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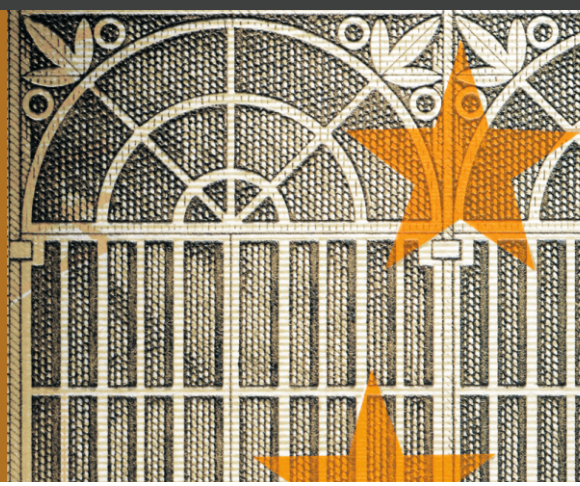

AGEING AND FISCAL SUSTAINABILITY IN A SMALL EURO AREA ECONOMY

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Ageing and fiscal sustainability in a small euro area economy*

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Abstract

Population ageing is a key trend in Western economies. The impact of this trend will be widespread, affecting investment and saving decisions over the next decades, and represents a major challenge to policymakers. Debt sustainability issues in euro area economies may (re)emerge, particularly given the pay-as-you-go nature of most public pension systems. In a decentralised fiscal policy framework, ageing and the respective policy response might intensify the latent macroeconomic imbalances that underlie the ongoing sovereign debt crisis. In this paper, we include a stylised pension system in an open economy New-Keynesian general equilibrium model with non-Ricardian agents. The model is used to assess the macroeconomic impacts of ageing in a small euro area economy. The results suggest that the impact can be significant, depending on the magnitude and pace of the ageing dynamics, the existing rules for social benefits and the policy response. It can be inferred from the results that supranational policy coordination at euro area level is crucial to foster economic and financial stability.

Keywords: ageing, macroeconomic impacts, DSGE model, small-open economy.

JEL classification numbers: E62, F41, H62, J11

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1 Introduction

Population ageing will emerge as a key trend in Western economies over the next decades. Its impacts in economic and social developments will be of utmost importance in the near future. Population ageing will contribute to a reshaping of the labour force. However, it will also lead to an increase in dependency ratios (i.e. an increase in the share of retirees in overall population) and, consequently, in the average marginal propensity to consume, shifting saving/consumption decisions and having an impact in the global saving and investment balance. In addition, the ageing trend will simultaneously increase age-related public spending and narrow the tax bases, raising issues on the sustainability of public debt (ECB 2012, Merola and Sutherland 2012). Nevertheless, the reshuffling of the labour force may foster technical progress in many industries, contributing to create jobs and relief the youth unemployment that arose during the Great Recession.

The ageing trend is likely to drive a protracted reduction in saving ratios in Western economies, which relied significantly on the saving for retirement by the baby-boom generation. The decline in savings will determine an increase in worldwide real interest rates with non-negligible impacts in global investment and technical progress, limiting potential output growth. It should be highlighted that the pay-as-you-go (PAYG) nature of most pension systems will necessarily limit social security revenues and will increase outlays. Given the public nature of most pension systems, imbalances in the social security are a contingent claim on Government revenues, thereby playing a key role on debt sustainability. The economic and social tensions that may arise in an increasingly open world economy may pose new challenges to policymakers, demanding a higher degree of international policy coordination.

Population ageing phenomena will be even more important for European Union (henceforth, EU) economies, in particular for those in the euro area, which are subject to a common monetary policy. In this framework, a widening of the macroeconomic imbalances cannot be discarded, given that ageing trends and impacts are unlikely to be identical across member states and policy responses may differ, reflecting country-specific fiscal policy features. This suggests that a coordinated policy response would be key in fostering economic and financial stability in the euro area.

In this paper, we use *PESSOA*, an open economy New-Keynesian general equilibrium model with non-Ricardian agents and we extend it with a stylised public pension system and a demographic structure. These extension presumably equip the model to capture some of the main features of the ageing process and allows for the assessment of its impacts in a small euro area economy. We simulate an increase in the old-age dependency ratio (OADR) and in age-related government spending under two alternative fiscal policy rules to illustrate how different impacts could be depending on the policy options. The first rule hinges on an increase in the social security premium on current generations to pay for accrued rights of retirees; the second one hinges on a cut in retirees' accrued rights, by reducing the replacement rate of old-age pensions. Results suggest that policy options bear sizeable differences. The impact in the economy will largely depend on the dynamics of the ageing process, on the accrued rights on social benefits (e.g public health care and old-age pensions) and on the policy response.

This article adds to the existing literature on debt sustainability analysis. One of the "drawbacks to conventional debt sustainability analysis is the fact that the standard debt accumulation equation does not capture interdependencies between the variables driving debt sustainability ..." (ECB 2012). This article contributes to account for that interdependencies in the assessment of the impact of ageing in a theoretically consistent framework. In the research oriented literature, most of the analysis on ageing issues is conducted on fully-fledged overlapping generation models, which lack open economy features to limit the degree of complexity (Ludwig, Schelkle and Vogel 2012, Altig, Auerbach, Kotlikoff, Smetters and Walliser 2001, Auerbach and Kotlikoff 1987). Our analysis relies on an open-economy model and the results are largely compatible with the stylised facts of ageing and with the macro impacts presented in articles that rely on fully-fledged overlapping generation models.

Some caveats are noteworthy. Firstly, although the DSGE model used in the analysis has appealing features from the viewpoint of fiscal policy realism, the demographic structure evolution and the built-in social security system are rude simplifications. Secondly, the overlapping generations structure that lies behind households follows Blanchard-Yaari-Buiter-Weill perpetual youth framework. Though this approach allows for meaningful non-Ricardian effects, it does not allow for a proper intergenerational accounting, which

might be important whenever demographic trends and the respective policy responses are being addressed.

The structure of the article is as follows. Section 2 raises some empirical evidence on the features of ageing and, hopefully, motivates the reader. The model is presented in section 3. In section 4, macroeconomic impacts of ageing are simulated using *PESSOA* and the results are presented and discussed, namely in the perspective of fiscal policy coordination. Section 5 concludes and puts forward some policy implications.

2 Motivation

Debt sustainability is currently one of the key topics in economic analysis. In the context of the ongoing sovereign debt crisis, the subject gained prominence as public debt soared in some euro area economies, in the context of subdued economic growth. Indeed, the debt-to-GDP ratio in EU as a whole increased by 18 percentage points (p.p) between 2008 and 2011, reaching 81.9 per cent at the end of 2011 (ECB 2012).

The development of debt sustainability analysis frameworks by many policy institutions largely relies on the expected path of the public debt ratio (Merola and Sutherland 2012, IMF 2012, ECB 2012). The path of the public debt ratio depends on the future primary balances, deficit-debt adjustments, nominal GDP growth and sovereign debt interest rates. In turn, GDP growth, sovereign debt interest rates and primary balances are intrinsically related and are affected by fiscal policy decisions, which, in turn, are to some extent determined by public debt. These interdependencies tend to be largely neglected in conventional debt sustainability frameworks. Ageing trends will affect directly the above mentioned variables in a non-trivial manner, implying that a fully-specified economic model is required to capture the impacts in full extent. In this article, a dynamic general equilibrium model equipped to deal with ageing trends is laid down.

The ageing of population is one of the factors that will put pressure on the budget balances over the next decades, in particular in Europe. The European Commission (henceforth, EC) has followed ageing trends in Europe and has tentatively assessed their impacts on public expenditure. Hence, the Ageing Report is a central piece of information in this respect and every three years puts forward medium-term economic and fiscal projections

for European countries, including some sensitivity analysis for the main parameters.

The 2012 Ageing Report includes projections for the period 2010-2060 for the age related expenditure items: pensions, health care, long-term care, education and unemployment benefits. The projections for pensions were supplied by member states' authorities on the basis of commonly agreed underlying assumptions to capture country-specific features. The projections for the remaining expenditure items were carried out by the EC. In terms of demographic assumptions, Eurostat population projections were used.[1] Concerning macroeconomic variables, there was agreement on a common set of assumptions and methodologies to project labour force (participation, employment and unemployment rates), labour productivity and the real interest rate.

[FIGURE 1 AND 2 AROUND HERE]

The demographic changes foreseen for the next decades at the European level are very significant. Fertility rates are expected to recover modestly, after the considerable decline witnessed over the last decades (Figure 1). For the EU as a whole, the total fertility rate, defined by the number of children per woman in fertile age, is projected to rise from 1.59 in 2010 to 1.64 by 2030 and further to 1.71 by 2060. Over this period, countries with lower rates are expected to converge towards member states with higher rates. It is worth mentioning, however, that in all countries the fertility rates are expected to remain below the natural replacement rate until 2060.[2] In the EU as a whole, life expectancy at birth for males is expected to rise from 76.7 in 2010 to 84.6 in 2060, while for females it is projected to increase from 82.5 to 89.1 years, implying some narrowing of the gender gap. Life expectancy is also anticipated to converge among EU member states for both males and females (Figure 2).

Demographic projections also consider net migration flows prospects. For EU as a whole, it is envisaged a 12% increase in population (corresponding to 60.7 million individuals) derived from assumed migration flows up to 2060. Among countries the results differ considerably but it is worth noting that in all member states, with the exception of

[1]The latest Eurostat population projections (EUROPOP2010) are publicly available at http://epp.eurostat.ec.europa.eu/portal/page/portal/population/data/database.

[2]The natural replacement rate is the rate that would allow for the maintenance of the age-structure of population and is estimated to be 2.1 in the absence of migration flows.

Bulgaria and Lithuania, population is expected to rise in the period considered on account of net migration. Figure 3 presents the cumulative net migration flows which were projected in the 2010-2060 period for EU member states, as a percentage of total population in 2010.

[FIGURE 3 AND 4 AROUND HERE]

If these assumptions materialise, the age structure of the EU population will change substantially in the coming decades, with an increasing share of elderly people. The old-age dependency ratio (OADR)[3] for the EU as a whole will increase from 25.9 per cent in 2010 to 52.6 per cent in 2060. This implies that by 2060 there will be two working age individuals for each elderly individual (Figure 4). The ageing process is also noticeable in the working-age population ratio (WAPR)[4], which is expected to decline from 67.0 per cent in 2010 to 56.2 per cent in 2060. To assess the sensitivity of OADR and WAPR to migration flows projection, the Ageing Report presents the evolution of these ratios under the no migration assumption. The results suggest an increase of 8.6 p.p. in the case of the OADR and a decline of 2.4 p.p. in the case of the WAPR by 2060 (Figure 4). Though the ageing trend is common to all EU member states, the starting position and the intensity differs substantially (Figure 5), putting in evidence the need for a coordination of age-related policies to address eventual intra-EU imbalances created by this idiosyncrasies.

[FIGURE 5 AND 6 AROUND HERE]

The demographic developments, in combination with the expected evolution of labour participation and unemployment rates, allow for a projection of age-related public spending until 2060. The 2012 Ageing Report results for the EU as a whole point to an increase in age-related spending of 4.1 per cent of GDP in the 2010-2060 period, although this figure differs substantially across member states (Figure 6). The expenditure in old-age pensions accounts for half of the impact, while health and long-term care spending is projected to increase by 1.1 and 1.7 per cent of GDP, respectively. In turn, expenditure in education and unemployment benefits is expected to decline modestly. Besides the impact

[3]The old-age dependency ratio is defined as the number individuals aged more than 65 per each individual aged 15-64.

[4]The working-age population ratio is defined as the share of individual aged 15-64 in overall population.

on the expenditure side, the estimation of the full-blown budgetary effect of ageing needs to encompass also the impacts on the revenue side. In particular, account should be taken of the reduction in social security premium revenues (paid by employers and employees) as a result of a decline in working age population.

The exercise carried in the context of the 2012 Ageing Report has acknowledged limitations. The fact that each member state produces pension projections on the basis of its own pension models may limit the comparability of results. In addition, the exercise has a partial equilibrium nature, i.e it does not embody interdependencies among the previously mentioned variables through a fully specified model.

Despite considerable uncertainty surrounding the evidence contained in the 2012 Ageing Report, ageing trends will certainly be a key risk factor for debt sustainability in the coming decades. In this context, policy makers face a substantial challenge and the adoption of adequate measures to tackle the issue is of utmost importance.

3 A model for a small euro area economy with ageing

This section presents *PESSOA*, the New-Keynesian dynamic general equilibrium model used in the analysis of the impact of ageing in a small-open economy. The version of the model used in this paper adds a demographic structure and a public pensions system to the original version (Almeida, Castro and Félix 2010, Almeida, Castro, Félix and Maria 2013).

The model features a small euro area economy, implying that the rest of the area is assumed to be immune to country-specific shocks and, hence, monetary policy decisions are orthogonal to country-specific shocks (Adolfson, Laseén, Lindé and Villani 2007).[5] In these conditions, the adjustment after a country-specific shock is ensured by real exchange rate and its impacts on competitiveness, trade and, thus, on external imbalances.

The demographic structure considered in this study is very stylised. The population size is assumed to be constant at all periods. The ageing dynamics implies a change in the demographic structure such that the WAPR declines and the OADR increases as a result of gradual though permanent change in retirement rate and in mortality rate.

In this article we reinterpret the Blanchard (1985) stochastic finite lifetime framework,

[5]Home economy interest rate may deviate from the area wide rate through a country-specific risk premium.

in such a way that the stochastic structure applies to the working-life, instead of the biological life. Hence, the *PESSOA* model version used in this study preserves the built-in non-Ricardian features inspired in Kumhof, Muir, Mursula and Laxton (2010) and that contribute to generate a realistic response of private consumption to government spending shocks (Blanchard 1985, Galí, López-Salido and Vallés 2007). This allows for sizeable wealth effects of public debt, implying that households strongly prefer government expenditure to be financed through debt issuance during their working life. The net foreign assets (henceforth, NFA) is endogenously determined, since households assets/debt accumulation is limited by the finite working life (Harrison, Nikolov, Quinn, Ramsay, Scott and Thomas 2005). This is an important feature when assessing steady-state transitions that affect asset holdings.[6]

Concerning the old-age pension scheme, we assume that households do not save for retirement during their working life, since they rely in the PAYG public pension scheme in which participation is compulsory. Hence, when households retire they mostly enjoy an old-age pension due by the government. Nevertheless, retirees are allowed to supply labour so that they can consume more than their pension income, but they do not hold assets/debt. This strategy of modelling retirement is an additional source of non-Ricardian behaviour, since retirees are an additional type of hand-to-mouth consumers.[7]

Finally, in line with most of the DSGE literature, the model features monopolistic competition in labour and product markets; nominal and real rigidities; and external habit formation in consumption. Though these features play a mute role in what respects the long-run macroeconomic impacts of ageing, they yield a smoother (and more realistic) transitional dynamics.

[6] In the workhorse infinitely-lived agents model, the steady-state net foreign asset position is pinned down exogenously (Schmitt-Grohe and Uribe 2003).

[7] Gertler (1997) extends Blanchard (1985) to allow for proper life-cycle behaviour related to retirement. Gertler (1997) builds a two-tier overlapping generations scheme in which workers face a random transition for retirement and retirees face a random transition to death. Though this approach is more elegant than ours, it introduces an additional degree of complexity, which in a larger scale model like ours may easily become intractable and hardly interpretable. In addition, in Gertler (1997) model workers save for retirement, which largely mimics households behaviour in a fully funded social security scheme. Since in many European countries social security systems are of PAYG type, saving for retirement out of the public system tends to be less important and pensioners behaviour might be well captured by hand-to-mouth type of behaviour.

3.1 Households

Households follow a modified version of the overlapping generations scheme first proposed in Blanchard (1985). The overall size of the population, N, is assumed to be constant. Households are subject to stochastic finite work lifetimes. All working-age households participate in the labour market, facing a constant instant probability of retirement $1-\theta$. Once households retire, they become pensioners and face an instant probability of death $1-\theta'$.[8]

Three types of households coexist: asset holders (type $\mathcal{A}$) that smooth out consumption over their working life by trading in assets; hand-to-mouth households *à lá* Galí et al. (2007) (type $\mathcal{B}$) that do not trade assets and consume all their income in each and every period; and pensioners (type $\mathcal{C}$), a specific type of hand-to-mouth consumers, that get a old-age pension due by government and may work to consume above their pension income.The demographic dynamics implied by this structure is such that in each period $\frac{(1-\theta)(1-\theta')}{(1-\theta)+(1-\theta')}N$ households die and the same number is born. θ and θ' exogenously determine the demographic structure, with the working age population ratio (WAPR) being $\frac{1-\theta'}{(1-\theta)+(1-\theta')}$ and the share of retirees, $\psi' = \frac{1-\theta}{(1-\theta)+(1-\theta')}$. Hence, the old-age dependency ratio (OADR), i.e. the number of retirees per working-age individual, is simply $\frac{1-\theta}{1-\theta'}$. The share of type $\mathcal{B}$ households is ψ and the share of type $\mathcal{C}$ households is ψ', implying that in each period there exists $N(1-\psi-\psi')$ asset holders, $N\psi$ hand-to-mouth households and $N\psi_t^{'}$ pensioners.

A representative household of type $H \in \{\mathcal{A}, \mathcal{B}, \mathcal{C}\}$ with age a derives utility from consumption, $C_{a,t}^H$, and leisure, $1-L_{a,t}^H$, according to a CRRA utility function.[9] Expected lifetime utility is given by:

$$E_t \sum_{s=0}^{\infty} (\beta\theta)^s \frac{1}{1-\gamma} \left[\left(\frac{C_{a+s,t+s}^H}{H a b_{a+s,t+s}^H} \right)^{\eta^H} (1 - L_{a+s,t+s}^H)^{1-\eta^H} \right]^{1-\gamma} \tag{1}$$

where E_t is the expectation operator, $0 \leq \beta \leq 1$ stands for the standard time discount factor, $\gamma > 0$ is the coefficient of risk aversion and $0 \leq \eta^H \leq 1$ is a distribution pa-

[8] Probability $1-\theta$ is traditionally seen as the probability of physical death, but has also been interpreted as the probability of "economic death" or the degree of "myopia" (Blanchard 1985, Frenkel and Razin 1996, Harrison et al. 2005, Bayoumi and Sgherri 2006).

[9] $L_{a,t}^H$ stands for hours worked as a percentage of households' full time endowment.

rameter. Hab_t^H stands for external habits, defined in terms of *per capita* consumption $\left[C_{t-1}^{\mathcal{A}}/(N(1-\psi_t-\psi_t^{'}))\right]^v$, $\left[C_{t-1}^{\mathcal{B}}/(N\psi_t)\right]^v$ and $\left[C_{t-1}^{\mathcal{C}}/(N\psi_t^{'})\right]^v$ for type $\mathcal{A}$, $\mathcal{B}$ and $\mathcal{C}$ households, respectively, with parameter $0 \leq v \leq 1$ controlling for the degree of habit persistence. In the case of pensioners, the discount factor is $\beta\theta'$ instead of $\beta\theta$.[10]

Type $\mathcal{A}$ households trade in both domestic ($B_{a,t}$) and foreign government bonds ($B_{a,t}^*$), which yield gross nominal interest rates i_t and i_t^*, respectively, assumed to be disbursed at the beginning of period $t+1$. Type $\mathcal{A}$ households earn a wage income determined by the aggregate wage level, W_t, and by the household's age-specific productivity level, $\Phi_a = k\chi^a$ (k is a scaling factor and $0 \leq \chi \leq 1$ is the labour productivity rate of decay over work lifetime). In addition, asset holders earn dividends from firms and labour unions, $D_{a,t}^{\mathcal{A}}(x)$. Finally, households pay consumption, labour income taxes and their share in the social security premium ($\tau_{C,t}$, $\tau_{L,t}$ and $\tau_{SPH,t}$ are the corresponding average tax rates) and receive non-pension transfers from both the government ($TRG_t^{\mathcal{A}}$) and from the rest of the euro area ($TRX_t^{\mathcal{A}}$). In comparison with the previous version of *PESSOA*, the model was modified to clarify the exact elements of the pension system. $\tau_{SPH,t}$ represents the social security premium on wage income due by households to the public pension system.

Asset holders' set the path of consumption, labour, domestic and foreign asset holdings that maximises (1) subject to a budget constraint:

$$P_t C_{a,t}^{\mathcal{A}} + B_{a,t} + B_{a,t}^* \leq \frac{1}{\theta}\left[i_{t-1}B_{a-1,t-1} + i_{t-1}^*\Psi_t B_{a-1,t-1}^*\right] + W_t\Phi_a L_{a,t}^{\mathcal{A}}(1-\tau_{L,t}-\tau_{SPH,t}) + \\ + \sum_{\substack{x=\mathcal{N},\mathcal{T},\mathcal{C},\\ \mathcal{G},\mathcal{I},\mathcal{X},\mathcal{U}}} D_{a,t}^{\mathcal{A}}(x) + TRG_t^{\mathcal{A}} + TRX_t^{\mathcal{A}} \qquad (2)$$

where $P_t = (1+\tau_{C,t})P_t^C$, the final consumption price, is used as numeraire.

Though type $\mathcal{A}$ households access asset/debt markets, finite working lifetime induces Non-Ricardian behaviour, implying they are not indifferent between tax or debt financing of government spending. Indeed, in the case of debt financing, current generations hold a share of the debt that exceeds the present discounted value of corresponding future tax

[10] Aggregation across generations is feasible only under multiplicative habits. However, it is acknowledged that this formulation generates lower consumption persistence than additive habits. Moreover, government consumption is not included in equation (1) and therefore does not contribute directly to household utility, as in Kumhof, Clinton, Mursula and Laxton (2011).

payments, as future tax liabilities will be shared with yet-to-be born generations. Hence, part of the debt held by current generations can be used to finance private consumption during their work lifetime.

The lack of access to asset markets by type $\mathcal{B}$ households is also a source of non-Ricardian behaviour. These households also maximise the utility function (1), however they cannot engage in intertemporal consumption smoothing, as they do not access assets markets. Type $\mathcal{B}$ households consume in each period up to their current income. The optimisation problem is to maximise (1) subject to the following budget constraint:

$$P_t C^{\mathcal{B}}_{a,t} \leq W_t \Phi_a L^{\mathcal{B}}_{a,t}(1 - \tau_{L,t} - \tau_{SPH,t}) + D^{\mathcal{B}}_{a,t}(\mathcal{U}) + TRG^{\mathcal{B}}_t + TRX^{\mathcal{B}}_t \tag{3}$$

Finally, type $\mathcal{C}$ households, the pensioners, were specifically introduced in the version of *PESSOA* used in this article. These households are identical to type $\mathcal{B}$ households, since they also do not access asset markets. However, they enjoy a very particular type of government transfers – old-age pensions – which enters their budget constraint. Pensioners' optimisation problem is to maximise (1) subject to the following budget constraint:

$$P_t C^{\mathcal{C}}_{a,t} \leq PENSION_t + W_t \Phi_a L^{\mathcal{C}}_{a,t}(1 - \tau_{L,t} - \tau_{SPH,t}) + D^{\mathcal{C}}_{a,t}(\mathcal{U}) + TRG^{\mathcal{C}}_t + TRX^{\mathcal{C}}_t \tag{4}$$

Pensioners are allowed to supply labour during the retirement period, though their labour supply elasticity to real wage should be much lower than in the case of type $\mathcal{B}$ households. The possibility of pensioners participate in the labour market allows for a reaction to fiscal policy measures that might affect their budget constraint and, hence, their consumption set.

The households' maximisation problem delivers a Euler condition for each type of household that determines consumption-labour allocation and a consumption function that depends solely on the current income in the case of hand-to-mouth households and pensioners (which represents all their wealth in each period) and on human and financial wealth in the case of asset holders.[11]

[11] Human wealth corresponds to the present discounted value of labour and dividend income accruing in the future to type $\mathcal{A}$ households, while financial wealth corresponds to their current domestic and foreign asset holdings.

3.2 Unions

There is a continuum of labour unions in the economy $h \in [0,1]$, which differentiate labour services into differentiated varieties, $U_t(h)$. Varieties are bundled and sold to manufacturers at an aggregate wage rate, V_t, higher than W_t. The limited substitutability among labour varieties in the bundle purchased by manufacturer j, $U_t(j)$, yields market power, allowing unions to behave in a monopolistic competitive manner.

Each manufacturer demands a specific labour bundle. Aggregating the demand for labour variety h across manufacturers we get to,

$$U_t(h) = \left(\frac{V_t(h)}{V_t}\right)^{-\sigma_{U,t}} U_t \tag{5}$$

$V_t(h)$ is the wage rate of variety h; $0 \leq \sigma_{U,t} \leq \infty$ is the elasticity of substitution across varieties.

Labour unions are subject to quadratic wage adjustment costs, $\Gamma_t^{\mathcal{U}}(h)$, as in Ireland (2001) and Laxton and Pesenti (2003), implying that abrupt changes in $V_t(h)$ are more costly than smooth adjustments.[12]

Period t dividends, $D_t^{\mathcal{U}}(h)$, are defined as:

$$D_t^{\mathcal{U}}(h) = (1 - \tau_{L,t} - \tau_{SPH,t}) \left[(V_t(h) - W_t)U_t(h) - P_t\Gamma_t^{\mathcal{U}}(h)\right] \tag{6}$$

and the labor union h solves the following dividend maximisation problem:

$$\max_{V_t(h)} E_t \sum_{s=0}^{\infty} \tilde{R}_{t,s} D_{t+s}^{\mathcal{U}}(h) \qquad \text{with} \qquad \tilde{R}_{t,s} = \prod_{l=1}^{s} \frac{\theta}{r_{t+l-1}} \text{ for } s > 0 \;\; (1 \text{ for } s = 0) \tag{7}$$

subject to labor demand (5) and quadratic adjustment costs $\Gamma_t^{\mathcal{U}}(h)$. $\tilde{R}_{t,s}$ stands for the subjective real discount factor; $r_t = \frac{i_t}{\pi_{t+1}^e}$ is the real interest rate; and π_{t+1}^e is the expected inflation. Labour unions are managed under the preferences of working-age households, despite pensioners also participate in the labour market. Therefore, the subjective discount factor in the maximisation problem of labour unions and firms incorporates θ.

[12] Quadratic adjustment costs are specified as $\Gamma_t^{\mathcal{U}}(h) = \frac{\phi_{\mathcal{U}}}{2} T_t U_t \left(\frac{V_t(h)/V_{t-1}(h)}{V_{t-1}/V_{t-2}} - 1\right)^2$, T_t is labour-augmenting technical progress. Prices and capital are also subject to this type of costs.

3.3 Firms

Two types of firms are featured: manufacturers and distributors. Manufacturers produce differentiated tradable ($\mathcal{T}$) and non-tradable ($\mathcal{N}$) intermediate goods, using a CES technology. Manufactures hire labour from unions and manage a capital stock, by purchasing new capital from the distributor who produces investment goods. Distributors combine domestic intermediate goods (both tradable and non-tradable) with imports to produce differentiated final goods.

Manufacturers

For each type of intermediate good $J \in \{\mathcal{T}, \mathcal{N}\}$ there is a continuum of manufacturers $j \in [0, 1]$. Each manufacturer produces a single variety, $Z_t^J(j)$, combining capital, $K_t^J(j)$, and labor, $U_t^J(j)$, through a CES production function with labour augmenting technology, which is the only source of real growth in the model. Manufacturers sell variety j at a price $P_t^J(j)$, corresponding to a markup over the marginal cost that reflects market power yielded by product differentiation.

Capital accumulation by manufacturer j follows $K_{t+1}^J(j) = (1 - \delta^J)K_t^J(j) + I_t^J(j)$, where $I_t^J(j)$ stands for the new capital goods purchased in period t that will start operating in $t + 1$, and $0 \leq \delta^J \leq 1$ is the depreciation rate of type J firms. To obtain a smooth response of investment, capital stock is subject to quadratic real adjustment costs, $\Gamma_t^{\mathcal{I}J}(j)$. Furthermore, inflation persistence is also ensured by quadratic inflation adjustment costs in the intermediate goods price, $\Gamma_t^{PJ}(j)$ (Rotemberg 1982).

In this framework, each distributor sets the demand for variety j of the intermediate good that is cost minimising. Aggregating across distributors, the demand for variety j is

$$Z_t^J(j) = \left(\frac{P_t^J(j)}{P_t^J}\right)^{-\sigma_{J,t}} Z_t^J \tag{8}$$

$P_t^J(j)$ represents the price of variety j; $0 \leq \sigma_{J,t} \leq \infty$ the elasticity of substitution between varieties.

Period t dividends $D_t^J(j)$, are defined as:

$$\begin{aligned} D_t^J(j) =&(1-\tau_{K,t})\left[P_t^J(j)Z_t^J(j) - (1+\tau_{SPF,t})V_tU_t^J(j) - \text{ adj. \& fixed costs}\right] \\ &- P_t^{\mathcal{I}}I_t^J(j) + \tau_{K,t}P_t^{\mathcal{I}}q_t^J\delta^J K_t^J(j) \end{aligned}$$

Dividends before corporate income tax correspond to sales revenues, $P_t^J(j)Z_t^J(j)$, net of labour costs, $(1+\tau_{SPF,t})V_tU_t^J(j)$ ($\tau_{SPF,t}$ is the firms' social security premium), adjustment and fixed costs[13] and investment spending, $P_t^{\mathcal{I}}I_t^J(j)$. The expression $\tau_{K,t}P_t^{\mathcal{I}}q_t^J\delta^J K_t^J(j)$ accounts for the corporate income tax rebate of capital depreciation. $\tau_{K,t}$ is the corporate income tax rate and q_t^J stands for the Tobin's-Q (the shadow price of a unit of installed capital in terms of new capital goods).

Manufacturer j solves the following dividend maximisation problem:

$$\max_{P_t^J(j),I_t^J(j),U_t^J(j),K_{t+1}^J(j)} \quad E_t\sum_{s=0}^{\infty}\tilde{R}_{t,s}D_{t+s}^J(j) \tag{9}$$

subject to the constraints imposed by the CES technology, capital accumulation condition, quadratic adjustment costs and the demand curve (8).

Distributors

There is a continuum of distributors $f \in [0,1]$ producing each type of final good $F \in \{\mathcal{C},\mathcal{G},\mathcal{I},\mathcal{X}\}$. Each type of final good is demanded by a unique type of costumer: consumer goods ($\mathcal{C}$) are demanded by households, new capital goods ($\mathcal{I}$) are demanded by manufacturers, government consumption goods ($\mathcal{G}$) are demanded by the public sector, and export goods ($\mathcal{X}$) are demanded by foreign costumers. Each distributor sells its good variety f at price $P_t^F(f)$ set as a markup over marginal costs (reflecting monopolistic competition).

Each distributor f uses a two-stage CES production technology. In the first stage, it uses a CES technology to obtain an assembled good, $Y_t^{\mathcal{A}F}(f)$, through the combination of domestic tradable goods, $Z_t^{\mathcal{T}F}(f)$, with imported goods, $M_t^F(f)$. The distributor incurs

[13] A real fixed cost term is used to ensure that economic profits arising from monopolistic competition are largely depleted in the steady state and, therefore, no firm enters or leaves the market. The fixed cost term is defined as a constant share of nominal output.

in quadratic real adjustment costs $\Gamma_t^{AF}(f)$, whenever it changes the import content of the assembled good. In the second stage, the distributor combines the assembled good with domestic non-tradable goods, $Z_t^{\mathcal{N}F}(f)$, using a CES technology to produce the variety f of the final good, $Y_t^F(f)$.[14] Similarly to manufacturers, distributors also face quadratic inflation adjustment costs, $\Gamma_t^{PF}(f)$, that generate realistic inflation dynamics.

In this framework, each costumer sets the demand for variety f of the final good that is cost minimising. Aggregating across costumers, the demand for variety f is

$$Y_t^F(f) = \left(\frac{P_t^F(j)}{P_t^F}\right)^{-\sigma_{F,t}} Y_t^F \tag{10}$$

where $0 \leq \sigma_{F,t} \leq \infty$ is the elasticity of substitution between varieties of the type F good.

Period t dividends, $D_t^F(j)$, are defined as:

$$D_t^F(f) = (1-\tau_{K,t})\left[P_t^F(f)Y_t^F(f) - P_t^{\mathcal{T}} Z_t^{\mathcal{T}F}(f) - P_t^{\mathcal{N}} Z_t^{\mathcal{N}F}(f) - P_t^* M_t^F(f) - \text{adj. \& fixed costs}\right]$$

Dividends before corporate income tax correspond to sales, $P_t^F(f)Y_t^F(f)$, net of input costs, $P_t^{\mathcal{T}} Z_t^{\mathcal{T}F}(f) + P_t^{\mathcal{N}} Z_t^{\mathcal{N}F}(f) + P_t^* M_t^F(f)$, and adjustment and fixed costs. P_t^* is the price of imported goods.

Each final goods producer f solves the following dividend maximisation problem:

$$\max_{P_t^F(f), Z_t^{\mathcal{T}F}(f), Z_t^{\mathcal{N}F}(f), M_t^F(f)} E_t \sum_{s=0}^{\infty} \tilde{R}_{t,s} D_{t+s}^F(f) \tag{11}$$

subject to the constraints imposed by the CES technology, adjustment costs and demand curve (10).

3.4 The government

The fiscal block allows for the assessment of the macroeconomic impacts of alternative fiscal policy strategies. Government finances expenditure through tax levies and manages a public debt stock. It consumes a specific final good, $P_t^{\mathcal{G}} G_t$ ($P_t^{\mathcal{G}}$ is the price charged by distributors for the government consumption good) and performs non-pension transfers to all households, TRG_t. In addition, government pays debt interest outlays, $(i_{t-1}-1)B_{t-1}$,

[14] The production technology can be formalised as a sector-specific nested CES production function, $Y_t^F(f) = CES_2\left\{CES_1\left[Z_t^{\mathcal{T}F}(f), M_t^F(f)\right], Z_t^{\mathcal{N}F}(f)\right\}$.

to asset holders and old-age pensions to retirees, $PENSION_t$.

The old-age pensions are indexed to the wage rate, V_t, through a net replacement ratio, ϱ_t. The overall pension transfer $PENSION_t$ is governed by the following rule:

$$PENSION_t = \varrho_t(1 - \tau_{L,t} - \tau_{SPH,t})V_t N \psi_t^{'} \tag{12}$$

The replacement ratio, ϱ_t, is a fiscal policy instrument fully controlled by the government.

Government spending is financed by taxes on labour income and households consumption, on corporate income and by the social security premium charged to households and firms on payroll. In addition, the government issues one-period bonds, paying interest outlays at the beginning of period t on the stock held from $t-1$. All government debt is assumed to be held by domestic asset holders (i.e. full home bias is assumed). These households can borrow in international debt markets to buy domestic government bonds.[15] The issuance of public debt allows for the postponement of the tax levies required to finance expenditure in each period, implying that the public sector account does not need to be balanced in each and every period. This has a non-trivial impact in households decisions, given the non-Ricardian features of households.

To ensure that public debt follows a non-explosive path, a fiscal policy rule imposes that the public debt-to-GDP ratio, B_t/GDP_t, and the fiscal balance-to-GDP ratio, SG_t/GDP_t, converge to pre-determined target levels. The rule implies that at least one fiscal instrument adjusts endogenously. Following Kumhof and Laxton (2009),

$$\left(\frac{SG}{GDP}\right)_t = \left(\frac{SG}{GDP}\right)_t^{target} + d_1\left(\frac{RV_t - RV_t^{ss}}{GDP_t}\right) + d_2\left(\frac{B_t}{GDP_t} - \left(\frac{B}{GDP}\right)_t^{target}\right) \tag{13}$$

where RV_t^{ss} is the structural overall tax revenue[16]; GDP_t is the observed GDP level. The response to business cycle fluctuations and the speed of convergence to the public debt target depend on parameters d_1 and d_2, respectively. Parameter d_1 controls for the response to the tax revenue gap and parameter d_2 controls for the government (in)tolerance to deviations from the debt target. In the steady state, both the tax revenue gap and the debt gap are zero.

[15] In an environment without financial frictions, the assumption of full home bias in public debt holding is likely to be neutral. The absence of financial frictions is an acknowledged fragility of the model.

[16] The structural overall tax revenue is the tax revenue that would have been collected in case tax bases stood at their steady-state levels.

The balance of the pension system, BPS_t, is:

$$BPS_t = (\tau_{SPF,t} + \tau_{SPH,t})V_t L_t - PENSION_t \tag{14}$$

The BPS_t explicitly allows for the breakdown of the fiscal balance between the pension system and the rest of the public sector. However, it should be made clear that this breakdown is purely notional, given that the government needs to honour all its commitments. Hence, any deficit of the pension system will be financed either through taxes or debt issuing. At this point, the fiscal instrument that becomes endogenous remains to be defined. In this article, two alternative instruments will be considered: (i) the social security premium; and (ii) net replacement ratio of pensions.

Finally, a word of caution is needed. Although the above-mentioned fiscal block is suited to implement several fiscal simulations, the model remains a simplification. Government consumption and investment are assumed not to generate any externalities. In addition, the model does not include a proper social security fund that is managed to face government implicit liabilities corresponding to future pensions. Hence, the modelling strategy followed is more suited for analysis of the impacts in the context of PAYG pension systems than for fully or partially funded pension systems.

3.5 The rest of the world

In *PESSOA*, the rest of the world (RoW) corresponds to the rest of the euro area and, hence, the nominal effective exchange rate is irrevocably set to unity.

As for trade flows, the demand for imports by domestic distributors results from the cost minimisation problem of distributors and reflects final demand conditions and competitiveness. Domestic exports are essentially determined by the foreign distributors' demand. Foreign distributors demand for domestic economy exports results from cost minimisation problem subject to a CES technology. The representative foreign distributor produces a final good variety, $Y_t^*(f^*)$, by assembling domestic economy exports (i.e. foreign economy imports), $X_t(f^*)$, and intermediate goods produced by foreign manufacturers, $Z_t^*(f^*)$.

Aggregating across foreign final goods producers and export good varieties, the demand

for domestic exports is

$$X_t = \alpha^* \left(\frac{P_t^X}{P_t^*} \right)^{-\xi^*} Y_t^* \tag{15}$$

P_t^X is the export price charged by domestic distributors, P_t^* is the price of the foreign good and Y_t^* is foreign output level. Parameter α^*, the CES quasi-share, is of key importance in determining the steady-state exports market share. In turn, ξ^* is the elasticity of substitution between home exports and foreign goods.

Equation (15) is fundamental to render the model dynamically stable. In particular, a large enough real exchange rate elasticity of exports is required. The model operates like a fixed nominal exchange rate model under perfect credibility, in which domestic price levels are pinned down by the external constraint that uniquely sets the real exchange rate in the steady state.[17]

Regarding financial flows, the SOE approach relies on the assumption that changes in the domestic economy net foreign asset position have negligible impacts on euro area aggregates and on policy decisions.

3.6 Market clearing conditions and GDP definition

The model is closed by a set of conditions imposing that labour, intermediate and final goods markets clear in each and every period.

In a frictionless international financial environment, the modelling of financial flows becomes trivial and is fully determined by domestic saving decisions at the prevailing interest rate and by the following market clearing condition:

$$B_t^* - i_{t-1}^* \Psi B_{t-1}^* = P_t^X X_t - P_t^* M_t + TRE_t \tag{16}$$

Nominal GDP is defined as:

$$GDP_t = P_t C_t + P_t^G G_t + P_t^I I_t + P_t^X X_t - P_t^* M_t \tag{17}$$

[17] In the standard small open economy model, monetary policy is actively managed and the adjustment of real interest rate supplements the real exchange rate in rendering the model dynamically stable. In the case of a small-open economy in a monetary union, the absence of monetary policy implies that the real interest rate dynamics tends to amplify business cycle fluctuations.

Real GDP is aggregated by the Fisher formula.

3.7 Calibration

PESSOA was calibrated to fit the Portuguese economy, using actual data and information from studies on the Portuguese and euro area economies. The model parameters are presented in detail in Appendix.

It seems worth mentioning that the steady-state real GDP growth was assumed to be identical in the entire euro area, ensuring the existence of a balanced growth path. The labour-augmenting productivity annual growth was set to 2%, consistently with available estimates for the potential output growth in euro area countries (Musso and Westermann 2005, Almeida and Félix 2006, Proietti and Musso 2007). Steady-state inflation was assumed to stand at 2% per year in line with ECB target. The nominal interest rate was set to 4.5% (Coenen, McAdam and Straub 2007).

The parameters related with the demographic data and the structure of government transfers, namely the share of pensions payments was calibrated to match historical data for the Portuguese economy, corresponding to a pre-ageing steady-state. Finally, the distribution parameter in the retirees utility function was calibrated such that the participation in the labour market is much lower than for those in their working-age. Specifically, households probabilities of retirement and death were set to replicate the OADR and WAPR in the Portuguese data for the pre-ageing era according to the 2012 EC Ageing Report. The share of type $\mathcal{B}$ households is set such that the overall share of rule-of-thumbers is 40%, broadly in line with the estimates of the share of liquidity constrained households for Portugal in Castro (2006). Concerning pensioners' labour supply, $\eta_{\mathcal{C}}$ was set to limit labour supply by retirees to a half of a working-age individual ($\eta_{\mathcal{A}}$ and $\eta_{\mathcal{B}}$ were calibrated so as to ensure a unitary elasticity of labour supply to real wage).

The remaining parameters governing households behaviour were calibrated as in Kumhof et al. (2010). The elasticities of substitution in the production functions of manufacturers and distributors, the parameters governing the wage and price markups, the adjustment costs, and the fiscal rule parameters also follow Kumhof et al. (2010), Coenen et al. (2007) and estimates for Portugal, whenever available.

4 Ageing and fiscal sustainability

This section details the implementation of the ageing related shocks in PESSOA (subsection 4.1) and presents the results of the simulations and the associated transmission channels (subsection 4.2). The assessment of the impact of alternative policy responses on potential euro area internal imbalances is discussed in subsection 4.3.

4.1 Implementation strategies

The assessment of the macroeconomic impacts of ageing through the lens of PESSOA model relies on the simulation of permanent shocks resembling a stylised ageing trend.

As documented in section 2, the ageing trend implies a substantial increase in the old-age dependency ratio. This will stress the fiscal balance, implying a decline in revenues from social security premia and an increase in age-related public spending. In PAYG pension systems, this corresponds to an increase in age-related transfers (old-age pensions) and to a reduction in wage income related revenues (labour income tax and social security premia). Moreover, in many Western economies, government also plays a key role in the funding of health and long-term care assistance, thereby contributing to stress further the fiscal balance. However, when assessing the impacts of ageing, one must also account for mitigating factors, in particular lower spending in education and unemployment insurance of the labour force.

The assessment of the macroeconomic impacts of ageing will be implemented through the simulation of two structural shocks. The first is a pure demographic shock. The shock is implemented through a permanent increase in the OADR and a decline in the WAPR, which is obtained by cutting the instant probability of death $1-\theta'$. It will trigger essentially the direct impacts of ageing on the balance of the social security system (namely, a rise in pension transfers, a decline in the contributory base of the social security premium and a reduction in unemployment benefits spending). The second is a government consumption shock, reflecting the impact of ageing in public spending on health and long-term care assistance net of savings in education.

A final issue that remains open is how the ageing trend and its impacts on the fiscal balance will be managed by fiscal authorities. Since the shock is of a permanent nature,

full debt financing is ruled out. In this circumstances, a no-policy change will drive public debt towards an unsustainable path and, hence, adequate policy measures need to be adopted. Instead of playing the role of the policymaker and choosing a specific policy mix, the discussion is focused on two polar policy options. The first policy option considered is an increase in the social security premium due by both employers and employees in identical magnitudes to restore the initial debt level. Given the magnitude of the aging phenomena, this option implies a substantial rise in the tax wedge on labour with non-negligible implications in the labour supply for future generations and corresponds to a wealth transfer from the future to the current generations. The second policy option is a cut in the net replacement rate of pensions. This corresponds to an unilateral reduction of government liabilities vis-a-vis current generations, implying a direct reduction in their pension income.

The details of the calibration of the shocks take into account the features presented in section 2. Specifically, it is considered a gradual increase in the OADR by 20 pp. and in government consumption by 2.5 per cent of GDP.[18] These shocks are implemented as permanent innovations that gradually feed in through the autoregressive process governing each shock in the model. Their impacts are discussed in the next subsection.

4.2 Main impacts and transmission channels

The assessment of the macroeconomic impacts of ageing in this subsection is done separately for each shock to keep the interpretation of the implied transmission channels as simple as possible. Since the ageing process corresponds to a permanent change in the steady state, it seems relevant to assess not only the transitional dynamics but also the long term impacts. Thus, in this subsection, we consider four simulation horizons corresponding to the short, medium and long run (corresponding to the 1st, the 10th, the 20th and the 50th year). The simulation results are summarised in Tables 1, 2, 3 and 4.

[TABLES 1 AND 2 AROUND HERE]

The increase in OADR affects the macroeconomic scenario through the decline of

[18] It is assumed that health and long-term care are provided directly by the public sector and therefore correspond to government consumption. The shock was calibrated based on health (1.1 per cent of GDP) and long-term care (1.7 per cent of GDP) spending net of the savings in education (0.3 per cent of GDP).

labour supply and the increase of old-age pension transfers. The shock is implemented as a permanent shift in the demographic structure of the population as detailed above, corresponding to an inward shift of the labour supply curve. In general, the impact in real GDP and in most demand components does not depend qualitatively on whether the fiscal authority opts for increasing the social security premium or cuts the replacement rate of pensions. The policy option affects mainly the magnitude of the impacts. Hence for both policy options, the gradual, though permanent, shrink in the labour supply leads to a decline in hours worked with direct impact on labour income and wealth, thereby inducing households to cut on consumption. Since adjusting the capital stock is costly, in the short run, the arising excess supply induces a real exchange rate depreciation, crowding in exports and, thereby, mitigating the negative impact in output. Short-run impacts in private investment are rather contained, since the decline in marginal productivity of capital is accompanied by a decline in real interest rate, in view of the anticipation of future price increases.[19] The magnitude of the decline in hours worked and in private consumption is significantly affected by the policy option, reflecting the labour supply response to the incentives in place. If the policy response hinges on a rise of the social security premium due by employers and employees, the increasing tax wedge on labour leads to larger distortions than in the case in which government cuts the net replacement rate of pensions and, thus, to a larger inward shift of the labour supply curve. In turn, if the fiscal authority opts for a cut in the replacement rate of pensions there is some incentive for retirees to supply additional hours to smooth consumption, thereby mitigating the inward shift in labour supply.[20]

[TABLES 3 AND 4 AROUND HERE]

In the long run, the decline in labour supply induces a widening of the short- and medium-run impacts for both policy options. In the case of private investment, it adjusts down sharply to restore the marginal productivity of capital. Hence, the excess supply turns into excess demand and the ensuing real exchange rate appreciation erodes short-

[19] It should be reminded that from the viewpoint of agents, it is the ex-ante real interest rate that matters and it depends on expected inflation developments.

[20] As detailed in section 3, retired households supply labour, though its labour supply elasticity is much lower than for working-age households.

run competitiveness gains and leads to a decline in exports in the long-run. It should be highlighted that the negative long-run impact of the shock in real GDP, domestic demand and exports is much larger in case the fiscal authority opts for a rise in social security premium than in the case of a reduction in the net replacement rate of pensions, reflecting the incentives in place. Hence, the alternative policy options considered drive rather different degrees of real exchange rate appreciation, implying different developments in the behaviour of imports, exports and, hence, in trade balance. As a result, the policy response is particularly important to determine the impact in the NFA position – a topic that is analysed in more detail in subsection 4.3.

Turning to the impact of ageing through government consumption, it will depend on the role of the government in provision of services. *Ceteris paribus*, a permanent increase in government spending will induce a fiscal expansion, with an increase in output and value-added as measured by real GDP. However, the impact in the economy will largely depend on the policymaker decision in what respects to re-balancing the public sector account.

In case the policymaker opts for a rise in the social security premium, this will imply that the gradual increase in government consumption crowds-out private consumption and exports. The impact on output is negative in the short-run, though negligible, and widens over the simulation horizon. The output loss reaches 0.6 per cent after 10 years and widens to 2.3 per cent after 50 years. The loss of households consumption is larger reaching 2.2 per cent after 10 years and 6.5 per cent after 50 years. Government consumption to GDP ratio will increase ex-post by 0.9 pp. after 10 years and 2.83 pp. after 50 years, respectively.

The impact in output reflects the decline in private sector output, which more than offsets the increase in government consumption. It should be noted that in case the increase in spending is financed through an increase in social security premium, this implies a substantial rise in the tax wedge on labour with the previously mentioned impacts. As firms face the increase in demand stemming from government consumption, they demand more labour and, hence, pay a higher wage rate. However, the increase in social security premium increases labour costs further and reduces households income prospects and, hence, their consumption level. The overall impact in the wage rate and hours worked hinges on the interaction between supply and demand in goods and labour markets and,

in particular, on elasticity, which in turn affects the cost and price of final goods and the adjustment in the goods markets.

Considering the case in which the authorities compensate the increase in age-related government consumption by cutting the net replacement rate of pensions, the impacts are substantially different. In the very short-run, output increases and households consumption increases marginally, in view of the expansionary impact of government consumption. As we move forward, the impact in real GDP remains in positive territory (0.4 per cent in the short-run, increasing up to 2.2 per cent after 50 years). On the contrary, the impact in households consumption over the medium and long run turns negative as income effects stemming from the cut in the net replacement rate of pensions mount (after increasing by 1.1 per cent in the short-run, private consumption is anticipated to decline by 1.2 per cent after 50 years).

The reduction in the net replacement rate of pensions will induce an outward shift in the labour supply curve, mainly related with the income effect. Hence, equilibrium wage rate will gradually decline. The positive impact in households consumption in the short run reflects the ability of pensioners to supply labour, creating slack that in the medium and long run will translate into a lower real wage rate. The resulting boost in price competitiveness will drive a shift in the resources from non-tradable goods to tradable goods production and leads to an increase in exports and to a decline in the import content of final demand. Over the medium and the long run output reverts to levels well above baseline and so hours worked and private investment. These developments imply a higher level of hours worked, thereby limiting households income decline and, hence, the fall in households consumption.

Summing up, the impact of ageing in long-term growth prospects might be substantial and different policy responses may lead to rather different outcomes. In particular, increases in social security premium tend to lead to more unfavourable developments in real GDP, hours worked and NFA position, reflecting the distortionary effect on labour/leisure decision of this policy option. In turn, the ageing process can have a positive effect on real GDP if the increase in government consumption is accompanied by a significant reduction in the net replacement rate of pension, which however implies a stronger negative impact in households consumption and lower levels of leisure.

4.3 On the impact of ageing in euro area internal imbalances

The macroeconomic impacts and alternative policy responses to cope with the ageing trend on the euro area are likely to differ across countries. Each country may be in a different position in terms of its ability to increase social security premium or to cut the net replacement rate of pensions. In the long run, the results show that the widening or reduction of external imbalances in a particular small open economy depend on these domestic conditioning factors.

To cope with the rise in OADR, an increase in social security premium implies for instance a real exchange rate appreciation that can go up to 5.7 per cent in the long-run, as presented in Table 4, and a deterioration of the NFA that reaches more than 8 per cent of GDP, while a cut in the pensions' replacement ratio implies an improvement in the NFA of close to 1.5 per cent. To cope with the rise in government consumption, the former policy response leads to a real exchange rate appreciation of around 2.4 per cent, which drives a reduction in exports and an increase in the import content of final demand. This represents a major contribution behind the deterioration of the NFA position, which widens up to 7.3 per cent of GDP in the long-run. In turn, a cut in the replacement ratio improves competitiveness and trade, but is insufficient to improve the NFA, which deteriorates up to 3 per cent of GDP in the long-run.

Taking the overall impacts of each policy response as the sum of the impacts of the respective columns for each structural shock, one can consider an hypothetical country in which ageing will likely move OADR and government consumption in the simulated magnitudes. The results suggest that such a country would suffer a significant impact in real GDP over the medium run if the policy response relies on increasing the social security premium.

The simulation results suggest that the sum of the respective columns of Tables 2 to 3, respectively, imply a reduction in the average real GDP growth over the first and the second decade close to 0.5 pp. per year. The equivalent results using Table 4 show that this impact is around 0.3 pp. over a 50 years time span. In case the adjustment relies in a cut in the replacement rate of pensions, the impact in the annual average real GDP growth is likely to be virtually nil over medium and long run, with the short-run negative

impacts dissipating rapidly.

In the first case, the large negative impact in real GDP growth prospects reflects essentially the effect of a higher social security premium in the labour tax wedge, as well as in the labour supply and in firms' wage costs. The increase in the labour tax wedge induces significant real exchange rate appreciation with impact in exports developments and in import contents, thereby leading to a deterioration of the trade balance. In the case of a cut in the net replacement rate of pensions, which induces an increase in the labour supply while leaving the labour tax wedge unchanged, most of the impact would result from a pure income effect, since households supply more labour to keep the optimal consumption/leisure allocation. This increase in labour supply will insulate firms' costs and real exchange rate from the impact of ageing and, hence, the impacts in trade balance are limited.

As a result, the overall impact on the evolution of the NFA largely depends on the policy response. In particular, the impact over the long run may vary from a deterioration of 15.5 per cent of GDP, in case the of an increase in the social security premium, to a deterioration of 1.5 per cent of GDP in the case of a cut in the replacement rate of pensions. This large gap in terms of the impact of ageing in the external balance of the economy suggests that ageing may well pose new challenges to the management of the macroeconomic imbalances inside the euro area. In particular, in the existing institutional environment of fully decentralised fiscal policy, an uncoordinated response of national fiscal authorities may affect imbalances among euro area economies.

As illustrated in section 2, the impact of ageing varies substantially across euro area economies reflecting the existing rules on pensions and social benefits and the public provision and financing of age related spending. In addition, some governments have already implemented significant reforms in pension systems, as well as in the coverage of health and long-term care, while others did not, implying discrepant impacts of ageing across economies. The ongoing sovereign debt crisis has proved that sizeable external imbalances among euro area economies may well affect access to foreign financial markets of some economies with non-negligible impacts in the financing conditions, domestic demand and ultimately economic activity and debt sustainability. Moreover, sizeable spill overs may arise, implying a propagation to financing conditions and raising sustainability concerns

across the area. Hence, in the euro area as a whole, coordination seems to be warranted if concerns on the imbalances among euro area economies remain important on the agenda.

5 Conclusions

This article assesses the impact of ageing in a small euro area economy. The evidence raised in empirical work conducted by many policy institutions shows the overwhelming importance of ageing when assessing debt sustainability. This issue becomes even more important in a context in which euro area institutions are struggling to overcome the sovereign debt crisis. Fiscal pressure stemming from ageing trends in Europe is still in the early stages but is already starting to affect macroeconomic equilibria.

The simulation results obtained in a general equilibrium framework suggest that ageing might lead to large negative impacts in real GDP and private consumption. Nevertheless, the magnitudes will depend on the policies adopted to ensure debt sustainability. The two polar cases considered in this article suggest that the impacts tend to be very large if the government opts for a permanent increase in the social security premium (on both employers and employees), i.e. an an increase of taxes on labour income. On the contrary, if the government opts for some form of reduction in the net replacement rate of pensions, the impacts in real GDP are likely to remain positive but both private consumption and leisure decline.

The simulations carried out also illustrate that, for the magnitude of the shocks assumed, using a single policy instrument implies policy changes that go well beyond realistic levels, jeopardising economic efficiency, debt sustainability and the social contract. A rise of more than 10 pp. in the social security premium of both employers and employees creates a huge incentive to evade on compulsory payments. In turn, a cut of more than 25 pp. in the net pensions replacement rate will lead to a breakdown in the implicit social contract. In addition, the government may opt by considering other types of measures that may mitigate the impact of ageing on expenditure. Increasing the retirement age may relief some pressure on the public pension system and allow for a smoother transition. However, implied impacts on labour productivity and job creation for youngsters need to be accounted for. Moreover, population ageing is also an opportunity to reassess the roles

of government in the provision of goods and services and in terms of the redistribution of resources. A resource shift benefitting the elderly will promote a downsizing of government spending in services more oriented to youngsters. Hence, tackling the impact of ageing requires a policy mix that shares the burden across current and future generations in an efficient and socially acceptable manner. The proper mix and the sharing of the burden is essentially a political decision that is beyond the scope of this study.

In what respects the impact of ageing in the external imbalance, the policy options also matter. If the government opts for increasing the social security premium, the deterioration of the NFA might be substantial, while in the case of a cut in the replacement rate of pensions the impact is likely to be negligible. Hence, depending on the policy options, the results suggest the possible need for policy coordination among euro area economies to avoid that ageing trends lead to a (re)widening of the macroeconomic imbalances that contributed to the ongoing sovereign debt crisis.

This article leaves open directions for future research. The need for policy coordination in Europe and, most likely, amongst largest economies seems warranted, if preserving/restoring global financial stability is a policymakers' key objective. Thus, the assessment of the implications of ageing on global financial stability seems a wide and promising avenue for further research in the context of a global economy model.

In addition, the ageing process is also likely to trigger substantial international migration flows in a globalised economy. The impact of migration flows in national labour markets equilibria is also an issue of utmost importance, since it might be largely idiosyncratic as a result of country-specific institutional arrangements. This may well determine scattered adjustment patterns in the labour market, a variety of country-specific macroeconomic impacts and, ultimately, may imply larger social tensions across euro area economies.

References

Adolfson, M., Laseén, S., Lindé, J. and Villani, M. (2007), 'Bayesian estimation of an open economy DSGE model with incomplete pass-through', *Journal of International Economics* **72**, 481–511.

Almeida, V., Castro, G. and Félix, R. M. (2010), 'Improving competition in the non-tradable goods and labour markets: the Portuguese case', *Portuguese Economic Journal* **9**(3).

Almeida, V., Castro, G., Félix, R. M. and Maria, J. R. (2013), 'Fiscal concolidation in a small euro area economy', *International Journal of Central Banking (forthcoming)* .

Almeida, V. and Félix, R. (2006), Computing potential output and the output-gap for the Portuguese economy, Economic Bulletin Autumn, Banco de Portugal.

Altig, D., Auerbach, A. J., Kotlikoff, L. J., Smetters, K. A. and Walliser, J. (2001), 'Simulating fundamental tax reform in the united states', *American Economic Review* **91**(3), 574–595.

Auerbach, A. J. and Kotlikoff, L. J. (1987), *Dynamic Fiscal Policy*, Cambridge University Press.

Bayoumi, T. and Sgherri, S. (2006), Mr Ricardo's great adventure: Estimating fiscal multipliers in a truly intertemporal model, Working Paper No. 06/168, International Monetary Fund.

Blanchard, O. (1985), 'Debts, deficits and finite horizons', *Journal of Political Economy* **93**(2), 223–247.

Castro, G. (2006), Consumption, disposable income and liquidity constraints, Economic Bulletin Summer, Banco de Portugal.

Coenen, G., McAdam, P. and Straub, R. (2007), Tax reform and labour-market performance in the euro area: a simulation-based analysis using the new area-wide model, Working Paper No. 747, European Central Bank.

ECB (2012), Analysing government debt sustainability in the euro area, Monthly Bulletin April 2012, European Central Bank.

Erceg, C. J., Henderson, D. W. and Levin, A. T. (2000), 'Optimal monetary policy with staggered wage and price contracts', *Journal of Monetary Economics* **46**(2), 281–313.

Fagan, G., Gaspar, V. and Pereira, A. (2004), Macroeconomic adjustment to structural change, *in* G. Szapary and J. von Hagen, eds, 'Monetary strategies for joining the euro', Edward Elgar, pp. 168–217.

Frenkel, J. and Razin, A. (1996), *Fiscal Policies and Growth in the World Economy*, 3 edn, The MIT Press.

Galí, J., López-Salido, J. D. and Vallés, J. (2007), 'Understanding the effects of Government spending on consumption', *Journal of the European Economic Association* **5**(1), 227–270.

Gertler, M. (1997), Government debt and social security in a life-cycle economy, NBER Working Papers 6000, National Bureau of Economic Research, Inc.

Harrison, R., Nikolov, K., Quinn, M., Ramsay, G., Scott, A. and Thomas, R. (2005), *The Bank of England Quarterly Model*, Bank of England.

Høj, J., Jimenez, M., Maher, M., Nicoletti, G. and Wise, M. (2007), Product market competition in OECD countries: taking stock and moving forward, Economics Department Working Paper No. 575, Organisation for Economic Co-operation and Development.

IMF (2012), Modernizing the framework for fiscal policy and public debt sustainability analysis, IMF Staff Report August 2011, International Monetary Fund.

Ireland, P. (2001), 'Sticky-price models of business cycle: specification and stability', *Journal of Monetary Economics* **47**(1), 3–18.

Kumhof, M., Clinton, K., Mursula, S. and Laxton, D. (2011), 'Deficit reduction: Short-term pain and long-term gain', *European Economic Review* **55**, 118–139.

Kumhof, M. and Laxton, D. (2007), A party without a hangover? On the effects of U.S. government deficits, Working Paper No. 07/202, International Monetary Fund.

Kumhof, M. and Laxton, D. (2009), Chile's Structural Fiscal Surplus Rule: a model-based evaluation, Working Paper No. 09/88, International Monetary Fund.

Kumhof, M., Muir, D., Mursula, S. and Laxton, D. (2010), The Global Integrated Monetary and Fiscal Model (GIMF) - Theoretical structure, IMF Working Paper 10/34, International Monetary Fund.

Laxton, D. and Pesenti, P. (2003), 'Monetary rules for small, open, emerging economies', *Journal of Monetary Economics* **50**(5), 1109–1146.

Ludwig, A., Schelkle, T. and Vogel, E. (2012), 'Demographic change, human capital and welfare', *Review of Economic Dynamics* **15**(1), 94–107.

Mendoza, E. (2005), Real exchange rate volatility and the price of non-tradables in sudden-stop-prone economies, Working Paper No. 11691, National Bureau of Economic Research.

Merola, R. and Sutherland, D. (2012), Fiscal consolidation: Part 3. long-run projections and fiscal gap calculations, OECD Economics Department Working Papers 934, OECD Publishing.

Musso, A. and Westermann, T. (2005), Assessing potential output growth in the euro area: a growth accounting perspective, Occasional paper No. 22, European Central Bank.

Proietti, T. and Musso, A. (2007), Growth accounting for the euro area: a structural approach, Working Paper No. 804, European Central Bank.

Rotemberg, J. J. (1982), 'Monopolistic price adjustment and aggregate output', *the Review of Economic Studies* **49**(4), 517–531.

Schmitt-Grohe, S. and Uribe, M. (2003), 'Closing small-open economy models', *Journal of International Economics* **61**, 163–185.

Appendix

Table 5 report the main parameters of the model and Table 6 the steady-state key ratios, including a comparison with actual data, when available.

[TABLES 5 AND 6 AROUND HERE]

The calibration of households parameters is largely based on Fagan, Gaspar and Pereira (2004), Harrison et al. (2005) and Kumhof and Laxton (2007).

Parameters $\eta_{\mathcal{A}}$ and $\eta_{\mathcal{B}}$ were calibrated so as to ensure a unitary elasticity of labour supply to real wage, while $\eta_{\mathcal{C}}$ was set to limit labour supply by retirees to a reasonable level. The coefficient of relative risk aversion was set to calibrate the inter-temporal elasticity of substitution to 0.2.

The steady-state wage markup of labour unions was set at 25%. Although relatively high, the strongly regulated Portuguese labour market may even justify an higher number. Nominal wage rigidity was calibrated to ensure that wages adjust to the new equilibrium in 6 quarters, a value slightly above euro area estimates published in Coenen et al. (2007), but still in the range usually found in the literature.

Turning to firms, the depreciation rate was assumed to be identical across manufacturers and was calibrated by taking into account actual data on investment-to-GDP ratio. The elasticity of substitution between capital and labour in the production function was assumed to be unitary and takes into account the actual labour income share. The steady-state price markup of tradable and non-tradable goods was calibrated using OECD product market regulation indicators and the correlation between tradable and non-tradable goods markups and product market regulation indicators found in Høj, Jimenez, Maher, Nicoletti and Wise (2007). The price markup of the non-tradable goods was set at 20%, in line with low competition levels in this sector. As for real rigidities, capital adjustment costs were calibrated so as to ensure plausible investment responses. Regarding nominal rigidities, price growth adjustment costs were calibrated to match average adjustment time spans, in which the adjustment of prices in the non-tradable goods sector is slightly slower than in the tradable goods sector. The elasticity of substitution between domestic tradable goods and imports was assumed to be identical across firms and set above unity (Coenen et al. 2007, Harrison et al. 2005, Erceg, Henderson and Levin 2000, Kumhof et al. 2010), while the combination of assembled goods with non-tradable goods was assumed to feature a low substitutability (Mendoza 2005, Kumhof et al. 2010). These production functions were also calibrated in line with the National Accounts import contents and the non-tradable goods content of each type of final good. The degree of monopolistic competition among distributors was assumed to be lower than among manufacturers, with the steady-state markup being set to 5%, except in the case of exporters, where fiercer competition justifies a lower markup. In terms of price stickiness, it was assumed that prices take 2 quarters to fully adjust for all distributors except exporters, whose prices are assumed to adjust faster. Real rigidities related to the import content adjustment costs were set to ensure a smooth adjustment of import contents to real exchange rate fluctuations.

The steady-state tax rates, as well as transfers from the rest of the MU, government consumption and investment and government transfers, were calibrated to match actual data. The fiscal policy rule was calibrated to ensure smooth tax adjustments. The target debt was set to 53% of GDP, implying a fiscal balance of -2.1% in line with the fiscal target set in the EU.

Tables

Table 1: Macroeconomic impacts of ageing (Year 1)

	+20 pp. OADR		+2.5 pp. Govt. Consumption	
	SS premium	Rep. Rate	SS premium	Rep. Rate
GDP	-3.86	-1.46	-0.64	0.37
Private consumption	-9.14	-4.75	-1.46	1.12
Private investment	-1.05	0.60	-0.07	-0.01
Exports demand	2.03	2.34	0.03	-0.65
Imports volume	-3.80	-1.78	-0.55	0.51
Hours worked	-3.65	-0.59	-0.71	0.39
Real wage rate (firms)	-2.25	-2.45	-0.18	0.73
Real exchange rate on the exports side	0.80	0.93	0.01	-0.26
Consumer price inflation (in pp.)	-0.61	-0.73	0.01	0.21
Foreign bonds (% of GDP)	-2.01	-0.97	-0.27	0.24
Government bonds (% of GDP)	0.49	1.24	-0.22	-0.28
Fiscal balance (% of GDP)	2.98	0.00	0.83	-0.10
SS premium (in pp.)	11.99	0.00	2.89	0.00
Government consumption (% of GDP)	0.99	0.39	0.21	-0.04
Replacement ratio (in pp.)	0.00	-5.29	0.00	1.81

Table 2: Macroeconomic impacts of ageing (Year 10)

	+20 pp. OADR		+2.5 pp. Govt. Consumption	
	SS premium	Rep. Rate	SS premium	Rep. Rate
GDP	-3.49	-0.29	-0.59	0.60
Private consumption	-6.30	-1.36	-2.13	-0.37
Private investment	-2.28	-0.39	0.18	1.16
Exports demand	-0.77	1.06	-0.92	-0.20
Imports volume	-2.99	-0.89	-0.40	0.42
Hours worked	-3.84	-0.58	-0.59	0.81
Real wage rate (firms)	-1.58	0.32	-0.75	-0.14
Real exchange rate on the exports side	-0.31	0.42	-0.37	-0.08
Consumer price inflation (in pp.)	0.29	0.14	0.04	-0.04
Foreign bonds (% of GDP)	14.06	7.21	1.16	-1.79
SS premium (in pp.)	7.37	0.00	2.89	0.00
Government consumption (% of GDP)	0.85	0.08	0.91	0.63
Replacement ratio (in pp.)	0.00	-7.36	0.00	-3.83

Table 3: Macroeconomic impacts of ageing (Year 20)

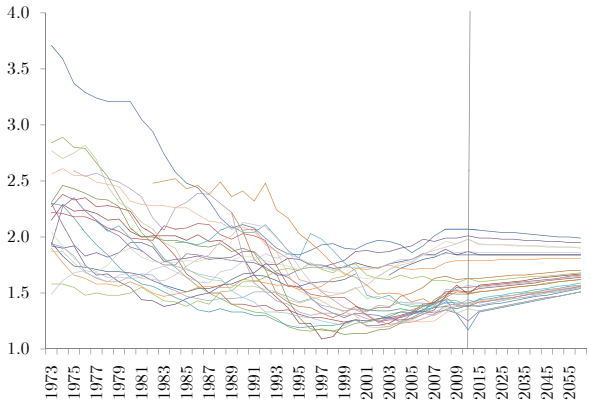
	+20 pp. OADR		+2.5 pp. Govt. Consumption	
	SS premium	Rep. Rate	SS premium	Rep. Rate
GDP	-6.31	-1.34	-0.92	1.24
Private consumption	-7.20	-1.34	-3.10	-0.71
Private investment	-4.76	-1.19	-0.18	1.50
Exports demand	-6.67	-1.61	-1.85	0.52
Imports volume	-2.80	-0.54	-0.53	0.38
Hours worked	-7.12	-1.67	-0.94	1.49
Real wage rate (firms)	-1.08	0.81	-1.05	-0.24
Real exchange rate on the exports side	-2.72	-0.65	-0.74	0.21
Consumer price inflation (in pp.)	0.21	0.07	0.04	-0.02
Foreign bonds (% of GDP)	18.13	9.66	0.37	-2.83
SS premium (in pp.)	10.34	0.00	4.39	0.00
Government consumption (% of GDP)	1.52	0.31	1.55	1.03
Replacement ratio (in pp.)	0.00	-12.00	0.00	-6.76

Table 4: Macroeconomic impacts of ageing (Year 50)

	+20 pp. OADR		+2.5 pp. Govt. Consumption	
	SS premium	Rep. Rate	SS premium	Rep. Rate
GDP	-13.42	-2.44	-2.27	2.15
Private consumption	-15.86	-2.69	-6.45	-1.15
Private investment	-8.87	-1.59	-0.92	1.99
Exports demand	-13.75	-2.75	-3.29	1.10
Imports volume	-5.77	-0.89	-1.45	0.47
Hours worked	-13.23	-2.49	-1.90	2.49
Real wage rate (firms)	-3.72	0.93	-2.42	-0.37
Real exchange rate on the exports side	-5.75	-1.11	-1.33	0.44
Consumer price inflation (in pp.)	0.01	0.00	0.00	0.00
Foreign bonds (% of GDP)	-8.25	1.47	-7.28	-2.99
SS premium (in pp.)	22.08	0.00	8.70	0.00
Government consumption (% of GDP)	3.49	0.57	2.83	1.73
Replacement ratio (in pp.)	0.00	-18.74	0.00	-11.28

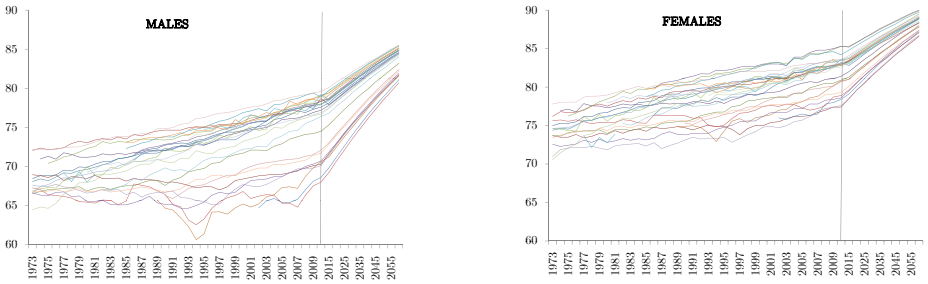
Graphs

Figure 1: Fertility rates in EU-27



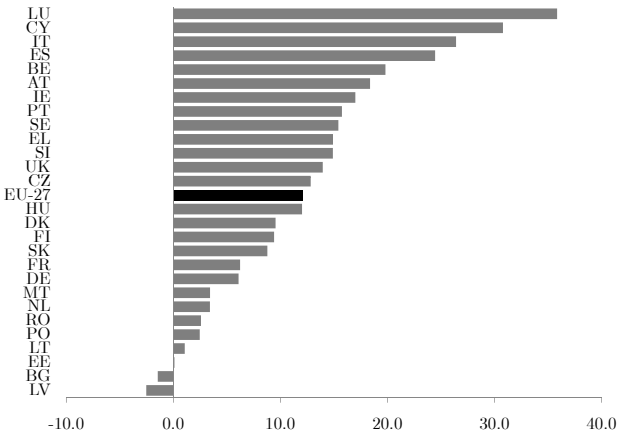
Notes: Fertility rate: number of children per woman in fertile age.
Source: Eurostat.

Figure 2: Life expectancy at birth in EU-27



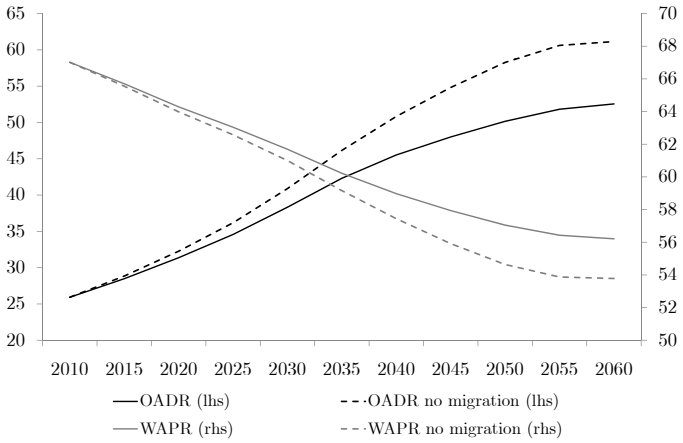
Source: Eurostat.

Figure 3: Cumulative net migration flows in 2010-2060 as a percentage of 2010 total population



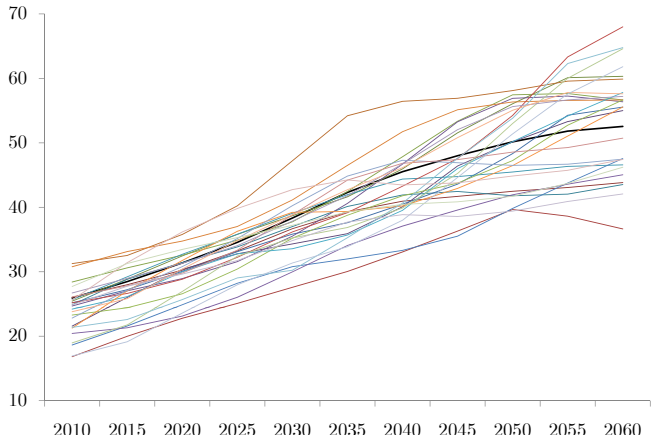
Sources: Eurostat and authors' calculations.

Figure 4: Old-age dependency ratio (OADR) and working age population ratio (WAPR)in EU-27: baseline and no migration scenarios



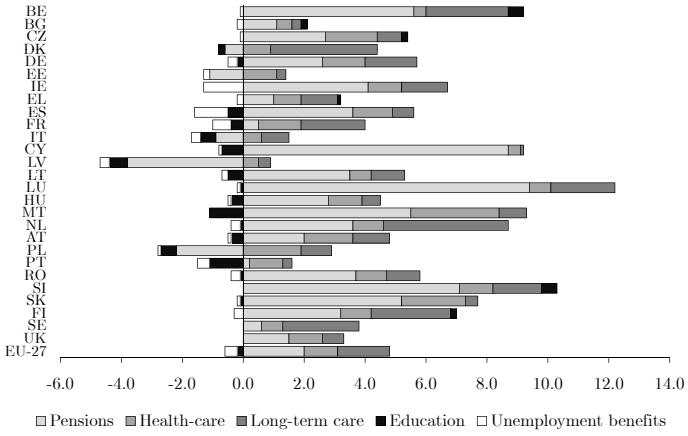
Sources: Eurostat and authors' calculations.

Figure 5: Old-age dependency ratio in EU Member States



Sources: Eurostat and authors' calculations.

Figure 6: Age-related expenditure in EU Member States, change in the 2010-2060 period, p.p. of GDP



Sources: 2012 Ageing Report.

Table 5: Initial (pre-aging) main parameters

	Parameter	Value
Monetary union parameters		
Euro area interest rate (annualised)	i^*	1.05
Euro area labour-augmenting prod. growth (annualised)	g	1.02
Euro area inflation target (annualised)	π^*	1.02
Euro area EoS between domestic and imported goods	ξ^*	2.50
Households and Unions		
Households discount rate (annualised)	β	0.97
Intertemporal elasticity of substitution	$\frac{1}{\gamma}$	0.20
Households instant probability of retirement (annualised)	$1-\theta$	0.04
Households instant probability of death (annualised)	$1-\theta'$	0.137
Households habit persistence	ν	0.20
Consumption share - Type $\mathcal{A}$ households	$\eta_{\mathcal{A}}$	0.70
Consumption share - Type $\mathcal{B}$ households	$\eta_{\mathcal{B}}$	0.60
Consumption share - Type $\mathcal{C}$ households	$\eta_{\mathcal{C}}$	0.50
Lifetime productivity decline rate (annualised)	$1-\chi$	0.04
Wage markup	$\frac{\sigma_U}{\sigma_U-1}$	1.25
Wage rigidity - Adjustment cost	ϕ_V	200
Manufacturers		
Depreciation rate (annualised)	δ	0.09
EoS between capital and labour	ξ_J	0.99
Price markup - tradables	$\frac{\sigma_T}{\sigma_T-1}$	1.10
Price markup - non-tradables	$\frac{\sigma_N}{\sigma_N-1}$	1.20
Capital adjustment cost	ϕ_{IJ}	10
Labour adjustment cost	ϕ_{UJ}	5
Price adjustment cost	ϕ_{PJ}	200
Quasi labour income share - tradables	α_T	0.56
Quasi labour income share - non-tradables	α_N	0.60
Distributors		
EoS domestic tradable/imported good	ξ_{AF}	1.50
EoS assembled/non-tradable good	ξ_F	0.50
Price markup (domestic distributors)	$\frac{\sigma_F}{\sigma_F-1}, F \neq X$	1.05
Price markup (exporters)	$\frac{\sigma_X}{\sigma_X-1}$	1.03
Import content adjustment cost	ϕ_{AF}	2
Price adjustment cost	ϕ_{PF}	200
Government		
Labour income tax rate	τ_L	0.23
Consumption tax rate	τ_C	0.31
Capital income tax rate	τ_K	0.17
Firms' payroll tax rate	τ_{SP}	0.19
Debt to GDP ratio (annualised)	$\frac{b}{gdp}$	0.53
Fiscal stance parameter	d_1	1.00
Speed adjustment towards the target debt ratio parameter	d_2	0.10

Table 6: Initial (pre-aging) steady-state key ratios

	Data	**Model**
Expenditure (as a % of GDP)		
Private consumption	0.64	0.60
Government consumption and GFCF	0.23	0.23
Private investment	0.21	0.21
Exports	0.30	0.29
Imports	0.38	0.33
Labour income share (as a % of overall income)	0.58	0.57
Tradable goods	0.54	0.55
Non-tradable goods	0.59	0.59
Capital-output ratio (as a % of output)	*NA*	2.34
Tradable goods	*NA*	2.53
Non-tradable goods	*NA*	2.21
Government (as a % of GDP)		
Debt stock	0.58	0.53
Fiscal balance	-0.03	-0.02
Overall revenues	0.42	0.43
Overall expenditure	0.45	0.45
External account (as a % of GDP)		
Net foreign assets	-0.64	-1.44
Current account	-0.08	-0.06
Trade balance	-0.08	-0.04
Demographic structure		
Old-age dependency ratio	0.29	0.29
Working-age population ratio	0.77	0.77

Note: *NA* stands for non-available data.

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