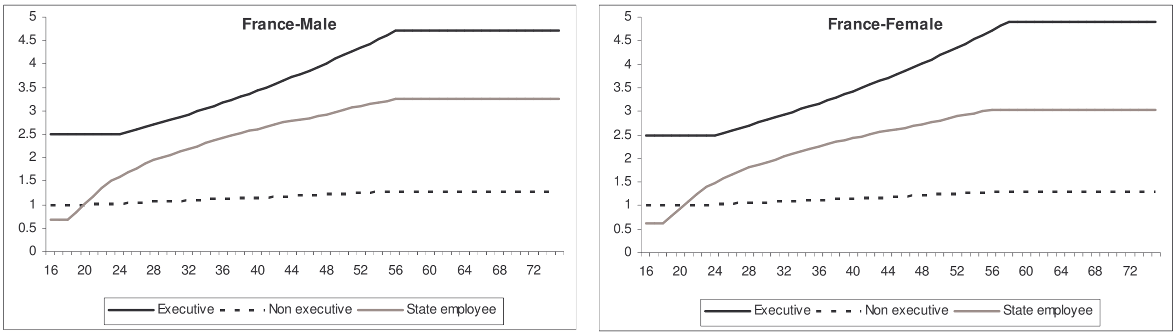


Figure 6: Wage profiles by age, sex and professional status in Germany ($profil_w(t, g, s, c)$)

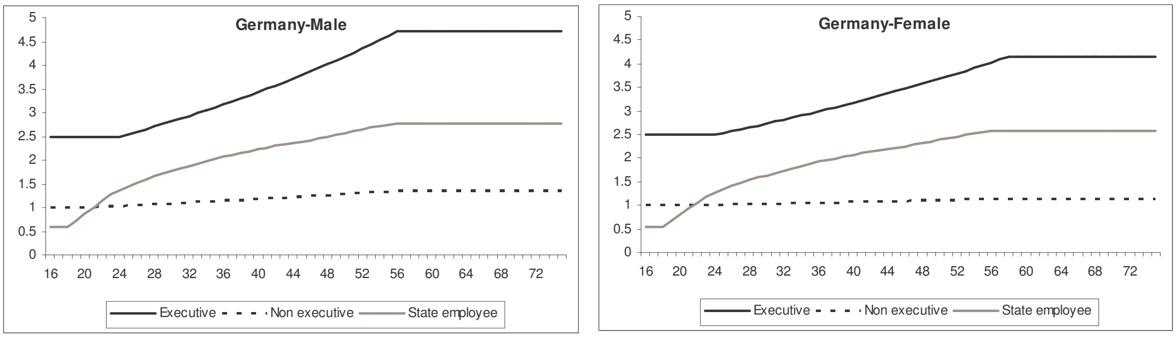
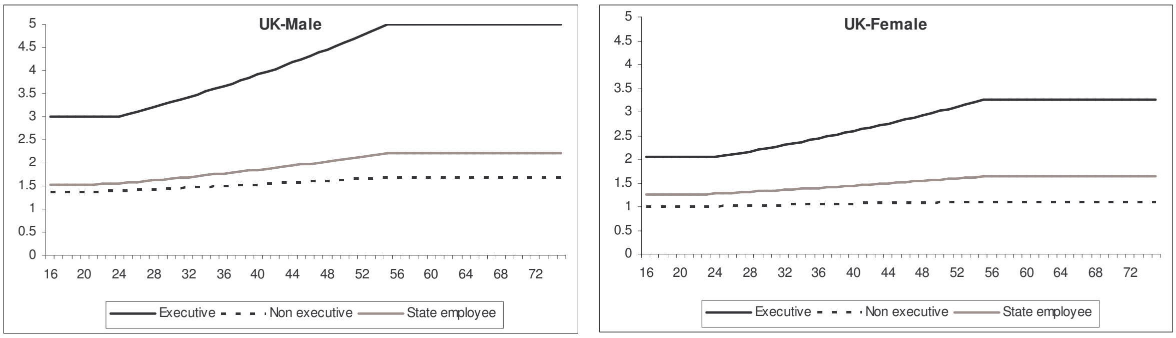


Figure 7: Wage profiles by age, sex and professional status in the UK ($profil_w(t, g, s, c)$)



3.3.3 Individual income

At each period of time, individual income is composed of financial income, labour income and pension benefits received. Financial income is the product of the financial wealth $A(t-1, g, s, c)$ accumulated by this individual until the previous period by the rate of return (r_t) on these assets. The labour income of the representative agents of class (g, s, c) at time t is given by $w_{rep}(t, g, s, c)$.

Until the minimum pre-retirement age, $\underline{r}^a$, the representative individual only perceives his average earned income $w_{rep}(t, g, s, c)$. Between $\underline{r}^a$ and the average effective retirement age $D_2(g, s, c) + D(g, s, c)$, the representative individual both receives average labour income and a replacement income of "pre-retirement" in proportion of the time devoted as "anticipated suspension of activity".[8] Between the average effective retirement age and 75 years old, the representative individual perceives his labour income as well as his pension income $P(t, g, s, c, fund)$. Finally, after 75 years old, he only perceives his pension income.

Due to the great diversity of pension schemes, the determination of the net income is specific to each country:

1. **The French case.** We consider three types of pension schemes, i.e. the general

[8]Note that these two types of income are often exclusive one of the other in reality. Given our assumption of a representative agent, we assume that he receives part of each type of income at the same time.

regime ("rb"), the complementary regimes composed of ARRCO and AGIRC[9] ("rc") and the public regime of the civil servants ("rf"). The average labour income is subject to different pension contribution rates. $\tau(t, "rb")$ is the contribution rate in the general regime. $\tau_1(t, c)$ and $\tau_2(t, c)$ are the contribution rates to the complementary scheme. $\tau_{ap}(t, c)$ is the surcharge coefficient for the two complementary schemes (ARRCO and AGIRC)[10]. Finally, $cet(t, c, "rb")$ and $cet(t, "ca", "rc")$ are exceptional contribution rates that do not untitled to pension benefits and are respectively fixed at 1.6% and 0.35% according to the legislation. It must be observed that civil servants are out of these schemes since they are directly paid on the state budget. They only pay a specific contribution rate ($\tau(t, "rf") = 7.85\%$). The income net of pension contributions, $Inc(t, g, s, c)$, then writes at each date t[11]:

- For French executives and non executives:

$Inc(g, s, c)$

$$= \left[1 - \sum_{fund} cet(c, fund)\right] w_{rep} - \left[\tau("rb") + \tau_{ap} \cdot \tau_1\right] Min(w_{rep}, w_{ss}) - \tau_{ap} \cdot \tau_2 Max(0, w_{rep}) \qquad \text{for } a(g) < \underline{r}^a \quad (18a)$$

$$= \left[1 - \sum_{fund} cet(c, fund) + \pi_{pr} n_{pre}\right] w_{rep} - \left[\tau("rb") + \tau_{ap} \cdot \tau_1\right] Min(w_{rep}, w_{ss}) - \tau_{ap} \cdot \tau_2 \cdot Max(0, w_{rep} - w_{ss}) \qquad \text{for } \underline{r}^a \leq a(g) < D_2 + D \quad (18b)$$

[9] Association des Régimes de Retraites Complémentaires (ARRCO) and Association Générale des Institutions de Retraite des Cadres (AGIRC).

[10] A certain number of contributions to the complementary schemes do not give any right to pension. Thus, a majoration coefficient is applied on the contribution rates to the complementary schemes. It is currently equal to 125% meaning that 25% of the contributions do not untitled to pension.

[11] In order to simplify the notation, we deliberately omit time (t), generation (g), sex (s) and professional status (c) subscripts when they are obvious.

$$= n_{ret}(g,s,c)\cdot[P(g,s,c,"rb")+P(g,s,c,"rc")]+\left[1-\sum_{fund} cet(c,fund)\right] w_{rep}$$

$$-\left\{[\tau("rb")+\tau_{ap}\cdot\tau_1]\, Min(w_{rep},w_{ss})+\tau_{ap}\cdot\tau_2\cdot Max(0,w_{rep}-w_{ss})\right\}$$

$$\text{for } D_2+D\leq a(g)<75 \quad (18c)$$

$$= P(g,s,c,"rb")+P(g,s,c,"rc") \qquad \text{for } 75\leq a(g) \quad (18d)$$

where $w_{ss}(t)$ is the Social Security ceiling, $n_{ret}(t,g,s,c) = N_{ret}(t,g,s,c)/N(t,g,s,c)$ and $n_{pre}(t,g,s,c) = N_{pre}(t,g,s,c)/N(t,g,s,c)$ are the shares of retirees and pre-retirees in each group. $\pi_{pr}(t,s,c)$ is calibrated so as to match the replacement ratio of pre-retirement pension to wage based on the data of Colin and al. (2000).

- For French state employees:

$$Inc(g,s,"f") = \begin{cases} [1-\tau("rf")]\cdot w_{rep}("f") & \text{for } a(g)<D_2("f")+D("f") \\ P(g,s,"f","rf") & \text{for } a(g)\geq D_2("f")+D("f") \end{cases} \quad (18e)$$

2. **The German case.** The German pension scheme is clearly less complicated and we consider here two different regimes: the public retirement insurance called "Gesetzliche Rentenversicherung" ($"grv"$) and the civil servants regime ($"rf"$). The average labour income is only subjected to $\tau(t,"grv")$ for those in the private sector. Civil servants do not pay any explicit contributions for their pension. The income net of pension contributions is thus simply given by:

- For German executives and non executives:

$Inc(g, s, c)$

$$= w_{rep} - \tau(\text{"}grv\text{"}) \cdot Min\left[w_{rep}, w_{ss}\right] \qquad \text{for } a(g) < \underline{r}^a \tag{19a}$$

$$= w_{rep} - \tau(\text{"}grv\text{"}) \cdot Min\left[w_{rep}, w_{ss}\right] + \pi_{pr} n_{pre} w_{rep} \qquad \text{for } \underline{r}^a \leq a(g) < D_2 + D \tag{19b}$$

$$= n_{ret} \cdot P(g, s, c, \text{"}grv\text{"}) + w_{rep} - \tau(\text{"}grv\text{"}) \cdot Min\left[w_{rep}, w_{ss}\right] \qquad \text{for } D_2 + D \leq a < 75 \tag{19c}$$

$$= P(g, s, c, \text{"}grv\text{"}) \qquad \text{for } 75 \leq a(g) \tag{19d}$$

For German civil servants:

$$Inc(g, s, c) = \left[\begin{array}{ll} w_{rep}(g, c, \text{"}f\text{"}) & \text{for } a(g) < D_2(\text{"}f\text{"}) + D(\text{"}f\text{"}) \\ P(g, s, \text{"}f\text{"}, \text{"}rf\text{"}) & \text{for } a(g) \geq D_2(\text{"}f\text{"}) + D(\text{"}f\text{"}) \end{array} \right. \tag{19e}$$

3. **The UK case.** The UK pension system is very complicated. It contrasts with those of other European countries, having features such as a high coverage of well-financed voluntary private schemes. State pension provision is split into two tiers. The first one consists in the Basic State Pension ("bsp") which is a flat rate contributory pension financed on a pay-as-you-go basis. The second tier consists in the State Earnings-Related Pension Scheme ("$serps$") which is also financed on a pay-as-you-go basis. Before the legal retirement age, individuals may also benefit from invalidity benefits which are often used as a route into early retirement. These three types of benefits are financed by the National Insurance Fund contributions through the flat tax $\tau_{nif}(t)$. However, provisions have always been included to allow individuals

to "opt out" of SERPS into funded private schemes. Those who contracted-out of SERPS then pay a reduced rate of contribution ($\tau_{nif}(t) - \tau_{red}(t)$) but have to contribute to an individual pension fund at the rate $\tau_{fund}(t, c)$. In addition, many elderly adults receive a significant amount of income-related benefits such as the Minimum Income Guarantee ($MIG(t)$) which are financed through the income tax $\widetilde{\tau}(t)$. Finally, the British civil servants do not benefit from the SERPS coverage but have to contribute to a public occupational pension scheme. The income net of pension contribution is then given by:

- For British executives and non executives:

$$Inc(g, s, c)$$

$$= w_{rep} - [\zeta_{in} \cdot \tau_{nif} \cdot \min(w_{rep}, w_{ss})] - [(1 - \zeta_{in}) \cdot (\tau_{nif} - \tau_{red}) \cdot \min(w_{rep}, w_{ss})] - [\tau_{fund} \cdot \zeta_{out} \cdot w_{rep}] \qquad \text{for } a(g) < \underline{r}^a \tag{20a}$$

$$= w_{rep} - [\zeta_{in} \cdot \tau_{nif} \cdot \min(w_{rep}, w_{ss})] - [(1 - \zeta_{in}) \cdot (\tau_{nif} - \tau_{red}) \cdot \min(w_{rep}, w_{ss})] - [\tau_{fund} \cdot \zeta_{out} \cdot w_{rep}] + \pi_{pr} n_{pre} w_{rep} \qquad \text{for } \underline{r}^a \leq a(g) < a_{ret}(g, s) \tag{20b}$$

$$= n_{ret} \cdot (P(g, s, c, "bsp") + P(g, s, c, "serps") + P(g, s, c, "fund") + MIG(t)) + w_{rep} - [\zeta_{in} \cdot \tau_{nif} \cdot \min(w_{rep}, w_{ss})] - [(1 - \zeta_{in}) \cdot (\tau_{nif} - \tau_{red}) \cdot \min(w_{rep}, w_{ss})] - [\tau_{fund} \cdot \zeta_{out} \cdot w_{rep}] \qquad \text{for } a_{ret}(g, s) \leq a(g) < 75 \tag{20c}$$

$$= P(g, s, c, "bsp") + P(g, s, c, "serps") + P(g, s, c, "fund") + MIG(t) \qquad \text{for } 75 \leq a(g) \tag{20d}$$

where $\zeta_{out}(t, s, c)$ is the share of those who have subscribed to a private pension scheme and $\zeta_{in}(t, s, c)$ are those who are covered by the SERPS scheme. Note that $\zeta_{out}(t, s, c)$ is different from $1 - \zeta_{in}(t, s, c)$ since it is possible to contribute to both SERPS and a private pension fund.

- For British civil servants:

$Inc(g, s, "f")$

$$= w_{rep} - (\tau_{nif} - \tau_{red}) \cdot \min(w_{rep}, w_{ss}) - \tau_{fund} \cdot w_{rep} \qquad \text{for } a(g) < a_{ret}(g, s) \tag{20e}$$

$$= n_{ret} \cdot [P(g, s, "f", "bsp") + P(g, s, "f", "fund") + MIG(t)] + w_{rep} - (\tau_{nif} - \tau_{red}) \cdot \min(w_{rep}, w_{ss}) - \tau_{fund} \cdot w_{rep} \qquad \text{for } a_{ret}(g, s) \leq a(g) < 75 \tag{20f}$$

$$= n_{ret} \cdot [P(g, s, "f", "bsp") + P(g, s, "f", "fund") + MIG(t)] \qquad \text{for } 75 \leq a(g) \tag{20g}$$

3.3.4 Consumption and saving behavior

In the spirit of the Solow model, we assume that current consumption, $c(t, g, s, c)$, depends on the net current available income, $Inc(t, g, s, c)$, and, as in d'Autume and Quinet (2001), on wealth, $A(t-1, g, s, c)$, accumulated at the beginning of the period:

$$c(t, g, s, c) = (1 - s(t, g))\,(1 - \widetilde{\tau}(t))\,[r(t)A(t-1, g, s, c) + Inc(t, g, s, c)] + c_A A(t-1, g, s, c) \qquad \text{for } a(t, g) \geq 16 \tag{21}$$

where $s(t, g)$ is the exogenous propensity to save which is independent of the professional status. c_A is the exogenous propensity to consume aggregate wealth. $\widetilde{\tau}(t)$ is a uniform proportional tax rate on income allowing to finance pre-retirement and civil servants pension benefits in France and Germany and Minimum Income Guarantee, $MIG(t)$, in the UK. Saving and consumption behaviors are thus different according to the life cycle stage. For the sake of simplicity, we assume that the saving rate by age only takes 2 values according to the fact that the individual is active or at age of retirement. $s(t, g)$ and $c_A(t)$ are fixed during the calibration step so as to reproduce a correct wealth accumulation profile. The main reason explaining the choice of this form for the consumption function is that it allows to reproduce a decreasing wealth accumulation at a given age without assuming negative saving rates for old age people.

The household snapshot budgetary constraint then takes the usual form (with $A(t-1,g,s,c)=0$ for $a(t,c)\leq 16$):

$$\begin{aligned} & A(t,g,s,c)+c(t,g,s,c)(1+cout(t,g,s,c)) \\ = \; & \left[1+(1-\widetilde{\tau}(t))\cdot r(t)\right]A(t-1,g,s,c)+(1-\widetilde{\tau}(t))Inc(t,g,s,c)+h(t,g,s,c) \end{aligned} \tag{22}$$

with $h(t,g,s,c)$ received inheritance. The variable $cout(t,g,s,c)$ is the equivalent in term of an adult consumption of the children (in charge) consumption. For simplicity, we assume that (i) this relative cost is uniform for all those aged 29 to 65 and that (ii) the "children" class is composed of all inactive individuals who are not on the labour market ($a(t,g)<\overline{D}_2(g,s)$). This relative cost is then calculated following this formula:

$$cout(t,g,s,c)=\frac{\sum_{a(t,g)<\overline{D}_2(g,s)}\beta(a(t,g))\cdot N(t,g,s,c)(1-\theta_{act}(t,g,s,c))}{\sum_{29\leq a(t,g)<65}N(t,g,s,c)} \tag{23}$$

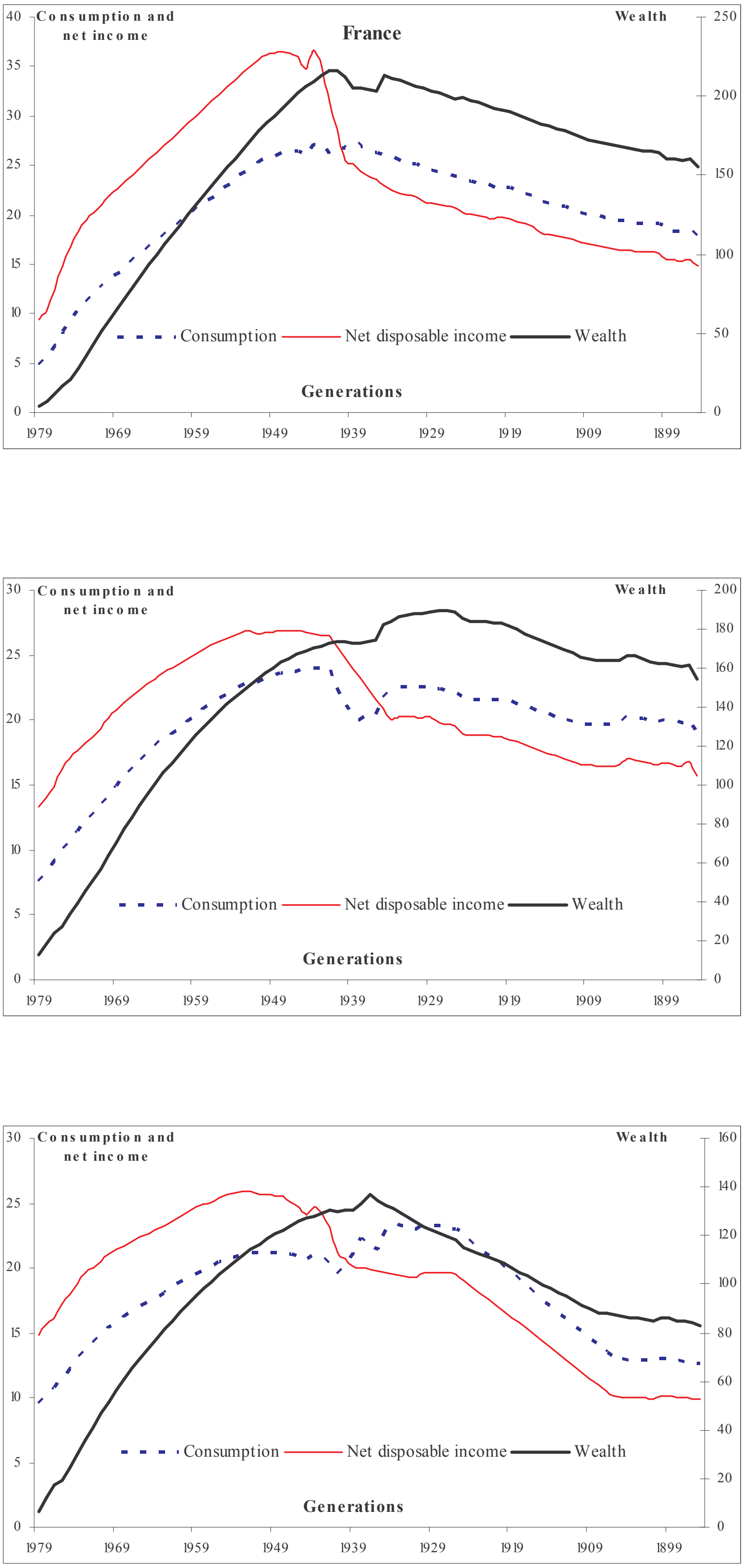
where $\beta(a(t,g))$ is the relative cost of an additional child in term of an adult consumption and it varies with age. The values are taken from Hourriez and Olier (1997) and are assumed to be the same for our three countries.

Some individuals die at each date and we then have to define what to do with their positive net wealth. Different solutions are considered in the literature. The first one consists in assuming a perfect annuity market which implies that accidental bequests are distributed implicitly as in a life insurance framework (see Rios-Rull, 2001). It is also possible to consider that this wealth is redistributed to offsprings but it implies to keep in memory the complete linkage history which makes the model heavy without bringing any crucial lesson to our purpose. Here, we prefer to adopt the idea, as Imrohoroglu (1998), that bequests are taxed to a 100% rate by the government and redistributed as a lump-sum uniform amount to all surviving adults. This inheritance, $h(t,g,s,c)$, concerns all those aged over 29:

$$h(t,g,s,c)=\frac{\sum_{(g,s,c)}A(t-1,g,s,c)\left[N(t,g,s,c)-N(t-1,g,s,c)\right]}{\sum_{(g,s,c)\in[a(\mathbf{t},\mathbf{g})\geq\mathbf{30}]}N(t,g,s,c)} \tag{24}$$

Given the uncertainty about the time of death, individuals die with a positive wealth even if they die at 105 years old (at least for likely values of c_A). Thus, given the lack of individual behavior maximization programme, the bequests do not correspond to the involuntary part of inheritance but have to be interpreted as the whole inherited wealth. We choose to fix the parameters $s(t, g)$ and $c_A(t)$ (i) so as to reproduce the initial capital stock with a stationary wealth by agents in 2000 and (ii) so that the average consumption level of retirees to the one of workers is equal to 110% in France, 95% in Germany and 80% in the UK (according to COR, 2004). Given this calibration, the following figures present the age profiles of consumption, net disposable income and wealth for all generations alive in 2000.

Figure 8: Consumption, wealth and average net disposable income by generations in 2001 (in thousands euros from 2000)



4 The pension systems

Our model includes the main pension systems and covers almost all pension benefits of the three countries. This section provides a precise description of the way pensions are calculated in the different countries considered.

4.1 The French pension system

The French pension system is often considered as very complex due to the coexistence of different regimes covering various segments of the population (Blanchet and Pelé, 1997). Our model focuses on those pension schemes that concern the bulk of the population. For 70% of the population (i.e. wage earners of the private sector), pensions consist in the combination of a basic general regime ("rb") and of mandatory complementary pension schemes ("rc") organized on a professional basis. The latter consist in a large number of specific schemes which are federated in two main institutions: AGIRC (Association Générale des Institutions de Retraites des Cadres) for executives ("ca") and ARRCO (Association des Régimes de Retraites Complémentaires) for non executives ("nc"). Complementary schemes currently provide 40% of the pension for wage earners of the private sector. All these schemes ("rb" and "rc") run on a pay-as-you-go basis. Beside this two-pillar structure, civil servants (20% of the population) have a single pension scheme ("rf") directly paid on the state budget. Our model also includes pre-retirement benefits that are assumed to be financed through the public superannuation fund ("rf").

4.1.1 The French civil servants pension scheme ("rf")

As a general rule, retirement is possible at age 60 provided at least 15 years of services have been completed. The pension $P_L(t, g, s, "f", "rf")$ paid to a new civil servant retiree (at age $D_2(g, s, "f") + D(g, s, "f")$) is a proportion of his last wage:[12]

$$P_L("f", "rf") = \pi("rf")\cdot w_{rep}(t-1)Min(D_1, D)(1-dec("rf")Max(0, Min(\overline{a}-a, D_1-D))) \tag{25}$$

where $\pi(t, g, "f", "rf")$ is the replacement ratio over the last wage $w_{rep}(t-1, g, s, "f")$, $D_1(g, s, "f")$ is the minimum contribution length to benefit from a complete pension and $D(g, s, "f")$ is the average length of civil servants working life. The key variable is the number of years a civil servant worked. Each year entitles him/her to a 2% annuity, the sum being truncated to 75%. $dec(g, "rf")$ is the penalty applied for early suspension of activity. It is specific to each generation.[13] It consists in reducing the pension by 1.25% for each quarter missing for attaining either the minimum contribution length, $D_1(g, s, "f")$, or the limit pension age ($\overline{a}(t, g, "rf")$). Note that the latter will progressively increase from 61 in 2006 to 65 in 2020.

Beyond the average effective retirement age ($D_2(g, s, "f") + D(g, s, "f")$), pensions are upgraded following a standard formula:

$$P(t, "f", "rf") = (1 + I(t, "rf"))P(t-1, "f", "rf") \qquad \text{for } a(t) > D_2 + D \tag{26}$$

where the public pension indexation factor, $I(t, "rf")$, is the growth rate of civil servant wage before the 2003 reform and to the inflation index afterwards.

4.1.2 The general regime ("rb")

We assume that all those who are not civil servants are affiliated to the general regime, which works as a defined benefit annuity regime. The basic general scheme offers contributory benefits corresponding to the share of wages below the Social Security ceiling. The principle is that the pension is proportional to the number of quarters of contribution and to a reference wage. The reference wage is an average of wages $W_R(t, g, s, c)$ perceived during the $An(g)$ last years of the pensioners' career (in fact, $An(g)$ best years which is

[12] Once again, we omit subscripts (t, g, s, c) when they are not useful

[13] This penalty have been decided by the Fillon reform of 2003 and will begin to apply in 2006. The penalty rate will progressively increase until it reaches 5%.

relatively similar given the experience premium):

$$W_R(t,g,s,c) = \frac{\sum_{D_2+D-An(g)<a(t,g)}^{a(t,g)<D_2+D} \left[\prod (1+I(t,"rb"))\right] Min(w_{rep}(t), w_{ss}(t))}{An(g)} \qquad (27)$$

with $I(t,"rb")$ the indexation factor on the wage received at time t when retiring.[14] $w_{ss}(t)$ is the Social Security ceiling above which any right to pension is obtained. In accordance with the current law, this ceiling is proportional to the average earning income of the private sector:

$$w_{ss}(t) = a_{plaf}(t) \frac{\sum_{(g,s,c);c\neq"f"} N_{act}(t,g,s,c) w(t,g,s,c)(1-\theta_{cho}(t,g,s,c))}{\sum_{(g,s,c);c\neq"f"} N_{act}(t,g,s,c)(1-\theta_{cho}(t,g,s,c))} \qquad (28)$$

where the proportionality parameter,$a_{plaf}(t)$, is fixed to 1.05 as the observed ratio of the Social Security ceiling to the average gross wage in the private sector in 1999.

The pension level at age of retirement, $P_L(t,g,s,c,"rb")$, (i.e. $a(t,g) = D_2(g,s,c) + D(g,s,c)$ and $c \neq "f"$) then is:

$$\frac{P_L("rb")}{W_R} = \pi("rb") - dec("rb") Max\left(0, Min\left(65-a, D_1 - D\right)\right) \cdot Min\left(1, \frac{D}{pro}\right) \qquad (29)$$

with $\pi(t,g,c"rb")$ the maximum replacement rate (50%) of the reference earning $W_R(t,g,s,c)$. $dec(g,"rb")$ is the penalty applied in case of early suspension of activity. This coefficient depends on the generation concerned. After the 2003 reform, it progressively decreased from 1.25% for each quarter missing to complete D_1 contribution years or to reach age 65 for generations born before 1944, to 0.625% for generations born after 1952. $pro(t,g)$ is the contribution length necessary to obtain a full pension and should reach 41 years (164 quarters) when the 1993 and 2003 reforms fully produce their effects (generations born after 1958).

After the effective retirement age $(D_2(g,s,c) + D(g,s,c))$, pensions of the general scheme are upgraded in line with price:

$$P(t,"rb") = (1+I(t,"rb"))P(t-1,"rb") \qquad \text{for } a(t) > D_2 + D \text{ and } c \neq "f" \qquad (30)$$

where $I(t,"rb")$ is inflation.

[14]Before the Balladur reform of 1993, the indexation factor was equal to the wage growth rate ; since the reform, it has been equal to the inflation rate.

4.1.3 Complementary schemes ($"rc"$)

Complementary schemes are almost fully contributory and are organized in defined-contribution systems. Pensions are calculated according to notional account. For executives, contributions are collected by ARRCO for the part of the wage below the social security ceiling ($w_{ss}(t)$), and by AGIRC for the segment of the wage which is comprised between 1 and 4 time the ceiling. Non-executives only contribute to ARRCO but the wage is truncated to 3 x ceiling, and different rules apply below and above the ceiling. Workers buy each year $point(t, g, s, c, fund)$ points to the fund they are affiliated to at a purchase price $P_{pt}(t, c)$ and they sell it at a price $V(t, c)$ when retiring.

Rather than distinguishing two funds depending on the professional status, we prefer to distinguish two types of cumulated points. For $a(t, g) < D(g, s, c) + D_2(g, s, c)$:

$$point_1(t, g, s, c) = \tau_1(t, c)\frac{Min(w_{rep}(t, g, s, c), w_{ss}(t))}{P_{pt}(t, c)} \quad (31)$$

$$point_2(t, g, s, c) = \tau_2(t, c)\frac{Max(0, w_{rep}(t, g, s, c) - w_{ss}(t))}{P_{pt}(t, c)} \quad (32)$$

with $\tau_1(t, c)$ and $\tau_2(t, c)$ the contribution rates to the complementary schemes. The number of points accumulated since the beginning of the working life is then simply given by:

$$NP_i(t, g, s, c) = cc(s, c)_i \sum_{a(t,g)\geq D_2(g,s,c)}^{a(t,g)\leq D_2(g,s,c)+D(g,s,c)} point_i(t, g, s, c) \qquad \text{for } i = 1, 2 \quad (33)$$

where $cc(s, c)_i$ are constant adjustment parameters that account for non-contributory advantages (such as unemployment, children, etc.). These parameters have been calibrated so as to reproduce complementary pension benefits at age of liquidation ($a(t, g) = D_2(g, s, c) + D(g, s, c)$) in accordance with the data of the EIR 2001 (Echantillon Inter Régime).

The total complementary pension $P(t, g, s, c, "rc")$ can therefore be written, at each date t and whatever the age of the individual, as:

$$P("rc") = Min(1, 1 - dec("rc") \cdot Max(D_1 - D, 0) \cdot (65 - D - D_2)) \cdot \sum_i V_i(c)NP_i \quad (34)$$

with $dec("rc")$ the penalty applied in case of anticipated suspension of activity ($dec("rc") = 4\%$). $V_i(t,c)$ is the point value of each complementary fund, calculated on historical data until 2003 and then indexed on the general price index as in Bardaji and al. (2003).

4.2 The German pension system

Germany has the oldest formal pension system, introduced in 1889 by Chancellor Bismarck. It is a completely pay-as-you-go, defined-benefit system (For more details, see for example Börsch-Supan and Wilke, 2003). Approximately 90% of the German population is covered by the "public retirement insurance" (Gesetzliche Rentenversicherung, $"grv"$). GRV is mandatory for private employees and also includes those public sector workers who are not civil servants. This scheme offers generous replacement rates (around 70% of average earnings for a complete career). Civil servants (7% of the total population) are covered by a special scheme ($"rf"$) that is even more generous than GRV. In addition to benefits through the public pension system, transfer payments (mainly unemployment compensation) enable what is referred to as "pre-retirement". As in the French case, pre-retirement benefits are assumed to be financed through the public superannuation fund ($"rf"$).

4.2.1 The Private sector pensions ($"grv"$)

The GRV pension scheme offers benefits that are proportional to lifetime contributions. Contributions, in turn, are proportional to earnings capped at about twice the average earning. Thus, the social security ceiling, $w_{ss}(t)$, is computed as in the French case (equation [28]) except for the proportionality parameter ($a_{plaf}(t) = 2$). Contributions entitle members to claim a fully-annuitized pension beginning between ages 60 and 65. Pension benefits are computed by multiplying the number of "earning points", $Pt_{ac}(t,g,s,c)$, the pension value, $PV(t)$, and an adjustment factor for incomplete career. $Pt_{ac}(t,g,s,c)$ measures the employee's relative contribution position in year t. The $Pt_{ac}(t,g,s,c)$ points accrued by individual of type (g,s,c) depend upon contribution assessment basis in each year of his working life and on the average contribution assessment basis of the population, $W_{base}(t)$. It is computed by cumulating his annual relative contribution positions over the entire earnings history:

$$Pt_{ac}(t,g,s,c) = \sum_{a(t,g)\geq D_2(g,s,c)}^{a(t,g)\leq D_2(g,s,c)+D(g,s,c)} \frac{Min((w_{rep}+\pi_{pr}n_{pre}w_{rep}), w_{ss})}{W_{base}(t)} \quad \text{for } c \neq \text{"}f\text{"} \quad (35)$$

where the contribution assessment basis of the population is simply given by:

$$W_{base}(t) = \frac{\sum_{(g,s,c);c\neq\text{"}f\text{"}} N_{act}(t,g,s,c)w(t,g,s,c)(1-\theta_{cho}(t,g,s,c))}{\sum_{(g,s,c);c\neq\text{"}f\text{"}} N_{act}(t,g,s,c)(1-\theta_{cho}(t,g,s,c))} \quad (36)$$

For each year of service, a worker receives an earning point which reflects his relative income position of that year. If he receives the average wage, then he gets exactly one earning point. If he receives more (or less) than the average wage, he receives points on a pro-rata basis capped by the social security ceiling, $w_{ss}(t)$.

The pension value $PV(t)$ is the crucial link between current wages and pensions. It is specified to ensure that an individual with 45 earning points will obtain a pension with a 70% replacement rate of average earnings when retiring:

$$PV(t) = \frac{\pi(t,\text{"}grv\text{"})}{45} W_{base}(t)\cdot(1-\tau(t,\text{"}grv\text{"})-\tau_{fict}(t)) \quad (37)$$

where $\pi(t,\text{"}grv\text{"})$ is the replacement rate. The Riester reform of 2001 will gradually (after 2010) reduce the replacement rate of 70% of average net earnings to around 67% in 2030. The Riester reform also changes the computational procedure for reference earnings, now subtracting a fictitious tax rate ($\tau_{fict}(t)$) of gross earning to be invested in a new funded supplementary private pension system[15]. This fictitious contribution to the new private pension account will gradually increase from 1% in 2003 to 4% in 2008.

The pension annuity payable upon retirement, $P_L(t,g,s,c,\text{"}grv\text{"})$, to individual of type (g,s,c) at time t by the GRV is then described by:

$$P_L(\text{"}grv\text{"}) = PV \cdot Pt_{ac} \cdot [(1-dec(g,\text{"}rc\text{"}))\cdot Max(0, 65-D-D_2)] \quad (38)$$

with $dec(g,\text{"}rc\text{"})$ the penalty applied in case of early suspension of activity and fixed at 3.54% (corresponding to a 0.3% discount for each month taken prior to the legal pension age).

[15] Since the new funded pensions are voluntary, it is very difficult to estimate how many people will build up supplementary pensions and how much they will save. For this reason, we prefer to not explicitly model this type of pension.

The German pension system appears to be one of the most generous in the world. Indeed, the high initial level of public pension was exacerbated by indexation to gross wages until the 1992 reform. This reform abolished the indexation of pension benefits to gross wages in favor of net wages. While this is still more generous than indexation on inflation (such as in France), it was conceived as a built-in stabilizer since any increase in the contribution rate for the pension system makes pension benefits grow at a slower rate. The mechanism will become very important when ageing speeds up since it implies implicit burden-sharing between generations.

The Riester reform introduces a rather complex new adjustment formula starting in 2002. It relates changes in the pension value, $PV(t)$, to lagged changes in gross income, $w_{rep}(t,g,s,c)$, modified by the actual contribution rate to the public pension, $\tau(t,"grv")$, and a fictitious contribution rate to the new private pension account ($\tau_{fict}(t)$):

$$PV(t) = PV(t-1)(1+I(t,"grv"))\frac{\xi_t - \tau(t-1,"grv") - \tau_{fict}(t-1)}{\xi_t - \tau(t-2,"grv") - \tau_{fict}(t-2)} \qquad (39)$$

with $I(t,"grv")$ the GRV pension indexation factor which is equal to inflation plus one percent per year. In practice, $I(t,"grv")$ is equal to the gross wage growth rate. The resulting drift in pension payments would however not be financially sustainable in the long run. As a result, we have like many other studies (see for example Börsch-Supan and Schnabel, 1998) considered a median way. ξ_t corresponds to a sensitivity factor which is fixed to one until 2010. Then, it decreases to 0.9 which effectively raises the sensitivity of $PV(t)$ to increases in the contribution rate.

4.2.2 Civil service pension ("rf")

Civil servants are exempted from the GRV public pension system. As seen before, they do not pay explicit contributions for their pensions as the other employees in the public and private sectors. Instead, they receive lower wages than other employees with similar education. The standard pension benefit for civil servants at age of liquidation, $P_L(t,g,s,c,"rf")$, is simply the product of the last gross wage, $w_{rep}(t-1,g,s,"f")$, the replacement rate $\pi(t,"rf")$, and the service length, $D(g,s,c)$:

$$P_L(t,g,s,c,"rf") = \pi(t,"rf") \cdot w_{rep}(t-1,g,s,"f") \cdot Min(45, D(g,s,c)) \qquad (40)$$

where $\pi(t, "rf")$ is calibrated so as to reproduce the civil service pension share in GDP in 2000 and then fixed at the corresponding value. In practice, the replacement rate, $\pi(t, "rf")$, grows by 1.875 percentage point for each year of service which allows a maximum replacement rate of 75% after 40 years of service. The maximum replacement rate is thus considerably higher than the official replacement rate of the private sector which is around 70% of net earnings. There are three crucial differences between civil service and private sector benefits. First, the benefit base is gross income rather than net income. Second, there is no ceiling, which implies a maximum pension higher than the private sector one. Third, the benefit base is the last wage rather than the life-time average.

Benefits are then updated annually by the growth rate of active civil servants net earnings:

$$P(t, g, s, c, "rf") = P(t-1, g, s, c, "rf") \cdot (1 + I(t, "rf")) \quad (41)$$

where, as for the GRV pension, $I(t, "rf")$ is inflation plus one percent.

4.3 The British pension system

The British pension system is three-tiered (for a detail discussion, see Dupont (2003), Blake (2003a) or Banks and Emmerson (2000). The first tier consists of the Basic State Pension (BSP) and a significant level of means-tested benefits. The second tier is compulsory for all employees with earnings above a certain floor and is made of the State Earnings-Related Pension Scheme (SERPS)[16] and a large and continually growing level of private provision. Finally, the third tier consists of additional voluntary contributions and other private insurance.

4.3.1 The Basic State Pension ("bsp")

The BSP is a flat-rate contributory benefit payable to people aged over the state pension age, provided the contribution conditions are satisfied. The state pension age is 65 for men and 60 for women. A recent reform raises this age for women by 6 months a year from 2010 to 2020 in order to make state pension age converge between men and women. To

[16] The State Second Pension (S2P), which is more generous to lower earners, replaced SERPS in April 2002.

get a full rate of benefit, contributions must have been paid or credited for 90% of working life (between age 16 and the legal state pension age, $a_{ret}(g,s)$). This presently requires 44 years of contribution for men and 39 years for women (rising to 44 when retirement ages are equalized at 65 in 2020). Reduced rates of benefits are paid if the contribution record is less than complete, with a minimum benefit rate of 25%. Below this threshold, no pension is paid. A qualifying year is defined as one in which an individual earned an annual income that exceeds the Lower Earnings Limit, LEL, (around 18% of average earnings in 2000). This implies that most households qualify for the full BSP. Note that all public sector personnel also receive this pension in addition to their occupational pension. There is no possibility of early retirement benefits.

The calculation of BSP entitlement is straightforward. It only depends on the total number of contribution years. Although the BSP is flat rate, total benefits can vary across individuals with similar contribution records for example due to widows with no pension in their own right being entitled to claim their former spouse's pension at full rate. The amount of BSP pension at age of liquidation, $P_L(t,g,s,c,"bsp")$, for those having reached the legal retirement age (i.e. $a(t,g) = a_{ret}(g,s)$) is simply given by:

$$P_L(t,g,s,c,"bsp") = \frac{D_{car}(g,s,c)}{0.9Anw(g,s)} BSP(t,g,s,c) \tag{42}$$

where $D_{car}(g,s,c)$ is the total number of contribution years, calculated as the sum of employment rates on the working life for each generation. $Anw(g,s)$ is the length of a complete working life necessary to get a full pension (49 years for men and between 44 and 49 years for women depending on the generation), and $BSP(t,g,s,c)$ is the lump-sum state pension allocation, calibrated so as to reproduce the observed state pension values reported in the 2003 Pensioners' Income Series.

Beyond the state pension age (i.e. $a(t,g) > a_{ret}(g,s)$), state pensions are upgraded following the standard formula:

$$P(t,g,s,c,"bsp") = (1 + I(t,"bsp"))P(t-1,g,s,c,"bsp") \tag{43}$$

where $I(t,"bsp")$ refers to inflation. Note however that the BSP was upgraded by 7.4% and 4.1% in 2001 and 2002, respectively.

4.3.2 The State Earnings-Related Pension Scheme ("*serps*")

Because of its flat-rate and low benefit level, the BSP has unsurprisingly been complemented with a second tier. The first part of this second tier is the State Earnings-Related Pension Scheme (SERPS). Membership to the second tier state pension is compulsory for all employees (but not self-employed), unless the employee has contracted-out into a private pension scheme. Introduced in 1978[17], it pays a pension equal to a fraction of an individual's qualifying annual earnings each year since 1978. Broadly speaking, it was originally designed to provide a pension equal to one quarter of earnings during the best 20 years of earnings. Subsequent reductions in the generosity of SERPS were introduced by the conservatives in the mid-1980s. The main change was a move from a benefit formula producing a pension worth 25% of the best 20 year earnings to one producing 20% of lifetime average earnings.

The earnings on which the pension is calculated are bounded by the Lower Earnings Limit, $LEL(t)$ and the Upper Earnings Limit, $UEL(t)$[18]. These thresholds move up each year in line with prices. The amount of first SERPS pension received by a pensioner is based on total earnings on which contributions were paid from 1978 to the year before the state pension age, $W_R(t,g,s,c)$. Earnings above the UEL are ignored. The LEL for the years worked are first subtracted from earnings of the same period. Then, the extra amounts earned for each year are up-rated in line with earnings growth. Finally, the re-evaluated relevant earnings are averaged over the period from 1978 to legal retirement age. The precise formula for calculating the individual working life earnings is given by (for $c \neq$ "f"):

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[17] Contributions paid between 1961 and 1975 entitle to an earning-related "graduated pension". No further accruals were earned after 1975. Thus, this pension is now of virtual irrelevance as its design purposely failed to allow for indexation so that it can be safely ignored.

[18] $UEL(t)$ is equal to the social security ceiling, $w_{ss}(t)$, defined at equation [28] with $a_{plaf}(t) = 1.2$ for the year 2000 and then evolving with prices. Indeed, in 2000, $UEL(t)$ represented around 120 % of average earnings.

$$W_R(t,g,s,c)\cdot A_{serps}(g,s) \tag{44}$$
$$= \sum_{a_{ret}(g,s)-A_{serps}(g,s)<a(t,g)}^{a(t,g)<a_{ret}(g,s)} \left[\prod(1+I_W(t))\right](Min(w_{rep}(t,g,s,c),UEL(t))-LEL(t))$$

where $A_{serps}(g,s)$ is the number of years between 1978 and the legal retirement age, $a_{ret}(g,s)$. $I_W(t)$ is an index of economy-wide average earnings.

The amount of SERPS pension at age of retirement, $P_L(t,g,s,c,"serps")$, at date t is then based on this average working life earning:

$$P_L(g,s,c,"serps") = \pi(g,s,c,"serps")\cdot\frac{D_{car}(g,s,c)}{0.9Anw(g,s)}\cdot W_R(g,s,c)\cdot\zeta_{in}(s,c) \tag{45}$$

where $\pi(t,g,s,c,"serps")$ is the accrual rate originally fixed at 25% of average earnings. For those retiring from 2000 to 2009, there will be a phased reduction in the accrual rate from 25% to 20%. Any employee can choose to contract out of SERPS into a secondary private pension. Since our model assumes a representative agent for each professional status, each pensioner receives simultaneously a SERPS and a private pension. $\zeta_{in}(t,s,c)$ refers to the share of those who contracted in SERPS by professional status and sex. These shares are based on the *Lifetime Labour Market Database*. On average, only 1/3 of workers are currently affiliated to SERPS.

As for the BPS pension, the SERPS pension, $P(t,g,s,c,"serps")$, is up-rated each year after retirement in line with prices:

$$P(t,g,s,c,"serps") = (1+I(t,"serps"))P(t-1,g,s,c,"serps") \tag{46}$$

From 2002, SERPS has been reformed to provide a more generous additional state pension for low and moderate earners. The reformed additional state pension is known as the State Second Pension (S2P). For those earning more than the average income, S2P equals to SERPS. For those earning above the LEL but below the new Low Earnings Threshold, LET (around 45% of the annual average earning), the accrual rate will be twice the SERPS one. Moreover, the S2P is calculated on the basis of LET. Between the two thresholds, the accrual rate is half of the relevant SERPS rate. S2P pensions are still up-rated with prices.

4.3.3 Incapacity Benefit and Minimum Income Guarantee

The BSP remains by far the most important element in social security spending on elderly. Nevertheless, BSP individual average amounts represent only around 15% of average earnings at present. In addition to the BSP and SERPS, there are two other state benefits that are taken up widely by elder people: income support and Incapacity Benefit. The state retirement pension system offers no incentive for people to retire early. However, there appears to be widespread use of invalidity and sickness benefits as a route into early retirement. Incapacity Benefit is payable to individuals who have paid National Insurance Contributions. Early retirement typically occurs from age 57 ($\underline{r}^a = 57$) and we assume that the benefits for not working during this period (from 57 to legal state pension age) come from the Incapacity Benefits. Note that Incapacity Benefits are here simply modelled as lump-sum benefits. The individual amount is adjusted so as to reproduce a total share of Incapacity Benefits around 0.7% of GDP in 2000.

There are also important income-related benefits. Currently, 40% of pensioners receive some form of income-related benefit (Department of Social Security, 2000). Income support is a flat rate, non-contributory, means-tested benefit. It is payable to those aged 60 or over who are on low incomes and are not in paid employment. In April 1999, income support was renamed Minimum Income Guarantee (MIG) and made more generous with an increase in the level and a commitment to up-rate in line with earnings. In addition, a similar number of elder people receive means-tested help with their housing costs. For the sake of simplicity, we assume that only non executives (and 74% of those employed in the public sector, corresponding to the share of non-executives in the public sector) receive this type of lump-sum benefits (MIG + Housing Benefit). As they are non-contributive, we assume they are financed thought a proportional flat-rate income tax, $\widetilde{\tau}(t)$.

4.3.4 Private pension

We now turn to a broad description of private pensions. Compared to France and Germany, the UK has a high level of coverage of private pensions. There are two types of private pension schemes open to individuals: occupational (run by a firm for its employees) and personal (based on an individual contract with an insurance company). Contributions into these schemes are made out of pre-tax income so that contributions are effectively subsidized (at the basic tax rate) by the government. A key element of the social security regulations which has underpinned the growth of occupational pension schemes is the ability of employees to "opt out" of SERPS.

For the sake of simplicity, we consider personal pensions as a form of discretionary saving. We only consider a defined-benefit rule since 90% of occupational pension schemes were in such a scheme in 2000. Occupational pension funds must be funded to cover obligations and not run on a pay-as-you-go basis (the only exceptions are for certain public sector employees, that is not treated in our model). The pension received at age of retirement ($a(t,g) = a_{ret}(g,s)$) at date t in a defined benefit occupational pension plan, $P_L(t,g,s,c,"prv")$, is determined by the following formula:

$$\frac{P_L(g,s,c,"prv")}{\pi(g,s,c,"prv")} = \left(w_{rep}(\widetilde{t}) - \beta LEL\right) \cdot \min(0.9Anw(g,s), D(g,s,c)) \cdot \zeta_{out}(s,c) \qquad (47)$$

where $\pi(t,g,s,c,"prv")$ is the scheme-specific accrual rate, $w_{rep}(\widetilde{t})$ is the average earnings in the last ten years before retirement (last year in the public sector), β is an integration factor and $\zeta_{out}(t,s,c)$ is the share of those having subscribed to a private occupational scheme. The key distinction that we make is between individuals who work in the public and in the private sector. We assume an accrual rate of 1/60th for the private sector and of 1/80th for the public one. We assume an integration factor of 1 for private sector schemes and 0 for public sector schemes. Finally, $\zeta_{out}(t,s,c)$ is fixed to 1 for employees of the public sector (since they are not covered by SERPS pensions) and estimated on the basis of National Income Contributions statistics for others.

As reported by Government Actuary, in 2000 there were 10.1 million employees in occupational pension schemes, of whom 5.7 million were in the private sector and 4.5

million in the public sector. These figures are assumed to change for future years with the demography and the share of those in an occupational scheme, $\zeta_{out}(t, s, c)$.

5 Equilibrium conditions

5.1 Superannuation funds

The French pension system described in our model is composed of three superannuation funds: the general regime ("rb"), the complementary scheme ("rc") and the civil servants scheme ("rf"). The German system is composed of two schemes: the private sector scheme ("grv") and the civil servants scheme ("rf"). Finally, the British pension is based on two types of superannuation funds : the public superannuation fund which is constituted by the main benefits paid by the National Insurance Fund ("nif")[19] and the private superannuation funds ("prv") that gather all occupational pension schemes (public and private).

5.1.1 Receipts of superannuation funds

For France:

The receipts of the superannuation funds covering the private sector ($rec(t,"rb")$ and $rec(t,"rc")$) are equal to the sum of all contributions of private sector employees in activity at time t. The receipts of the public superannuation fund ($rec(t,"rf")$) are also based on the proportional income tax, $\widetilde{\tau}(t)$.

$$rec("rb") = \sum_{(c \neq "f",g,s)} N \cdot [cet(c,"rb")w_{rep} + \tau("rb")Min(w_{rep}, w_{ss})] \tag{48a}$$

$$\begin{aligned} rec("rc") = & \sum_{(c \neq "f",g,s)} cet(c,"rc")w_{rep} \cdot N \\ & + \sum_{(c \neq "f",g,s)} \tau_{ap}(c) \cdot N \cdot [\tau_1(c)Min(w_{rep}, w_{ss}) + \tau_2(c)Max(0, w_{rep} - w_{ss})] \end{aligned} \tag{48b}$$

[19] That includes the Basic State Pension, the State Earnings Related Pension Scheme and the Incapacity Benefits.

$$rec("rf") = \tau("rf") \sum_{(c="f",g,s)} N \cdot w_{rep} + \widetilde{\tau} \left[\left(r \cdot \sum_{(c="f",g,s)} N \cdot A \right) + (1-\alpha)Y \right] \tag{48c}$$

For Germany:

The private sector scheme is financed through a single tax rate $\tau(t, "grv")$. The public sector scheme is only financed through the income tax rate, $\widetilde{\tau}(t)$, since civil servants don't pay any effective contribution.

$$rec("grv") = \sum_{(c \neq "f",g,s)} N \cdot \tau("grv") \cdot Min(w_{rep}, w_{ss}) \tag{49a}$$

$$rec("rf") = \widetilde{\tau} \left[\left(r \cdot \sum_{(g,s,c)} N \cdot A \right) + (1-\alpha)Y \right] \tag{49b}$$

For the UK:

Public pension receipts are the sum of all employees' contributions[20]. We distinguish between two types of employees depending on whether they have contracted-in SERPS (paying the normal tax rates of contributions, $\tau_{nif}(t)$) or they have contracted-out of SERPS (paying a reduced rate of contribution, $\tau_{nif}(t) - \tau_{red}(t)$). At each time t, the public superannuation fund receipts are thus given by:

$$\begin{aligned} rec("nif") \quad &= \quad \sum_{(g,s,c)} N \cdot \zeta_{in} \cdot [\tau_{nif} \min(w_{rep}, UEL)] \\ &\quad + \sum_{(g,s,c)} N \cdot (1-\zeta_{in}) \left[(\tau_{nif} - \tau_{red}) \min(w_{rep}, UEL) \right] \end{aligned} \tag{50}$$

5.1.2 Superannuation funds expenditures

At each date t, superannuation funds expenditures are simply given by the sum of each type of pension with the number of pensioners.

For France:

$$Dep("rb") = \sum_{(c \neq f,g,s);a(g) \geq D+D_2} N_{ret}(g,s,c) P(g,s,c,"rb") \tag{51a}$$

[20] Private employees as well as civil servants.

$$Dep("rc") = \sum_{(c \neq f, g, s); a(g) \geq D + D_2} N_{ret}(g, s, c) P(g, s, c, "rc") \tag{51b}$$

$$\begin{aligned} Dep("rf") &= \sum_{(g,s); a(g) \geq D("f") + D_2("f")} N_{ret}(g, s, "f") P(g, s, "f", "rf") \\ &+ \sum_{c \neq ("f", g, s)} N_{pre}(g, s, "f") \pi_{pr}(s, "f") w_{rep}(g, s, "f") \end{aligned} \tag{51c}$$

For Germany:

$$Dep("grv") = \sum_{(c \neq f, g, s); a(g) \geq D + D_2} N_{ret}(g, s, c) P(g, s, c, "grv") \tag{52a}$$

$$\begin{aligned} Dep("rf") &= \sum_{(g,s); a(g) \geq D("f") + D_2("f")} N_{ret}(g, s, "f") P(g, s, "f", "rf") \\ &+ \sum_{c \neq ("f", g, s)} N_{pre}(g, s, "f") \pi_{pr}(s, "f") w_{rep}(g, s, "f") \end{aligned} \tag{52b}$$

For the UK:

$$\begin{aligned} Dep("nif") &= \sum_{(g,s,c); a(g) \geq a_{ret}(g,s)} N_{ret}(g, s, c) P(g, s, c, "bsp") \\ &+ \sum_{(g,s,c \neq "f"); a(g) \geq a_{ret}(g,s)} N_{ret}(g, s, c) P(g, s, c, "serps") \\ &+ \sum_{(g,s,c)} N_{pre}(g, s, c) \pi_{pre}(s, c) w_{rep}(g, s, c) \end{aligned} \tag{53a}$$

$$Dep("prv") = \sum_{(g,s,c); a(g) \geq D + D_2} N_{ret}(g, s, c) P(g, s, c, "prv") \tag{53b}$$

5.1.3 Pension funds equilibria

At each time t, the primary deficit of the public superannuation funds, $Def(t, fund)$, is defined by the difference between public superannuation fund receipts, $rec(t, fund)$, and expenditures, $Dep(t, fund)$. For each fund, it simply writes:

$$\begin{aligned} Def(t, fund) &= rec(t, fund) - Dep(t, fund) \\ & \text{for } fund = "rb", "rc", "rf", "grv", "nif" \end{aligned} \tag{54}$$

5.1.4 The British occupational pension fund equilibrium

British occupational pension scheme must be funded at each date to cover obligations and not run on a pay-as-you-go basis. Calculation of appropriate funding levels requires a number of actuarial assumptions, in particular the assumed return on assets (based on the current interest rate), projected future real wage growth, $I_W(t)$ (since occupational pensions depends on final salaries) and future inflation ($I(t, "prv")$) as well as estimates of annuity factor ($annuity(t)$) and the expected evolution of the relative number of contributors and beneficiaries over time. The value of accrued pension rights is calculated using the "projected unit method" (which is used by about 75% of UK pension schemes to value their liabilities). At each period t, the present value of the pension liability for an active pension scheme member, $PVLiab(t, g, s, c)$, is calculated as follows (for more details, see for example Blake and Orszag, 1997, or Blake, 2003b):

$$\begin{aligned} PVLiab &= \pi("prv") \cdot \zeta_{out} \cdot (a(g) - D_2) w_{rep} \left[(1 + I_W)(1 + I("prv")\right]^{(a_{ret}(g,s) - a(g))} \\ &\cdot \left(\frac{1}{1 + r_{t-1}}\right)^{(a_{ret}(g,s) - a(g))} \cdot annuity \end{aligned} \tag{55}$$

where the expected annuity factor (the present value of a pension annuity of 1 euro per year) at age of retirement is calibrated so that the contribution rate to the private scheme, $\tau_{fund}(t, c)$, is equal to 14% in the year 2000[21] (Government Actuary's Department, 2003). Then, $annuity(t)$ is fixed and $\tau_{fund}(t, c)$ is calculated endogenously to insure the sustainability of the pension fund at each date. Equation [55] thus implicitly assumes that the date of entry into the scheme is the same as the date of entry into the labour force, $D_2(g, s, c)$.

The pension scheme is fully funded when the current value of the financial assets in the pension fund, $Assets(t)$, is equal to the present value of the pension liabilities aggregated across all scheme members:

$$Assets(t) = \sum_{(g,s,c)} N(t, g, s, c) \cdot PVLiab(t, g, s, c) \tag{56}$$

[21] Note that this annuity factor depends in practice of survival probabilities. So as to simplify the model, we prefer to adopt an easier strategy and calibrate $annuity(t)$ once and for all.

and the assets of a pension fund consist of the financial assets purchased with the accumulating contributions:

$$Assets(t) = Assets(t-1)(1+r_{t-1}) + \sum_{(g,s,c)} N \cdot \tau_{fund} \cdot \zeta_{out} \cdot w_{rep} - \sum_{(g,s,c)} N_{ret} \cdot P("prv") \quad (57)$$

5.2 Calibration of the pension funds receipts and expenditures

When gauging the model, we try to reproduce the historical level of expenditures of each superannuation fund considered (Table 3). For France, the model reproduces for the year 2000 the following figures: a ratio of ageing benefits to GDP of 12.6% (Mesnard, 2001) which is share among the various funds: $Dep("rb") = 44.8\%$, $Dep("rc") = 26.2\%$, $Dep("rf") = 28.9\%$. For Germany, we assume a share of pension benefits of 11.8% (OECD, 2001) divided between the private sector pensions ($Dep("grv") = 82\%$) and the civil servants scheme ($Dep("rf") = 18\%$). For the UK, the model reproduces a ratio of public ageing benefits to GDP of 4.7% (Department for Work and Pension) and an occupational pensions to GDP ratio of 4.4% (Government Actuary's Department). Public expenditures are allocated in the following way: 75.2% for BSP pensions, 11% for SERPS pensions and 13.8% for invalidity benefits (pre-retirement). Occupational pensions expenditures are constituted of private occupational pensions (61%) and of public occupational pensions (39%).

So as to catch these data, we have to adjust and calibrate some variables. The stock profiles of pension benefits received in 2000 by age, sex and professional status reproduce for each fund the data of EIR (2001) for France, Börsch-Supan and Wilke (2003) for Germany and the Pensioners' Incomes Series (2004) for the UK. At the same date, the average amount of pension benefits paid by each fund and the replacement rate at age of retirement for the different type of agents (as well as the points value) are adjusted so as to catch the aggregate spending of each fund.

We thus assume that each fund is balanced in 2000 and that the funds have no debt. In order to obtain these results for the initial year, we have to adjust some parameters related to the different schemes receipts: the contribution rates $\tau(2000,"rb")$, $\tau(2000,"grv")$ and

Table 3: Social Security payments in 2000

	Billion of euros	Percentage of GDP
	France	
General Regime "rb"	79.3	5.6%
Complementary Schemes "rc"	46.4	3.3%
Civil Servants Schemes "rf"	51.3	3.6%
Pre-Retirement	8.1	0.6%
Total	**185.1**	**13.1%**
	Germany	
Private Sector Pensions "grv"	196.4	9.7%
Civil Servants Schemes "rf"	43.1	2.1%
Pre-retirement	0.5	0.0%
Total	**240.0**	**11.8%**
	UK	
Basic State Pension "bsp"	47.8	3.5%
Second State pension "serps"	7.0	0.5%
Pre-Retirement	8.8	0.6%
Income Support (MIG)	11.7	0.9%
Private occupational pension funds	36.9	2.7%
Public occupational pension funds	23.2	1.7%
Total	**135.4**	**9.9%**

Sources: Mesnard (2001b), OECD (2001), Department for Work and pension, Government Actuary's department

$\tau_{nif}(2000)$, the additional contribution for complementary schemes, $\tau_{ap}(2000, c)$, the tax rate $\widetilde{\tau}(2000)$ for the civil servants schemes (and pre-retirement) and the tax rate for occupational pension funds, $\tau_{fund}(2000, c)$.

For the following years, we could consider different types of adjustments so as to insure (or not) the primary equilibrium of each fund. If the fund is unbalanced, the excess receipts (resp. expenditures) have to be financed (resp. capitalized) through debt. The total debt of the pension system, $Debt_{pen}(t)$, then evolves in the following way:

$$Debt_{pen}(t) = R(t)Debt_{pen}(t-1) + \sum_{fund} Def(t, fund) \tag{58}$$

with $R(t) = 1 + (1 - \widetilde{\tau}(t))r(t)$.

We assume that there is initially no debt ($Debt_{pen}(\text{"}2000\text{"}) = 0$) whatever the country. On the other hand, in accordance with the French legislation, we assume the existence of a reserve fund for pensions, $FR(t)$. From 2000 to 2003, we use the historical data of the Social Security. Then, given the lack of details related to the reserve fund evolution, we assume a simple evolution path:

$$FR(t) = R(t)FR(t-1) \tag{59}$$

At each date, the net debt of the public pay-as-you-go pension systems are then given by[22]:

$$Debt_{pub}(t) = Debt_{pen}(t) - FR(t-1) \tag{60}$$

5.3 The financial market equilibrium

The macroeconomic equilibrium of the model depends on the capital market functioning. In this study, we consider three different financial environment. The first one is based on the closed economy assumption. Ex ante, the net capital supply of national residents, i.e. the household aggregated wealth of the period t, $A(t) = \sum_{(g,s,c)} N(t, g, s, c)A(t, g, s, c) + assets(t)$[23], determines the capital stock of the country at the next period:

$$K(t) = A(t) - Debt_{pub}(t) \tag{61}$$

[22] For Germany and the Uk, $FR(t)$ is thus equal to zero at each date.

[23] Note that $assets(t) = 0$ in the French and German cases.

and the net return of capital, $r(t)$, thus equilibrates supply and demand for capital within the considered country.

The second environment is based on the small open economy assumption. The resident accumulation of assets and the resident demand for capital are assumed to be insignificant at the world level so that they do not have any influence on the world interest rate $r^*(t)$. Given the assumed perfect substitutability of assets between home and foreign securities as well as between public debt and others assets, the real interest rate is then fixed on the world financial market. Consequently, the capital demand emanating from firms (equation [9a]) adjusts to these external conditions. In this case, we assume that expectations are backward looking:[24]

$$K_{t-1} = N_{t-1}\Gamma_{t-1}f'^{-1}(r_{t-1} + \delta) \tag{62}$$

In this case, the financial market equilibrium is obtained by the amount $B^*(t)$ of debt incurred by residents to foreign agents:

$$B^*(t) = K(t) + Debt_{pub}(t) - A(t) \tag{63}$$

The factor prices are then fixed by external conditions, so that, according to the Leontieff's theorem, the productive decisions are independent of households behavior.

The third environment assumes that our three countries belong to a financial union which is closed relative to the rest of the world. Market clearing on the international capital market and the assumption of perfect capital mobility across our three countries ("fr","all","uk") requires that the interest rate net of income taxes is equalized across all countries and that the aggregated demand of capital is equal to the aggregated supply of capital:

[24] We could have assumed perfect expectations so that $K_t = N_{t+1}\Gamma_{t11}f'^{-1}(r_{t+1} + \delta)$. However, given the absence of adjustment costs on the capital stockpiling, such an assumption implies erratic capital adjustments without being essential for our study.

$$r_t^{fr}(1-\widetilde{\tau}^{fr}(t)) = r_t^{all}(1-\widetilde{\tau}^{all}(t)) = r_t^{uk}(1-\widetilde{\tau}^{uk}(t)) \tag{64a}$$

$$\begin{aligned} K^{fr}(t)+K^{all}(t)+K^{uk}(t) &= (A^{fr}(t)-Debt_{pub}^{fr}(t)) \\ &\quad +(A^{all}(t)-Debt_{pub}^{all}(t))+(A^{uk}(t)-Debt_{pub}^{uk}(t)) \end{aligned} \tag{64b}$$

6 Macroeconomic results

In this section, we present the results of several macroeconomic simulations of the model. We start with a benchmark scenario which accounts for recent pension reforms carried out in the three countries as well as for anticipated increasing activity rates discussed in section 2.2.2. However no further reform is undertaken in this first scenario. Hence pension schemes may be in deficit.[25]. The deficit is financed through government bond issuing whereas any surplus leads to reserve accumulation (Equation [58]). Obviously, this benchmark scenario of deficit financing of pension schemes does not correspond to the line adopted by the different governments. It must be seen as a "business-as-usual" case necessary to illustrate the financial tensions emanating from ageing process. The second scenario is a counterfactual one where it is assumed that no pension reform has been undertaken in recent years. By comparing this scenario to the benchmark, it is possible to disentangle the direct effects of population ageing, notably on capital markets, and potential feedback effects from pension reforms. The third scenario accounts for recent reforms but assumes unchanged activity rates compared to year 1999. The two last scenarios explore two alternative balancing rules for superannuation pension funds. In the fourth scenario, financial equilibrium of pension schemes is achieved through an adjustment of replacement rates, whereas in the fifth one, it is obtained through adjusting social security contribution rates.

For each scenario, three successive assumptions are considered concerning the capital market. The first case is the small economy assumption where there is perfect capital mobility at the world level and the country has no impact on the interest rate which is exogenous. The second case is that of autarky where the capital market must be balanced at the country level. This second case is designed to evaluate the contribution of capital mobility to the results obtained under the first assumption. Finally, the third case assumes perfect capital mobility between the three countries of the model, but no capital mobility between this group of countries and the rest of the world. Hence, each of the three countries can have an impact on the common interest rate.

[25] Except British occupational pension funds, because they do not run on a pay-as-you-go basis and are balanced on an actuarial basis based on Equation [57].

6.1 Benchmark scenario: increasing activity rates

This first scenario accounts for past pension reforms but assumes no further reform. However a rise in activity rates is assumed in this scenario.

6.1.1 Small open economy

In this first case, each of the three countries is a "small open economy", i.e. the interest rate is given. Here interest rates are fixed at their 2000 levels, i.e. 3.5% for France, 3.7% for Germany and 3.75% for the UK. Hence in this case capital accumulation by the firms is only dependent on external conditions (Equation [62]), once the employment level is determined. Any deficit in national saving is automatically financed through capital inflows (Equation [63]). Consequently, the small open economy environment is close to the accounting approach adopted in most public reports (Charpin, 1999, or COR, 2001) since the debt accumulation resulting from successive imbalances does not influence interest rate.

The main results for macroeconomic and pension schemes variables are provided in Table 4. Two standard-of-living indicators are also reported. The first one is the net replacement rate defined as the ratio of average net pension, composed of the different pension schemes, to the average net income of workers. Note that it is not a replacement ratio calculated on a standard case and on a complete career but rather an indicator of the average level of pensions compared to earnings. The second standard-of-living indicator is the ratio of retirees to workers average consumption. Finally, we provide an indicator of capital inflows or outflows related to demographic changes: the capital property ratio corresponds to the ratio of residents wealth to capital needs of the nation. This ratio increases (resp. decreases) with net outflows (resp. inflows) of foreign capital.

Recent pension reforms, combined with the assumed rise in activity rates of elder workers, ensures the solvability of pension regimes in France until 2010, contrasting with Germany and the UK which immediately have to face up with debt. After 2010, the accumulation of negative financial balances leads to a rise in pension schemes' indebtedness which appears to be particularly critical in the long run for France and Germany. For example, public schemes debt reaches 100% of GDP around 2040 in France and Germany

Table 4: Benchmark scenario: Small open economy

	2001	2010	2020	2030	2040	2050
			France			
GDP growth rate (in %)	2.14	2.20	1.50	1.25	1.41	1.34
Annual capital growth (in %)	3.84	2.42	1.65	1.25	1.39	1.33
Annual labour force growth (in %)	0.37	0.45	-0.19	-0.34	-0.18	-0.26
Public pension payments (in % of GDP)	12.2	12.5	13.7	15.7	17.1	17.8
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.2	0.1	7.8	41.1	104.1	178.8
Net replacement rate	64.6	63.0	59.2	55.6	53.7	52.9
Relative consumption of retirees	1.10	1.02	0.96	0.93	0.91	0.90
Capital property rate (in %)	1.01	0.97	0.96	0.95	0.86	0.71
			Germany			
GDP growth rate (in %)	0.99	1.96	1.16	0.74	1.46	0.95
Annual capital growth (in %)	3.10	2.10	1.22	0.73	1.54	0.96
Annual labour force growth (in %)	-0.39	0.12	-0.62	-0.98	-0.34	-0.79
Public pension payments (in % of GDP)	11.8	12.5	13.9	16.2	17.5	18.0
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	6.4	20.5	53.7	112.6	184.2
Net replacement rate	67.5	61.1	59.3	61.0	64.8	65.2
Relative consumption of retirees	0.95	0.85	0.79	0.79	0.82	0.83
Capital property rate (in %)	1.01	0.91	0.87	0.85	0.75	0.60
			UK			
GDP growth rate (in %)	2.30	2.49	1.67	1.25	1.70	1.50
Annual capital growth (in %)	3.39	2.71	1.80	1.23	1.67	1.52
Annual labour force growth (in %)	-0.11	0.54	-0.21	-0.53	-0.08	-0.32
Public pension payments (in % of GDP)	5.0	5.0	4.8	5.1	5.0	4.4
Pension funds payments (in % of GDP)	4.5	4.9	5.4	7.0	8.4	8.7
Debt of public pension schemes (in % of GDP)	0.2	3.9	7.6	15.5	30.6	44.4
Net replacement rate	62.8	62.6	60.9	59.8	57.9	55.6
Relative consumption of retirees	0.80	0.76	0.71	0.70	0.67	0.65
Capital property rate (in %)	1.01	0.92	0.87	0.87	0.79	0.68

Source: Author calculations

whereas this value is only around 30% in the UK. The low generosity of the UK public scheme combined with a less marked ageing process explain this result. Although the share of public pension in GDP is relatively stable over the period in the UK, private pension payments made by pension funds clearly increase, reaching 8.4% of GDP in 2040.

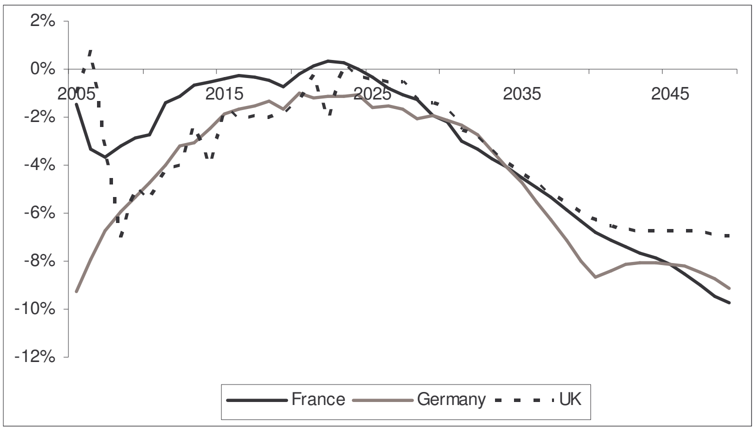
These deficits of pension systems translate into large capital inflows, from 2010 onwards in the three countries (Figure 9).[26] Capital flows are the result of two possibly competing effects. The first one is linked to the saving behavior of households and the second one comes from the financial needs of pension systems. Between 2010 and 2020, public pension systems generate small public deficits that are partially counterbalanced by the high saving rates. After 2020, the impact of ageing becomes more pronounced and transcripts into an explosion of the public debt as well as a reduction in households saving rates. As shown by the capital property rate in Table 4, Germany is especially affected due to strong ageing process and generous pension scheme. In France, one needs wait until year 2040 to observe financial needs comparable to those of Germany in 2010-2020. Due to the relatively weak debt of the public pension scheme, the UK situation is clearly linked to the ageing process, i.e. the fact that the baby boom generation quickly decumulates assets, a pattern that is accentuated by the importance of private pension funds.

Until 2020, capital accumulation remains sustained in the three countries, but Germany suffers from lower GDP growth (1.7% on average over 2000-2020 compared to 2% and 2.2% respectively in France and the UK). Once again, this effect may be accounted for by the importance of the deterioration in the old-age dependency ratio: from 2010, this dependency ratio weights on pension payments and induces deficits that capture a significant share of national savings. After 2020, average GDP growth rates are lower in the three countries (1,3% in France, 1% in Germany and 1,4% in the UK) due to further deceleration of the labor force.

This first scenario can be considered an optimistic one given the assumptions of upward activity rates for elder workers (based on the official national projections). In spite of this, the relative situation of retirees, measured by the net replacement rate, deteriorates in

[26] Capital flows are simply defined by the difference between foreign assets in two successive periods. Hence a negative capital flow amounts to a net capital inflow.

Figure 9: Benchmark scenario - Small open economy: Capital flows (in % of regional GDP)



France and in the UK given the indexation of pension benefits on prices. In Germany, there is no continuous deterioration: the net replacement rate first decreases due to the Riester reform that makes retirees participate to the increasing in contribution rates until 2030 (and also because of the decrease in the actual replacement rate)[27]; after 2030, the contribution rate is fixed at 22% (and the actual replacement rate at 67%) and the relative situation of retirees improves due to favorable indexation of pensions (inflation + 1%). Whatever the country, the results are more marked concerning the relative consumption of retirees. Indeed, the drop in fertility rates induces a decrease in the number of dependent children and the financial incomes of retirees will be lower since the GDP growth rate of the 2000-2040 period is clearly lower on average than during the last 40 years. We have to remind that saving behaviors are assumed to be exogenous in this model and are only age dependent. Consequently, some of recent implemented reforms implicitly assume a change in individual saving behaviors which is not taken into account in our results.

6.1.2 Closed Economy

In the small open economy assumption, each economy is assumed to be perfectly integrated in the world capital market so that it always finds financial resources at a fixed

[27] See section 4.2.1.

interest rate. The second environment of a closed economy takes the opposite view of no international capital flow. Of course, this assumption is highly unrealistic for our three countries. However, by comparing this environment to the small open economy case, it will be possible to understand the specific role of capital mobility when measuring macroeconomic consequences of ageing and pension reforms.

Here, debt financing of public pension schemes and of productive capital accumulation only comes from national savings (Equation [61]). By raising the domestic interest rate, increasing financing needs of pension systems now have a negative impact on capital accumulation, hence on growth. The fact that the French and German economies are on a negative growth path after 2040 is purely illustrative in the sense that it illustrates that public pension systems are unsustainable without capital inflows, and that parametric reforms need to be undertaken. In fact, the interest rate jumps due to the growing shortage of household net saving (levied by financial needs of pension systems): the gap between depressed economic growth and higher interest rate induces a negative cumulative spiral.

The consequences for pension schemes are dramatic (Table 5). Indeed, the share of pension payments in GDP rises compared to the small open economy case, not because of a higher purchasing power of pensions, but due to lower GDP. The increase in the relative cost of productive capital involves a lower ratio of capital stock to efficiency unit of labor. Since the labor supply is fixed, employment is reduced as the gap between real earnings supplied by firms (that decrease) and earnings desired by workers (that temporarily remain at a high level) transcripts into unemployment. The UK is less affected by this phenomenon given the lower share of public pension payments.

6.1.3 Financial union

Here we assume the EU capital market[28] to be perfectly integrated but isolated to the world market. Again, this is not a realistic assumption since in reality there is perfect capital mobility between this zone and the rest of the world. This environment aims at accounting for the fact that the group of our three countries constitutes a large economy

[28] Composed of our three countries and noted EU3.

Table 5: Benchmark scenario: Closed economy

	2001	2010	2020	2030	2040	2050
			France			
GDP growth rate (in %)	2.25	1.83	1.37	0.74	-0.36	-5.19
Annual capital growth (in %)	1.76	1.75	1.41	0.36	-1.62	-9.03
Annual labour force growth (in %)	-0.01	0.27	-0.25	-0.62	-1.16	-4.28
Public pension payments (in % of GDP)	12.2	12.7	14.0	16.3	19.5	26.0
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.3	0.1	10.4	50.2	145.4	392.1
Net replacement rate	64.6	63.9	60.6	57.6	60.1	73.8
Relative consumption of retirees	1.10	1.04	0.99	0.97	1.02	1.25
Interest rate (in %)	3.70	3.81	3.86	3.96	4.68	6.79
			Germany			
GDP growth rate (in %)	1.00	1.22	0.75	-0.27	-3.50	-
Annual capital growth (in %)	0.62	0.76	0.49	-0.99	-6.49	-
Annual labour force growth (in %)	-1.00	-0.24	-0.83	-1.54	-3.31	-
Public pension payments (in % of GDP)	11.8	13.1	15.1	18.3	23.7	-
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.1	8.8	35.3	99.6	291.9	-
Net replacement rate	67.5	64.1	63.6	65.8	78.5	-
Relative consumption of retirees	0.80	0.74	0.72	0.73	0.86	-
Interest rate (in %)	3.86	4.27	4.59	5.00	6.80	-
			UK			
GDP growth rate (in %)	2.30	1.81	1.65	1.21	1.10	0.83
Annual capital growth (in %)	1.19	1.49	1.72	1.17	0.61	0.36
Annual labour force growth (in %)	-0.87	0.21	-0.20	-0.56	-0.40	-0.66
Public pension payments (in % of GDP)	5.0	5.2	5.2	5.4	5.5	5.1
Pension funds payments (in % of GDP)	4.5	5.1	5.6	7.0	8.5	9.1
Debt of public pension schemes (in % of GDP)	0.2	4.6	11.4	23.5	47.2	77.9
Net replacement rate	62.2	65.1	64.1	60.8	59.9	59.8
Relative consumption of retirees	0.80	0.79	0.75	0.72	0.71	0.71
Interest rate (in %)	4.04	4.32	4.49	4.39	4.67	5.11

Source : Author calculations

that may impact on the world interest rate, which is not the case in the small economy assumption. Hence for each country the interest rate is neither exogenously given, nor determined by the domestic savings-investment imbalance.

Here, the real interest rate is assumed to be the same for the three countries. It is determined on a single European capital market by equating EU3 capital demand - i.e. the sum of regional gross investment flows - and the EU3 capital supply - i.e. the sum of country savings -, or equivalently by equalizing the stock of accumulated productive capital and the stock of accumulated wealth (Equation [64a]). This allows us to examine the impact of differences in demographic perspectives and of extremely diverse types of pension schemes in European countries on capital flows within the zone.

As shown in Table 6, the results under the EU financial market assumption are close to the closed-economy case. However, now the consequences of ageing are shared between the three countries through the common interest rate. This allows faster ageing country (Germany) to enjoy a lower interest rate (5.3% in 2040, compared to 6.8% in the closed economy case), whereas slower ageing one (the UK) suffers from higher interest rate compared to the closed economy case (5.2% against 4.7%). Consequently, the debt weight is clearly reduced in Germany (202% of GDP in 2040, compared to 292% in the closed economy case) as well as the share of public pension (20.1% of GDP compared to 23.7%). By contrast, the UK suffers from a negative cumulative spiral, which is not the case if the economy is closed. Indeed, public debt clearly increases after 2040, strongly weighting on capital accumulation. Furthermore, capital accumulation of the British economy is now limited by capital outflows to Germany.

Capital flows are clearly different than in the small open economy case (Figures [9] and [10]): since the European union is a closed zone, the three countries cannot simultaneously benefit from positive capital inflows, as in the small open economy case, so as to finance their public debt.

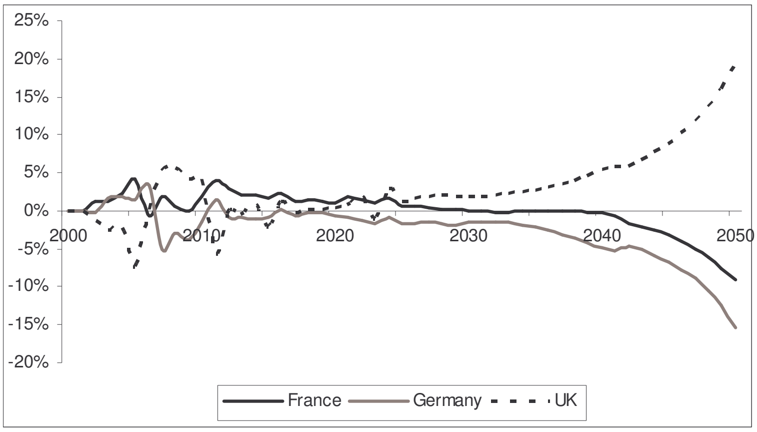
In France, the two scenarios are very similar during the transition stage as well as in the long run. Indeed, the French economy faces lower capital flows compared to Germany and the UK (Figure [10]) that transcripts into a capital property rate around 1.

Table 6: Benchmark scenario: Financial area

	2001	2010	2020	2030	2040	2050
			France			
GDP growth rate (in %)	2.08	1.53	1.25	0.74	-0.31	-4.11
Annual capital growth (in %)	1.47	1.19	1.19	0.39	-1.54	-7.32
Annual labour force growth (in %)	0.26	0.14	-0.30	-0.63	-1.13	-3.62
Public pension payments (in % of GDP)	12.8	13.3	14.6	16.7	19.7	25.4
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.2	0.0	10.4	49.9	146.6	392.2
Net replacement rate	67.9	67.0	63.3	59.2	61.2	72.8
Relative consumption of retirees	1.10	1.04	1.00	0.97	1.03	1.23
Interest rate (in %)	3.93	4.22	4.42	4.56	5.34	7.32
Capital property rate (in %)	1.01	1.04	1.09	1.10	1.10	1.01
			Germany			
GDP growth rate (in %)	0.98	1.45	1.00	0.27	-0.46	-4.32
Annual capital growth (in %)	0.38	1.11	0.94	-0.08	-1.68	-7.50
Annual labour force growth (in %)	-1.18	-0.09	-0.69	-1.24	-1.43	-3.99
Public pension payments (in % of GDP)	11.7	13.0	14.7	17.3	20.1	25.7
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.1	8.8	32.7	85.3	201.6	504.9
Net replacement rate	67.1	63.3	62.3	63.5	70.4	81.0
Relative consumption of retirees	0.95	0.88	0.83	0.84	0.92	1.05
Interest rate (in %)	3.86	4.15	4.34	4.48	5.25	7.20
Capital property rate (in %)	1.01	1.00	0.99	0.95	0.87	0.58
			UK			
GDP growth rate (in %)	2.27	1.81	1.45	0.79	0.09	-3.68
Annual capital growth (in %)	1.67	1.47	1.38	0.44	-1.13	-6.86
Annual labour force growth (in %)	-0.87	0.21	-0.31	-0.78	-0.94	-3.42
Public pension payments (in % of GDP)	4.9	5.1	5.1	5.6	6.0	6.5
Pension funds payments (in % of GDP)	4.3	5.0	5.6	7.1	8.9	11.0
Debt of public pension schemes (in % of GDP)	0.2	4.1	10.1	21.4	46.4	103.2
Net replacement rate	60.2	62.8	63.2	61.8	63.5	72.8
Relative consumption of retirees	0.80	0.79	0.76	0.74	0.77	0.87
Interest rate (in %)	3.79	4.07	4.26	4.40	5.15	7.07
Capital property rate (in %)	1.01	1.02	1.01	1.04	1.13	1.47

Source : Author calculations

Figure 10: Benchmark scenario - Financial area: Capital flows (in % of regional GDP)



6.2 Scenario 2 : No reforms

We now try to evaluate the effect of the reforms recently introduced in our three countries by performing a counterfactual exercise where the reforms have not been implemented. The reforms which need to be removed from our assumptions are the following:

In France, the Fillon reform of 2003, i.e.:

- A progressive extension of the contribution period necessary to obtain a full replacement rate ($D_1(g, s, c)$) from 40 to 42 years in the private sector and from 37.5 to 42 years in the public sector, combined with a change in the scale of the proportional coefficients in the basis and public schemes ($pro(t, g)$)
- A change in the rebate rate of the private sector ($dec(g, "rb")$) and the progressive introduction of a rebate rate in the public sector ($dec(g, "rf")$);
- The indexation of public sector pensions on prices rather than wages ($I(t, "rf")$);
- The increase in the contribution rate in the basic scheme ($\tau(t, "rb")$) of 0.2 percentage point from 2006.

In Germany, the Riester reform of 2001 aimed to achieve three main objectives:

- A stabilization in the contribution rate at 20% until 2020 and 22% until 2030 ($\tau(t, "grv")$);

- A slight cut in the average net replacement rate ($\pi(t, "grv")$) from 70% in 2000 to 67% in 2030;

- The introduction of a fictitious contribution rate ($\tau_{fict}(t)$) to be invested in private pensions when calculating the reference earning (Equation [37]) and the indexation rate of pension benefits (equation [39]).

In the UK, the most recent reform:

- A progressive increase in the women state pension age ($a_{ret}(g, "F")$) and the women contribution length ($Anw(g, "F")$);

- The replacement of the SERPS by a more generous pension for low earners called S2P;

- The introduction of the MIG which is more generous than the income support.

In order to evaluate the effects of these reforms, we make some counterfactual simulations where these reforms have not been implemented. The gap between this scenario and the benchmark one provides an evaluation of the results of these reforms.

We start with the small open economy case. As illustrated in Table 7, the absence of reforms leads to higher public pension schemes debt. The difference in debt ratios amounts to approximately 10% of GDP in France and Germany in 2020 and respectively 60 and 40% in 2040. The public pension payment ratio is more than one percentage point higher for the two countries in 2040. In other words, even if these reforms do not ensure the solvability of the pension systems in the long run - unless if the activity rates and the productivity growth adopt an even more optimistic path -, they do have a very significant impact.

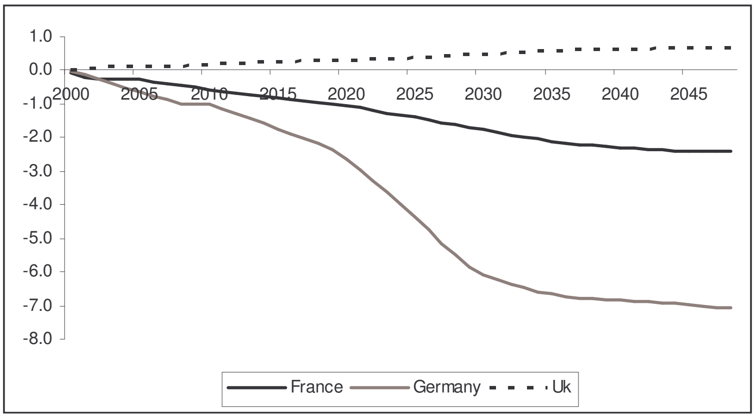
Figure 11 confirms these results by evaluating the impact of each reform on the public superannuation fund equilibrium. Even though it does not stabilize the public pay-as-you-go pillar in the coming decades, the German reform substantively reduces the public pension schemes deficit (by almost 7 percentage points in 2040). The French reform allows to reduce public deficit by about 2.5 percentage points in the long run. However,

Table 7: No Reforms scenario: Small open economy

	2001	2010	2020	2030	2040	2050
			France			
GDP growth rate (in %)	2.14	2.20	1.50	1.25	1.41	1.34
Annual capital growth (in %)	3.84	2.42	1.65	1.25	1.39	1.33
Annual labour force growth (in %)	0.37	0.45	-0.19	-0.34	-0.18	-0.26
Public pension payments (in % of GDP)	12.3	12.9	14.6	17.3	19.4	20.2
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.2	3.2	19.7	70.6	162.5	271.3
Net replacement rate	65.0	64.9	62.7	60.7	59.9	59.0
Relative consumption of retirees	1.10	1.04	0.99	0.97	0.96	0.95
Capital property rate (in %)	1.01	0.97	0.94	0.90	0.75	0.53
			Germany			
GDP growth rate (in %)	0.99	1.96	1.16	0.74	1.46	0.95
Annual capital growth (in %)	3.10	2.10	1.22	0.73	1.54	0.96
Annual labour force growth (in %)	-0.39	0.12	-0.62	-0.98	-0.34	-0.79
Public pension payments (in % of GDP)	11.8	13.0	14.6	17.7	19.4	20.1
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	9.3	33.0	93.3	199.5	326.2
Net replacement rate	67.5	63.7	62.1	64.8	69.7	70.4
Relative consumption of retirees	0.95	0.86	0.80	0.81	0.86	0.87
Capital property rate (in %)	1.01	0.91	0.86	0.80	0.61	0.35
			UK			
GDP growth rate (in %)	2.30	2.49	1.67	1.25	1.70	1.50
Annual capital growth (in %)	3.39	2.71	1.80	1.23	1.67	1.52
Annual labour force growth (in %)	-0.11	0.54	-0.21	-0.53	-0.08	-0.32
Public pension payments (in % of GDP)	5.0	4.9	4.5	4.7	4.4	3.7
Pension funds payments (in % of GDP)	4.5	4.9	5.4	7.2	8.7	9.1
Debt of public pension schemes (in % of GDP)	0.2	2.8	3.7	6.5	13.2	17.1
Net replacement rate	62.6	61.8	58.0	56.5	55.5	53.5
Relative consumption of retirees	0.80	0.76	0.70	0.69	0.66	0.64
Capital property rate (in %)	1.01	0.92	0.88	0.88	0.82	0.72

Source: Author calculations

Figure 11: Public pension schemes deficit (Change in percentage points of GDP compared to the benchmark scenario)



comparing Table 4 and Table 7, it appears that a large part of the positive effect of French and German reforms pass through a deterioration in the relative income of retirees. Finally, lower financial needs due to the reforms translate into lower capital inflows, i.e. higher capital property ratio when the reforms are implemented than when they are not.

On the other hand, the UK is not facing such a serious state pension crisis: the recent reforms adopted by T. Blair's government induced a higher generosity (relative compared to the two other countries) of public pensions for the poorest workers. The share of public pension in GDP and the associated debt is thus slightly lower without the reform. Consistently, the reform induces an increase of the public deficit by almost 1 percentage point in 2050. The share of private pensions in GDP is a little higher in 2040 since the age at liquidation in occupational pension schemes is linked with the legal retirement age. Results in terms of relative consumption of retirees and of capital property are very similar with or without the reforms given their low impact. Whatever the country considered, capital flows are modified in the same direction and in relatively similar proportions as the deficit of public pension schemes (Figure 12).

Whatever the country considered, all these results are amplified in the financial union case (Table 8).[29] Without reforms, economic growth is especially lower in Germany which has to deal with considerable debt from 2030. The absence of reforms then transcripts into a higher common interest rate (around 1 percentage point higher) and higher public indebtedness. Capital flows are clearly amplified (Figure 12), particularly in the second sub-period. Note that the different reforms do not change the direction of these capital flows.

6.3 Scenario 3: Constant activity rates

In this section, the specific role of activity rates for the elderly is assessed. More specifically, we assume that in spite of the current reforms of the pension systems, activity rates stay unchanged at their 1999 level. Due to steadily lengthening of working age, active population keeps on rising until 2006 in the French case, 2000 in the German case and 2013 in the UK case (see Figure 13) Compared to the benchmark scenario of rising

[29] The results for the closed economy case are presented in Appendix.

Table 8: No reforms scenario: Financial area

	2001	2010	2020	2030	2040
			France		
GDP growth rate (in %)	2.08	1.45	1.07	0.25	-2.34
Annual capital growth (in %)	1.47	1.05	0.87	-0.45	-4.77
Annual labour force growth (in %)	0.26	0.10	-0.40	-0.91	-2.39
Public pension payments (in % of GDP)	12.8	13.7	15.7	19.0	24.5
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.2	2.5	22.7	88.3	277.5
Net replacement rate	68.0	68.8	67.3	66.2	74.4
Relative consumption of retirees	1.10	1.06	1.04	1.05	1.19
Interest rate (in %)	3.93	4.24	4.52	4.86	6.39
Capital property rate (in %)	1.01	1.04	1.09	1.09	1.07
			Germany		
GDP growth rate (in %)	0.97	1.37	0.83	-0.21	-2.43
Annual capital growth (in %)	0.38	0.97	0.63	-0.89	-4.83
Annual labour force growth (in %)	-1.18	-0.13	-0.79	-1.51	-2.63
Public pension payments (in % of GDP)	11.7	13.8	15.9	19.7	25.2
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.1	13.9	53.6	150.9	414.2
Net replacement rate	75.8	72.2	70.3	73.9	85.7
Relative consumption of retirees	0.95	0.89	0.84	0.87	0.99
Interest rate (in %)	3.86	4.17	4.44	4.78	6.28
Capital property rate (in %)	1.01	1.00	0.98	0.90	0.63
			UK		
GDP growth rate (in %)	2.27	1.73	1.28	0.32	-1.84
Annual capital growth (in %)	1.67	1.33	1.08	-0.36	-4.23
Annual labour force growth (in %)	-0.87	0.17	-0.40	-1.04	-2.10
Public pension payments (in % of GDP)	4.8	5.0	4.9	5.3	6.0
Pension funds payments (in % of GDP)	4.3	5.0	5.5	7.1	9.4
Debt of public pension schemes (in % of GDP)	0.2	3.8	7.9	15.0	36.8
Net replacement rate	60.0	62.0	59.7	58.3	63.9
Relative consumption of retirees	0.80	0.79	0.76	0.75	0.82
Interest rate (in %)	3.79	4.09	4.36	4.70	6.17
Capital property rate (in %)	1.01	1.03	1.03	1.13	1.46

Source : Author calculations

Figure 12: No Reforms scenario: Capital flows (Percentage points of change compared to the benchmark scenario)

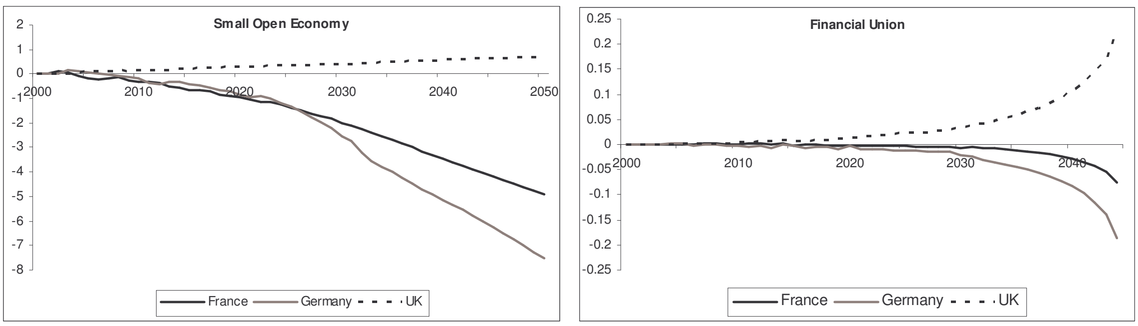
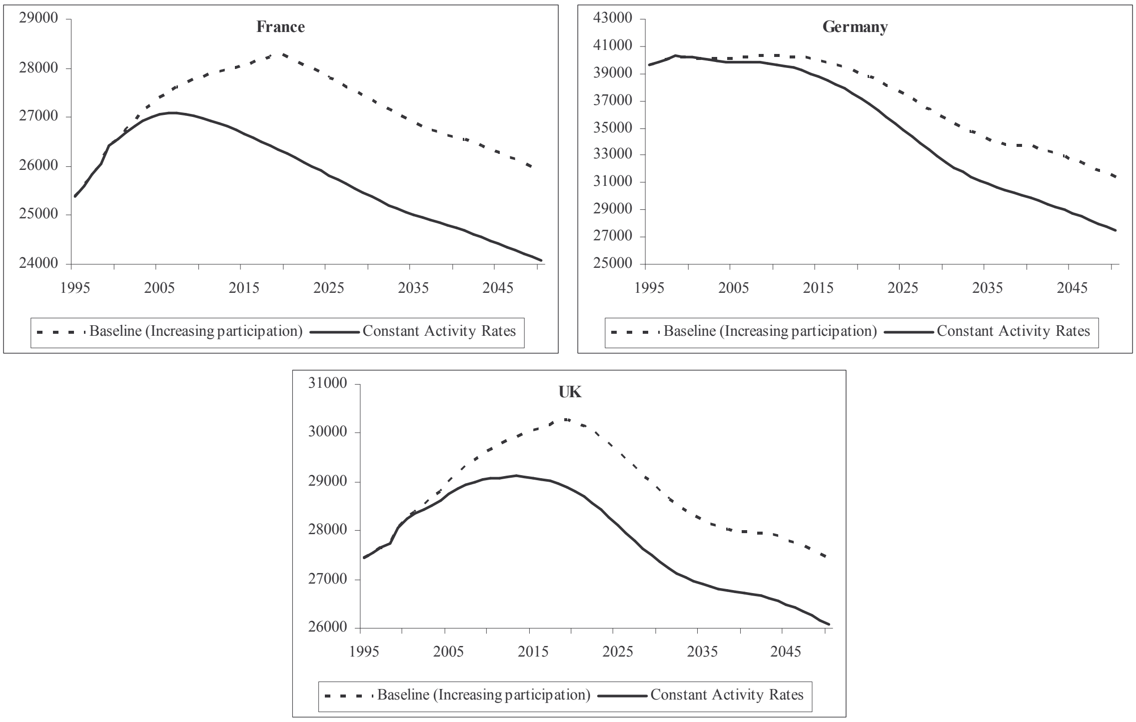


Figure 13: Working age population projections through 2050 (in thousand)



activity rates, the working age population is respectively 7.1%, 12.6% and 5% lower in 2050 for France, Germany and the UK.

As shown by Table 9 and Table 10, activity rates appear to be one of the key parameter of pension system sustainability, particularly in countries endowed with bismarckian pension schemes such as France and Germany. In reducing the annual labor force growth, this scenario involves relatively similar results as the no-reform scenarios concerning pension system imbalances. For instance, the pension burden is less than 1 percentage point higher in the French and UK case in 2040 but more than 6 point higher in the German case compared to the benchmark scenario. Then, the public debt is markedly higher in 2050 because of lower receipts to the pension systems as well as lower economic growth.

The especially marked situation of the German economy in this scenario of constant activity rates can easily be explained by three reasons. First, the benchmark scenario assumes an optimistic assumption concerning the activity behavior of elder workers in the German case. Indeed, based on official projections, we assume a progressively shift

Table 9: Constant activity rates scenario: Small open economy

	2001	2010	2020	2030	2040	2050
			France			
GDP growth rate (in %)	2.01	1.79	1.27	1.25	1.36	1.33
Annual capital growth (in %)	3.77	2.02	1.28	1.25	1.37	1.32
Annual labour force growth (in %)	0.20	0.05	-0.32	-0.34	-0.25	-0.26
Public pension payments (in % of GDP)	12.2	13.0	14.9	16.6	17.7	18.3
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.2	4.8	30.1	84.9	168.4	264.0
Net replacement rate	64.3	61.8	57.7	53.4	50.8	49.8
Relative consumption of retirees	1.10	1.02	0.94	0.89	0.85	0.84
Capital property rate (in %)	1.01	0.99	0.97	0.91	0.75	0.55
			Germany			
GDP growth rate (in %)	0.88	1.74	0.72	0.43	1.05	0.81
Annual capital growth (in %)	3.05	1.92	0.82	0.37	1.05	0.83
Annual labour force growth (in %)	-0.52	-0.11	-1.07	-1.26	-0.69	-0.94
Public pension payments (in % of GDP)	11.8	13.0	16.0	21.2	23.9	23.8
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	9.5	38.5	121.3	267.0	445.7
Net replacement rate	67.3	61.0	59.5	61.0	64.4	66.9
Relative consumption of retirees	0.95	0.85	0.79	0.78	0.82	0.84
Capital property rate (in %)	1.01	0.92	0.88	0.82	0.55	0.17
			UK			
GDP growth rate (in %)	2.19	2.22	1.47	1.30	1.69	1.46
Annual capital growth (in %)	3.33	2.46	1.53	1.26	1.68	1.48
Annual labour force growth (in %)	-0.25	0.27	-0.35	-0.47	-0.10	-0.35
Public pension payments (in % of GDP)	5.0	5.2	5.1	5.5	5.3	4.7
Pension funds payments (in % of GDP)	4.5	5.0	5.3	6.2	6.8	7.0
Debt of public pension schemes (in % of GDP)	0.3	5.5	14.3	29.4	52.2	73.5
Net replacement rate	62.7	62.3	59.9	54.7	50.6	48.0
Relative consumption of retirees	0.80	0.77	0.70	0.65	0.61	0.58
Capital property rate (in %)	1.01	0.93	0.89	0.88	0.81	0.73

Source: Author calculations

by 5 years of activity rates of those aged 45 to 65 in Germany, to be compared with a 3 year shift in the French and UK cases. Moreover, a large part of ageing costs are financed through an increase in contribution rates: the Riester reform progressively increases the contribution rates to 22% by 2030. By reducing the number of people in the work force, the scenario without activity rate increase also severely reduces the future receipts of the superannuation funds. Finally, the pension loss associated with an incomplete career is clearly less marked compared to the French and British pension systems (see the net replacement rate as well as the relative consumption of retirees in Table 9 and Table 10).

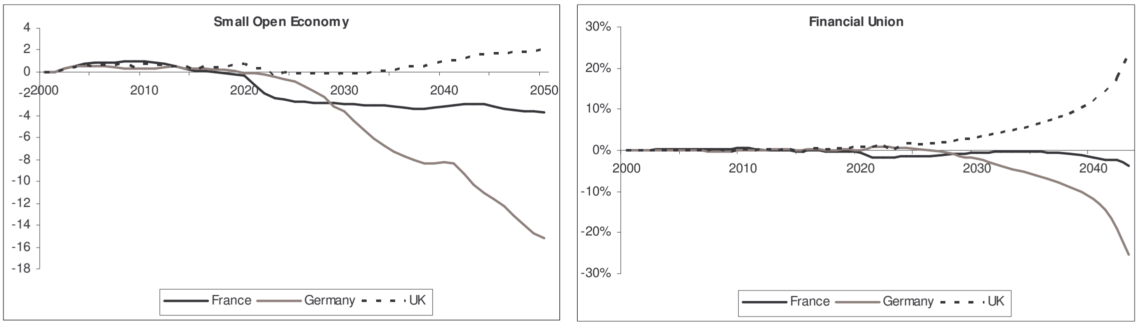
Capital flows are consistent with previous results (Figure 14). In the small open economy case, assuming constant activity rates magnifies capital flows for the three countries

Table 10: Constant activity rates scenario: Financial area

	2001	2010	2020	2030	2040
			France		
GDP growth rate (in %)	1.97	1.20	1.00	0.01	-3.46
Annual capital growth (in %)	1.43	0.91	0.80	-0.85	-6.42
Annual labour force growth (in %)	0.11	-0.22	-0.46	-1.04	-3.15
Public pension payments (in % of GDP)	12.8	13.8	15.9	18.3	23.9
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.2	4.7	34.2	105.7	310.9
Net replacement rate	67.8	65.7	61.9	58.8	67.8
Relative consumption of retirees	1.10	1.03	0.98	0.96	1.10
Interest rate (in %)	3.93	4.16	4.35	4.76	6.60
Capital property rate (in %)	1.01	1.05	1.09	1.07	1.07
			Germany		
GDP growth rate (in %)	0.92	1.25	0.34	-0.67	-3.61
Annual capital growth (in %)	0.39	0.96	0.14	-1.52	-6.54
Annual labour force growth (in %)	-1.28	-0.32	-1.26	-1.87	-3.46
Public pension payments (in % of GDP)	11.7	13.5	16.9	23.2	31.3
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	11.7	51.3	169.2	516.4
Net replacement rate	66.8	63.0	62.7	66.1	82.4
Relative consumption of retirees	0.95	0.88	0.83	0.86	1.03
Interest rate (in %)	3.86	4.08	4.28	4.68	6.49
Capital property rate (in %)	1.01	1.00	0.99	0.94	0.60
			UK		
GDP growth rate (in %)	2.18	1.59	1.15	0.17	-2.85
Annual capital growth (in %)	1.66	1.31	0.95	-0.67	-5.78
Annual labour force growth (in %)	-1.00	-0.03	-0.52	-1.09	-2.75
Public pension payments (in % of GDP)	4.9	5.2	5.4	6.1	7.3
Pension funds payments (in % of GDP)	4.4	5.0	5.5	6.4	8.3
Debt of public pension schemes (in % of GDP)	0.2	5.5	16.2	36.6	92.1
Net replacement rate	60.2	62.4	62.0	58.3	63.7
Relative consumption of retirees	0.80	0.79	0.75	0.72	0.79
Interest rate (in %)	3.79	4.01	4.20	4.59	6.37
Capital property rate (in %)	1.01	1.02	1.02	1.10	1.46

Source : Author calculations

Figure 14: Constant activity rates scenario: Capital flows (Percentage points of change compared to the benchmark scenario)



compared to the benchmark scenario. The results are relatively comparable with the No Reforms scenario in the French and British cases but capital flows are even more important in the German case, translating from huge financial needs of the German pension system. These results are confirmed when examining the case of a financial union with Germany attracting a large part of European capital flows.

6.4 Scenario 4: Adjustment of replacement rates

As shown in Table 4, the combination of expected higher activity rates and of pension reforms does not ensure the pension systems sustainability. Hence further reforms will have to be implemented. Here we explore an adjustment of replacement rates. More specifically, we assume that the average replacement rates of the different pension schemes considered are adjusted to ensure that the different superannuation funds are balanced at each date:

$$Def(t, fund) = 0 \qquad \text{for } fund = "rb", "rc", "rf", "grv", "nif" \tag{65}$$

For this purpose, we adjust the generosity of pension benefits received by retirees $P_L(t, g, s, c, fund)$ and $P(t, g, s, c, fund)$ for each superannuation fund ($fund$ = "rb", "rc", "rf", "grv", "bsp", "$serps$"). We also assume that occupational pensions in the UK are adjusted in the same way as public pensions, which allows to reduce the private contribution rate, $\tau_{fund}(t, c)$, compared to the benchmark. The minimum income guarantee (MIG) receipts are adjusted too.

The main assessment following this type of pension reform is a higher growth rate compared to the case of debt financing retained in the benchmark scenario. This is especially true in the case of the financial union (see Table 6 and 12), which becomes a sustainable scenario even in the long run. When comparing the effects of pension adjustment between the two capital mobility assumptions (Table 11 and 12), it appears that economic growth is higher in the small open economy case compared to the financial union case until 2020 whatever the country considered. After 2020, this ranking is reversed.

Indeed, in the financial union case, the increase of global income at the macroeconomic level progressively allows for more robust capital accumulation. This additional capital compared to the small open economy case then durably sustains a slightly higher economic growth. In the case of the small open economy, the economic growth rate is not affected by the reform since the growth rate only changes with total factor productivity growth ($\gamma^{\Gamma}(t)$) and employment growth (capital intensity is exogenously established by the world rate of return).

The counterpart of these good macroeconomic performances resulting from adjusting replacement rates is the important deterioration in the relative standard-of-living of retirees compared to workers. This is obviously the ultimate objective of such a reform to make retirees support most of the financial consequences of ageing. For example, it implies a reduction of the net replacement rate of almost 30 percentage points in 2040 for French retirees, nearly 20 points for German ones and more than 10 points for the British ones. The share of public pension payments in GDP is then very stable over the period for our three countries.

Note that the increase of the labor income on the life cycle nevertheless allows agents to accumulate higher wealth during their activity period, which raises the financial income of retirees. This explains why the relative standard-of-living of retirees is less affected when considering the relative consumption of retirees indicator. However, we have to keep in mind that household saving behaviors are exogenous in this model. If households were to increase their private saving so as to compensate for the reducing in the pension level, then wealth accumulation would be even larger.

Figure 15 presents the evolution of capital flows compared to the benchmark for the

Table 11: Adjustment of replacement rates scenario: Small open economy

	2001	2010	2020	2030	2040	2050
				France		
GDP growth rate (in %)	2.14	2.20	1.50	1.25	1.41	1.34
Annual capital growth (in %)	3.84	2.42	1.65	1.25	1.39	1.33
Annual labour force growth (in %)	0.37	0.45	-0.19	-0.34	-0.18	-0.26
Public pension payments (in % of GDP)	12.4	12.4	12.2	11.6	11.7	12.3
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0	0.0
Net replacement rate	65.7	62.6	53.7	42.8	38.4	38.4
Relative consumption of retirees	1.10	1.01	0.91	0.81	0.76	0.75
Capital property rate (in %)	1.01	0.97	0.96	1.00	1.03	1.04
				Germany		
GDP growth rate (in %)	0.99	1.96	1.16	0.74	1.46	0.95
Annual capital growth (in %)	3.10	2.10	1.22	0.73	1.54	0.96
Annual labour force growth (in %)	-0.39	0.12	-0.62	-0.98	-0.34	-0.79
Public pension payments (in % of GDP)	11.8	11.7	12.2	13.2	13.2	13.2
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0	0.0
Net replacement rate	67.7	57.3	51.1	49.2	49.5	48.4
Relative consumption of retirees	0.95	0.82	0.73	0.71	0.72	0.71
Capital property rate (in %)	1.01	0.92	0.89	0.92	0.93	0.93
				UK		
GDP growth rate (in %)	2.30	2.49	1.67	1.25	1.70	1.50
Annual capital growth (in %)	3.39	2.71	1.80	1.23	1.67	1.52
Annual labour force growth (in %)	-0.11	0.54	-0.21	-0.53	-0.08	-0.32
Public pension payments (in % of GDP)	4.8	4.7	4.5	4.3	4.0	3.8
Pension funds payments (in % of GDP)	4.5	4.6	5.1	6.1	7.0	7.8
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0	0.0
Net replacement rate	61.2	59.0	57.7	51.2	47.9	49.7
Relative consumption of retirees	0.80	0.75	0.70	0.64	0.61	0.61
Capital property rate (in %)	1.01	0.93	0.90	0.93	0.92	0.89

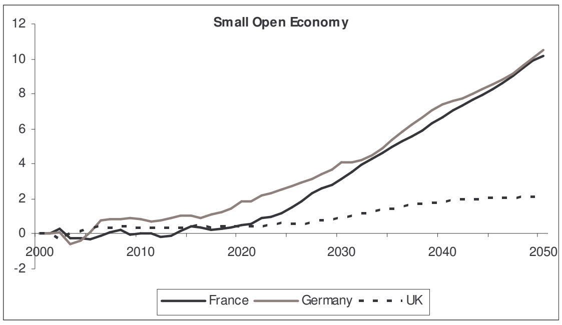
Source: Author calculations

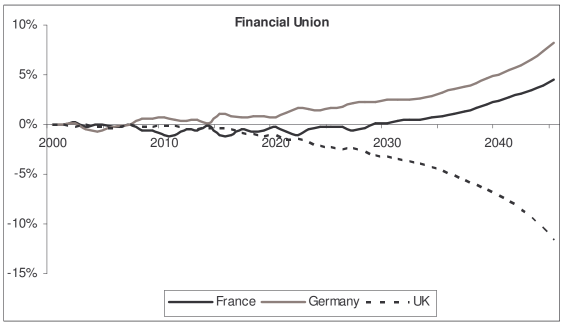
Table 12: Adjustment of replacement rates scenario: Financial area

	2001	2010	2020	2030	2040
			France		
GDP growth rate (in %)	2.08	1.66	1.57	1.48	1.42
Annual capital growth (in %)	1.47	1.40	1.73	1.66	1.40
Annual labour force growth (in %)	0.26	0.21	-0.13	-0.23	-0.16
Public pension payments (in % of GDP)	13.0	13.0	12.9	12.2	12.3
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	69.2	66.0	56.7	45.1	40.4
Relative consumption of retirees	1.10	1.02	0.93	0.82	0.76
Interest rate (in %)	3.93	4.18	4.24	4.04	3.99
Capital property rate (in %)	1.01	1.03	1.06	1.06	1.07
			Germany		
GDP growth rate (in %)	0.97	1.57	1.31	0.99	1.23
Annual capital growth (in %)	0.38	1.32	1.47	1.17	1.20
Annual labour force growth (in %)	-1.18	-0.03	-0.53	-0.86	-0.50
Public pension payments (in % of GDP)	11.7	11.7	12.2	13.2	13.1
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	67.4	56.9	50.5	48.6	49.1
Relative consumption of retirees	0.95	0.84	0.75	0.72	0.72
Interest rate (in %)	3.86	4.11	4.17	3.97	3.92
Capital property rate (in %)	1.01	0.99	0.99	0.98	0.97
			UK		
GDP growth rate (in %)	2.27	1.93	1.75	1.49	1.74
Annual capital growth (in %)	1.67	1.67	1.91	1.67	1.72
Annual labour force growth (in %)	-0.87	0.28	-0.15	-0.41	-0.04
Public pension payments (in % of GDP)	4.7	4.6	4.5	4.2	4.0
Pension funds payments (in % of GDP)	4.3	4.4	5.0	5.8	6.6
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	58.9	56.8	56.4	49.1	45.7
Relative consumption of retirees	0.80	0.75	0.71	0.64	0.61
Interest rate (in %)	3.79	4.03	4.09	3.90	3.85
Capital property rate (in %)	1.01	1.03	1.01	1.01	1.01

Source : Author calculations

Figure 15: Adjustment of replacement rates scenario: Capital flows (Percentage points of change compared to the benchmark scenario)





two alternative levels of economy opening. In both cases, assuming an adjustment through replacement rates clearly reduces capital flows, that now take values between +2% and -2% a year. Indeed, as seen before, most capital flows are driven by financial needs resulting from the debt accumulation of the pension systems. These needs then totally disappear when adjusting the pension generosity to equilibrate the system.

6.5 Scenario 5: Adjustment of contribution rates

This last scenario assumes that the contribution rates adjust at each date to avoid any financial needs of the different superannuation funds. As in the previous scenario, it is based on the assumption of a zero deficit of public pension schemes (Equation [65]). More precisely, we assume an endogenous adjustment of the following contribution rates: the contribution rate to the general regime ($\tau(t, "rb")$) and the surcharge coefficient to the complementary schemes ($\tau_{ap}(t, c)$) for France, the contribution rate to the private sector pension ($\tau(t, "grv")$) for Germany, the contribution rate to the National Assurance Fund ($\tau_{nif}(t)$) for the UK[30] and the tax rate on all income ($\widetilde{\tau}(t)$) for the three countries.

In this model, only pension contributions are taken into account when moving from gross earnings to net earnings. This scenario implies that the contribution rates are adjusted at each date to balance the different pension schemes. We implicitly assume

[30]The contribution rate to occupational pension funds ($\tau_{fund}(t, c)$) is already endogenously calculated (see equation [56])

that the increase in the average social security contribution has no impact on average earning determination (Equation [10a]). In other words, we do not model the impact of the tax wedge on gross wages, hence on gross earnings and unemployment.

Table 13 and 14 present our results. Once again, GDP growth is not affected by the equilibrium conditions of the pension systems in the small open economy case. By contrast, in the case of the financial union, an adjustment through contribution rates implies a lower overall growth rate compared with the scenario with replacement rate adjustment. Nevertheless, GDP growth rates are higher than those observed in the benchmark scenario (see Table 6 and 14). The main effect of this type of pension reform consists in reducing the financing capacity of workers. Indeed, a higher part of their gross income is now deducted for pension systems, which explains lower capital accumulation in the financial union case.

On the other hand, this type of adjustment allows to limit the inequality between earnings and pension benefits that is observed in the replacement rate scenario. In the French and German cases, the net replacement rate is even higher than in the benchmark scenario as a result of higher contribution rates paid by workers. In the UK, the net replacement rate (as well as the relative consumption of retirees) are comparable with those of the benchmark scenario because contribution rates need not change much.

By rebalancing superannuation pension funds, the adjustment of contribution rates greatly reduces the financial needs of the three countries. Then, as in the previous scenario, capital flows are hugely reduced compared to benchmark scenarios, under both the small open economy and the financial union assumptions (Figure 16).

Table 13: Adjustment of contribution rates scenario: Small open economy

	2001	2010	2020	2030	2040	2050
			France			
GDP growth rate (in %)	2.14	2.20	1.50	1.25	1.41	1.34
Annual capital growth (in %)	3.84	2.42	1.65	1.25	1.39	1.33
Annual labour force growth (in %)	0.37	0.45	-0.19	-0.34	-0.18	-0.26
Public pension payments (in % of GDP)	12.2	12.5	13.7	15.7	17.1	17.8
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0	0.0
Net replacement rate	64.3	62.9	59.9	58.3	57.7	57.4
Relative consumption of retirees	1.10	1.03	0.97	0.97	0.96	0.96
Capital property rate (in %)	1.01	0.97	0.96	1.00	1.01	1.02
			Germany			
GDP growth rate (in %)	0.99	1.96	1.16	0.74	1.46	0.95
Annual capital growth (in %)	3.10	2.10	1.22	0.73	1.54	0.96
Annual labour force growth (in %)	-0.39	0.12	-0.62	-0.98	-0.34	-0.79
Public pension payments (in % of GDP)	11.8	12.5	13.9	16.2	17.5	18.0
Pension funds payments (in % of GDP)	-	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0	0.0
Net replacement rate	68.2	62.7	62.2	65.2	71.1	72.4
Relative consumption of retirees	0.95	0.86	0.81	0.82	0.88	0.89
Capital property rate (in %)	1.01	0.92	0.89	0.92	0.94	0.93
			UK			
GDP growth rate (in %)	2.30	2.49	1.67	1.25	1.70	1.50
Annual capital growth (in %)	3.39	2.71	1.80	1.23	1.67	1.52
Annual labour force growth (in %)	-0.11	0.54	-0.21	-0.53	-0.08	-0.32
Public pension payments (in % of GDP)	5.0	5.0	4.8	5.1	5.0	4.4
Pension funds payments (in % of GDP)	4.5	4.9	5.4	7.0	8.4	8.7
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0	0.0
Net replacement rate	63.0	62.9	61.2	60.5	58.6	55.9
Relative consumption of retirees	0.80	0.77	0.71	0.70	0.68	0.65
Capital property rate (in %)	1.01	0.92	0.88	0.89	0.85	0.77

Source: Author calculations

Figure 16: Adjustment of contribution rates scenario: Capital flows (Percentage points of change compared to the benchmark scenario)

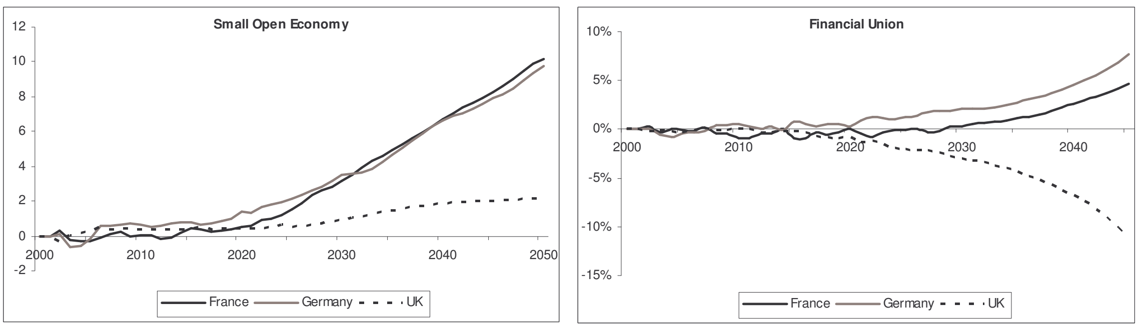


Table 14: Adjustment of contribution rates scenario: Financial area

	2001	2010	2020	2030	2040
			France		
GDP growth rate (in %)	2.09	1.55	1.59	1.42	1.30
Annual capital growth (in %)	1.48	1.25	1.75	1.56	1.18
Annual labour force growth (in %)	0.26	0.14	-0.10	-0.26	-0.22
Public pension payments (in % of GDP)	12.8	13.2	14.4	15.8	17.1
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	67.7	66.8	63.3	58.9	57.4
Relative consumption of retirees	1.10	1.04	1.00	0.96	0.95
Interest rate (in %)	3.93	4.20	4.29	4.13	4.15
Capital property rate (in %)	1.01	1.04	1.07	1.07	1.09
			Germany		
GDP growth rate (in %)	0.96	1.58	1.24	0.89	1.11
Annual capital growth (in %)	0.35	1.32	1.36	1.00	0.99
Annual labour force growth (in %)	-1.19	-0.01	-0.58	-0.91	-0.56
Public pension payments (in % of GDP)	11.7	12.9	14.4	16.5	17.6
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	67.6	65.3	64.9	66.0	71.4
Relative consumption of retirees	0.95	0.89	0.85	0.85	0.90
Interest rate (in %)	3.86	4.11	4.18	4.03	4.06
Capital property rate (in %)	1.01	1.00	1.00	1.00	1.00
			UK		
GDP growth rate (in %)	2.28	1.93	1.69	1.42	1.63
Annual capital growth (in %)	1.69	1.67	1.83	1.55	1.52
Annual labour force growth (in %)	-0.86	0.28	-0.18	-0.45	-0.10
Public pension payments (in % of GDP)	4.9	5.1	5.0	5.3	5.2
Pension funds payments (in % of GDP)	4.3	4.9	5.5	6.8	8.0
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	60.4	63.1	62.6	59.8	57.6
Relative consumption of retirees	0.80	0.79	0.75	0.72	0.69
Interest rate (in %)	3.79	4.04	4.12	3.95	3.97
Capital property rate (in %)	1.01	1.02	0.99	0.98	0.95

Source : Author calculations

7 Conclusion

This study presents a quantitative analysis of the impact of population ageing and pension reforms in the three largest European countries: France, Germany and the UK. We carry out a peculiar attention on capital flows induced by differential ageing across countries and by pension reforms. The model used has been built to accommodate such analytical needs. This study demonstrates that the macroeconomic equilibrium of the model highly depends on the extent of capital mobility. In a world of closed economies, differential ageing generates differences in rates of return that are likely to be accentuated by implemented reforms. In reality, we do not have closed economies but a global capital market. Population ageing and pension reforms therefore induce large capital flows between countries when it is assumed that each economy always finds financial resources at a fixed interest rate (small open economy). Capital flows are significantly smaller in the intermediate case where capital is perfectly mobile between the three European countries but immobile from the countries to the rest of the world.

Whatever the openness level, this study insists on the financial unsustainability of large pay-as-you-go pension schemes in France and Germany. This result is usually unclear in pure accounting approaches since debt accumulation has no macroeconomic consequences in such models. Two main conclusions may be drawn from the examination of the various prospective scenarios. First of all, the critical assumptions for PAYG systems are the future trend of the global factor productivity and the behavior of agents concerning activity and labour market participation. Secondly, in the long run, resorting to debt financing seems to be a dead end to finance retirement systems. Indeed, public pension systems are unsustainable and generate important public debt which strongly weights on economic growth. A planned fall of the replacement rates presents some virtues with respect to growth but implies a large disequilibrium in the standard of living of retirees compared to active people. A progressive rise in the social contribution rates permits to avoid this but at the cost of a lower growth of resources.

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8 Appendix

8.1 Expected years of schooling

The average number of years of schooling plays an important role in our model. Indeed, combined with the effective age of retirement, it determines the average length of working. The expected years of schooling is estimated on Destinie (1999) for France and OECD (2004a) for Germany and the UK. We assume that the temporal evolution is similar in our three countries and follows a logistic function adjusted on the French data. Figures 17 to 19 present our assumptions.

Figure 17: Expected years of schooling by generation, sex and professional status in France (D_2)

Figure 18: Expected years of schooling by generation, sex and professional status in Germany (D_2)

Figure 19: Expected years of schooling by generation, sex and professional status in the UK (D_2)

8.2 Calculation of the career length

For each generation, the length of career is calculated using the historical effective average retirement age given in Coeffic (2003) for France and in Blondal and Scarpetta (1997) for Germany and the UK from which we subtract the average years of study given at Figures 17 to 19. For current and future generation of pensioners, we extrapolate past trends as shown on Figures 20 to 20.

Figure 20: Average length of career by sex, generation and professional status (D) in France

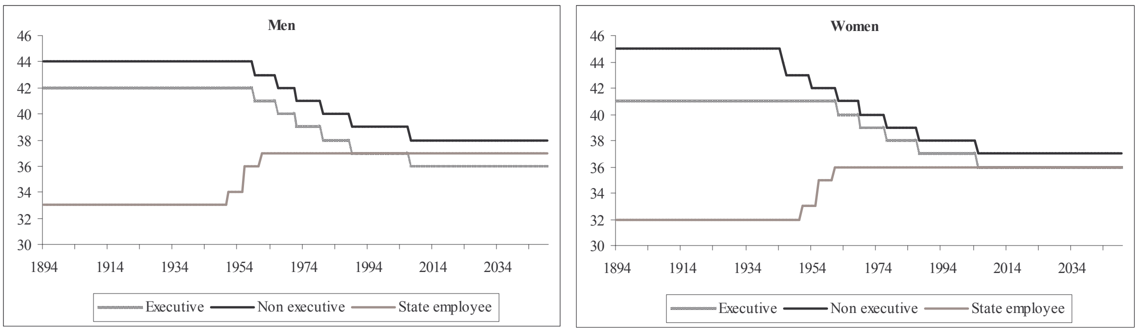

Figure 21: Average length of career by sex, generation and professional status (D) in Germany

Figure 22: Average length of career by sex, generation and professional status (D) in the UK

8.3 Results of the closed economy scenario

Table 15: No Reforms scenario: Closed economy

	2001	2010	2020	2030	2040
			France		
GDP growth rate (in %)	2.24	1.76	1.18	0.20	-2.77
Annual capital growth (in %)	1.75	1.63	1.07	-0.56	-5.46
Annual labour force growth (in %)	-0.01	0.23	-0.35	-0.92	-2.64
Public pension payments (in % of GDP)	12.3	13.1	15.1	18.6	24.6
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.2	3.3	23.8	89.4	277.0
Net replacement rate	65.0	65.9	64.7	64.7	74.0
Relative consumption of retirees	1.10	1.05	1.02	1.04	1.20
Interest rate (in %)	3.70	3.83	3.97	4.29	5.83
			Germany		
GDP growth rate (in %)	1.00	1.15	0.48	-1.51	-20.46
Annual capital growth (in %)	0.61	0.64	0.03	-3.03	-29.20
Annual labour force growth (in %)	-1.00	-0.28	-0.97	-2.27	-16.04
Public pension payments (in % of GDP)	11.8	13.7	16.1	21.2	38.3
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.1	12.0	51.6	168.7	726.6
Net replacement rate	67.5	67.1	67.5	73.3	110.0
Relative consumption of retirees	0.95	0.90	0.88	0.93	1.24
Interest rate (in %)	3.86	4.28	4.71	5.56	9.97
			UK		
GDP growth rate (in %)	2.31	1.83	1.69	1.25	1.17
Annual capital growth (in %)	1.20	1.53	1.80	1.25	0.73
Annual labour force growth (in %)	-0.86	0.22	-0.18	-0.54	-0.36
Public pension payments (in % of GDP)	5.0	5.1	4.8	4.9	4.8
Pension funds payments (in % of GDP)	4.5	5.1	5.7	7.2	8.8
Debt of public pension schemes (in % of GDP)	0.2	3.4	7.2	13.5	26.2
Net replacement rate	62.4	64.4	60.8	57.5	57.2
Relative consumption of retirees	0.80	0.79	0.74	0.71	0.70
Interest rate (in %)	4.04	4.30	4.44	4.31	4.55

Source : Author calculations

Table 16: Constant activity rates scenario: Closed economy

	2001	2010	2020	2030	2040
			France		
GDP growth rate (in %)	2.16	1.50	0.95	0.10	-2.78
Annual capital growth (in %)	1.75	1.49	0.72	-0.73	-5.44
Annual labour force growth (in %)	-0.15	-0.10	-0.51	-0.97	-2.68
Public pension payments (in % of GDP)	12.2	13.2	15.2	18.0	23.2
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	-0.2	4.4	32.2	102.2	287.8
Net replacement rate	64.4	62.3	59.0	57.5	65.4
Relative consumption of retirees	1.10	1.02	0.96	0.95	1.08
Interest rate (in %)	3.70	3.73	3.78	4.21	5.79
			Germany		
GDP growth rate (in %)	0.93	1.01	0.12	-2.35	-29.61
Annual capital growth (in %)	0.60	0.60	-0.26	-4.26	-38.10
Annual labour force growth (in %)	-1.11	-0.47	-1.38	-2.87	-15.18
Public pension payments (in % of GDP)	11.8	13.7	17.4	25.1	47.2
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	11.8	55.5	201.7	877.3
Net replacement rate	67.9	64.7	65.1	71.8	119.6
Relative consumption of retirees	0.95	0.88	0.85	0.91	1.27
Interest rate (in %)	3.86	4.22	4.56	5.46	10.29
			UK		
GDP growth rate (in %)	2.22	1.60	1.44	1.20	1.20
Annual capital growth (in %)	1.18	1.35	1.46	1.10	0.82
Annual labour force growth (in %)	-0.99	-0.04	-0.36	-0.53	-0.35
Public pension payments (in % of GDP)	5.0	5.3	5.5	5.8	5.8
Pension funds payments (in % of GDP)	4.5	5.2	5.6	6.2	6.9
Debt of public pension schemes (in % of GDP)	0.2	6.2	18.4	38.8	73.0
Net replacement rate	62.5	64.7	62.7	56.0	52.8
Relative consumption of retirees	0.80	0.79	0.74	0.68	0.64
Interest rate (in %)	4.04	4.25	4.38	4.35	4.63

Source : Author calculations

Table 17: Adjustment of replacement rates scenario: Closed economy

	2001	2010	2020	2030	2040
			France		
GDP growth rate (in %)	2.22	1.85	1.61	1.50	1.50
Annual capital growth (in %)	1.71	1.80	1.83	1.70	1.57
Annual labour force growth (in %)	-0.03	0.28	-0.12	-0.21	-0.14
Public pension payments (in % of GDP)	12.5	12.4	12.3	11.6	11.7
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	66.0	62.9	54.0	42.9	38.4
Relative consumption of retirees	1.10	1.02	0.92	0.81	0.75
Interest rate (in %)	3.70	3.81	3.79	3.59	3.47
			Germany		
GDP growth rate (in %)	1.00	1.40	1.25	0.97	1.24
Annual capital growth (in %)	0.61	1.07	1.36	1.14	1.18
Annual labour force growth (in %)	-1.00	-0.15	-0.56	-0.87	-0.46
Public pension payments (in % of GDP)	11.8	11.8	12.3	13.3	13.3
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	68.6	58.0	51.3	49.3	49.7
Relative consumption of retirees	0.95	0.84	0.76	0.73	0.73
Interest rate (in %)	3.86	4.21	4.32	4.16	4.17
			UK		
GDP growth rate (in %)	2.33	1.96	1.83	1.57	1.67
Annual capital growth (in %)	1.23	1.75	2.06	1.80	1.63
Annual labour force growth (in %)	-0.85	0.28	-0.11	-0.37	-0.10
Public pension payments (in % of GDP)	4.8	4.8	4.6	4.3	4.1
Pension funds payments (in % of GDP)	4.5	4.6	5.1	5.9	6.8
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	61.2	59.6	57.9	50.2	47.0
Relative consumption of retirees	0.80	0.76	0.71	0.64	0.60
Interest rate (in %)	4.04	4.24	4.28	4.00	3.93

Source : Author calculations

Table 18: Adjustment of contribution rates scenario: Closed economy

	2001	2010	2020	2030	2040
			France		
GDP growth rate (in %)	2.22	1.85	1.59	1.45	1.45
Annual capital growth (in %)	1.72	1.79	1.78	1.61	1.48
Annual labour force growth (in %)	-0.03	0.28	-0.13	-0.24	-0.16
Public pension payments (in % of GDP)	12.2	12.7	13.9	15.6	16.8
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	64.4	64.0	61.1	58.0	56.4
Relative consumption of retirees	1.10	1.04	0.99	0.97	0.95
Interest rate (in %)	3.70	3.81	3.80	3.62	3.54
			Germany		
GDP growth rate (in %)	0.99	1.40	1.26	0.98	1.25
Annual capital growth (in %)	0.61	1.07	1.37	1.15	1.19
Annual labour force growth (in %)	-1.00	-0.15	-0.55	-0.87	-0.46
Public pension payments (in % of GDP)	11.8	13.1	14.6	16.6	17.7
Pension funds payments (in % of GDP)	-	-	-	-	-
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	68.1	66.1	65.8	66.5	71.6
Relative consumption of retirees	0.95	0.89	0.86	0.85	0.90
Interest rate (in %)	3.86	4.21	4.31	4.15	4.15
			UK		
GDP growth rate (in %)	2.33	1.88	1.74	1.40	1.41
Annual capital growth (in %)	1.22	1.61	1.90	1.50	1.16
Annual labour force growth (in %)	-0.85	0.24	-0.15	-0.46	-0.23
Public pension payments (in % of GDP)	5.0	5.2	5.1	5.3	5.3
Pension funds payments (in % of GDP)	4.5	5.1	5.6	6.9	8.3
Debt of public pension schemes (in % of GDP)	0.0	0.0	0.0	0.0	0.0
Net replacement rate	62.8	65.6	64.1	60.9	59.3
Relative consumption of retirees	0.80	0.79	0.75	0.72	0.69
Interest rate (in %)	4.04	4.28	4.38	4.19	4.28

Source : Author calculations