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A SEMI-AGGREGATE MODEL FOR SOCIAL EXPENDITURE PROJECTIONS

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Pier Marco Ferraresi and Chiara Monticone*

Abstract

This report describes the semi-aggregate model (SAM) developed to deliver aggregate projections of social protection expenditures as well as semi-aggregate projections of income sources by age class and gender for a number of European countries (Denmark, France, Germany, Italy, Latvia, Luxembourg, Netherlands, Poland, Spain and United Kingdom) over the horizon 2005 - 2050. The partial equilibrium stance adopted allows both a greater flexibility in the choice of countries and in the building of scenarios, while at the same time offering an easier understanding of the model's inner mechanisms with respect to general equilibrium modelling. Results for aggregate projections are presented, including various sensitivity scenarios devoted at analysing the role of theoretical replacement rates and employment rates – such as the one necessary to fulfil the Lisbon targets – on public pensions expenditures.

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1. Introduction

CeRP's Semi-Aggregate Model (SAM) is a highly stylised and simplified model meant to capture the effects of population ageing on both the labour market and the social protection expenditure within differently shaped welfare systems. It was developed mainly to deliver semi-aggregate projections of income sources as an input for the computation of Comprehensive Replacement Rates (COREs, AIM WP9). In addition, it can deliver aggregate macroeconomic projections of social protection benefits and an indicator that will lead to important insights into the sustainability of social security systems in different countries.

The relations between demographic and economic variables and their dynamics could be modelled within a general equilibrium approach, allowing for both the effects of demographic measures on economic ones and the parallel effects of economic variables on demographics, according to the kind of framing provided by the theory of endogenous family formation (Becker, 1960). The analytical complexity of general equilibrium models, however, requiring as they do the simultaneous modelling of different complex systems, does not allow us to disentangle simultaneous feedback effects. Thus, relying on a partial equilibrium framework strengthens our understanding of the direct effects of demography on the economy and on the budgetary consequences of different policy measures.

Even within a partial equilibrium framework, an analysis of some specific issues has been performed, in particular:

- the effects of demographic dynamics on the structure of the labour supply,
- the effects of the changes in the structure of the labour supply on economic growth,
- the effects on the sustainability and adequacy of the welfare state of changes in the age composition of the population, in the labour supply and in economic growth.

These objectives could also be reached by means of a microsimulation model. However, SAM has the advantage of avoiding the massive input requirements and complex modelling of microsimulation models, while at the same time providing fairly disaggregated projections with an understanding of the driving mechanisms. With respect to aggregate models, SAM uses data disaggregated by gender, 5-year age classes and labour market status (employed, unemployed, inactive). In addition, given the objective to perform a comparative analysis of different European countries, characterised by different welfare systems, the parameterisation of national economic and institutional features is quite stylised, in order to easily allow for the possible inclusion of new countries in the analysis.

The approach is the same adopted by the Macro Economic Model already built and used by Soede et al. (2004).[1] This version of the model, however, is quite a radical modification and extension of the previous work, as shown in Appendix 1.

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[1] An earlier version of the model was also employed for simulations in the study "Implications of demographic change in enlarged EU on patterns of saving and consumption and in related consumer's behaviour", commissioned by the DG Employment and Social Affairs (DG Employment and Social Affairs, 2007).

The major driving force of the model is constituted by the demographic projections provided by Eurostat. The evolution of the age structure of the population – together with assumptions on participation rates and unemployment – affects the time composition of the labour supply. The resulting development of employment and an exogenously assumed productivity growth are the basis for the projection of economic growth. Income sources, including social benefits, evolve again in line with demography and labour productivity growth. Old-age pensions have been modelled more carefully than other benefits, taking into account already legislated reforms. Other benefits for the computation of comprehensive replacement rates include survivors' pensions, invalidity and unemployment benefits, education, housing, family-related, and other social benefits according to the European classification adopted by the European Community Household Panel (ECHP) survey. Finally, projections of income, GDP and employment constitute the main ingredients for the computation of country-specific social protection benefits and expenditures up to 2050.

All the main assumptions, such as those concerning labour productivity growth, participation rates and unemployment, are drawn from the European Commission projections (EPC-EC, 2005), which provides a sound and comparable basis for the current exercise.

As a result, the main outputs of SAM are projections of income sources (labour and capital income, and social benefits in cash) for the computation of COREs, aggregate social protection expenditures and an indicator of the pension system sustainability.

The paper proceeds as follows: Section 2 provides a brief overview of modelling approaches in order to better define the 'semi-aggregate' methodology. Section 3 describes the model. Section 4 highlights the hypotheses and illustrates baseline aggregate simulations. Section 5 shows hypotheses and results for a number of alternative scenarios. Section 6 concludes.

2. The meaning of Semi-Aggregate

The simulation approach as a support to policy-making is seeing rapid growth worldwide. With respect to social security, at least one simulation model has been developed in almost every country of the European Union (see Appendix 2). However, the models adopted in the various countries cannot be easily used to build a unified approach because the simulation approach differs greatly among them, with consequences in terms of data requirements, exogenous and endogenous variables and interpretation of results. In addition, these models were not in the first instance intended to produce a common set of indicators, even though they are now, following the Open Method of Coordination.

As Table A2.1 (in Appendix 2) shows, in most cases the outputs are aggregate variables. This generates some difficulty in assessing the adequacy of pension systems, since, while the trends in pension expenditures are usually captured, the redistributive features of the systems as well as measures of pension wealth for representative subjects are not the main focus for most of these simulation models.

2.1 Key choices in building a model

Three key aspects may be considered to broadly classify the different simulation approaches: the time horizon, the degree of internal consistency of the approach, and the level of 'aggregation' in the model.

The time horizon allows us to distinguish among:

- static models that are interested in investigating the effects of reforms on current population within a short time interval (e.g. one year);
- static models aimed at performing comparative static analyses between two steady states;

- dynamic models, built to investigate not only the properties of steady states, but also the transition processes; they are also capable of estimating lifetime income and related variables.

The degree of consistency. This issue may be addressed from three main perspectives:

- microeconomic consistency: does the model contain behavioural equations? Most of the models do not (a notable exception being the Auerbach-Kotlikoff kind of models) and substitute individual optimisation processes with reduced form equations, or simply with exogenous transition matrices;
- macroeconomic consistency, i.e. a general or a partial equilibrium model; the general equilibrium approach is particularly suitable to capture the effects of pension reforms on capital accumulation and labour supply as well as on factor prices. However, this normally comes at the cost of a loss in terms of institutional details. Moreover, even in general equilibrium models, due to the analytical difficulties (and the consequent need for numerical solutions), labour supply is frequently assumed to be inelastic, thus reducing the advantage of implementing a general equilibrium model, since the effects of social security reforms on labour supply cannot be assessed;
- demographic consistency: whenever more than one social security scheme is in place, for different categories of beneficiaries, from the point of view of sustainability demographic and occupational dynamics of different population subgroups cannot permanently diverge (and do not diverge in a steady state), although some occupations do disappear, while others temporarily expand and divergences may occur over a few decades. An institutional approach would consider the participants of each social security scheme separately, while a demographically consistent one would consider the whole population. The first approach can catch the effects of the dynamics of mortality rate, including specific probabilities of death, but cannot detect the variations in birth-rates and in migratory flows. A demographic model resumes these functions, but is less suitable for evaluating normative changes in a detailed way.

The level of aggregation of the model refers to the minimum unit of analysis. Apart from aggregate projections, where calculations only refer to aggregate variables that are, in turn, obtained only as a function of other aggregate variables (e.g. aggregate pension expenditures and pension deficits as percentages of GDP), we can distinguish three levels of disaggregation:

- splitting by individuals and processes (agent-based simulations): each individual has a different history, because stochastic and behavioural processes are specific to the single agent. Agent-based modelling allows for the introduction of non-maximising behaviour (e.g., random or imitative behaviour), otherwise difficult to study.
- splitting by individuals (dynamic microsimulations): each individual is considered separately; the dynamics are obtained by applying a common stochastic process (instead of an individual-specific one, like in agent-based simulations) to each individual, in order to simulate a personal history. The approach preserves the maximum amount of heterogeneity but requires a long calculation time, like agent-based simulations. Moreover, since a Monte Carlo experiment must be applied to each single individual in order to change its status, the probability treatment is inefficient, in the sense that a small sample size generates a high variance in the results.
- splitting by groups (dynamic multistate simulations): individuals are grouped according to the different values assumed by given 'state variables' and their combinations (e.g. male-married-workers, female-single-pensioners...). In order to add dynamics to the model, transition matrices are applied to move people from one group to another (e.g. male-married-workers have a given probability of becoming male-divorced-unemployed). With respect to microsimulation, the advantages of this approach are reduced computational time

and a more efficient probability treatment of the groups. This is because shifting the individuals in each cell from one ‘state’ to another via the application of transition probabilities approximates the aggregate result of the application of individual stochastic processes to each person in the cell. The disadvantage is the loss of heterogeneity within each group.

The approach we called “semi-aggregate” is a demographically-driven dynamic one, presenting some features of the multistate approach as well as some of the aggregate models.

2.2 SAM: a Semi-Aggregate Model

In a multistate approach (also named “cell-based” or macrosimulation approach), starting from a sample or a true population, individuals are aggregated in groups that are considered sufficiently homogeneous, through the following operations: i) the selection of relevant features of the population; ii) the homogenisation of the modalities that each of the relevant features can assume; iii) the transformation of some of the continuous ones (such as age) into discrete ones, by grouping them in classes.

Each sample position (or ‘cell’) is thus defined by a number of characteristics (such as age, gender, occupational status etc.), and is characterised by a certain frequency (number of individuals pertaining to the cell) and by an average value of the variables under observation (such as income or pension).[2] The model evaluates the transition of individuals from one position to another by using matrices of transition probabilities.

For SAM we adopted a ‘semi-aggregate’ approach. Without contradicting the multistate philosophy, the number of characteristics that determine each position is limited to three: age class, gender and labour market status (i.e. employed, unemployed, or out of the labour force). Moreover transition probabilities are not explicitly modelled and estimated; they are implicitly derived by the need to achieve consistency of the population structure with some assumed macroeconomic parameters, like unemployment, employment or participation rates.

The institutional setting, like the pension rules, are sketched in a more simplified way with respect to multistate simulations, allowing for a large number of countries to be added to the analysis, without the need for modelling every single social security system in depth.

3. Model description

The model delivers projections up to 2050 of public expenditure on pensions and other social benefits, and produces a sustainability indicator. Data for model parameterisation are derived mainly from cross-national studies, in particular ECHP and SHARE data constitute the main source of information, while Eurostat “Europop 2004” baseline forecast constitutes the demographic input. For each income or benefit category, the number of earners or recipients and the average amount in euro (at 2004 constant prices) are calculated, in a way consistent with the projected trend in the age profile of the population.

Ten countries are covered in our simulation: Denmark, France, Germany, Italy, Latvia, Luxembourg, the Netherlands, Poland, Spain and the UK. Their populations amount to 80% of the EU25[3] total and about 75% that of the EU27. At the same time, the variety of countries accommodates different welfare regimes, thus allowing a comparison among them.

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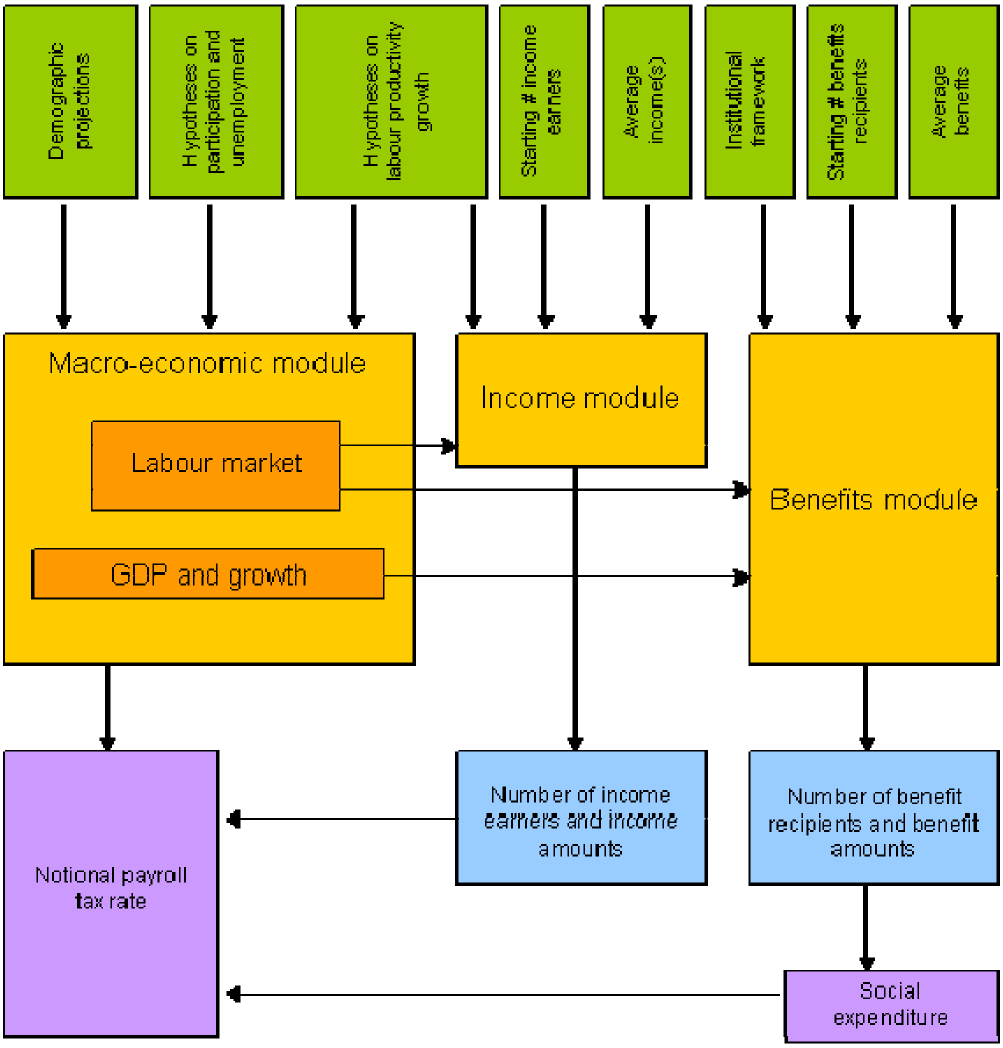
[2] This model shares with multistate ones the shortcoming of having a loss of heterogeneity, since distributions may be considered across different classes but not within each of them.

[3] The selection of countries is partly carried out on a demographic basis for the report commissioned by DG Employment and Social Affairs (2007), and partly in order to represent different welfare regimes.

SAM is constituted by three modules: the Macroeconomic Framework module, the Income module, and the Benefits module. A stylised representation of the model is given in Figure 1, where the key relations between inputs (in the first row), the three modules (second row) and the main results (third row) are sketched. Before describing the model thoroughly, the data sources and the hypotheses used are briefly outlined.

Figure 1. Stylised representation of the model



3.1 Input sources and hypotheses

Data sources for the various modules are collected in Table 1. The demographic projections are those provided by Eurostat (Europop 2004). Conservative assumptions regarding future migration flows are also included (EPC-EC, 2005). Projections for the main macroeconomic variables, such as participation rates, unemployment rate and labour productivity growth are drawn from the European Commission projections (EPC-EC, 2005) so as to provide a homogeneous and comparable basis. General unemployment rates and labour productivity growth rates used as inputs are shown in Tables 2 and 3 respectively.

The main semi-aggregate variables (namely, the amounts of income sources and the number of beneficiaries) are projected starting from 'initial values' computed on ECHP data. In particular, we computed population shares of income/benefits recipients and average amounts of income/benefits. In this last respect, it has to be remembered that ECHP income data on France are recorded gross of personal taxes. Consequently, other input data – namely replacement rates – for France are taken gross.

The starting value of GDP is taken from Eurostat, where it is recorded in current euro also for the countries not participating in the single currency,[4] such as Denmark, Latvia, Poland and the UK.

Further assumptions regarding interest rates, the share of income paid to capital and the cohort effects for consumption are collected in Table 4.

Table 1. Data sources

Variable	Source
Demographic projections by gender and age	Eurostat – Europop 2004
Participation rates projections	EPC-EC (2005)
Structural unemployment	EPC-EC (2005)
Labour productivity growth	EPC-EC (2005)
Number of earners by labour market status, gender and age	ECHP (2003)
Net average income by age	ECHP (2003)
Number of benefits recipients by labour market status, gender and age	ECHP (2003)
Net average benefits by age classes	ECHP (2003)
Starting values of public debt to GDP and GDP (2004 constant prices)	Eurostat
Nominal GDP used to update ECHP income data from 2000 to 2004	Eurostat
Survival tables by country	Calculated on Eurostat 2003 data
Starting years values of aggregate social expenditure	Eurostat (ESSPROS) and EC (2005)
Rules on indexation mechanism for pensions	MISSOC tables (EC, 2006)
Replacement ratios (I and II pillars) for new pensioners and their evolution.	ISG-SPC (2006)

Table 2. Unemployment rate assumptions

	2003	2010	2015	2025	2050
Denmark	5.5	4.3	4.3	4.3	4.3
France	9	8.3	7	7	7
Germany	9.9	8.5	7	7	7
Italy	8.9	7.3	6.5	6.5	6.5
Latvia	10.7	7.6	7	7	7
Luxembourg	3.7	4.2	4.2	4.2	4.2
Netherlands	3.7	3.2	3.2	3.2	3.2
Poland	20.1	15.8	12.9	7	7
Spain	11.6	8.7	7	7	7
United Kingdom	5.1	4.6	4.6	4.6	4.6

Source: EPC-EC (2005).

[4] In the compilation of the euro/ECU series for all countries, non-euro currencies are converted at market exchange rates. (Eurostat, 2007).

Table 3. Labour productivity growth assumptions

	2004-2010	2011-2030	2031-2050
Denmark	1.9	1.8	1.7
Germany	0.9	1.6	1.7
Spain	1.1	1.9	1.7
France	1.4	1.7	1.7
Italy	0.7	1.7	1.7
Luxembourg	1.8	1.9	1.7
Netherlands	1.1	1.7	1.7
United Kingdom	2.1	2.1	1.7
Latvia	6.5	4.1	1.9
Poland	3.8	3.1	1.9

Source: EPC-EC (2005).

Table 4. Baseline assumptions for economic projections

Variable	**Assumption**
Interest rate (short term real)	2% for all countries and all periods
Debt to GDP ratio	Constant for the whole projection period

SAM is a single projection model, but it was designed to provide a unifying framework for economic projections of a large number of countries and a wide spectrum of social expenditures, including pensions, which are usually left to single country models, in consideration of the specific characteristics they assume in each country.

As a consequence, simplifications are hardly avoidable, and they have been introduced depending on data availability for each single country. We may in particular distinguish three levels of gradually more ‘stylised’ projections; starting from the first, the higher level includes all the simplifications of the previous one, plus some more. Table 5 summarises the simplification levels by country.

Projections should be interpreted keeping in mind that the higher the level of simplification, the more results assume the role of a picture of benchmark economies with a country-focused demographic evolution, and cannot be considered as reliable country-specific projections. This is especially true for Latvia and Poland, whose results deserve more caution.

Table 5. Different simplification levels

	Level 0	**Level 1**	**Level 2**
Simplifying assumption with respect to lower level	Baseline assumptions from Tables 1 and 2	Hypotheses of Level 0 + Average instead of country-specific age-consumption profile	Hypotheses of Level 1 + ECHP data are missing, thus other countries’ average are applied. Unemployment level constant for all age classes for the first year. Average incomes rescaled[(1)]
Countries	France, Germany, Spain, Italy, Netherlands, Denmark	Luxembourg, UK	Latvia, Poland

[(1)] The average income by age class has been rescaled by the ratio between per capita GDP of the considered country and average per capita GDP of the whole cluster composed by countries belonging to lower simplification levels.

3.2 Macroeconomic framework

The Macroeconomic module is aimed at projecting GDP growth and the development of employment. Exogenous variables for this module are:

- demographic projections by gender and age classes;
- participation rates by gender and age classes;
- structural unemployment rate;
- labour productivity growth;
- consumption profiles by age.

The Eurostat demographic projections drive the economic projections through the interaction between the age structure of the population and the assumptions concerning the developments of the labour market.

In particular, labour market participation rates by gender and age class, the level of total unemployment (i.e. for all age and gender classes), and the rate of growth of labour productivity (the ratio between output and employed workers), are taken from EPC-EC (2005), which delivers country-specific projections of these quantities up to 2050.

The number of active people results directly from the exogenous input data:

$$\#ACTIVE_{t,g,a} = \#POP_{t,g,a} * PART\_RATE_{t,g,a} \qquad (1)$$

where $\#ACTIVE_{t,g,a}$ is the number of active people of gender g, age class a at time t, $\#POP_{t,g,a}$ is the number of people of gender g, age class a at time t, and $PART\_RATE_{t,g,a}$ is the participation rate for individuals of gender g, age class a at time t. The number of unemployed individuals is derived by applying the unemployment rate to the number of active individuals. In each period t the unemployment rates by gender/age are computed scaling the 2004 unemployment rates proportionally so that they match the exogenous projections of the general unemployment rate (i.e. the unemployment rate projection not disaggregated by gender and age). Finally, the number of employed people by gender and age class is derived as a difference between the active and the unemployed at each time t.

As an alternative to the methodology described above, the model also allows us to fix the exogenous employment rates to be reached in a given year. This is particularly useful to analyse the effect of labour market reforms such as the employment targets set in the Lisbon and Stockholm European Councils. In this case, participation rates are no longer exogenous, but are computed as a function of the target employment and unemployment rates.

The annual growth of GDP is simply calculated as the sum of the annual growth of employment and of productivity.[5,6]

[5] This definition of GDP growth does not imply that other factors, in particular capital, are assumed to be irrelevant. The productivity of capital has not been explicitly considered because the estimation of the evolution of the capital stock in the economy is not our aim. However, since labour productivity is defined as GDP/Labour units, the definition of economic growth through the concept of labour productivity accounts for the role of capital and of total factor productivity in an indirect way.

[6] We also attempted a different methodology, whereby the rate of growth of GDP and the evolution of interest rates receives feedback from the ageing process. Even though this alternative procedure has not been used, it is described in Appendix 3.

3.3 The individual incomes

The Incomes module projects the number of earners of wages, self-employed income and private income, as well as the average labour and capital income.

Exogenous inputs to this module are:

- results from the Macroeconomic module. In particular, the number of employed, unemployed and inactive people by gender and 5-year age classes from 2004 to 2050;
- the proportion in the population of earners of wages, self-employment income and private income respectively, by labour market status, gender and age computed from ECHP database (as of 2000);
- net average incomes (wages, self-income, private income) at the beginning of the period by gender/age classes computed from ECHP database (as of 2000).

As mentioned above, income sources are taken net of taxes, with the exception of France, because they are recorded so in ECHP and divided into three categories: i) wages and salaries; ii) self-employment income and iii) private income. These are described more in detail in Box 1.

Results from the Macro-economic module include the number of employed, unemployed, and out of the labour market, for each age/gender class, for all the projection period. The ECHP dataset provides the number of wage earners by age/gender and employment status in 2000. The number of wage earners is projected by keeping the percentage of people earning a wage in a given class (determined by gender/age/labour market status) constant during the whole projection period. The same procedure is adopted for self-employed income and private income. Overlapping is allowed, however, since a wage earner may also be self-employed and/or receive a private income. As a consequence, the total number of income recipients is driven exclusively by the demographic evolution and not by modifications in the structure by age/gender/occupational status of the recipients over time. This hypothesis implies that the evolution of the number of earners in each age/gender/labour market group does not affect the overall number of earners, since this is only determined by demographic factors.

The evolution of the number of wage earners is in detail:

$$\begin{aligned} WE_{t,g,a} = {} & (\%WE_{2000,empl,g,a} * \#empl_{t,g,a}) + \\ & + (\%WE_{2000,unempl,g,a} * \#unempl_{t,g,a}) + \\ & + (\%WE_{2000,inact,g,a} * \#inact_{t,g,a}), \end{aligned} \tag{2}$$

where $WE_{t,g,a}$ is the number of wage earners at time t, $\%WE_{2000,empl,g,a}$ is the share of employed wage earners in the population (constant at 2000), $\%WE_{2000,unempl,g,a}$ is the share of unemployed wage earners in the population (at 2000), $\%WE_{2000,inact,g,a}$ is the share of inactive wage earners in the population (at 2000), and $\#empl_{t,g,a}$, $\#unempl_{t,g,a}$ and $\#inact_{t,g,a}$ are respectively the number of employed, unemployed and inactive people at each time t. As a matter of fact there should be no wage earners among the unemployed and the inactive. However, since this discrepancy results directly from the ECHP micro data and the number of unemployed and inactive earning a labour income is very small, we included them in the computations.

The evolution of the number of self-employed and private income earners is analogously determined.

The average amount of each income component (wage, self-employed income and private income) is taken from ECHP at its 2000 level and then it is updated to the year 2004 using nominal GDP to be consistent with the macroeconomic inputs, whose starting level is at the 2004 value. All income sources are assumed to grow for each age/gender class according to labour productivity. For instance, the evolution of wages follows this pattern:

$$w_{t,g,a} = w_{t-1,g,a} * (1+j_t), \quad (3)$$

where $w_{t,g,a}$ is the wage at time t, $w_{t,g,a}$ in the first year of the projections is the average 2000 wage from ECHP (updated to 2004 with nominal GDP) and j_t is the growth of labour productivity. Each $w_{t,g,a}$ is computed for every gender g and age class a, whereas j_t is constant over age and gender but varies over time.

This implies that the overall average income amounts (i.e. the average of all age/gender classes) grows at a rate that is a function both of the assumed labour productivity growth and of the age/gender structure of earners. For private income, growth is assumed to be the same as household income; this avoids income shares converging to zero/one in the long-run. The overall wage bill by gender/age at time t ($WB_{t,g,a}$) is thus:

$$WB_{t,g,a} = WE_{t,g,a} * w_{t,g,a} \quad (4)$$

The overall self-income and private income bills are computed analogously.

Box 1. Income sources (ECHP classification)

Income sources are derived directly from ECHP data, with no adjustment on our part.

Wages and salaries

Normal income from work as an employee or apprentice and additional earnings from overtime, commission or tips. Additional payments (13^{th} and 14^{th} month's salary), holiday pay or allowance, profit-sharing bonus, other lump-sum payments and company shares are also covered.

Self-employed income

Data on income from a person's own business, profession or farm are gathered as the pre-tax profit, i.e. the profit after deducting all expenses and wages paid, but before deducting tax or funds withdrawn for private use. This pre-tax profit is converted into net profit on the basis of a net/gross ratio.

Private income

- Income from property: rental income after deducting mortgage, repairs, maintenance, insurance. The value before tax is converted into a net figure on the basis of a net/gross ratio. Data on income from property is gathered at household level and divided equally among all adult members (persons aged 16 or more) of the household.
- Capital income: Interest on savings certificates, bank deposits and dividend from shares.
- Private transfers: Any financial support or maintenance from relatives, friends or other persons outside the household.

3.4 The projection of semi-aggregate social protection benefits

The Benefits module delivers projections of the number of (non-old age) social benefits recipients, the average value of the benefits over time and the corresponding expenditure as a percentage of GDP. Old-age pension benefits and recipients are computed in this module but will be described in the next section. This module provides two sets of results:

- The projection of net[7] social protection cash benefits *semi-aggregated* by age/gender to serve as an input for COREs;

[7] They are gross for France, however.

- The projection of *aggregate* social protection benefits.

Exogenous inputs are:

- results from the previous modules, in particular the number of employed, unemployed and inactive people by gender and 5-year age classes from 2004 to 2050;
- number of benefits recipients by labour market status, gender and age class from ECHP database (as of 2000);
- net average benefits by gender/age classes as from ECHP database (as of 2000), and subsequent uprating.

For the purpose of computing COREs, total disposable income is needed. The reference benefits used to construct total disposable income are those deriving from the ECHP survey. Benefit amounts collected in ECHP are limited to cash ones and are classified according to the categories displayed in Box 2 (EC-Eurostat, 2002). This classification is very comprehensive, as it includes not only personal benefits but also household-directed assistance (as in the case of housing and social allowances). Consequently, this data source proves a useful input for the computation of a disposable income measure needed for the analysis of Comprehensive Replacement Rates (COREs).

For all the benefits mentioned above, with the exception of sickness/invalidity and old-age, the number of recipients is calculated following a procedure similar to the one adopted in the Incomes module. For each labour market status, the percentage of recipients of a particular benefit in a certain age-gender class is kept constant at its year 2000 level throughout the projected period. As mentioned above, this hypothesis implies that the overall number of recipients is only driven by demographic factors, because the population shares of recipients in each age/gender/working group remain constant over time. For instance, the number of recipients of benefit *B* is:

$$
\begin{aligned}
BR_{t,g,a} = {} & (\%BR_{2000,empl,g,a} * \#empl_{t,g,a}) + \\
& + (\%BR_{2000,unempl,g,a} * \#unempl_{t,g,a}) + \\
& + (\%BR_{2000,inact,g,a} * \#inact_{t,g,a}),
\end{aligned}
\qquad (5)
$$

where $BR_{t,g,a}$ is the number of recipients of any specific benefit *B* at time *t* by gender/age, $\%BR_{2000,empl,g,a}$ is the share of employed benefit recipients in the population (constant at 2000) and $\#empl_{t,g,a}$ is the number of employed people by gender/age at each time *t*, etc. The evolution of the number of all benefit recipients is analogous, with the exception of sickness/invalidity and old-age pension beneficiaries.

Consequently, the absolute number of recipients evolves according to the demographic and labour market projections. For example, population ageing is likely to reduce total number of family-related beneficiaries, since the percentage of people getting them is lower among the elderly. Similarly, the number of people on unemployment benefits if affected by the development of the labour market. Thus, their number shrinks whenever the Macroeconomic module projects a decrease of the unemployment rate.

The average benefit in each category is assumed to increase, within each class, according to wage growth, that is with labour productivity. For instance, the evolution of the average benefit *B* for every gender/age class follows this rule:

$$b_{t,g,a} = b_{t-1,g,a} * (1+j_t), \qquad (6)$$

where $b_{t,g,a}$ is the average benefit *B* by gender/age at time *t*, $b_{t,g,a}$ in the first year of the projection is the average 2000 wage from ECHP (updated to 2004 with nominal GDP) and j_t is the growth of labour productivity, depending only on time.

Box 2. Social protection benefits (ECHP classification, EC-Eurostat, 2002)

Income sources are derived directly from ECHP data, with no adjustment on our part.

Unemployment related benefits

Component 1: Unemployment insurance benefit
Component 2: Unemployment assistance
Component 3: Training / retraining allowance
Component 4: Placement, resettlement, and rehabilitation benefits
Component 5: Other unemployment related benefits

Pension or benefit relating to old-age or retirement

Component 1: Old-age pension – Basic schemes (first pillar)
Component 2: Old-age pension – Supplementary schemes (second pillar)
Component 3: Old-age pension – Personal schemes (third pillar)
Component 4: Old-age pension – Means-tested welfare schemes
Component 5: Early retirement schemes
Component 6: Other old-age related schemes or benefits

Survivor's pension or benefits, that is, for widows or orphans

Component 1: Widows pension – Basic schemes (first pillar)
Component 2: Widows pension – Supplementary schemes (second pillar)
Component 3: Widows pension – Personal schemes (third pillar)
Component 4: Widows pension – Means-tested welfare schemes
Component 5: Other widow's benefits
Component 6: Orphan's pension / allowance

Family related benefits, including maternity and single-parent benefits

Component 1: Child allowance
Component 2: Allowance for care of invalid dependants
Component 3: Maternity allowance
Component 4: Birth allowance
Component 5: Unmarried mother's allowance
Component 6: Deserted wife's allowance
Component 7: Other family-related benefits

Benefits relating to sickness or invalidity

Component 1: Income maintenance benefits in case of sickness or injury
Component 2: Other sickness benefits
Component 3: Compensation for occupational accidents and diseases
Component 4: Invalidity pension
Component 5: Other invalidity benefits

Education related allowances

Scholarships, study grants

Housing allowance

Subsidies or other payments from public schemes to help meet housing costs. Data are gathered at household level and divided equally among all adult members (persons aged 16 or over) of the household.

Social assistance

Payments from the welfare office. Data are collected at household level and divided equally among all adult members (persons aged 16 or more) of the household.

Any other personal social benefits

Residual benefits not included in the above sub-categories.

This methodology implies that the total expenditure on any benefit (i.e. over all age/gender classes) increases at a rate that is a function of both the wage growth and the age/gender structure of recipients. In the absence of a thorough modelling of each type of benefit, this seems a reasonable assumption for all the benefits other than old-age and sickness/invalidity benefits. Thus, the expenditure on benefit *B* is:

$$BE_t = \sum_{g,a} (BR_{t,g,a} * b_{t,g,a}) , \tag{7}$$

where BE_t, is the expenditure on each benefit *B* at time *t*, $BR_{t,g,a}$ is the number of benefit recipients – depending on demographic projections – and $b_{t,g,a}$ is the average benefit, growing at the projected rate of growth of labour productivity.

For sickness/invalidity benefits, however, a somewhat different methodology is followed. In this case, the number of recipients is determined as a constant fraction of employed workers, instead of as a fraction of the overall population. The reason for this approach rests in the link between invalidity and employment: first, people are required to have been employed to be entitled to invalidity benefits; second, in many cases invalidity is related to features of the job (level of danger, unhealthy job conditions, and so on) or to accidents on the job; third, sickness benefits not related to work are a small fraction of cash benefits (public expenditure on sickness is mostly delivered in kind). The evolution of the number of invalidity beneficiaries is thus computed as:

$$IR_{t,g,a} = \%IRempl_{2004} * (\#IR_{2004,g,a}/\#IR_{2004}) * \#empl_t, \tag{8}$$

where $IR_{t,g,a}$ is the number of invalidity benefit recipients by age/gender at time *t*, $\%IRempl_{2004}$ is the share of people receiving invalidity benefits over the employed population in 2004 (remaining constant throughout the whole projection period), $\#IR_{2004,g,a}$ is the number of recipients by age and gender in 2004, $\#IR_{2004}$ is the total number of recipients over all age and gender classes in 2004, and $\#empl_t$ is the total number of employed people over all age and gender classes at time *t*.

The average sickness/invalidity benefit is assumed to grow with wages, as the other kinds of benefits.

As for old-age pensions, given their importance in the overall welfare budget, benefits and beneficiaries are modelled through a specific sub-unit simulation, which deserves a lengthier explanation.

3.5 Old-age pension projections (semi-aggregate cash benefits)

As mentioned above, the exogenous inputs for the sub-module dedicated to old-age pensions are:

- results from the previous modules, in particular the number of employed, unemployed and inactive people by gender and 5-year age classes from 2004 to 2050;
- number of old-age benefit recipients by labour market status, gender and age class from ECHP database (as of 2000);
- net average old-age benefits by gender/age classes as from ECHP database (as of 2000), and subsequent uprating;
- rules on indexation mechanism for old-age pensions;
- net theoretical replacement rates from ISG-SPC (2006).

Starting from the number of pensioners, projections should, in principle, reflect the application of the eligibility rules to the changing demography, as well as the effect of incentives and of greater flexibility. Other relevant complications, however, mainly pertaining to the evolution of the labour market, cannot be dismissed. In particular, the European objective of increasing the employment rates of both the elderly and women will influence labour market performance, determining two opposing effects on the number of pensioners: while an increase in the employment rate of the elderly is going to reduce the number in the short run, the higher employment rate of women will increase it in the long run.

The procedure adopted in the pension unit divides old-age pension recipients into two broad groups, the first constituted by the age classes we called 'sensitive', and the second constituted by 'constant-ratio' classes. The sensitive classes are constituted by old-age pension recipients aged 60 and over, who are assumed to be out of the labour force. The implicit assumption being made is that no one aged over 60 receiving an old-age pension is actively working. This is justified by the negligible number of pensioners older than 60 that are still in the labour force, and by the fact that reform efforts are usually addressed at increasing employment in the 50-60 age groups, rather than at raising the employment rates of older individuals. Constant-ratio classes are constituted by people younger than 60. For this group no assumption about labour market participation is made, in order to include both pensioners not fully retired (that is, in the labour force, like partial retirees) and early retirees (that is, out of the labour force).

The methodology for projecting benefits and beneficiaries of the a) constant-ratio classes and b) sensitive classes will be described in turn.

a) 'Constant-ratio' classes

In the case of the constant-ratio group, the proportion of old-age pension recipients by labour market status is projected analogously onto the number of recipients of non-pension benefits, that is, it is kept constant at the level of year 2000, as it was the case for all the other benefits. The reason for treating relatively young pension recipients in this unsophisticated way rests on the fact that a physiological number – however small – of retirees aged less than 60 will probably always exist (i.e. for the possibility of early retirement, industry restructuring, etc…). In this way the impact of any legislative change on the magnitude and age/gender structure of this group is neglected.

Therefore, the number of pensioners in the constant-ratio group is:

$$\begin{aligned} PR^{(cr)}_{t,g,a} = & (\%PR^{(cr)}_{2000,empl,g,a} * \#empl^{(cr)}_{t,g,a}) + \\ & + (\%PR^{(cr)}_{2000,unempl,g,a} * \#unempl^{(cr)}_{t,g,a}) + \\ & + (\%PR^{(cr)}_{2000,inact,g,a} * \#inact^{(cr)}_{t,g,a}), \end{aligned} \tag{9}$$

where $PR^{(cr)}_{t,g,a}$ is the number of pension recipients in the constant-ratio group at time t by gender/age, $\%PR^{(cr)}_{2000,empl,g,a}$ is the share of employed pension recipients in the constant-ratio group in the population (constant at 2000), $\#empl^{(cr)}_{t,g,a}$ is the number of employed people in the constant-ratio group by gender/age at each time t, etc.

The pension benefit of the constant-ratio classes is projected in line with the average pension of recipients aged 60-64 (that is, the immediately older age class):

$$p^{(cr)}_{t,g,a} = p^{(cr)}_{t-1,g,a} * (1 + k^{(60-64)}_{t,g,a}), \tag{10}$$

where $p^{(cr)}_{t,g,a}$ is the average benefit of those in the constant-ratio group by gender/age at time t, $p^{(cr)}_{t,g,a}$ in the first year of the projection is the average 2000 (updated to 2004 with nominal

GDP) old -age pension of those in the constant-ratio group by gender/age from ECHP and $k_{t,g,a}^{(60-64)}$ is the rate of growth of the average pension of those in the age class 60-64.

It is worth noting that the average pension includes not only the public pension, but also the supplementary (second pillar) and personal (third pillar) schemes, consistently with ECHP definitions recalled above.

b) 'Sensitive' classes

The number of pensioners within the sensitive classes and their average pension are projected in a more refined way. The projection procedure for the number of retirees can be summarised by referring to three elements:

- the stock of existing pensioners in each period;
- the flow of 'new' pensioners;
- the number of pensioners dying in each period.

As the projection of the number of new pensioners is done by 5 year age-brackets and 5 year-intervals, the number of pensioners aged 60+ at time *t* is determined by adding to the stock of pensioners at time *t-5* the flow of new pensioners, and subtracting pensioners that die between *t-5* and *t*. The demographic projections drawn from Eurostat are used to compute survival probabilities that allow us to determine the number of surviving pensioners in each age class and year.[8] Projections with constant – at 2004 – survival rates will be also provided in order to allow comparisons. Tables comparing the number of pensioners obtained with constant and 'evolving' life tables are collected in Appendix 5.

Two hypotheses are made in this computation:

- there are no active people aged 65 or over, so that all individuals alive after 65 are retired;
- there are no 'new' pensioners aged 70 or over. This derives from the first assumption (since the projection of pensioners' number is done in 5 year-intervals, if no one is in the labour force at 65, no one retires at 70).

The following rule describes the computation of the number of new pensioners:

$$\begin{aligned} &\# NP_t^{(60-64)} = \\ &= LF_{t-5}^{(55-59)} - LF_t^{(60-64)} - (1-\omega_{(60-64)}^{(55-59)}) \times LF_{t-5}^{(55-59)} = \\ &= LF_{t-5}^{(55-59)} \omega_{(60-64)}^{(55-59)} - LF_t^{(60-64)} \end{aligned} \tag{11}$$

where $\# NP_t^{(60-64)}$ are the new pensioners, at time *t*, exiting from the labour force within the age bracket 60-64, while *LF* indicates the labour force at a given time and age class and $\omega_{(60-64)}^{(55-59)}$ is the 5 year-survival rate between age class 55-59 and age class 60-64 and between *t* and *t+5*. Thus the number of new pensioners in the age bracket 60-64 is equal to those who were active 5 years before when they were aged 55-59, minus those active now (at 60-64) and those that died in the meantime.

[8] The demographic projections used to compute life tables are those contained in the 'no migration' variant. This variant is particularly useful since it adopts the same parameters – fertility and life expectancy – as the baseline variant but assumes no migration.

For new pensioners exiting from the labour force within the age bracket 65-69 an analogous rule is followed:

$$\# NP_t^{(65-69)} = LF_{t-5}^{(60-64)} \times \omega_{(65-69)}^{(60-64)}, \tag{12}$$

but – as mentioned – it is assumed that there are no active individuals in the age bracket 65-69 or subsequent ones. Remaining age classes (70+) do not explicitly originate new pensioners in the model:

$$\# NP_t^{(70+)} = 0 . \tag{13}$$

The evolution of existing pensioners aged 60+ is projected by 5 year-intervals and 5 years age brackets, then a linear interpolation is used to smooth the curve, generating approximate projections by intervals of 1 year.

The average pension of 'sensitive classes' pensioners includes – again – public pension and supplementary (second and third pillar) schemes, as from ECHP. Even though the pension formulae of each country are not explicitly modelled, some link to the already legislated reforms is embedded in the replacement ratio and the pension indexation mechanism. In each period *t*, the average pension is determined as a weighted average of:

a) the pension earned by pensioners (old and new) already existing at time *t-1*, and

b) the pension calculated for new pensioners.

The latter (*b*) is computed by multiplying the average wage of the age class *a-5* at time *t*-1 by the replacement ratio. The evolution of replacement ratios over the whole projection period is taken exogenously. Target replacement ratios for new pensioners are set to be reached in a linear fashion by 2050. In the baseline and alternative scenarios the replacement rates for public and private pensions are those provided by the Indicators Sub-Group of the Social Protection Committee (ISG-SPC, 2006). It has to be noted, however, that the baseline replacement rates refer to individuals with a continuous career, thus they may not provide an accurate representation of the average individual. Replacement ratios are collected in Appendix 4.

The formula to compute the average pension of sensitive classes is as follows:

$$p_{t,g,a}^{(sens)} = \frac{\begin{array}{c}[\# OP_{t,g,a}^{(sens)} * p_{t-1,g,a}^{(sens)} * (\pi + (1-\pi) * w_{t,g,a-5})] + \\ +[\# NP_{t,g,a}^{(sens)} * RR_t * (\pi * W_{t,g,a-5} + (1-\pi) * \frac{W_{t-1,g,a-5} + W_{t,g,a-5}}{2})]\end{array}}{\# OP_{t,g,a}^{(sens)} + \# NP_{t,g,a}^{(sens)}} \tag{14}$$

where $p_{t,g,a}^{(sens)}$ is the average pension of sensitive classes at time *t* for each age/ gender class, and $p_{t,g,a}^{(sens)}$ in the first year of the projection are the ECHP values for 2000 updated at 2004 with nominal GDP growth. $\# OP_{t,g,a}^{(sens)}$ and $\# NP_{t,g,a}^{(sens)}$ are the numbers of old and new pensioners respectively at time *t* for each age/ gender class, π is the percentage of price indexation (constant for the whole projection period), $w_{t,g,a-5}$ is the wage growth from *t-1* to *t* in the age class 5 years younger, RR_t is the replacement rate at time *t*, and $W_{t,g,a-5}$ is the wage level in the age class 5 years younger. The term $\frac{W_{t-1,g,a-5}+W_{t,g,a-5}}{2}$ captures at the same time the wage level in the age class *a-5* and the wage growth between time *t-1* and *t*.

For the countries where there is full indexation of pensions to prices (π=1) equation 14 boils down to:

$$p_{t,g,a}^{(sens)}=\frac{[\#OP_{t,g,a}^{(sens)}*p_{t-1,g,a}^{(sens)}]+[\#NP_{t,g,a}^{(sens)}*RR_t*W_{t,g,a-5}]}{\#OP_{t,g,a}^{(sens)}+\#NP_{t,g,a}^{(sens)}}. \qquad (15)$$

On the contrary, for the countries where there is full indexation to wages (π=0) equation 14 above boils down to:

$$p_{t,g,a}^{(sens)}=\frac{[\#OP_{t,g,a}^{(sens)}*p_{t-1,g,a}^{(sens)}*w_{t,g,a-5}]+[\#NP_{t,g,a}^{(sens)}*RR_t*\frac{W_{t-1,g,a-5}+W_{t,g,a-5}}{2}]}{\#OP_{t,g,a}^{(sens)}+\#NP_{t,g,a}^{(sens)}}. \qquad (16)$$

Finally, the total old-age pension expenditure (in cash) is obtained as the sum of semi-aggregate values by gender/age:

$$\mathrm{PE_t}=\sum_{g,a}\mathrm{PE_{t,g,a}}=\sum_{g,a}(\mathrm{PE_{t,g,a}^{(cr)}}+\mathrm{PE_{t,g,a}^{(sens)}})=\sum_{g,a}(\#\mathrm{P_{t,g,a}^{(cr)}}*\mathrm{p_{t,g,a}^{(cr)}}+\#\mathrm{P_{t,g,a}^{(sens)}}*\mathrm{p_{t,g,a}^{(sens)}}) \qquad (17)$$

where $\mathrm{PE_t}$, is the total pension expenditure (in cash) at time *t*, $\#\mathrm{P_{t,g,a}^{(cr)}}$ is the number of pensioners aged less than 60 by age/gender, $\mathrm{p_{t,g,a}^{(cr)}}$ is the average pension benefit of pensioners aged less than 60 by age/gender, $\#\mathrm{P_{t,g,a}^{(sens)}}$ is the number of pensioners aged 60 and over by age/gender, and $\mathrm{p_{t,g,a}^{(sens)}}$ is the average pension benefit of pensioners aged 60 and over by age/gender.

3.6 Aggregate social protection expenditure projections

Total social expenditure can be computed as the product of the number of recipients times the average amount of each benefit, as shown above in Equations 7, 8 and 17. However, those projected figures are not suitable to obtain the expenditure as a percentage of GDP, even though they are suitable to compute COREs, because of the underestimation of the average amounts provided by ECHP with respect to national statistics.[9]

Therefore, in order to obtain a measure of the evolution of aggregate public expenditure in social protection and have an insight into the model ability to deliver macroeconomic projections, the dynamics of semi-aggregate public expenditures (i.e. those derived in Equations 7, 8 and 17) is applied to the 2004 level of aggregate social expenditures drawn from official statistics.

In our case, the starting (i.e. 2004) levels of aggregate social expenditure can be taken from two sources. The differences between the chosen input data are described here:

[9] This is mainly due to the fact that ECHP figures are net of taxes and of administration costs, but they might also suffer from underreporting problems.

1) First, we took starting levels from Eurostat data, classified according to ESSPROS depending on their function and their type (i.e. cash or kind) (EC-Eurostat, 1996). In this dataset, "social protection encompasses all interventions from public or private bodies intended to relieve households and individuals of the burden of a defined set of risks or needs, provided that there is neither a simultaneous reciprocal nor an individual arrangement involved" (EC-Eurostat, 2006, p. 12). For a more detailed description of this classification see Box 3. It is important to note that: i) expenditure from public and private bodies is not disentangled, therefore these aggregate starting values will grow in line with both *public and private* semi-aggregate expenditures; ii) on the contrary, in-cash and in-kind benefits can be disaggregated, so we will use cash benefits only, since in-kind benefits are not explicitly modelled in SAM. Point ii) implies that the evolution with respect to GDP of aggregate expenditures might not be directly comparable with official statistics about total public social expenditure. This is especially true for the benefits delivered mostly in kind, such as health care (see Table 6 below).

2) Second, we drew starting levels from EC (2005) where the 2004 level of public pension expenditure with respect to GDP is provided. It is worth noting that: i) these data refer to public expenditures only, so they are made to grow in line with semi-aggregate *public* expenditures; ii) these data exclude private pension provisions, but they include public old-age and early retirement pensions as well as disability and widow's pensions, so the figures might turn out higher than those produced using starting levels from ESSPROS (described under point 1 above).

As a remark, the projections used as an input for COREs are directly taken from semi-aggregate expenditures computed in Equations 7, 8 and 17, and, as for old-age pensions, they include both public and private pensions.

Box 3. Social protection expenditure (ESSPROS classification, EC-Eurostat, 1996)

Sickness/Health care

Income maintenance and support in cash in connection with physical or mental illness, excluding disability. Health care ended to maintain, restore or improve the health of the people protected irrespective of the origin of the disorder.

Disability

Income maintenance and support in cash or kind (except health care) in connection with the inability of physically or mentally disabled people to engage in economic and social activities.

Old age

Income maintenance and support in cash or kind (except health care) in connection with old age.

Survivors

Income maintenance and support in cash or kind in connection with the death of a family member.

Family/children

Support in cash or kind (except health care) in connection with the costs of pregnancy, childbirth and adoption, bringing up children and caring for other family members.

Unemployment

Income maintenance and support in cash or kind in connection with unemployment.

Housing

Help towards the cost of housing.

Social exclusion not elsewhere classified

Benefits in cash or kind (except health care) specifically intended to combat social exclusion where they are not covered by one of the other functions.

*Table 6. Social protection benefits, by function and type, 2004, as % GDP**

	Sickness/ Health care		Invalidity		Old age		Survivors	
	In cash	In kind	In cash	In kind	In cash	In kind	In cash	In kind
Denmark	1	5.1	2.9	1.3	9.2	1.9	0	0
Germany	1.4	6.3	1.6	0.6	11.8	0.2	0.4	0
Spain	1.1	4.9	1.3	0.2	7.6	0.4	0.6	0
France	0.7	8	1.2	0.5	10.6	0.3	1.9	0
Italy	0.5	6	1.5	0.1	12.8	0.1	2.5	0
Latvia	0.5	2.5	0.9	0.3	5.7	0.1	0.3	0
Luxembourg	0.8	4.7	2	1	5.8	0	2.3	0
Netherlands	2.2	5.9	2.7	0.2	8.8	0.9	1.4	0
Poland	0.7	3.1	2.2	0	10.8	0	0.9	0
United Kingdom	0.6	7.2	1.9	0.4	10.1	0.6	0.9	0
	Family/Children		**Unemployment**		**Housing**		**Social exclusion n.e.c.**	
	In cash	In kind	In cash	In kind	In cash	In kind	In cash	In kind
Denmark	1.6	2.3	2.7	0.1	-	0.7	0.8	0.2
Germany	2.2	0.7	2.2	0.3	-	0.2	0.4	0
Spain	0.4	0.3	2.3	0.2	-	0.2	0	0.1
France	2	0.5	2.2	0	-	0.8	0.4	0
Italy	0.7	0.5	0.5	0	-	0	0	0
Latvia	1	0.2	0.4	0	-	0.1	0.1	0.1
Luxembourg	3.3	0.6	1	0	-	0.2	0.4	0.1
Netherlands	0.7	0.5	1.7	0	-	0.3	0.5	0.8
Poland	0.9	-	0.7	0	-	-	0.1	0.1
United Kingdom	1.3	0.4	0.5	0.2	-	1.5	0.1	0.1

* ESSPROS definition.

Source: Eurostat.

3.7 An indicator of social security sustainability

Given the model's focus on adequacy measures, it does not provide a sustainability analysis based on the government's budget constraint. However, the model can compute a notional payroll tax rate for pensions, which represent the most relevant fraction of social benefits. Even though the financial sustainability of the pension system is not determined only by the taxation of wages or self-employment income, this notional rate captures the quota of aggregate income that is devoted to pension expenditure. This indicator can also be compared with the effective payroll tax rates in force in every country to gain an insight into the burden of ageing on public finances.

The exogenous inputs for this sub-module are:

- Old-age pension expenditure from Equation 17 and income bill (wages plus self-employment income) from Equation 4 *et sim.*;
- Hypotheses on the constancy of public debt with respect to GDP and on interest rates (assumed to be constant at 2% for all countries).

The notional equilibrium payroll tax rate is defined as the average contribution rate which should be levied on the wages and the self-employed income to finance the payments of pensions:[10]

$$\vartheta_t = \frac{PE_t}{WB_t + SB_t}, \tag{18}$$

where ϑ_t is the notional payroll tax rate, PE_t is the pension expenditure at time *t* (from Equation 17), WB_t is the wage bill at time *t* and SB_t is the self-employment income bill at time *t* (Equation 4).

In addition, the government debt may be considered in the analysis, since a high debt reduces the room for deficits in the public pension system. Thus, a correction can be applied to take into account the interest payments on government debt. The rationale for this is that a higher level of debt increases the burden of public finances and reduces the government's possibility to require additional effort (in terms of social contributions) to finance current pensions. In practice, an additional component is added to the numerator by summing part of the service of the debt to public pension expenditure.

Not all the debt, of course, is generated by the need to cover pension deficits. As a consequence a rule of thumb is applied, and the cost of debt is corrected for the ratio between pension expenditure and the overall social expenditure, as a proxy of the fraction of debt imputable to past pension deficits. Furthermore, since it is assumed here that the government debt is a constant fraction of GDP and, holding a balanced budget, such a fraction would decrease when a country pays the total service, countries can finance part of their service by extra borrowing, and not all the service of the debt is bound to go to the detriment of the contribution rate.[11] Therefore, an alternative measure of the sustainability indicator is:

$$\vartheta_t = \frac{PE_t + (serv_t - \Delta debt_t) * \dfrac{PE_t}{TOTE_t}}{WB_t + SB_t}, \tag{19}$$

where $serv_t$ is the debt service at time *t*, $\Delta debt_t$ is annual increase in debt that the country can afford maintaining the debt/GDP ratio constant (that is, since GDP grows also debt can grow in absolute terms), PE_t is the public pension expenditure and $TOTE_t$ is the overall social protection expenditure.

Of course this method, given the partial equilibrium approach that has been adopted, does not prevent the 'notional contribution rate' from becoming unsustainable. On the contrary, an unsustainable path would require active policies. Moreover, increases in the equilibrium payroll

[10] A note of caution must be added: social security schemes of employed and self-employed workers are different in many countries; the notional equilibrium contribution rate, however, is an average sustainability indicator, it is not aimed at distinguishing among different pension regimes, but only at determining how much the overall labour income bill should be taxed to pay the overall pension expenditure; as a consequence the indicator is not differentiated between a wage and a self-income contribution rates.

[11] The service of the government debt is computed with a 2% constant real interest. Moreover, interest rates are corrected for the effects of ageing on consumption, through the use of the production function, as explained more extensively in Appendix 3.

tax rates should be read as an encouragement to increase contribution rates – as this would hardly be feasible – but rather as an indicator of the sustainability evolution.

A further note of caution in reading the results is needed. Since as all the income values used to compute social expenditure and the wage bill are net of taxes, so the notional payroll tax rate suffers from this shortcoming too.

4. Baseline projections: hypotheses and results

The simulation framework just described is meant to answer a range of questions about the effects of ageing on the sustainability and adequacy of social security systems. In order to investigate these topics, we will first describe baseline projections, while subsequent sections will be devoted to illustrate new scenarios.

The baseline scenario is built using:

- ‘endogenous’ employment rates (i.e. as resulting from participation and unemployment exogenous projections and without reaching Lisbon targets);
- the baseline variant of demographic projections;
- replacement rates referring to a representative individual earnings 100% of mean national income.

4.1 Demography and macroeconomics

This section presents demographic and macroeconomic projections, obtained according to the methodology described in Section 3.2, for the baseline scenario. Table 7 shows old-age dependency rates computed on the demographic projections (exogenous inputs to the model). Italy and Spain, among the countries considered, have the highest ratio at the end of the period.

Table 7. Old-age dependency rates, %

	2005	2010	2020	2030	2040	2050
Denmark	22.6	24.8	31.2	37.1	42.1	40.0
France	25.3	25.9	33.2	40.7	46.9	47.9
Germany	27.8	31.0	35.1	46.0	54.6	55.8
Italy	29.4	31.3	36.6	45.2	59.8	66.0
Latvia	24.1	25.2	28.0	33.4	37.4	44.1
Luxembourg	21.2	21.6	24.7	31.5	36.7	36.1
Netherlands	20.7	22.2	29.0	36.7	41.6	38.6
Poland	18.7	18.8	27.1	35.7	39.7	51.0
Spain	24.5	25.4	30.0	38.9	54.3	67.5
United Kingdom	24.4	25.1	30.3	37.4	43.8	45.3

Source: our computation on Eurostat data.

Note: computed as population 65+/population 15-64.

Table 8 presents growth rates in GDP and GDP per capita respectively. There is a slowdown on growth for all countries. In particular, growth rates decrease substantially for Poland and Latvia, showing a convergence with the EU-15 around the 2020s and 2030s. Moreover, Table 8 shows, with only a few exceptions, that GDP per capita growth rates become larger than overall growth rates by the end of the projection. GDP per capital levels are collected in Table 9.

Table 8. GDP growth rate, period average, %

	2005-2010		2011-2020		2021-2030		2031-2040		2041-2050	
		Per capita		*Per capita*		*Per capita*		*Per capita*		*Per capita*
Denmark	2.2	2	1.9	1.8	1.4	1.3	1.3	1.4	1.8	2
France	2.1	1.7	1.9	1.5	1.7	1.4	1.6	1.4	1.6	1.6
Germany	1.9	1.8	1.6	1.6	0.7	0.9	1	1.3	1.1	1.6
Italy	1.8	1.6	1.7	1.7	1.1	1.3	0.6	0.9	0.9	1.4
Latvia	7.9	8.5	4.3	4.9	2.4	2.9	1.5	2	0.7	1.1
Luxembourg	3.2	2.2	2.9	2	2.1	1.2	2.2	1.5	2.3	1.7
Netherlands	1.7	1.3	1.8	1.5	1.4	1.2	1.6	1.5	1.8	1.9
Poland	5.8	6	3.7	4	2.7	2.9	1.3	1.6	0.5	1
Spain	3.3	2.4	2.5	2.3	1.4	1.4	0.6	0.7	0.6	1
United Kingdom	2.9	2.5	2.5	2.2	1.7	1.4	1.5	1.4	1.5	1.6

Source: our calculations (SAM).

Table 9. Per capita GDP, euro (constant prices 2004)

	2005	2010	2020	2030	2040	2050
Denmark	37,682	41,539	49,427	56,273	64,506	78,620
France	28,790	31,148	36,228	41,802	48,158	56,578
Germany	27,711	30,408	35,728	39,050	44,571	52,173
Italy	24,456	26,565	31,590	35,963	39,467	45,508
Latvia	4,863	7,320	11,856	15,762	19,126	21,250
Luxembourg	59,738	66,591	81,540	91,899	106,197	126,095
Netherlands	30,928	32,971	38,253	42,896	49,903	60,425
Poland	5,387	7,218	10,637	14,099	16,519	18,253
Spain	19,183	21,517	26,932	31,024	33,349	36,873
United Kingdom	29,516	33,421	41,411	47,764	55,146	64,444

Source: our calculations (SAM).

Table 10. Employment rates

	2005	2010	2020	2030	2040	2050
Denmark	75.5	76.4	77.3	77.1	77.4	77.8
France	63.7	64.4	66.2	67.4	68.2	68.0
Germany	66.4	70.8	73.4	72.9	73.7	73.3
Italy	57.5	61.0	63.7	64.1	65.1	65.6
Latvia	63.6	69.9	73.7	72.6	72.2	71.4
Luxembourg	63.5	64.4	65.1	65.0	65.8	65.5
Netherlands	74.3	75.3	76.6	76.7	78.2	77.9
Poland	52.2	57.0	64.8	68.6	66.2	66.1
Spain	61.7	66.3	70.1	70.1	70.3	71.3
United Kingdom	71.8	72.8	74.3	74.3	75.1	74.7

Source: our calculations (SAM).

Employment rates (Table 10) are around 70% and above in Denmark, the Netherlands and the UK, with little variation over the projection period. Germany shows a considerable increase from 2005 to 2020 as an effect of increased participation and then decreases, due the decrease in working age population. France and Luxembourg increase slightly. Finally, Italy and Poland start from the lowest employment rates, but show a very dynamic increase afterwards.

4.2 Social protection and sustainability

The main results about social protection expenditure in cash – according to the ESSPROS definition – are collected in Table 11. The same results are shown graphically in Figures 2 and 3. In this case, old-age pensions include public as well as private pension provisions. Old-age pensions constitute the major component of social expenditure in cash. It is projected to grow in most countries, with the exception of Poland. This result is mainly driven by the dramatically decreasing replacement rates used in the projections. All other benefits develop according to wage growth and the evolution of their beneficiaries, which in turn is driven by demography. Housing benefits are not reported in the table because their value is zero. The old-age pensions expenditure reported in Table 11 is computed with survival probabilities consistent with the demographic projections. Table 12 shows the effect of introducing ‘evolving’ survival rates compared with the case of constant life tables.

Old-age expenditure is decomposed according to its determinants in Equation 20. The dependency effect (i.e. the ratio between population older than 65 and working age population) is the demographic driver of pension expenditure. The employment effect (i.e. the inverse of the employment rate) is the macroeconomic driver: an increase in employment rate busts economic growth and reduces the number of people in working age receiving a pension; thus an increase of employment ratio (i.e. a decrease of the ‘employment effect’) alleviates the pension burden. The take-up effect (i.e. the ratio between the number of pensioners and population aged more than 65) and the benefit effect (i.e. the ratio between average pension and average productivity) combine the influence of pension rules and of the macroeconomic framework. The take-up effect mirrors the pension eligibility rules, but is mainly a consequence of the evolution of participation and employment rates: if employment increases among women, for example, then a higher number of them will receive a pension in the future. The benefit effect depends on the pension calculation formula, on the indexation mechanism, on the pension eligibility rules and on past employment rates as far as the average pension is concerned (numerator). The denominator is the average labour productivity, whose determinants are linked to macroeconomic and technological factors, and, in our simulations, is also influenced by the effects that the ageing process has on private savings and consumption (EC, 2005).

$$\frac{PensExp}{GDP} = \underbrace{\frac{Pop > 65}{Pop(15-64)}}_{Dependency\_effect} \times \underbrace{\frac{Pop(15-64)}{Employed}}_{Employment\_effect} \times \underbrace{\frac{PensNo}{Pop > 65}}_{Take-up\_effect} \times \underbrace{\frac{PensExp / PensNo}{GDP / Employed}}_{Benefit\_effect} \qquad (20)$$

Equation 21 shows the same relation expressed as the product of the ratios of each item at time *t* and at time *0*, where the ratio is measured between 2004 and 2050. Table 12 displays this decomposition, that can be read as (a) = (b)*(c)*(d)*(e).

$$\frac{PensExp / GDP_t}{PensExp / GDP_0} = \frac{DepEff_t}{DepEff_0} \times \frac{EmplEff_t}{EmplEff_0} \times \frac{Take-upEff_t}{Take-upEff_0} \times \frac{BenefitEff_t}{BenefitEff_0} \qquad (21)$$

The role of demography in increasing pension expenditure is clearly visible in Table 13. The variation of the dependency effect is often higher than pension expenditure growth itself. Labour market and pension reforms undertaken by governments, captured by the variations of other decomposition factors, prove quite effective in partially offsetting the burden of ageing on pension expenditure, which would be otherwise explosive.

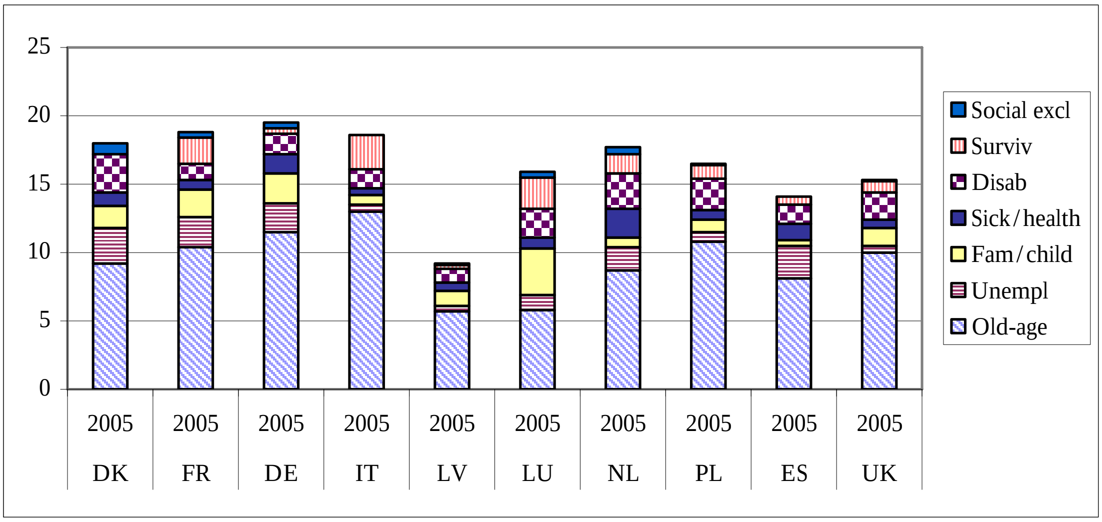
Table 11. Social protection expenditure in cash (ESSPROS definition), as a % of GDP

		Old age	Un empl	Fam/ child	Sick/ health	Disab	Surviv	Social excl	Total
Denmark	*2005*	9.2	2.6	1.6	1.0	2.8	0.0	0.8	18.0
	2050	16.8	2.3	1.4	1.0	2.8	0.0	0.7	25.0
France	*2005*	10.4	2.2	2.0	0.7	1.2	1.9	0.4	18.8
	2050	10.8	1.9	1.8	0.7	1.2	1.6	0.3	18.3
Germany	*2005*	11.5	2.1	2.2	1.4	1.5	0.4	0.4	19.4
	2050	16.5	1.7	2.1	1.4	1.5	0.7	0.4	24.2
Italy	*2005*	13.0	0.5	0.7	0.5	1.4	2.5	0.0	18.6
	2050	24.3	0.5	0.7	0.5	1.4	2.4	0.0	29.8
Latvia	*2005*	5.7	0.4	1.1	0.6	1.0	0.3	0.1	9.2
	2050	15.7	0.3	1.1	0.6	1.0	0.3	0.1	19.2
Luxembourg	*2005*	5.8	1.1	3.4	0.8	2.1	2.3	0.4	15.8
	2050	13.3	1.3	3.2	0.9	2.1	1.6	0.4	22.6
Netherlands	*2005*	8.7	1.7	0.7	2.1	2.6	1.4	0.5	17.8
	2050	13.0	1.7	0.7	2.1	2.6	1.4	0.4	22.0
Poland	*2005*	10.8	0.7	0.9	0.7	2.3	1.0	0.1	16.5
	2050	8.3	0.3	0.9	0.7	2.3	1.0	0.1	13.7
Spain	*2005*	8.1	2.4	0.4	1.2	1.4	0.6	0.0	14.1
	2050	27.2	2.0	0.4	1.2	1.4	0.6	0.0	32.7
United Kingdom	*2005*	10.0	0.5	1.3	0.6	2.0	0.8	0.1	15.4
	2050	15.6	0.5	1.2	0.6	2.0	0.5	0.1	20.4

Source: our calculations (SAM).

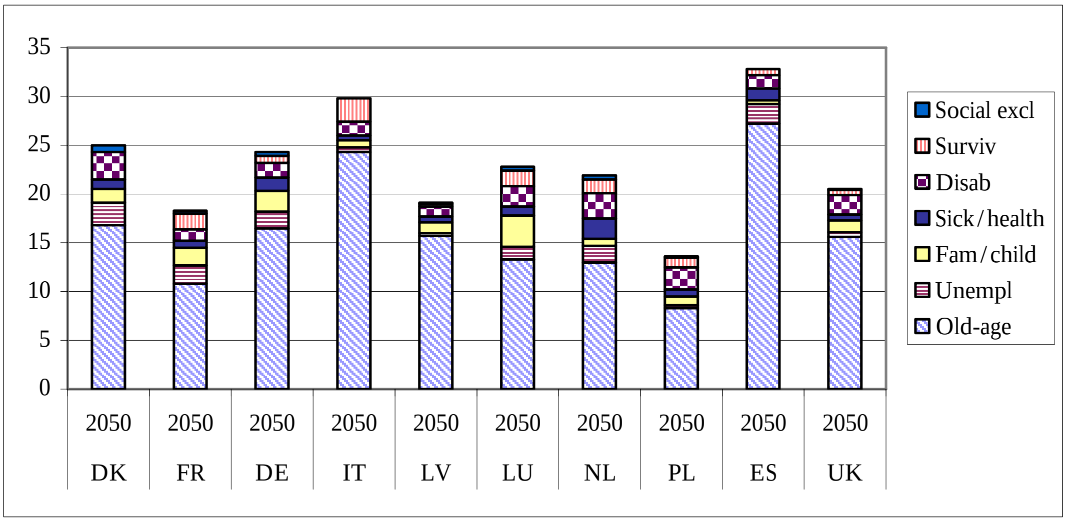
Note: old-age includes public and private pensions, 'evolving' life tables.

Figure 2. Social protection expenditure in cash (ESSPROS), as a % of GDP, 2005



Source: our calculations (SAM).

Figure 3. Social protection expenditure in cash (ESSPROS), as a % of GDP, 2050



Source: our calculations (SAM).

Table 12. Old-age expenditure (in cash, ESSPROS definition), as a % of GDP

	2005	2010	2020	2030	2040	2050
'Evolving' tables						
Denmark	9.2	10.6	12.9	15.8	17.6	16.8
France	10.4	10.3	10.4	10.8	11.1	10.8
Germany	11.5	10.6	10.7	13.8	15.7	16.5
Italy	13.0	13.0	13.9	17.3	22.3	24.3
Latvia	5.7	5.5	7.4	9.9	12.4	15.7
Luxembourg	5.8	6.3	8.4	11.6	13.0	13.3
Netherlands	8.7	8.9	10.2	12.6	13.5	13.0
Poland	10.8	7.8	6.5	6.3	7.2	8.3
Spain	8.1	9.1	11.1	15.7	22.9	27.2
United Kingdom	10.0	10.1	11.0	13.2	14.4	15.6
Constant tables						
Denmark	9.2	10.4	12.1	14.0	15.0	13.7
France	10.4	9.9	9.5	9.3	9.1	8.6
Germany	11.6	10.2	9.6	11.8	12.7	12.7
Italy	13.0	12.6	12.8	15.3	18.9	19.5
Latvia	5.7	5.4	6.7	8.5	9.8	11.8
Luxembourg	5.7	6.0	7.6	10.1	10.8	10.5
Netherlands	8.7	8.7	9.6	11.3	11.8	11.2
Poland	10.8	7.5	5.9	5.3	5.7	6.4
Spain	8.0	8.7	10.1	13.9	19.7	22.4
United Kingdom	10.0	9.8	10.1	11.5	12.0	12.5

Table 13. Old-age pension expenditure decomposition

	$\frac{PensExp/GDP_t}{PensExp/GDP_0}$	$\frac{DepEff_t}{DepEff_0}$	$\frac{EmplEff_t}{EmplEff_0}$	$\frac{Take-upEff_t}{Take-upEff_0}$	$\frac{BenefitEff_t}{BenefitEff_0}$
	(a)	(b)	(c)	(d)	(e)
Denmark	1.34	1.77	0.97	0.90	0.87
France	1.03	1.89	0.94	0.81	0.72
Germany	1.07	2.01	0.91	0.79	0.74
Italy	1.58	2.24	0.88	0.81	0.99
Latvia	2.78	1.83	0.89	1.04	1.65
Luxembourg	2.31	1.71	0.97	1.11	1.25
Netherlands	1.44	1.87	0.95	0.79	1.02
Poland	0.77	2.72	0.79	0.80	0.45
Spain	3.37	2.75	0.87	1.14	1.24
United Kingdom	1.72	1.86	0.96	0.80	1.20

Source: our calculations (SAM).

Note: pension expenditure is computed according to the ESSPROS definition, 'evolving' life tables.

Table 14 presents projections of public pensions expenditure calculated with SAM using alternative starting values, that is those taken from EPC-EC (2005). For an explanation of the difference between data in Tables 11 and 14, see sub-section 3.6. Spain and Luxembourg have the fastest growing expenditure, and Poland shows a decreasing expenditure to GDP, as in the EPC-EC (2005). Results in Table 14 can be compared with those in Table 15, that collects results from EPC-EC (2005) itself. The initial values in Tables 14 and 15 are very similar by hypothesis, but our results at 2050 are generally higher than EPC-EC (2005)'s ones, with the exception of France, Germany and the Netherlands where they are lower.

Table 14. Public pensions (AWG definition), as % of GDP

	2005	2010	2020	2030	2040	2050
Denmark	9.8	11.1	12.8	14.5	14.9	13.1
France	12.8	12.6	12.8	13.3	13.7	13.2
Germany	11.3	10.3	9.9	11.8	12.5	12.0
Italy	14.2	14.1	14.6	17.6	21.6	22.5
Latvia	6.8	6.6	8.8	11.9	14.8	18.8
Luxembourg	10.0	11.0	14.5	20.1	22.5	23.1
Netherlands	7.7	7.8	8.8	10.9	11.5	11.0
Poland	13.0	9.3	7.8	7.6	8.7	10.0
Spain	8.8	9.9	12.1	17.1	24.9	29.6
United Kingdom	6.6	6.7	7.4	9.1	10.3	11.4

Source: our calculations (SAM).

Note: public pensions include old-age, early retirement, disability and widows' pensions, 'evolving' life tables.

Table 15. EC's projections of public pensions expenditure, as % of GDP

	2005	2010	2020	2030	2040	2050
Denmark	9.5	10.1	11.3	12.8	13.5	12.8
France	12.8	12.9	13.7	14.3	15	14.8
Germany	11.4	10.5	11	12.3	12.8	13.1
Italy	14.2	14	14	15	15.9	14.7
Latvia	6.8	4.9	4.9	5.6	5.9	5.6
Luxembourg	10	9.8	11.9	15	17	17.4
Netherlands	7.7	7.6	9	10.7	11.7	11.2
Poland	13.9	11.3	9.7	9.2	8.6	8
Spain	8.6	8.9	9.3	11.8	15.2	15.7
United Kingdom	6.6	6.6	6.9	7.9	8.4	8.6

Source: ECP-EC (2005).

The sustainability analysis is presented in Tables 16 and 17. In this exercise, sustainability is not about the pension expenditure-GDP ratio per se, but about the possibility of governments to tax citizens, or to issue public debt, in order to support that ratio. We calculated the public pension 'notional contribution rate', displayed in Table 17. A comparison of the theoretical index with the effective national payroll taxes and with the current level of debt to GDP can be helpful to gain insights on the present and future sustainability of the system. Even though there are no objective criteria to assess what a tolerable notional payroll tax rate is, it is straightforward that a notional payroll tax rate projected to increase well above its current effective level, accompanied by a high level of public debt, is a signal of future sustainability problems.

For instance in both Italy and Spain the notional payroll tax rate in 2030 and 2050 is higher than the current one, but the two countries will face different sustainability problems given their present remarkable difference in the debt to GDP ratio, that is palpably higher in Italy that in Spain. The comparison between current and notional payroll tax rates is, instead, less meaningful in Denmark and the UK, because public pensions are financed by taxes in the first place and there are no separate contributions for old-age pensions in the UK.

Table 16. Notional equilibrium payroll tax rate

	"Standard definition"			Corrected with public debt		
	2010	2030	2050	2010	2030	2050
Denmark	19.2	25.4	23.0	19.1	25.9	23.1
France	31.5	33.6	33.4	31.5	34.3	34.1
Germany	27.8	32.2	33.0	27.7	34.1	34.3
Italy	35.7	45.0	57.6	38.0	49.6	61.1
Latvia	13.1	23.0	36.7	11.9	22.8	37.0
Luxembourg	20.2	37.3	43.0	20.2	37.3	43.0
Netherlands	10.7	15.3	15.5	11.1	16.0	15.8
Poland	25.4	20.9	28.0	20.9	20.4	30.1
Spain	21.2	37.0	64.2	20.9	37.8	65.3
United Kingdom	4.9	6.7	8.4	4.7	6.9	8.7

Source: our calculations (SAM).

Note: pension expenditure and income bill are both from semi-aggregate projections, 'evolving' life tables.

Table 17. Context indicators for sustainability

	Effective old-age contribution rates (employee plus employer), 2004	Public debt to GDP, % 2004
Denmark	Tax-financed	36.0
France	24	66.2
Germany	19.5	67.3
Italy	33	108.8
Latvia	33.09	10.9
Luxembourg	16	4.4
Netherlands	19.5	52.1
Poland	32.52	47.7
Spain	28.3	42.9
United Kingdom	No separate pension contribution	43.1

Source: payroll tax rates: OECD (2007) and EC (2006); debt: Eurostat.

5. Alternative scenarios: hypotheses and results

This section presents results for alternative scenarios. Since the main driving factors of the projections are the demographic evolution and the hypotheses on the labour market, a number of scenarios will deal with these exogenous assumptions. Moreover, since the old-age pension expenditure is also driven by the assumptions on the replacement rates, this hypothesis will also be investigated.

Section 5.1 presents results for the so-called 'Lisbon scenario'. In Section 5.2 the effect of high and low demographic scenarios on macroeconomic variables and social expenditure is alternatively analysed. Section 5.3 explores the impact of different replacement rates.

5.1 Lisbon scenario

As mentioned in its description, the model also allows us to set exogenous targets for the employment rates to be reached in a given year. This can be used to analyse the effect of reaching the employment targets set in the Lisbon and Stockholm European Councils on the overall economy and on social expenditure. This is obviously an unrealistic scenario, since it is apparent that many countries will not meet such targets by the given date. However, this allows us to appreciate the effects of higher employment and participation rates on social protection expenditure. Further, the same exercise could be repeated imposing the attainment of the targets over a more reasonable horizon (e.g. 2015 or later).

The employment targets the model is imposing are:

- 70% for total employment;
- 60% for female employment;
- 50% for middle-aged (55-64) employment.

The Lisbon scenario does not change anything in Denmark, Germany, the Netherlands and the UK because the employment level they attain in 2010 in the baseline projection scenario is already beyond 70%. For other countries, employment rates increase steeply – and unrealistically – between 2005 and 2010 to reach the targets and then vary according to the evolution of demography and the unemployment exogenous projections (Tables 18 to 20). After 2010 total employment rates vary very little both across countries and over time, as they already reached relatively high levels. A higher degree of variation is present, however, in the employment rates of women and the middle-aged (Tables 19 and 20).

Table 18. Employment rate, total – Lisbon scenario, %

	2005	2010	2020	2030	2040	2050
Denmark	76.4	77.3	77.1	77.4	77.8	76.4
France	70.0	70.0	70.1	70.9	71.0	70.0
Germany	70.8	73.4	72.9	73.7	73.3	70.8
Italy	70.0	70.0	70.0	71.1	71.6	70.0
Latvia	70.0	71.6	71.6	71.7	72.1	70.0
Luxembourg	70.0	70.0	70.3	70.6	70.6	70.0
Netherlands	75.3	76.6	76.7	78.2	77.9	75.3
Poland	70.0	71.6	72.0	72.0	72.8	70.0
Spain	70.0	70.0	70.0	70.7	71.8	70.0
United Kingdom	72.8	74.3	74.3	75.1	74.7	72.8

Source: our calculations (SAM).

Table 19. Employment rate, female – Lisbon scenario, %

	2005	2010	2020	2030	2040	2050
Denmark	70.9	72.0	72.9	72.5	72.9	73.4
France	57.3	63.6	63.6	63.7	64.5	64.5
Germany	59.8	64.8	67.2	66.8	67.8	67.2
Italy	47.2	60.0	60.1	60.3	61.3	61.7
Latvia	59.5	65.5	67.1	67.5	67.5	67.9
Luxembourg	54.2	60.2	60.4	60.7	61.0	61.0
Netherlands	66.9	69.5	72.4	73.3	74.9	74.6
Poland	49.8	65.1	66.8	67.4	67.4	68.2
Spain	51.8	60.0	60.0	60.0	60.9	62.1
United Kingdom	65.8	67.3	69.6	70.3	71.4	71.1

Source: our calculations (SAM).

Table 20. Employment rate, middle-aged (55-64) – Lisbon scenario, %

	2005	2010	2020	2030	2040	2050
Denmark	60.7	60.8	64.8	63.1	62.3	65.9
France	39.2	50.0	50.9	51.2	53.0	53.1
Germany	39.5	53.1	61.9	60.0	62.7	61.6
Italy	33.1	50.0	52.3	53.0	53.2	54.1
Latvia	45.0	50.8	51.3	53.3	54.4	54.7
Luxembourg	33.8	50.0	50.9	50.9	52.0	52.6
Netherlands	46.2	50.0	52.9	52.5	54.2	54.8
Poland	28.2	50.0	50.0	52.3	54.7	54.9
Spain	41.1	50.0	52.3	54.0	54.1	54.9
United Kingdom	55.3	56.3	61.3	61.3	63.3	62.9

Source: our calculations (SAM).

Old-age pensions expenditure decreases as a percentage of GDP for all the countries where the Lisbon targets would not be achieved in the baseline scenario (Tables 21 and 23). In Poland, Spain and Italy, the reduction is of two percentage points or more in both tables. Other types of expenditure undergo modest reductions as well, but by smaller percentages. A similar reduction applies to the notional payroll tax rate (Table 24).

This reduction in pension expenditure goes through the three channels where employment plays a role, these are the employment effect, the take-up effect and the benefits effect (Table 22). In particular, the employment effect has a greater offsetting impact in this scenario with respect to the baseline one.

Table 21. Social protection expenditure in cash (ESSPROS definition), as a % of GDP

		Old age	Un empl	Fam/ child	Sick/ health	Disab	Surviv	Social excl	Total
Denmark	*2005*	9.2	2.6	1.6	1.0	2.8	0.0	0.8	18.0
	2050	16.8	2.3	1.4	1.0	2.8	0.0	0.7	25.0
France	*2005*	10.3	2.2	2.0	0.7	1.2	1.8	0.4	18.6
	2050	10.3	1.8	1.8	0.7	1.2	1.5	0.3	17.5
Germany	*2005*	11.5	2.1	2.2	1.4	1.5	0.4	0.4	19.4
	2050	16.5	1.7	2.1	1.4	1.5	0.7	0.4	24.2
Italy	*2005*	12.4	0.4	0.6	0.5	1.4	2.4	0.0	17.9
	2050	22.0	0.4	0.6	0.5	1.4	2.2	0.0	27.1
Latvia	*2005*	5.6	0.4	1.1	0.6	1.0	0.3	0.1	9.2
	2050	14.4	0.3	1.1	0.6	1.0	0.3	0.1	17.8
Luxembourg	*2005*	5.7	1.1	3.3	0.8	2.1	2.3	0.4	15.6
	2050	13.8	1.3	3.0	0.9	2.1	1.5	0.3	22.8
Netherlands	*2005*	8.7	1.7	0.7	2.1	2.6	1.4	0.5	17.8
	2050	13.0	1.7	0.7	2.1	2.6	1.4	0.4	22.0
Poland	*2005*	10.2	0.7	0.9	0.7	2.3	1.0	0.1	15.9
	2050	7.6	0.3	0.9	0.7	2.3	1.0	0.1	12.9
Spain	*2005*	8.0	2.3	0.4	1.2	1.4	0.6	0.0	13.9
	2050	25.2	1.9	0.4	1.2	1.4	0.6	0.0	30.7
United Kingdom	*2005*	10.0	0.5	1.3	0.6	2.0	0.8	0.1	15.4
	2050	15.6	0.5	1.2	0.6	2.0	0.5	0.1	20.4

Source: our calculations (SAM).

Note: old-age includes public and private pensions, ‘evolving’ life tables.

Table 22. Old-age pension expenditure decomposition

	$\frac{PensExp/GDP_t}{PensExp/GDP_0}$	$\frac{DepEff_t}{DepEff_0}$	$\frac{EmplEff_t}{EmplEff_0}$	$\frac{Take-upEff_t}{Take-upEff_0}$	$\frac{BenefitEff_t}{BenefitEff_0}$
	(a)	(b)	(c)	(d)	(e)
Denmark	1.34	1.77	0.97	0.90	0.87
France	1.00	1.89	0.90	0.81	0.72
Germany	1.07	2.01	0.91	0.79	0.74
Italy	1.49	2.24	0.82	0.80	1.01
Latvia	2.56	1.83	0.88	0.93	1.69
Luxembourg	2.44	1.71	0.91	1.15	1.37
Netherlands	1.44	1.87	0.95	0.79	1.02
Poland	0.74	2.72	0.75	0.79	0.46
Spain	3.16	2.75	0.87	1.03	1.29
United Kingdom	1.72	1.86	0.96	0.80	1.20

Source: our calculations (SAM).

Note: pension expenditure is computed according to the ESSPROS definition, ‘evolving’ life tables.

Table 23. Public pensions (AWG definition), as % of GDP

	2005	2010	2020	2030	2040	2050
Denmark	9.8	11.1	12.8	14.5	14.9	13.1
France	12.5	10.7	11.7	12.8	13.0	12.4
Germany	11.3	10.3	9.9	11.8	12.5	12.0
Italy	13.7	11.3	13.7	16.7	20.0	20.5
Latvia	6.7	6.5	9.0	11.5	14.1	17.2
Luxembourg	9.6	8.7	14.4	20.2	23.3	23.5
Netherlands	7.7	7.8	8.8	10.9	11.5	11.0
Poland	12.3	6.8	7.2	7.7	8.2	9.1
Spain	8.6	8.8	12.2	16.8	23.2	27.2
United Kingdom	6.6	6.7	7.4	9.1	10.3	11.4

Source: our calculations (SAM).

Note: public pensions include old-age, early retirement, disability and widows' pensions, 'evolving' life tables.

Table 24. Notional payroll tax rate – without public debt

	Lisbon			Baseline		
	2010	2030	2050	2010	2030	2050
Denmark	19.2	25.4	23.0	19.2	25.4	23.0
France	28.0	33.8	32.8	31.5	33.6	33.4
Germany	27.8	32.2	33.0	27.8	32.2	33.0
Italy	29.6	44.3	54.3	35.7	45.0	57.6
Latvia	13.1	22.5	34.1	13.1	23.0	36.7
Luxembourg	16.6	38.6	45.1	20.2	37.3	43.0
Netherlands	10.7	15.3	15.5	10.7	15.3	15.5
Poland	19.4	21.8	26.4	25.4	20.9	28.0
Spain	19.3	36.8	60.2	21.2	37.0	64.2
United Kingdom	4.9	6.7	8.4	4.9	6.7	8.4

Source: our calculations (SAM).

Note: pension expenditure and income bill are both from semi-aggregate projections, 'evolving' life tables.

5.2 Sensitivity analysis on demographic projections

Eurostat releases several variants of population projections. Among the various available, we selected the 'high' and 'low' variants to serve as an input for sensitivity tests. The high demographic projections differ from the baseline in that they assume higher values for the key parameters, which are net migration, total fertility rate and life expectancy at birth for males and females. The reverse applies to the low variant.

Dependency rates presented in Table 25 are based on the demographic projections that constitute an input to the model. They are higher with respect to the baseline for the low demographic variant and lower for the high variant. For some countries, the low variant tends to produce slightly higher employment rates, by one or two percentage points, during the middle of the simulation period, around 2020s-2030s (Table 27). In the ling run, per capita GDP growth rates are higher in the high variant (Table 26).

The lower dependency rates for the high variant correspond to lower values of social protection expenditures (Table 28). Analogously, notional payroll tax rates are lower in the high variant (Table 29).

Table 25. Dependency rates

	2005	2010	2020	2030	2040	2050
Low demographic scenario						
Denmark	22.6	24.8	31.0	37.0	43.1	42.1
France	25.3	25.8	33.0	40.8	47.8	49.8
Germany	27.8	31.1	35.3	47.3	58.1	60.9
Italy	29.4	31.3	36.6	45.8	62.1	70.2
Latvia	24.1	25.2	27.9	34.0	38.8	46.2
Luxembourg	21.2	21.7	25.4	33.9	41.2	41.1
Netherlands	20.7	22.2	29.0	37.4	43.6	41.5
Poland	18.7	18.7	26.7	36.1	40.6	53.0
Spain	24.5	25.4	29.9	39.2	56.4	72.5
United Kingdom	24.4	25.2	30.6	38.5	46.6	49.2
Baseline demographic scenario						
Denmark	22.6	24.8	31.2	37.1	42.1	40.0
France	25.3	25.9	33.2	40.7	46.9	47.9
Germany	27.8	31.0	35.1	46.0	54.6	55.8
Italy	29.4	31.3	36.6	45.2	59.8	66.0
Latvia	24.1	25.2	28.0	33.4	37.4	44.1
Luxembourg	21.2	21.6	24.7	31.5	36.7	36.1
Netherlands	20.7	22.2	29.0	36.7	41.6	38.6
Poland	18.7	18.8	27.1	35.7	39.7	51.0
Spain	24.5	25.4	30.0	38.9	54.3	67.5
United Kingdom	24.4	25.1	30.3	37.4	43.8	45.3
High demographic scenario						
Denmark	22.6	24.9	31.5	37.4	41.8	39.2
France	25.3	25.8	33.3	40.4	45.7	45.9
Germany	27.8	30.9	35.0	44.9	51.2	50.5
Italy	29.4	31.4	37.1	45.3	57.9	61.9
Latvia	24.1	25.2	28.1	32.6	35.0	40.1
Luxembourg	21.1	21.5	24.4	30.6	35.0	34.4
Netherlands	20.7	22.1	28.9	36.0	39.6	36.1
Poland	18.7	18.8	27.3	35.2	38.0	46.7
Spain	24.5	25.4	30.2	38.6	52.4	62.9
United Kingdom	24.4	25.1	30.6	37.3	42.5	43.2

Source: our computation on Eurostat data.

Note: computed as population 65+/population 15-64.

Table 26. Per capita GDP growth, period average, % growth

	Low demographic scenario					**High demographic scenario**				
	2005-2010	2011-2020	2021-2030	2031-2040	2041-2050	2005-2010	2011-2020	2021-2030	2031-2040	2041-2050
Denmark	2.1	1.9	1.4	1.3	2.0	2.0	1.6	1.2	1.4	2.0
France	1.7	1.7	1.5	1.4	1.6	1.6	1.4	1.4	1.4	1.7
Germany	1.9	1.7	0.9	1.2	1.5	1.7	1.5	0.8	1.4	1.7
Italy	1.6	1.9	1.4	0.8	1.3	1.5	1.6	1.2	1.0	1.5
Latvia	8.6	5.1	2.9	1.9	1.0	8.4	4.7	2.8	2.0	1.1
Luxembourg	2.3	2.1	1.2	1.4	1.7	2.2	2.0	1.1	1.4	1.7
Netherlands	1.4	1.6	1.2	1.4	1.9	1.3	1.4	1.1	1.6	1.9
Poland	6.1	4.1	2.9	1.5	0.9	5.9	3.7	2.7	1.7	1.1
Spain	2.5	2.4	1.5	0.6	0.9	2.3	2.1	1.3	0.8	1.1
United Kingdom	2.6	2.3	1.5	1.4	1.5	2.5	2.0	1.4	1.5	1.6

Source: our calculations (SAM).

Table 27. Employment rates, %

	Low demographic scenario					**High demographic scenario**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Denmark	76.4	77.3	77.2	77.7	78.0	76.3	77.3	77.0	77.3	77.8
France	64.4	66.2	68.0	68.9	68.3	64.4	66.1	67.0	67.6	67.6
Germany	70.8	73.4	73.2	74.2	73.6	70.8	73.4	72.5	73.1	72.9
Italy	61.0	63.7	64.5	65.5	65.8	61.1	63.8	63.7	64.4	65.2
Latvia	69.9	73.7	73.4	72.7	71.3	69.9	73.7	71.6	71.3	71.0
Luxembourg	64.3	64.7	65.1	66.2	65.9	64.4	65.3	65.0	65.4	65.2
Netherlands	75.3	76.5	76.7	78.1	77.6	75.4	76.7	76.8	78.3	78.2
Poland	57.0	64.8	69.5	66.3	65.5	57.0	64.9	67.6	65.5	66.2
Spain	66.3	70.1	70.6	70.7	71.6	66.3	70.1	69.6	69.7	70.8
United Kingdom	72.8	74.2	74.4	75.2	74.7	72.9	74.4	74.2	75.0	74.7

Source: our calculations (SAM).

Table 28. Social protection expenditure in cash (ESSPROS definition), as a % of GDP

		Old age	Unempl	Fam/ child	Sick/ health	Disab	Surviv	Social excl	Total
Low demographic scenario									
Denmark	2005	9.2	2.6	1.6	1.0	2.8	0.0	0.8	18.0
	2050	18.7	2.3	1.3	1.0	2.8	0.0	0.7	26.8
France	2005	10.4	2.2	2.0	0.7	1.2	1.9	0.4	18.8
	2050	11.6	1.9	1.8	0.7	1.2	1.6	0.3	19.2
Germany	2005	11.5	2.1	2.2	1.4	1.5	0.4	0.4	19.5
	2050	18.8	1.7	2.2	1.3	1.5	0.8	0.4	26.7
Italy	2005	13.0	0.5	0.7	0.5	1.4	2.5	0.0	18.6
	2050	26.6	0.5	0.7	0.5	1.4	2.5	0.0	32.3
Latvia	2005	5.7	0.4	1.1	0.6	1.0	0.3	0.1	9.2
	2050	18.2	0.3	1.1	0.6	1.0	0.3	0.1	21.6
Luxembourg	2005	5.8	1.1	3.4	0.8	2.1	2.3	0.4	15.8
	2050	15.3	1.3	3.2	0.8	2.1	1.8	0.4	24.9

Netherlands	2005	8.7	1.7	0.7	2.1	2.6	1.4	0.5	17.8
	2050	14.7	1.8	0.7	2.1	2.6	1.6	0.4	24.0
Poland	2005	10.8	0.7	0.9	0.7	2.3	1.0	0.1	16.5
	2050	9.6	0.3	0.9	0.7	2.3	1.0	0.1	15.0
Spain	2005	8.1	2.4	0.4	1.2	1.4	0.6	0.0	14.1
	2050	30.2	2.0	0.3	1.2	1.4	0.6	0.0	35.8
United Kingdom	2005	10.0	0.5	1.3	0.6	2.0	0.8	0.1	15.4
	2050	17.5	0.4	1.1	0.6	2.0	0.6	0.1	22.4
High demographic scenario									
Denmark	2005	9.2	2.6	1.6	1.0	2.8	0.0	0.8	18.0
	2050	15.5	2.3	1.4	1.0	2.8	0.0	0.7	23.7
France	2005	10.4	2.2	2.0	0.7	1.2	1.9	0.4	18.8
	2050	10.0	1.9	1.8	0.7	1.2	1.5	0.3	17.5
Germany	2005	11.5	2.1	2.2	1.4	1.5	0.4	0.4	19.4
	2050	14.2	1.6	2.1	1.4	1.5	0.6	0.4	21.8
Italy	2005	13.0	0.5	0.7	0.5	1.4	2.5	0.0	18.6
	2050	22.0	0.4	0.7	0.5	1.4	2.3	0.0	27.3
Latvia	2005	5.7	0.4	1.1	0.6	1.0	0.3	0.1	9.2
	2050	13.3	0.3	1.1	0.6	1.0	0.3	0.1	16.7
Luxembourg	2005	5.8	1.1	3.3	0.8	2.1	2.3	0.4	15.8
	2050	12.3	1.3	3.1	0.9	2.1	1.5	0.4	21.5
Netherlands	2005	8.7	1.7	0.7	2.1	2.6	1.4	0.5	17.8
	2050	11.5	1.6	0.7	2.1	2.7	1.3	0.4	20.3
Poland	2005	10.8	0.7	0.9	0.7	2.3	1.0	0.1	16.5
	2050	7.0	0.3	0.9	0.7	2.3	1.0	0.1	12.4
Spain	2005	8.1	2.4	0.4	1.2	1.4	0.6	0.0	14.0
	2050	24.4	1.9	0.4	1.2	1.4	0.6	0.0	29.9
United Kingdom	2005	10.0	0.5	1.3	0.6	2.0	0.8	0.1	15.4
	2050	14.0	0.5	1.2	0.6	2.0	0.5	0.1	18.9

Source: our calculations (SAM).

Note: old-age includes public and private pensions, 'evolving' life tables.

Table 29. Sustainability indicator – not corrected for public debt

	Low demographic scenario			**High demographic scenario**		
	2010	2030	2050	2010	2030	2050
Denmark	19.2	26.0	25.1	19.1	24.8	21.4
France	31.5	34.0	35.6	31.3	33.0	31.2
Germany	28.0	33.8	37.4	27.7	30.7	28.7
Italy	35.8	45.7	62.6	35.6	43.8	52.6
Latvia	13.2	24.0	42.3	13.0	22.0	31.2
Luxembourg	20.4	40.4	49.1	20.1	35.5	39.9
Netherlands	10.8	15.8	17.3	10.7	14.6	13.9
Poland	25.5	21.7	32.1	25.3	20.3	23.8
Spain	21.3	38.0	70.9	21.1	36.0	58.4
United Kingdom	5.0	7.1	9.4	4.9	6.5	7.6

Source: our calculations (SAM).

Note: pension expenditure and income bill are both from semi-aggregate projections, 'evolving' life tables.

5.3 Sensitivity analysis on old-age benefits level

The work by the Indicators Sub-Group of the Social Protection Committee (ISG-SPC, 2006) contains theoretical replacement rates (RRs) projections for several ‘representative individuals’. Individuals with income equal to the national average are chosen as the benchmark and used in the baseline scenario of the present study. These are male full-time workers, employed from the age of 25 to 65, thus with 40 years’ seniority.

These replacement rates not only might not be representative of the whole population but might not provide a correct representation of the evolution of future benefits level. Given the unavoidable uncertainty of long-term projections and the importance of theoretical replacement rates in the computation of aggregate expenditure, a sensitivity analysis on replacement rates is needed.

Results are presented assuming that replacement rates of new pensioners – and therefore their old-age benefits – can be 5 percentage points higher or lower than the baseline.

As expected, lower replacement rates produce pension expenditures by 0.5-1.5 percentage points lower depending on the countries (Tables 30 and 31). In the same way, the notional payroll tax rate is lower for lower RRs in all the countries analysed (Table 32).

Table 30. Social protection expenditure in cash (ESSPROS definition), as a % of GDP

		Old –age expenditure with **Higher RR**	Old-age expenditure with **Lower RR**
Denmark	*2005*	9.2	9.2
	2050	17.7	15.9
France	*2005*	10.4	10.4
	2050	11.6	10.0
Germany	*2005*	11.5	11.5
	2050	17.5	15.5
Italy	*2005*	13.0	13.0
	2050	25.3	23.3
Latvia	*2005*	5.7	5.7
	2050	16.6	14.8
Luxembourg	*2005*	5.8	5.8
	2050	13.8	12.8
Netherlands	*2005*	8.7	8.7
	2050	15.6	14.4
Poland	*2005*	10.8	10.8
	2050	10.1	8.6
Spain	*2005*	8.1	8.1
	2050	28.4	25.9
United Kingdom	*2005*	10.0	10.0
	2050	20.1	18.3

Source: our calculations (SAM).

Note: old-age includes public and private pensions, ‘evolving’ life tables.

Table 31. Public pensions expenditure (AWG definition)

	Public pension expenditure with **Higher RR**			Public pension expenditure with **Lower RR**		
	2010	2030	2050	2010	2030	2050
Denmark	11.1	15.0	14.1	11.0	14.1	12.1
France	12.6	13.7	14.2	12.6	12.9	12.3
Germany	10.3	12.2	13.0	10.3	11.4	11.0
Italy	14.1	17.9	23.6	14.1	17.2	21.4
Latvia	6.6	12.2	19.8	6.6	11.5	17.7
Luxembourg	11.0	20.5	24.0	10.9	19.7	22.2
Netherlands	8.2	13.0	14.0	8.1	11.8	11.5
Poland	9.6	8.6	12.2	9.6	8.1	10.4
Spain	9.9	17.5	30.9	9.8	16.8	28.2
United Kingdom	7.2	12.1	16.6	7.1	10.1	11.7

Source: our calculations (SAM).

Note: ‘Evolving’ life tables.

Table 32. Notional payroll tax rate (without public debt)

	Notional payroll tax rate with **Higher RR**			Notional payroll tax rate with **Lower RR**		
	2010	2030	2050	2010	2030	2050
Denmark	19.2	26.2	24.7	19.1	24.6	21.2
France	31.5	34.6	35.8	31.4	32.7	31.0
Germany	27.9	33.3	35.7	27.8	31.0	30.3
Italy	35.8	46.0	60.4	35.7	44.0	54.7
Latvia	13.2	23.6	38.7	13.1	22.3	34.6
Luxembourg	20.3	38.0	44.6	20.2	36.6	41.4
Netherlands	11.0	17.8	19.4	11.0	16.3	15.9
Poland	23.0	21.0	30.0	23.0	19.8	25.6
Spain	21.3	37.8	67.1	21.2	36.2	61.3
United Kingdom	5.2	8.7	11.9	5.1	7.3	8.4

Source: our calculations (SAM).

Note: pension expenditure and income bills are both from semi-aggregate projections, ‘evolving’ life tables.

6. Conclusions

The SAM model described in this study was mainly developed to deliver semi-aggregate projections by age class and gender of income sources, including social protection benefits, in order to provide an input to compute Comprehensive Replacement Rates (COREs). The model includes a selection of European countries – namely Denmark, France, Germany, Italy, Latvia, Luxembourg, Netherlands, Poland, Spain and the UK – and carries out projection over a time horizon spanning from 2005 to 2050.

The partial equilibrium adopted allows both a greater flexibility in the choice of countries and in the building of scenarios, while at the same time offering an easier understanding of its inner mechanisms with respect to general equilibrium models. While providing semi-aggregate projections, the model can also supply projections of main macroeconomic aggregates.

In particular, the model is able to provide insights into labour market evolution and economic growth developments, taking into account the effect of population ageing on the basis of demographic projections up to 2050. It also produces projections of different components of household income, devoting special attention to old-age benefits. Projections of other social protection transfers, such as survivors' and invalidity pensions, unemployment, family-related benefits, education-related benefits, and housing and social assistance are also included in the modelling framework.

The results presented in this report show macroeconomic aggregate projections. The baseline scenario highlights the rising trend of old-age dependency rates in all countries analysed. The exogenous increase in the rates of participation in the labour force, as well as the decrease in unemployment, bring about a substantial improvement of employment rates until the 2020s. In the following decades, employment growth slows down.

In spite of the increasing labour productivity growth, the rate of growth of GDP undergoes a slight decrease in the countries of the EU15 and a remarkable fall in Poland and Latvia. In the ageing context, the increase in social spending is evident in many countries. The increase in employment and the recent reforms are at least partially able to offset the rise in public pensions expenditure.

To give robustness to the projections, several sensitivity scenarios are built. They are mainly devoted to analysing the role of the main model's driving forces, which are demographic projections and – as far as old-age expenditure is concerned – theoretical replacement rates. In addition, the role of an increase in employment – such as the one necessary to fulfil the Lisbon targets – is also explored.

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Appendix 1.
Improvements on semi-aggregate modelling

Although, as already stated, the semi-aggregate approach is based on previous work, and, in particular on Soede et al. (2004), many new features have been added to SAM, requiring a complete rewriting of the model.

The structure and working of SAM were described in some detail in Section 3. Below is a list of the features already described that are new with respect to previous work.

Programming features

- While in Soede et. al. (2004) only three wide age classes were considered (the younger, in the age-bracket 15-54, the middle aged, aged 55-64, and the elderly, aged 65 or more), SAM groups the population in 5-year age classes, in order to allow for a more detailed analysis of adequacy of social security. The implementation of 5-year age classes also makes the calculation of the flows of new pensioners for each year easier, which was partially constrained by the overly wide age classes in Soede et. al. (2004).
- SAM allows for the implementation of a matrix containing detailed projections of labour market participation rates by gender and age class, while more simplified hypotheses were adopted in previous work.

Projection features

- Time horizon was expanded from 2025 to 2050, thus allowing us to capture the peak of the number of pensioners occurring in most countries after 2025.
- The number of countries was increased from 6 to 10; moreover, they were chosen in order to obtain a demographically representative ensemble as well as an overview of different welfare regimes. As a consequence Spain, Luxembourg, Latvia and Poland were added to the picture.
- Endogenous participation rate/exogenous employment rate, for instance for the Lisbon scenario.
- The economic growth, as well as the interest rates, are corrected to take into account the effects of ageing on consumption; those corrections affect in turn the sustainability of the social security system, although to a nearly negligible extent.
- In the computation of the number of old-age pensions recipients, survival probabilities evolve consistently with the demographic projections, whereas they used to be constant at their 2004 values.

Scenarios building

Additional features have been added, in order to make the scenario-building process more flexible, in particular:

- Change of consumption habits may be analysed, although in a basic way, by altering the age-consumption profiles embedded in the model
- Scenarios with different demographic projections
- Scenarios with different replacement rates.

Appendix 2.
Main social security simulation models in Europe

Table A2.1 Main social security simulation models in Europe up to 2003

Country	Model/Author	Main features	Output
Belgium	MALTESE (Federal Planning Bureau) http://www.plan.be/nl/events/co000120/perugia.pdf	Partial equilibrium/ Multistate	Projections of all social expenditures
Denmark	DREAM http://www.dreammodel.dk/english5CEnglish.htm (web site) http://www.dreammodel.dk/english/intro.asp (introduction page in the web site)	General equilibrium overlapping generations model	Projections of pension expenditure
Germany	CESifo http://www.cesifo.de	Partial Equilibrium	Projections of pension expenditure
Greece	Ministry of Public Finance's model http://europa.eu.int/comm/economy_finance/epc/documents/gr_en.pdf	Partial equilibrium	Projections of the insurance fund Pension System, including the public sector
Spain	Three models (two by the INSS and one by CPE) http://europa.eu.int/comm/economy_finance/epc/documents/es_en.pdf	Partial equilibrium	Projections of pension expenditure
	Model by the Ministry of Economy and Finance http://www.igae.minhac.es/documentos/Ficheros/SGAPRS-2000-01_Ingles.PDF	Partial equilibrium	Projections of pension expenditure
France	Model by the « Comité de Politique Economique » http://europa.eu.int/comm/economy_finance/epc/documents/fr_fr.pdf	Partial equilibrium	Projections of pension expenditure
Austria	Two coordinated models covering the private sector and the civil service scheme http://europa.eu.int/comm/economy_finance/epc/documents/a_en.pdf	Partial equilibrium	Projections of pension expenditure
Sweden	Swedish Pension Simulation Model (by the National Social Insurance Board, RFV) http://www.lse.ac.uk/Depts/sage/conference/work_pres/Swed-pen-mod.ppt	Partial equilibrium microsimulation	Projections of pension expenditure
	Ministry of Public Finance's model (FASIT)	Static model based on the Swedish National Accounts	Projections of public income and expenditure

Country	Model/Author	Main features	Output
	Model for retiring incentives by Martene Palme and Ingemar Svensson http://swopec.hhs.se/hastef/papers/hastef0184.pdf	Partial equilibrium representative agents	Simulation of the social security outcome for a single individual
Finland	Model by Central Pension Security Institute (ETK) http://www.etk.fi http://europa.eu.int/comm/economy_finance/epc/documents/sf_en.pdf	Partial equilibrium	Projections of earning related pensions
	Model by the Social Insurance Institution (KELA) http://193.209.217.5/in/internet/english.nsf?Open	Partial equilibrium	Projections of national pension expenditure
	FOG Model (by Lassila-Valkonen for the ETLA) http://www.etla.fi/english/research/publications/searchengine/pdf/dp/dp765.pdf (in Appendix 2)	A-K type, general equilibrium perfect foresight numerical overlapping generations	Projections of pension expenditures and revenues
Netherlands	General Accounting (GA) model (by the Netherlands Bureau of Economic Policy Analysis, CPB) http://europa.eu.int/comm/economy_finance/epc/documents/nl_en.pdf	Partial equilibrium	Projections of all social expenditures and revenues
	GAMMA model (by the Netherlands Bureau of Economic Policy Analysis, CPB) http://www.cpb.nl/eng/cpbreport/2002_4/s3_3.pdf	Extends the GA model to general equilibrium	Projections of all social expenditures and revenues
Portugal	Model by Pereira and Rodrigues http://europa.eu.int/comm/economy_finance/epc/documents/pt_en.pdf	Actuarial, partial equilibrium	Projections of all social expenditures and revenues as a percentage of GDP
Ireland	Model by the Minister of Finance http://europa.eu.int/comm/economy_finance/epc/documents/irl_en.pdf	Partial equilibrium	Integrated economic and pension projections
United Kingdom	Model by the HM Treasury http://europa.eu.int/comm/economy_finance/epc/documents/uk_en.pdf	Partial equilibrium	Separated projections of all major social expenditures

Country	Model/Author	Main features	Output
Italy	INPS Prevision model Cinzia Ferrara, "Il modello di previsione dell'INPS", in *Le previsioni della spesa per pensioni*, *ISTAT, Annali di statistica,* Serie 10, Vol. 16, pp. 13-22	Partial equilibrium multistate	Projections of the main elements of public pension expenditure
	Model of the Department of General Accounts (RGS) http://cerp.unito.it/Forum/downloads/Archivio/aprile_sidoti.pdf	Partial equilibrium multistate	Projections of pension expenditure (including both social pensions and those paid for the compulsory pension system)
	MODSIM http://www-user.ined.fr/~mad/Rencontres-Sauvy-Paris/Actes/Baldacci.pdf	General equilibrium	Projections of all social expenditures
	Venturini: "Un modello per la stima della ricchezza pensionistica delle famiglie", in *Le previsioni della spesa per pensioni*, *ISTAT*, *Annali di statistica,* Serie 10, Vol. 16, pp. 81-98	Microsimulation	Households' Social Security Wealth
	Cannari and Nicoletti Altimari: "A Dynamic Micro Simulation Model of the Italian Households' Sector" in *Le previsioni della spesa per pensioni, ISTAT, Annali di statistica,* Serie 10, Vol. 16, pp. 103-134	Microsimulation	Households' Social Security Wealth; pension expenditure projections

Source: CeRP.

Appendix 3. Consumption profiles and economic growth[12]

In order to enrich the model, we attempted the introduction of feedback effects from population ageing to GDP growth, through the effect of ageing on consumption and saving behaviour of households.

More precisely, from estimated age-consumption profiles, the total consumption rate over GDP and, in turn, the saving rate can be obtained. The changes in the saving rate induced by ageing then affect – through a production function in a Solow-like environment – the steady state levels of capital and output per unit of productive labour. Therefore, the dynamics of GDP growth (and of interest rate) are modified according to these feedback effects.

A detailed explanation of these mechanisms is provided in the following section. However, we deemed the procedure in appropriate for the purposes of this study and therefore did not use it in the projections. Furthermore, the results obtained with and without the more sophisticated procedure are very similar and do not justify the use of such a complicated tool. The different results are shown in Tables A3.1, A3.2 and A3.3 below.

The methodology would consist of several steps:

- country-specific individual consumption profiles by age are estimated using the SHARE dataset
- age consumption profiles are applied to the evolving structure of the population
- total private consumption over age classes is obtained and its path is calculated throughout all the projection period
- variations of consumption and of GDP are matched to obtain the evolution of the private consumption-GDP ratio.

The effects of ageing on the economic growth and on the interest rates

The estimation of private consumption allows us to disentangle the effects that ageing has on economic growth and on interest rates through the consumption transmission channel.

It must be stressed, however, that no behavioural equation is explicitly considered in the model, and the variation of consumption is deterministically obtained through the application of the age-consumption profile to the evolving age-structure of the population. There is a 'one-way' process from ageing to consumption, income does not influence consumption. The saving rate is jointly determined by the evolution of consumption and the evolution of income; the evolution of income, in turn, is affected by the evolution of the saving rate, and, thus, by consumption.

The procedure we implemented starts from the average saving rate (1-consumption/GDP), which results from our age-related average profiles, and links it, through a Cobb-Douglas production function, to the steady state value of capital per unit of productive labour, as well as to the steady state value of output per unit of productive labour. This means that the variation of the saving rate induced by demographic dynamics causes a succession of 'overlapping transitions' to different steady states; the speed of these transitions is set consistently with empirical evidence on the speed of convergence.[13] Since we are more interested in variations

[12] This appendix comes, with minor variations, from DG Employment and Social Affairs (2007), and the reader should refer to that work for an in-depth explanation of the estimation of the age-consumption profiles.

[13] See Robert J. Barro and Xavier Sala-i-Martin (1995).

than absolute values, with a relatively parsimonious parameterisation of the production function, based on benchmark values, we may generate an interest rate dynamics induced by ageing, as well as a correction of the GDP growth per worker, with respect to the assumed exogenous rate.

In general, from growth accounting, with a production function exhibiting constant returns to scale and labour-augmenting technical progress, $Y = F(K, AL)$, the rate of growth of output may be written as:[14]

$$g = n + (1-\alpha)a + \alpha(\frac{\dot{K}}{K} - n) \tag{A3.1}$$

where g the wanted rate of growth, *n* the rate of growth of the employment, *a* is the rate of growth of the technology term *A*, and α is the capital share, which is constant if we consider a Cobb-Douglas production function.

According to the Solow framework, on the steady growth path, the rate of growth of capital is equal to $a+n$, consequently, the rate of growth of output may be rewritten as: $g = n + a$. This implies that the rate of growth of output per worker, as well as the rate of growth of capital per worker, equal the rate of growth of the labour-augmenting technical progress *a*.

Indeed, as we already stated, assuming we are on the steady growth path, we can obtain the rate of growth of GDP by summing up the rate of growth of employment, and the rate of growth of labour productivity, estimated as output per worker.

If the saving rate changes continuously, however, we never reach a steady state but, on the contrary, experience short intervals of overlapping transitions, each of them driven by a different steady state level of capital per unit of productive labour (K/AL).

Since capital per unit of productive labour varies during transitions, ceteris paribus, the rate of growth of capital will no longer be equal to $a+n$, but a transitional component, m_t , is added, which will gradually shrink approaching the new steady state; thus equation A3.1 may be rewritten as:

$$g_t = n + (1-\alpha)a + \alpha(a + m_t) \tag{A3.2}$$

The m_t component is the rate of growth of $\frac{K}{AL}$, which is gradually adjusting to its new steady state level.

Given a Cobb-Douglas production function we can calculate for each period *T* the new steady state level of $\frac{K}{AL}$ with respect to the first one:

$$\frac{k_T^*}{k_o^*} = \left(\frac{s_T}{s_o}\right)^{1/(1-\alpha)} \tag{A3.3}$$

where k_i^* represent steady state levels of $\frac{K}{AL}$ depending on the saving rate *s* at time *i*.

During transitions, the variation m_t of the capital per unit of productive labour at time *t* may be written as:[15]

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[14] For lengthier explanations see Robert J. Barro and Xavier Sala-i-Martin (1995), from p. 346.

[15] Op cit., pp. 36-38.

$$m_t = \frac{\dot{k}_t}{k_t} = \beta\left(\frac{k_T^*}{k_t} - 1\right) \text{ where } \beta = (1-\alpha)(n + a + \delta) \qquad \text{(A3.4)}$$

δ is the depreciation rate of capital, and β indicates the speed of convergence, in terms of the fraction that vanishes at each period of the gap between the present level of capital per unit of productive labour and its steady state value.

$\frac{k_T^*}{k_t}$ may be obtained even without directly knowing the level of capital per unit of productive labour, but only the ratios between steady state levels:

$$\frac{k_T^*}{k_t} = \frac{k_T^*}{k_0^*}\frac{k_0^*}{k_t} = \frac{k_T^*}{k_0^*}\frac{k_0^*}{k_0^*\prod_{i=1}^{t}(1+m_{i-1})} = \frac{k_T^*}{k_0^*}\frac{1}{\prod_{i=1}^{t}(1+m_{i-1})} \qquad \text{(A3.5)}$$

In such a way, assuming that *k* in the first period of our simulation is not too far from the initial steady state, we are able to 'correct' the growth rate of GDP in order to take into account the alteration of consumption induced by population ageing.

As for the interest rate, unlike the capital stock, we assume it adjusts immediately to its new steady state level.

The rental rate of capital, given by the arbitrage condition,[16] is:

$$R_t = P(r_t + \delta) \qquad \text{(A3.6)}$$

Where *P* is the price, that we assume constant over the projection period, and *r* is the economy-wide real interest rate; from A3.6 we can obtain the variation of the interest rate at each time *t*:

$$r_{t+1} - r_t = (r_t + \delta)\left(\frac{R_{t+1}}{R_t} - 1\right) \qquad \text{(A3.7)}$$

Since in competitive markets the rental rate of capital equals its marginal product, assuming our usual Cobb Douglas framework, the ratio between two steady state levels of the rental rate may be written as:

$$\frac{R_{t+1}^*}{R_t^*} = \left(\frac{k_{t+1}^*}{k_t^*}\right)^{\alpha-1} \qquad \text{(A3.8)}$$

which allows us, finally, to project the variations of the interest rate induced by ageing through the consumption 'channel'.

Table A3.1 below shows the different results for GDP per capita growth rates with or without endogenous feedback from consumption. The computations are done assuming that the income share paid to capital (α) is equal to 0.35 and that the depreciation rate of capital (δ) is zero. Indeed, the additional variation induced by ageing through the consumption channel is very small. Similarly, a comparison of the same growth rates with those of EPC-EC (2005) (Table A3.2) reveals modest differences (in most cases about 0,2 percentage point, slightly higher for Luxembourg, Poland and Spain).

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[16] Op. cit., pp. 348-350.

Real interest rates computed with SAM with endogenous feedback from consumption are displayed in Table A3.3. The same interest rates without the feedback effect would have been equal to 2% in all countries and for the whole period. In EPC-EC (2005) real interest rates are assumed to be equal to 3% in all countries and periods.

Table A3.1 GDP per capita growth rates

	Without endogenous feedback from consumption			**With** endogenous feedback from consumption		
	2004-10	2011-30	2031-50	2004-10	2011-30	2031-50
Denmark	2.0	1.5	1.7	2.0	1.5	1.6
France	1.7	1.5	1.5	1.6	1.4	1.4
Germany	1.8	1.3	1.5	1.8	1.3	1.4
Italy	1.6	1.5	1.2	1.6	1.5	1.1
Latvia	8.5	3.9	1.5	8.4	4.0	1.5
Luxembourg	2.2	1.6	1.6	2.2	1.6	1.5
Netherlands	1.3	1.3	1.7	1.3	1.3	1.6
Poland	6.0	3.4	1.3	6.0	3.6	1.4
Spain	2.4	1.8	0.9	2.5	1.9	0.9
United Kingdom	2.5	1.8	1.5	2.5	1.7	1.3

Source: our calculations (SAM), baseline scenario.

Table A3.2 GDP per capita growth rates, period averages

	2004-10	2011-30	2031-50
Denmark	1.8	1.5	1.7
France	1.7	1.5	1.6
Germany	1.6	1.4	1.5
Italy	1.6	1.6	1.3
Latvia	8.3	3.9	1.5
Luxembourg	3.1	2.1	2.4
Netherlands	1.3	1.3	1.7
Poland	4.7	3.4	1.3
Spain	2.0	1.9	0.9
United Kingdom	2.4	1.8	1.5

Source: EPC-EC, 2005.

Table A3.3 Real interest rates

	2005	2010	2020	2030	2040	2050
Denmark	2.0	2.1	2.2	2.3	2.4	2.4
France	2.0	2.0	2.2	2.3	2.5	2.6
Germany	2.0	1.9	1.9	2.2	2.4	2.5
Italy	2.0	1.9	2.0	2.1	2.4	2.6
Latvia	2.2	2.0	1.9	2.1	2.2	2.5
Luxembourg	2.0	2.0	2.0	2.1	2.2	2.2
Netherlands	2.0	2.0	2.2	2.4	2.5	2.5
Poland	2.1	1.8	1.7	1.7	1.8	2.1
Spain	2.0	1.9	1.8	2.0	2.2	2.4
United Kingdom	2.1	2.1	2.2	2.6	2.9	3.1

Source: our calculations (SAM), baseline scenario.

Appendix 4. Replacement rates from ISG-SPC (2006)

Table A4.1 Denmark

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	45.1	39.2	67.7	62.5	43	37.3	37.6	32.7	22.6	17.8	43.6	41
Gross RR 2nd pillar	3.6	24.8	3.6	24.8	3.6	23.6	3.5	20.6	3.4	18.4	3.6	18.6
Total gross RR	48.7	64	71.3	87.3	46.6	60.9	41.1	53.2	26	36.2	47.2	59.7
Total net RR	71.3	76.1	97.6	101.8	68.5	72.9	61.5	65.1	44.5	51	70	71.5

Table A4.2 Germany

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	43	34	43.3	33.8	41.2	32.2	36.1	28.2	32.5	25.4	34.6	31.6
Gross RR 2nd pillar	0	15	0	14.5	0	13.7	0	11.9	0	10.3	0	12.3
Total gross RR	43	48	43.3	48.3	41.2	45.9	36.1	40.1	32.5	35.7	34.6	43.9
Total net RR	63	67	57.4	66.7	61.2	64.3	55.5	57.8	56.4	49.6	50.8	61.6

Table A4.3 Spain

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	90.5	85.3	90.5	85.3	90.2	85.1	84.9	80.1	71.2	62.2	81.5	76.8
Gross RR 2nd pillar	-	-	-	-	-	-	-	-	-	-	-	-
Total gross RR	90.5	85.3	90.5	85.3	90.2	85.1	84.9	80.1	71.2	62.2	81.5	76.8
Total net RR	97.2	91.6	97.1	91.6	96.8	91.3	91.7	86.6	78.8	70.6	88.6	82.4

Table A4.4 France

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	66.2	49.3	65.8	49.2	65.2	48.5	58.5	43	48.3	32.4	51.1	35.4
Gross RR 2nd pillar	-	-	-	-	-	-	-	-	-	-	-	-
Total gross RR	66.2	49.3	65.9	49.2	65.2	48.5	58.5	43	48.3	32.4	51.1	35.4
Total net RR	79.7	62.6	81.2	61.7	78.8	61.7	71.7	55.6	60.6	43.6	63.9	46.7

Table A4.5 Italy

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	78.9	64.1	78.9	64.1	78.9	61.2	77.1	53.7	73.1	48.4	na	na
Gross RR 2nd pillar	0	15.5	0	15.5	0	14.8	0	12.9	0	11.5	na	na
Total gross RR	78.9	79.7	78.9	79.7	78.9	76	77.1	66.5	73.1	60	na	na
Total net RR	87.8	92	88.1	92	87.7	88.1	85.9	78.3	83.1	74.5	na	na

Table A4.6 Latvia

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	60.8	54.5	64.6	54.5	60.8	51.1	60.8	50.3	60.8	43	45.4	39.8
Gross RR 2nd pillar	-	-	-	-	-	-	-	-	-	-	-	-
Total gross RR	60.8	54.5	64.6	54.5	60.8	51.1	60.8	50.3	60.8	43	45.4	39.8
Total net RR	77.6	71.8	80.3	71.4	77.6	67.3	78.2	66.4	79.3	57	57.9	52.4

Table A4.7 Luxembourg

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	90.8	90.7	97.5	97.3	86.5	86.4	75.7	75.6	65.1	65	52.9	52.8
Gross RR 2nd pillar	0	0	0	0	0	0	0	0	0	0	0	0
Total gross RR	90.8	90.7	97.5	97.3	86.5	86.4	75.7	75.6	65.1	65	52.9	52.8
Total net RR	98.3	98.8	107.4	107.1	94.8	95.3	86.4	86.2	74.1	74	63.5	63.8

Table A4.8 Netherlands

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	29.6	29.6	44.4	44.4	28.2	28.2	24.6	24.6	14.8	14.8	29.6	29.6
Gross RR 2nd pillar	41.6	45.2	26.4	31.8	43	43.2	46	38	55.8	41.1	31.2	33.9
Total gross RR	71.1	74.8	70.8	76.2	71.2	71.3	70.7	62.7	70.6	55.9	60.8	63.5
Total net RR	92.9	97.3	87.9	93.6	93.5	93.9	91.7	84.9	93.6	77.9	81	84.3

Table A4.9 Poland

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	63.2	35.7	63.2	38.7	61.9	33.9	60.4	29.7	59.5	26.8	55.9	26.8
Gross RR 2nd pillar	-	-	-	-	-	-	-	-	-	-	-	-
Total gross RR	63.2	35.7	63.2	38.7	61.9	33.9	60.4	29.7	59.5	26.8	55.9	26.8
Total net RR	77.7	43.9	77.7	43.8	76.1	41.7	74.7	36.6	73.2	33	68.7	32.9

Table A4.10 United Kingdom

	100% of average earnings		2/3 of avg earnings		Concave earning profile		Earnings from 80% to 120% of avg		Earnings from 100% to 200% of avg		Broken career	
	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050	2005	2050
Gross RR 1st pillar	17	19	25	28	16	18	14	16	8	10	17	21
Gross RR 2nd pillar	50	50	49	50	0.5	50	50	50	50	50	33	33
Total gross RR	66	69	74	78	65	68	63	66	58	60	50	54
Total net RR	82	85	91	95	81	84	78	81	71	73	64	69

Appendix 5. Survival probabilities

These two tables compare the number of pensioners computed with 'evolving' and constant survival probabilities. As expected, the use of projected survival rates brings an additional ageing component to the picture, thus increasing the number of pensioners both in absolute values and in relation to the elderly population (65+).

Table A5.1 Number of pensioners

	2005	2010	2020	2030	2040	2050
With 'evolving' life tables						
Denmark	935,993	1,003,167	1,165,169	1,343,133	1,421,852	1,357,851
France	12,029,163	12,439,556	14,008,507	15,735,990	17,180,942	17,637,111
Germany	18,053,229	17,463,196	18,078,243	21,185,359	22,353,584	21,898,156
Italy	12,582,143	12,471,519	12,864,800	14,579,860	16,581,518	16,723,306
Latvia	378,072	368,809	381,803	425,065	460,189	501,326
Luxembourg	46,595	50,327	65,066	89,300	105,464	113,923
Netherlands	2,553,552	2,573,136	2,879,469	3,473,859	3,708,485	3,604,675
Poland	5,514,220	5,332,118	6,017,548	6,715,790	7,673,219	8,676,657
Spain	5,040,000	5,190,614	6,094,984	8,298,718	11,038,222	12,187,115
United Kingdom	12,541,672	12,764,616	13,922,541	16,005,685	17,271,397	17,929,041
With constant life tables						
Denmark	935,993	985,918	1,091,105	1,198,393	1,223,462	1,124,287
France	12,029,163	12,053,998	12,811,462	13,559,440	14,111,389	14,052,198
Germany	18,053,229	16,960,387	16,388,271	18,188,577	18,283,864	17,059,507
Italy	12,582,143	12,156,041	11,877,633	12,787,273	13,999,259	13,443,696
Latvia	378,072	357,340	345,738	359,691	363,014	374,862
Luxembourg	46,595	47,980	58,419	77,198	86,863	89,319
Netherlands	2,553,552	2,523,165	2,714,881	3,127,777	3,282,033	3,129,133
Poland	5,514,220	5,167,679	5,464,138	5,636,490	6,079,756	6,726,065
Spain	5,040,000	5,020,590	5,567,102	7,322,412	9,551,683	10,143,960
United Kingdom	12,541,672	12,412,510	12,705,019	13,754,907	14,156,360	14,155,173

Source: our calculations (SAM) – baseline variant.

Table A5.2 Ratio of total pensioners over the population aged 65+

	2005	2010	2020	2030	2040	2050
With "evolving" life tables						
Denmark	115%	113%	106%	106%	104%	104%
France	121%	120%	107%	100%	97%	98%
Germany	118%	103%	97%	95%	92%	93%
Italy	111%	104%	95%	93%	90%	90%
Latvia	99%	95%	98%	99%	101%	103%
Luxembourg	72%	72%	76%	79%	78%	80%
Netherlands	112%	103%	89%	88%	85%	88%
Poland	110%	105%	89%	81%	88%	88%
Spain	70%	67%	68%	74%	79%	80%
United Kingdom	130%	126%	114%	108%	103%	105%
With constant life tables						
Denmark	115%	111%	99%	95%	89%	86%
France	121%	117%	98%	86%	80%	78%
Germany	118%	100%	88%	82%	75%	72%
Italy	111%	101%	87%	81%	76%	72%
Latvia	99%	92%	89%	84%	79%	77%
Luxembourg	72%	69%	68%	69%	64%	63%
Netherlands	112%	101%	84%	79%	76%	77%
Poland	110%	101%	81%	68%	69%	68%
Spain	70%	65%	62%	65%	69%	66%
United Kingdom	130%	122%	104%	93%	84%	83%

Source: our calculations (SAM) – baseline variant.

About AIM (Adequacy & Sustainability of Old-Age Income Maintenance)

The AIM project aims at providing a strengthened conceptual and scientific basis for assessing the capacity of European pension systems to deliver adequate old age income maintenance in a context of low fertility and steadily increasing life expectancy. The main focus is on the capacity of social security systems to contribute to preventing poverty among the old and elderly and more generally to enable persons to take all appropriate measures to ensure stable or "desired" distribution of income over the full life cycle. In addition it will explore and examine the capacity of pension systems to attain broad social objectives with respect to inter- and intra generational solidarity.

Furthermore it will examine the capacity of pension systems to allow workers to change job or to move temporarily out of the labour market and to adapt career patterns without losing vesting of pensions rights. The project will also address the specific challenges with respect to providing appropriate old age income for women.

A general objective of the research project is to clearly identify and analyse the potential trade-offs between certain social policy objectives and overall stability of public debt.

AIM is financed under the 6th EU Research Framework Programme. It started in May 2005 and includes partners from both the old and new EU member states.

Participating institutes

- Centre for European Policy Studies, CEPS, Belgium, coordinator
- Federal Planning Bureau, FPB, Belgium
- Deutsches Institut für Wirtschafsforschung (German Institute for Economic Research), DIW, Germany
- Elinkeinoelämän tutkimuslaitos, (Research Institute of the Finnish Economy), ETLA, Finland
- Fundación de Estudios de Economía Aplicada , FEDEA, Spain
- Social and Cultural Planning Office, SCP, Netherlands
- Instituto di Studi e Analisi Economica (Institute for Studies and Economic Analysis), ISAE, Italy
- National Institute for Economic and Social Research, NIESR, United Kingdom
- Centrum Analiz Spolleczno-Ekonomicznych (Center for Social and Economic Research), CASE, Poland
- Tarsadalomkutatasi Informatikai Egyesules (TARKI Social Research Informatics Centre), TARKI, Hungary
- Centre for Research on Pensions and Welfare Policies, CeRP, Italy
- Institute for Economic Research, IER, Slovak Republic
- Inštitut za ekonomska raziskovanja (Institute for economic research), IER, Slovenia