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Fiscal consolidation in a small euro area economy*

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Abstract

This article focuses on the costs and benefits of a fiscal consolidation in a small euro area economy. The macroeconomic impacts and the welfare analysis are conducted in a New-Keynesian general equilibrium model with non-Ricardian agents. We define a benchmark fiscal consolidation strategy based on a permanent reduction in Government expenditure. We find that, over the long run, fiscal consolidation leads to a considerable increase in the level of output and consumption, and is welfare improving. In addition, the gains are boosted if the fiscal strategy also involves a tax reform that shifts the tax burden away from labour income towards the final goods consumption. However, important short-run costs arise, notably output, consumption and welfare losses. Finally, we assess the effect of alternative fiscal consolidation paths in terms of the degree of front loading, the speed of its completion and the interaction with risk premium.

Keywords: fiscal policy, fiscal consolidation, DSGE model, euro area, small-open economy.
JEL classification numbers: E62, F41, H62

*The views expressed in this paper are those of the authors and do not necessarily reflect the views of Banco de Portugal. Any errors and mistakes remain ours.

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1 Introduction

The Great Recession triggered by the international financial crisis led to the implementation of massive fiscal stimulus plans in many economies. In addition, the injection of public funds in many troubled financial institutions assumed also a crucial role in taming systemic risk. In this context, public debt increased substantially across developed economies, including the United States, euro area economies, the United Kingdom and Japan. These developments raised increasing concerns over the public finances sustainability, bringing the discussion on the need of a fiscal consolidation to the center stage of the economic policy debate.

In a context of tense global financing conditions created by increased risk aversion, the uncertainty on public finances sustainability in many economies led to a reappraisal of the sovereign debt risk pricing, which translated into an uneven increase in Government bond yields, in particular across euro area economies. These developments challenged the widely-held belief that the euro was a bulletproof vest against risk price discrimination among participant economies, since the common monetary policy coupled with the Stability and Growth Pact rules were taken as almost ensuring perfect risk-sharing.

The international financial and economic crisis put in evidence the heterogeneity of euro area economies and discredit the perfect risk sharing assumption. Those economies revealing more fragilities, in particular larger fiscal imbalances, asset price bubbles and/or higher dependence of the banking system from wholesale international financial markets, started to be more discriminated in what respects debt pricing. More precisely, higher quality sovereign debt experienced a relative price increase against lower quality debt. The need for credible fiscal consolidation strategies became more evident after Greece entered the IMF/European Financial Stability Facility programme. Policymakers in Europe and the IMF asked for the quick implementation of credible fiscal consolidation programmes in the remaining economies under pressure to avoid systemic problems over the entire euro area, in particular after the collapse of the Irish banking system. Under these circumstances, the debate on the fiscal consolidation strategies and the associated costs and benefits became topical.

The article focuses on short, medium and long run impacts on economic activity, demand conditions and welfare of fiscal consolidation based on specific fiscal policy measures, encompassing permanent cuts in government expenditure and temporary increases in labour income taxes. The impact of unbalancing the instruments towards a stronger increase in consumption taxes in exchange for a smaller increase on taxation on labour income is also analysed, which in the context of a small-open economy integrated in a monetary union is a possible way of forcing a real exchange rate devaluation, thereby regaining competitiveness and reducing the external imbalance. This might be an important objective in the case where the fiscal deficit and the external deficit (the "twin deficits") are a major topic. The impact of alternative timings to complete fiscal consolidation is also addressed. Finally, we consider the case in which the consolidation strategy restores

credibility, bringing interest rates to levels below the pre-consolidation period.

The article is exclusively focused on the macroeconomic impacts in a small euro area economy. The discussion is based on *PESSOA*, a New-Keynesian model described in Almeida, Castro and Félix (2010). The model was designed and calibrated to fit the characteristics of a small open economy (SOE) integrated in a monetary union. This implies that foreign variables (corresponding to the rest of the monetary union) are assumed to be orthogonal to domestic developments as in Adolfson, Laseén, Lindé and Villani (2007), with the stability of the model being granted by the full credibility of the inflation objective and by the large elasticities of real trade variables to real exchange rate fluctuations. Domestic price levels are pinned down by the external constraint that sets a unique steady-state real exchange rate level. To use an expression from Giavazzi and Pagano (1988), the SOE in *PESSOA* is effectively "tying its hands" with the rest of the euro area.

Contrary to most DSGE models in the literature on SOE, *PESSOA* is intrinsically non-Ricardian, featuring finite-lifetime households (Blanchard 1985, Yaari 1965), distortionary taxation and liquidity constrained households (Galí, López-Salido and Vallés 2007). These features, coupled with a rich fiscal block, make the model particularly suited for fiscal policy analysis. In particular, the finite-lifetime framework creates a non-trivial role for fiscal policy over the medium and long run, introducing a source of non-Ricardian behaviour absent in the mainstream infinitely-lived agents environment. In addition, this framework allows for the endogenous determination of the net foreign asset position (Harrison, Nikolov, Quinn, Ramsay, Scott and Thomas 2005), thereby delivering a realistic co-movement between public debt and the net foreign asset position, in contrast with the infinitely lived agents case (Schmitt-Grohe and Uribe 2003).

The structure of the article is as follows. In section 2, we motivate the analysis and briefly survey some literature. The model is presented in section 3, along with the calibration strategy. Section 4 addresses the impact of alternative fiscal consolidation strategies, with alternative timings, on the main macroeconomic aggregates and on welfare. This section includes a scenario in which the fiscal consolidation is accompanied by a reduction in the domestic risk premium. Section 5 concludes and draws some policy implications.

2 Motivation

The behavior of public debt over the last 15 years has not been homogenous across euro area countries. Figure 1 reports the public debt ratio in selected Member-states, between 1995 and 2007. Several countries recorded a reduction in debt ratio, while others recorded significant increases. Between 2007 and 2009, however, uneven developments disappeared with all euro area countries sharing an upward trend. Ireland, Spain and the Netherlands are among those where the increase in public debt in recent years was in clear contrast with the pre-crisis period, while in Greece and Portugal the deterioration trend aggravated.

The increase in public debt in the recent past occurred against a background of an international financial crisis, triggered in August 2007 by mounting problems in the sub-

prime housing credit in the United States (US). The crisis gained momentum, in a second phase, after the collapse of Lehman Brothers in September 2008 (Rother, Schuknecht and Stark 2010). Spring 2010 may have marked the beginning of the third phase of the international financial crisis, when concerns over fiscal positions intensified dramatically the sovereign debt crisis.

During 2009, fiscal authorities in many economies (not only in the euro area, but also elsewhere, including the United States, United Kingdom or Japan) decided to implement massive fiscal stimulus, aimed at supporting demand conditions through public investment plans, increased generosity of transfers to households and non-financial firms that were more hardly hit by the crisis, while promoting in some cases a tax burden relief. The implementation of these discretionary measures, coupled with the operation of the automatic stabilisers, in a context in which the economic activity suffered a major slump (despite the stimulus measures) and prices declined, led to strong fiscal imbalances. Moreover, injections of public funds in troubled financial institutions were also performed to tame systemic risk.

In an international context dominated by increased risk aversion, financial market participants reassessed sovereign debt spreads. In particular, a number of small euro area economies revealing structural fragilities suffered a strong rise in sovereign risk pricing as measured by the spread of national Government bond yields vis-à-vis Deutsche Bunds. This was initially the case of Greece, where concerns on the sustainability of the public finances started well before the financial crisis, but materialised into soaring debt spreads only in late 2009 as a huge imbalance started to unveil. In April 2010 Greece asked for the activation of the IMF/European Financial Stability Facility programme.

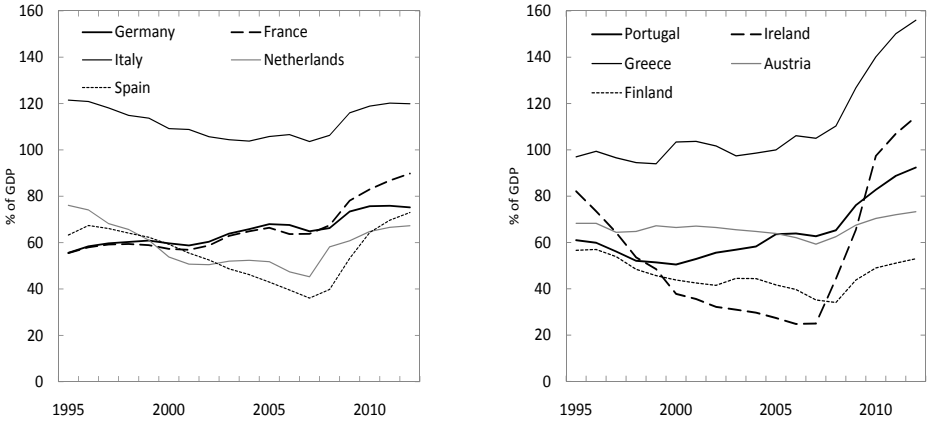
Spain, Portugal and Ireland also suffered, in early 2010, strong sovereign debt spread rises after unveiling huge fiscal imbalances in the 2009 accounts.[1] In the case of Spain and Ireland, the strong growth pace recorded in the last decade largely fueled a housing market bubble, the burst of which implied a strong adjustment in both households and the banking sector. In the case of Ireland, the collapse of the banking system implied the request for a rescue package from IMF and Europe in the end of 2010.

Preliminary data for 2010 and EC forecasts for 2011-12 confirm that government debt ratios reached "unprecedent peacetime levels" in some cases, to recover a rather worrying expression of Rother et al. (2010)[2], and clear unsustainable dynamics, as depicted in Figure 1. In general, all these developments challenged the widely-held belief that the common monetary policy coupled with the implementation of the Stability and Growth Pact rules were stringent enough to ensure public finances sustainability and price stability in the euro area.

[1] In the case of Portugal, the huge imbalance in 2009 resulted from a discretionary increase in public expenditure, which can only partly be justified by the stimulus package. For instance, the civil servants wage scale in the general election year of 2009 was updated by 2.9 per cent, a figure well above all inflation expectations and that materialised ex-post into an increase in real wage close to 4 per cent. This evolution followed a fiscal consolidation period initiated in 2005, which brought the fiscal deficit from above 5 per cent of GDP to below the 3 per cent threshold in 2008.

[2] Rother et al. (2010), p.6.

Figure 1: General government gross debt in the euro area



Source: European Commission. Forecasts from EC (2010), published in November 2010.

The high public debt levels are particularly worrisome in economies that also have ongoing long-run sustainability issues, namely due to structural features such as ageing and its future impacts in social security outlays or developments in health expenditures. The policy advices of international institutions, calling for a substantial and fast debt reduction, are addressed theoretically by Caprioli, Rizza and Tommasino (2010). The results, obtained in a DSGE model, are confronted with those of the mainstream optimal fiscal policy literature that calls for debt stabilization.

In this context, restoring debt sustainability after the crises, evaluating the benefits of fiscal consolidation in the long-run and creating conditions for a successful consolidation process have become a major focus of the current economic literature (Rother et al. 2010, Mulas-Granados, Baldacci and Gupta 2010, Barrios, Langedijk and Pench 2010). This literature addressed several topics. For instance, it is mentioned that fiscal consolidation supports fiscal sustainability both directly and indirectly via positive growth effects, highlighting that consolidation can have positive wealth effects on consumption. Furthermore, fiscal consolidation improve the availability of funds and reduce the probability of sudden stops (where all market-based funding ceases), reduces the contingent liabilities across countries, strengthens the robustness and insurability of the financial system and reduces solvency risks. It was also highlighted that the margin of manoeuver to use fiscal policy as a countercyclical tool when deemed necessary increases if the economy is in a sound fiscal position. The macroeconomic impacts of fiscal consolidation are also addressed by Coenen, Mohr and Straub (2008*a*) using a two country open-economy model. The results suggest positive long-run impacts on key macroeconomic aggregates, in particular when the improved budgetary position is used to cut distortionary taxes in the long run.

3 A model for a small euro area economy

This section presents *PESSOA*, the New-Keynesian dynamic general equilibrium model behind the analysis of the macroeconomic impacts of a fiscal consolidation. The model was used to analyse shocks that hit the Portuguese economy over the last decade in Almeida, Castro and Félix (2009) and is described in Almeida, Castro and Félix (2010). The model features a SOE integrated in a fully-fledged monetary union, the euro area. It is assumed from the outset that the rest of the monetary union is not affected by domestic shocks, implying that monetary policy decisions are orthogonal to domestic developments as in Adolfson et al. (2007). In the SOE setup, the domestic economy is modelled in detail, while the rest of the monetary union modeling is very parsimonious. Contrary to most general equilibrium models in the literature on SOE, *PESSOA* has intrinsic non-Ricardian features inspired by the IMF's Global Integrated Monetary and Fiscal model (Kumhof, Muir, Mursula and Laxton 2010).

It is well known that breaking the Ricardian equivalence is of paramount importance to generate realistic impulse response functions of private consumption in the advent of a fiscal shock (Blanchard 1985, Galí et al. 2007). *PESSOA* is intrinsically non-Ricardian, featuring: finitely-lived households in line with the stochastic finite lifetime framework (Blanchard 1985, Yaari 1965, Buiter 1988, Weil 1989); distortionary taxation on households consumption, labour and capital income; and hand-to-mouth households (Galí et al. 2007). The fiscal block of the model is detailed enough to account for several types of distortionary taxation, lump-sum transfers to households (to all or to a targeted group), and government expenditure.

This setup generates a non-trivial role for fiscal policy not only in the short-run but also in the medium and long-run. As clarified in Frenkel and Razin (1996) and in Kumhof and Laxton (2009*b*), the stochastic finite lifetime framework may generate sizeable wealth effects of public debt issuance, which are absent in the workhorse infinitely-lived agent framework. In the Blanchard-Yaari-Buiter-Weil world, households strongly prefer debt issuance to tax financing of Government expenditure, since future generations will bear some of the tax burden (Buiter 1988). In addition, this framework allows for the endogenous determination of the net foreign asset position (Harrison et al. 2005), since finite lifetimes limit the amount of assets/debt that a household can accumulate.[3] This represents an appealing feature for the simulation of permanent fiscal shocks, since it generates a positive correlation between public debt and the net foreign debt position of the economy. On the contrary, in the workhorse infinitely lived agents model, the steady-state net foreign asset position is pinned down exogenously (Schmitt-Grohe and Uribe 2003), implying that changes in steady-state public debt are fully offset by private saving and are, by assumption, uncorrelated with the net foreign debt.

[3]It should be pointed out that by definition a SOE does not affect the world investment-savings balance and, therefore, the world real interest rate. Hence, infinitely lived agents will be able to borrow or lend in infinite amounts that can be paid or received in the indefinite future. For further details refer to Barro and Sala-i-Martin (1995).

Since *PESSOA* is designed for a SOE integrated in a monetary union, the adjustment mechanism of the economy to domestic shocks is rather different from the standard general equilibrium model setup, in which monetary policy and real interest rate movements are crucial to render the model dynamically stable. In *PESSOA*, monetary policy is trivial in the sense that the domestic interest rate is orthogonal to domestic shocks and can only deviate from the rest of the union rate by a risk premium, assumed to be exogenous. This implies that domestic shocks affecting domestic inflation developments tend to generate powerful effects on the real interest rate, amplifying domestic economy fluctuations. The dynamic stability of the model is ensured instead by an active role of the real exchange rate (which in the case of an irrevocably fixed nominal exchange rate simply reflects the relative price of domestic goods vs. foreign goods) in the adjustment of international trade in goods and assets. Domestic agents in *PESSOA* are assumed to trade in goods and assets/debt solely with agents in the monetary union. Therefore, real exchange rate fluctuations have sizeable impacts on competitiveness, trade and thus in the net foreign asset/debt position of the economy. Since foreign prices developments are assumed to be independent of domestic shocks, the real exchange rate pins down uniquely the domestic price level.

Finally, *PESSOA* features monopolistic competition and a number of nominal and real rigidities that give rise to realistic short-run impacts and create room for stabilisation policy. On the nominal side, differentiation in the labour and product markets stemming from monopolistic competition, allows for staggered wage and price inflation. On the real side, the model incorporates external habit formation in consumption and quadratic adjustment costs on investment and import contents.

The model is populated by households, which will be presented in detail in subsection 3.1; unions, presented in subsection 3.2; and firms (intermediate goods producers and final goods producers), which will be presented in subsection 3.3. These agents interact with a Government, which is described in subsection 3.4. The rest of the world, corresponding to the rest of the monetary union, is presented in subsection 3.5, while the market clearing conditions are presented in subsection 3.6. The model calibration is clarified in subsection 3.7.

3.1 Households

Households evolve in line with the overlapping generations scheme first proposed in Blanchard (1985). All households have stochastic finite lifetimes, facing an instant probability of death $1-\theta$ (θ is the probability of surviving between two consecutive periods), which is constant throughout life, independent of age and equal for all households.[4] However, the

[4]The probability of an individual dying after t periods of life is equal to $(1-\theta)\theta^{t-1}$ and the expected life horizon at any point in time is equal to $(1-\theta)^{-1}$. Probability $1-\theta$ can also be interpreted as a probability of "economic death" or a degree of "myopia" (Blanchard 1985, Frenkel and Razin 1996, Harrison et al. 2005, Bayoumi and Sgherri 2006). It represents the inverse of the average planning horizon of the household, which is likely to be far more shorter than its biologic lifetime. Bayoumi and Sgherri (2006) present econometric evidence for the US in this direction.

overall size of the population is assumed to remain constant and equal to N households, implying that in each period $N(1-\theta)$ households die and the same number of households is born. In addition, two types of households coexist: type $\mathcal{A}$, the asset holders, who can access asset markets and perform both intra and inter-temporal optimisation, smoothing out their consumption over lifetime by trading assets; and type $\mathcal{B}$, the hand-to-mouth households that do not access asset markets and are, therefore, not allowed to engage in inter-temporal optimisation, consuming all of their income in each and every period as in Galí et al. (2007). The share of type $\mathcal{B}$ households is assumed to be ψ, implying that in each period there coexist $N(1-\psi)$ households holding assets and $N\psi$ hand-to-mouth households.

A representative household of type $H \in \{\mathcal{A}, \mathcal{B}\}$ with age a derives utility from consumption, $C^H_{a,t}$, and leisure, $1 - L^H_{a,t}$, according to a CRRA utility function (with $L^H_{a,t}$ representing labour supply). The household's expected lifetime utility is:

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

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 parameter. Hab^H_t represents external habits, defined in *per capita* terms as $\left[C^{\mathcal{A}}_{t-1}/(N(1-\psi))\right]^v$ and $\left[C^{\mathcal{B}}_{t-1}/(N\psi)\right]^v$ for type $\mathcal{A}$ and $\mathcal{B}$ households, respectively, with parameter $0 \leq v \leq 1$ controlling for the degree of habit persistence.[5]

Households of type $\mathcal{A}$ save in both domestic and foreign government bonds, $B_{a,t}$ and $B^*_{a,t}$, which yield gross nominal interest rates i_t and i^*_t, respectively, from period t to period $t+1$ (by convention, interest is paid at the beginning of period $t+1$). Domestic public debt is assumed to be solely held by domestic agents (full home bias). Besides returns from financial assets, these households also receive labour income, earning a wage rate, W_t, adjusted by the household's age-specific productivity level, $\Phi_a = k\chi^a$, where k is a scaling factor and $0 \leq \chi \leq 1$ is the labour productivity rate of decay per period that generates a life-cycle income profile. Furthermore, they receive dividends from firms and from labour unions (the later reflect a wage premia that will be motivated later on). These are represented by $D^{\mathcal{A}}_{a,t}(x)$ where x can be: the intermediate goods producers of tradable ($\mathcal{T}$) and non-tradable goods ($\mathcal{N}$); the final goods producers of private consumption ($\mathcal{C}$), government consumption ($\mathcal{G}$), capital ($\mathcal{I}$), or export goods ($\mathcal{X}$); or labour unions ($\mathcal{U}$). Finally, households are taxed by the Government in their consumption and labour activities by $\tau_{C,t}$ and $\tau_{L,t}$, respectively, and receive transfers from the domestic Government and from abroad, $TRG^{\mathcal{A}}_t$ and $TRX^{\mathcal{A}}_t$, respectively.

The asset holders' optimisation problem consists in setting the path of consumption, labour, domestic and foreign asset holdings, that maximises (1) subject to the following

[5] Aggregation across generations is made possible by assuming that habits are multiplicative instead of additive. However, it should be recognised that this generates a low habit persistence.

budget constraint:

$$P_t C^{\mathcal{A}}_{a,t} + B_{a,t} + B^*_{a,t} \leq \frac{1}{\theta}\left[i_{t-1}B_{a-1,t-1} + i^*_{t-1}\Psi_t B^*_{a-1,t-1}\right] + \tag{2}$$

$$+ W_t \Phi_a L^{\mathcal{A}}_{a,t}(1-\tau_{L,t}) + \sum_{\substack{x=\mathcal{N},\mathcal{T},\mathcal{C},\\ \mathcal{G},\mathcal{I},\mathcal{X},\mathcal{U}}} D^{\mathcal{A}}_{a,t}(x) + TRG^{\mathcal{A}}_t + TRX^{\mathcal{A}}_t$$

where $P_t = (1+\tau_{C,t})P^C_t$, the after-tax price of the final consumption good, is the numeraire price of the economy and P^C_t is the before-tax price of the final consumption good.

Type $\mathcal{A}$ households are not indifferent between government expenditure financing with tax levies or debt issuance (which corresponds to future taxes). They strongly prefer debt issuance and take part of government bond holdings as net wealth. This non-Ricardian feature results essentially from finite lifetime and is amplified by the life-cycle income profile due to declining lifetime productivity. The intuition is that if government expenditure is financed with debt issuance, households will hold a share of this debt that exceeds the present discounted value of future tax liabilities, since future taxes will also be levied on yet-to-be born generations. Hence, part of the debt held by households is net wealth in the sense that it can be used to finance private consumption expenditures during lifetime, instead of being used to face future tax payments. These effects are magnified by the fact that the labour income tax represents an important part of overall tax revenue. The life-cycle income profile implies that labour productivity and wage income decline throughout lifetime and, therefore, farther apart in time taxes are levied the lower the labour income tax payments. The combination of stochastic finite lifetimes and life-cycle income profile implies that households tend to be more short-term oriented, than in the standard infinitely lived agents framework.

For type $\mathcal{B}$ households, the lack of access to assets/debt market implies that the intertemporal optimisation problem collapses to an intra-temporal optimisation problem (due to the impossibility of shifting consumption across periods by trading in assets). These households merely choose consumption and labour that maximise their instant utility introducing an additional layer of non-Ricardian behavior that is crucial to obtain realistic short-run responses of consumption to fiscal stimulus (Galí et al. 2007). Therefore, shocks occurring in a given period are totally reflected in the budget constraint of that period and create powerful income effects.

The optimisation problem of type $\mathcal{B}$ households is then to maximise (1) subject to the following budget constraint:

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

where all variables have the interpretation previously defined for asset holders.

The households utility maximisation problem delivers a condition for each type of household that yields their optimal consumption-leisure allocation, the consumption func-

tion, which depends on wealth in the case of asset holders and on per-period income in the case of hand-to-mouth households, and a degenerated interest rate parity condition. The consumption function expresses consumption as a function of human and financial wealth. Human wealth corresponds to the expected present discounted value of labour supply endowments and dividend income, while financial wealth is composed by the households' current domestic and foreign asset holdings. The interest rate parity condition defines the equilibrium in the bonds market and essentially implies that domestic interest rates depart from foreign interest rates by an exogenous risk premium, Ψ (in short, $i_t = i_t^* \Psi$).

3.2 Unions

There is a continuum of labour unions in the economy, indexed by $h \in [0, 1]$, who buy the homogeneous labour from households and transform it into different varieties, $U_t(h)$. The labour differentiation scheme gives market power to each union over its respective variety, allowing it to charge manufacturers a wage, $V_t(h)$, higher than the one paid to households. The different varieties are then combined to produce a labour bundle, $U_t(j)$, sold to manufacturer j at an aggregate wage, V_t, higher than W_t. This wedge reflects the fact that manufacturers pay a higher price for $U_t(j)$, as it incorporates differentiated labour inputs, contrary to the labour supplied by households.

Each manufacturer demands a certain quantity of all varieties of labour to be included in the labour bundle. Aggregating across manufacturers, the demand for variety h is given by:

$$U_t(h) = \left(\frac{V_t(h)}{V_t} \right)^{-\sigma_{U,t}} U_t \tag{4}$$

where $0 \leq \sigma_{U,t} \leq \infty$ is the elasticity of substitution across different varieties of labour, which determines the degree of union h market power, i.e., the markup charged over the wage paid to households in the steady state.

The wage-setting process is costly, with abrupt union wage ($V_t(h)$) changes being more costly than smooth wage adjustments. This is implemented by assuming that labour unions incur in wage adjustment costs, $\Gamma_t^{\mathcal{U}}(h)$. In the spirit of Ireland (2001) and Laxton and Pesenti (2003), quadratic adjustment costs are used:

$$\Gamma_t^{\mathcal{U}}(h) = \frac{\phi_{\mathcal{U}}}{2} T_t U_t \left(\frac{V_t(h)/V_{t-1}(h)}{V_{t-1}/V_{t-2}} - 1 \right)^2 \tag{5}$$

where $\phi_{\mathcal{U}}$ is the adjustment cost parameter and T_t is the level of the labour-augmenting technical progress, which enters as a scaling factor, ensuring that adjustment costs do not vanish along the balanced growth path.

Each labour union h solves the following maximisation problem:

$$\max_{V_t(h)} E_t \sum_{s=0}^{\infty} \tilde{R}_{t,s} D_{t+s}^{\mathcal{U}}(h) \tag{6}$$

subject to labour demand conditions and adjustment costs. $\tilde{R}_{t,s} = \prod_{l=1}^{s} \frac{\theta}{r_{t+l-1}}$ for $s > 0$ (1 for $s = 0$) stands for the subjective real discount factor and $r_t = \frac{i_t}{\pi_{t+1}^e}$ is the real interest rate, with π_{t+1}^e being the numeraire good expected inflation rate. Period t dividends, $D_t^{\mathcal{U}}(h)$, are defined as:

$$D_t^{\mathcal{U}}(h) = (1 - \tau_{L,t}) \left[(V_t(h) - W_t) U_t(h) - P_t \Gamma_t^{\mathcal{U}}(h) \right] \tag{7}$$

It should be noted that usually households directly provide the differentiated services and explore the corresponding market power in New-Keynesian general equilibrium models, while wages are subject to a staggered adjustment process *à la* Calvo in line with Erceg, Henderson and Levin (2000), in many cases with indexation, as in Smets and Wouters (2007) and Altig, Christiano, Eichenbaum and Linde (2005). This is not the case in the model used herein. Such option creates heterogenous labour and wages across households that can jeopardise aggregation in a model with an overlapping generations environment and a life-cycle income profile (since it increases the degree of wage heterogeneity across cohorts already in place due to the life-cyle income profile). Therefore, to keep the model tractable, the differentiated wage-setting problem is performed by the union, as in Fagan, Gaspar and Pereira (2004) and Kumhof et al. (2010), while wage stickiness is modelled as in (5).

3.3 Firms

The production block of the model features two types of firms: manufacturers, who produce intermediate goods, and distributors, who produce final goods. Manufacturers combine labour and capital to produce different varieties of tradable ($\mathcal{T}$) and non-tradable ($\mathcal{N}$) intermediate goods. Labour is purchased from unions, while capital results from the accumulation of new capital goods (investment) purchased from the respective distributor. The intermediate goods are sold to distributors, who combine them with imports to produce differentiated final good varieties. There are four types of final goods: consumer goods ($\mathcal{C}$); new capital goods ($\mathcal{I}$); Government consumption goods ($\mathcal{G}$) and export goods ($\mathcal{X}$), which differ in its content of tradable, non-tradable and imported goods.

Manufacturers

For each type of intermediate good $J \in \{\mathcal{T}, \mathcal{N}\}$ there is a continuum of manufacturing firms $j \in [0, 1]$. Each firm produces a variety of the good, $Z_t^J(j)$, using capital, $K_t^J(j)$, and labour, $U_t^J(j)$, as inputs. The firm sells the good at price $P_t^J(j)$, higher than the marginal cost, reflecting the market power yielded by product differentiation.

The production is modelled using the following CES technology:

$$Z_t^J(j) = \left((1-\alpha_U^J)^{\frac{1}{\xi_{ZJ}}} \left(K_t^J(j)\right)^{\frac{\xi_{ZJ}-1}{\xi_{ZJ}}} + (\alpha_U^J)^{\frac{1}{\xi_{ZJ}}} \left(T_t A_t^J U_t^J(j)\right)^{\frac{\xi_{ZJ}-1}{\xi_{ZJ}}} \right)^{\frac{\xi_{ZJ}}{\xi_{ZJ}-1}} \tag{8}$$

where $0 \leq \xi_{ZJ} \leq \infty$ is the elasticity of substitution between capital and labour in sector J; $0 \leq \alpha_U^J \leq 1$ is the quasi-labour income share; A_t^J is a stationary sector-specific technology shock; and T_t is a labour-augmenting technical progress, assumed to evolve deterministically at a constant exogenous rate g, such that $T_t/T_{t-1} = g$.

To accumulate capital, manufacturers invest, $I_t^J(j)$, subject to a standard capital accumulation condition:

$$K_{t+1}^J(j) = (1-\delta^J)K_t^J(j) + I_t^J(j) \tag{9}$$

where $0 \leq \delta^J \leq 1$ is a sector-specific constant depreciation rate.

In order to obtain a smooth response of production factor quantities to changes in their desired level, investment and labour are subject to quadratic real adjustment costs, $\Gamma_t^{\mathcal{I}J}(j)$ and $\Gamma_t^{\mathcal{U}J}(j)$, respectively, given by:

$$\Gamma_t^{\mathcal{I}J}(j) = \frac{\phi_{\mathcal{I}J}}{2} I_t^J \left(\frac{I_t^J(j)/g}{I_{t-1}^J(j)} - 1 \right)^2 \tag{10}$$

$$\Gamma_t^{\mathcal{U}J}(j) = \frac{\phi_{\mathcal{U}J}}{2} U_t^J \left(\frac{U_t^J(j)}{U_{t-1}^J(j)} - 1 \right)^2 \tag{11}$$

where $\phi_{\mathcal{I}J}$ and $\phi_{\mathcal{U}J}$ determine the cost of changing the investment rate and the labour intensity for firms in sector J; and I_t^J and U_t^J are aggregate investment and labour, respectively.

Furthermore, in order to obtain a realistic short-run behaviour of intermediate goods price inflation, quadratic adjustment costs, $\Gamma_t^{PJ}(j)$, following Rotemberg (1982), are considered:

$$\Gamma_t^{PJ}(j) = \frac{\phi_{PJ}}{2} Z_t^J \left(\frac{P_t^J(j)/P_{t-1}^J(j)}{P_{t-1}^J/P_{t-2}^J} - 1 \right)^2 \tag{12}$$

where ϕ_{PJ} determines how costly is to adjust prices for firms operating in sector J; Z_t^J is the aggregate output of sector J, which is sold to distributors at the price P_t^J.

Each distributor sets the demand of each variety of type J intermediate good, by solving a standard cost minimisation problem. Aggregating across distributors, the demand for variety j is given by:

$$Z_t^J(j) = \left(\frac{P_t^J(j)}{P_t^J} \right)^{-\sigma_{J,t}} Z_t^J \tag{13}$$

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

Each intermediate goods producer j solves the following maximisation problem:

$$\max_{P_t^J(j), I_t^J(j), U_t^J(j), K_{t+1}^J(j)} \quad E_t \sum_{s=0}^{\infty} \tilde{R}_{t,s} D_{t+s}^J(j) \tag{14}$$

subject to the constraints imposed by the production technology, capital accumulation condition, adjustment costs and demand conditions. Period t dividends, $D_t^J(j)$, are defined as:

$$D_t^J(j) = \textit{Operational cashflow}_t - \tau_{K,t} \times \left[\textit{Net operational profit}_t\right]$$

The $\textit{Operational cashflow}_t$ is defined as the difference between overall revenue and expenditure, as follows:

$$P_t^J(j) Z_t^J(j) - \left[(1+\tau_{SP,t}) V_t U_t^J(j) + P_t^{\mathcal{I}} I_t^J(j) + P_t^{\mathcal{I}} \Gamma_t^{\mathcal{I}J}(j) + V_t \Gamma_t^{\mathcal{U}J}(j) + P_t^J \Gamma_t^{PJ}(j) + P_t^J T_t \omega^J\right]$$

with $P_t^J(j) Z_t^J(j)$ corresponding to overall revenue, $(1+\tau_{SP,t}) V_t U_t^J(j)$ being labour costs inclusive of employer's social security contributions ($\tau_{SP,t}$ is motivated below in subsection 3.4), and $P_t^{\mathcal{I}} I_t^J(j)$ standing for investment spending, where $P_t^{\mathcal{I}}$ is the price of new capital goods. The term $P_t^{\mathcal{I}} \Gamma_t^{\mathcal{I}J}(j) + V_t \Gamma_t^{UJ}(j) + P_t^J \Gamma_t^{PJ}(j)$ includes costs related with price adjustments and with changes in the quantities of labour and capital used. Finally, a real fixed cost term, ω_J, scaled by the technological progress and by the output price level, $P_t^J T_t \omega^J$, is used to ensure that economic profits arising from monopolistic competition are largely depleted in the steady state and, therefore, there are no firms entering or leaving the market.[6]

A dividend income tax, $\tau_{K,t}$, is charged on *Net operational profit*, which differs from *Operational cashflow* by the fact that capital depreciation is tax rebatable, but investment expenditures are not. *Net operational profit* is defined as:

$$P_t^J(j) Z_t^J(j) - \left[(1+\tau_{SP,t}) V_t U_t^J(j) + P_t^{\mathcal{I}} q_t^J \delta^J K_t^J(j) + P_t^{\mathcal{I}} \Gamma_t^{\mathcal{I}J}(j) + V_t \Gamma_t^{UJ}(j) + P_t^J \Gamma_t^{PJ}(j) + P_t^J T_t \omega^J\right]$$

where q_t^J is Tobin's-Q, the shadow price of a unit of installed capital in terms of new capital goods.

Distributors

For each type of final good $F \in \{\mathcal{C}, \mathcal{G}, \mathcal{I}, \mathcal{X}\}$ there is a continuum of distributors $f \in [0,1]$. 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 manufacturing firms, government consumption goods ($\mathcal{G}$) are demanded by the Government, and export goods ($\mathcal{X}$) are demanded by foreign costumers. Distributors sell their goods at price $P_t^F(f)$, which incorporates a markup over the marginal costs.

[6] The fixed cost term is defined as a constant share of nominal output, ensuring that it does not vanish along the inflationary balanced growth path of the economy.

Each distributor uses a two-stage production technology. In the first stage, the distributor combines domestic tradable goods, $Z_t^{\mathcal{T}F}(f)$, with imported goods, $M_t^F(f)$, to obtain $Y_t^{\mathcal{A}F}(f)$, which is an assembled good of variety f; in the second stage, the distributor combines the assembled good with domestic non-tradable goods, $Z_t^{\mathcal{N}F}(f)$, to produce the variety f of the final good, $Y_t^F(f)$, which is then sold to its costumers. The production technology is formalised as a sector-specific nested CES production function.

The production function for variety f of the assembled good of type F is defined as:

$$Y_t^{\mathcal{A}F}(f) = \left[(\alpha_{\mathcal{A}F})^{\frac{1}{\xi_{\mathcal{A}F}}} \left(Z_t^{\mathcal{T}F}(f) \right)^{\frac{\xi_{\mathcal{A}F}-1}{\xi_{\mathcal{A}F}}} + (1-\alpha_{\mathcal{A}F})^{\frac{1}{\xi_{\mathcal{A}F}}} \left(M_t^F(f) \left[1 - \Gamma_t^{\mathcal{A}F}(f) \right] \right)^{\frac{\xi_{\mathcal{A}F}-1}{\xi_{\mathcal{A}F}}} \right]^{\frac{\xi_{\mathcal{A}F}}{\xi_{\mathcal{A}F}-1}} \tag{15}$$

where $0 \leq \xi_{\mathcal{A}F} \leq \infty$ is the elasticity of substitution between the domestic and the imported tradable goods; $0 \leq \alpha_{\mathcal{A}F} \leq 1$ is a home bias parameter; and $\Gamma_t^{\mathcal{A}F}(f)$ stands for a real adjustment cost on changes in the import content, $M_t^F(f)/Y_t^{\mathcal{A}F}(f)$, given by:

$$\Gamma_t^{\mathcal{A}F}(f) = \frac{\phi_{\mathcal{A}F}}{2} \frac{\left(\mathcal{A}_t^{\mathcal{A}F}(f) - 1 \right)^2}{1 + \left(\mathcal{A}_t^{\mathcal{A}F}(f) - 1 \right)^2} \quad \text{with} \quad \mathcal{A}_t^{\mathcal{A}F}(f) = \frac{M_t^F(f)/Y_t^{\mathcal{A}F}(f)}{M_{t-1}^F/Y_{t-1}^{\mathcal{A}F}} \tag{16}$$

where $\phi_{\mathcal{A}F}$ is a sector-specific adjustment cost parameter; M_t^F and $Y_t^{\mathcal{A}F}$ represent aggregate imports and assembled goods, respectively.

The production function of the variety f of the final good of type F is defined as:

$$Y_t^F(f) = \left[(1-\alpha_F)^{\frac{1}{\xi_F}} \left(Y_t^{AF}(f) \right)^{\frac{\xi_F-1}{\xi_F}} + (\alpha_F)^{\frac{1}{\xi_F}} \left(Z_t^{NF}(f) \right)^{\frac{\xi_F-1}{\xi_F}} \right]^{\frac{\xi_F}{\xi_F-1}} \tag{17}$$

where $0 \leq \xi_F \leq \infty$ is the elasticity of substitution between assembled and non-tradable goods, and $0 \leq \alpha_F \leq 1$ is the non-tradable goods bias parameter.

As in the case of labour unions and manufacturers, distributors face quadratic costs in the adjustment of the final good price, $\Gamma_t^{PF}(f)$, which take the following form:

$$\Gamma_t^{PF}(f) = \frac{\phi_{PF}}{2} Y_t^F \left(\frac{P_t^F(f)/P_{t-1}^F(f)}{P_{t-1}^F/P_{t-2}^F} - 1 \right)^2 \tag{18}$$

where ϕ_{PF} is the sector-specific price adjustment cost parameter; Y_t^F is the aggregate output of final good F, to be sold at price P_t^F.

Aggregate demand for variety f of final good F is given by:

$$Y_t^F(f) = \left(\frac{P_t^F(j)}{P_t^F} \right)^{-\sigma_{F,t}} Y_t^F \tag{19}$$

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

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

$$\max_{P_t^F(f),Z_t^{\mathcal{T}F}(f),Z_t^{\mathcal{N}F}(f),M_t^F(f)} E_t \sum_{s=0}^{\infty} \tilde{R}_{t,s} D_{t+s}^F(f) \tag{20}$$

subject to the constraints imposed by the production technology, adjustment costs and demand conditions. Period t dividends, $D_t^F(j)$, are defined as:

$$D_t^F(f) = (1-\tau_{K,t}) \left[P_t^F(f) Y_t^F(f) - P_t^{\mathcal{T}} Z_t^{\mathcal{T}F}(f) - P_t^{\mathcal{N}} Z_t^{\mathcal{N}F}(f) - P_t^* M_t^F(f) - P_t^F \Gamma_t^{PF}(f) - P_t^F T_t \omega^F \right]$$

corresponding to the after-tax overall revenue $P_t^F(f)Y_t^F(f)$ deducted of expenditure, including 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, $P_t^F(f)\Gamma_t^{PF}(f) + P_t^F(f) T_t \omega^F$. Finally, P_t^* is the price of imported goods, $M_t^F(f)$, set by foreign exporters.

3.4 The Government

The fiscal block of the model is detailed enough to allow for the assessment of macroeconomic impacts of alternative fiscal policy strategies. The Government has a number of fiscal instruments that can be used to stabilise the business cycle, though with different macroeconomic impacts. Government finances expenditure through tax levies that need not to coincide with expenditure in time, since Government manages a public debt stock. The disaggregation considered for the public sector account is illustrated in Table 1.

On the expenditure side, the government buys a specific final good, $P_t^{\mathcal{G}} G_t$ (recall that $P_t^{\mathcal{G}}$ is the price charged by distributors for the government consumption good) and performs lump-sum transfers to households, TRG_t. In addition, Government pays debt interest outlays, $(i_{t-1}-1)B_{t-1}$ (where B_{t-1} are one-period bonds which pay an interest rate i_{t-1} at the beginning of period t).

On the revenue side, the government levies taxes on households' labour income, $RV_{L,t} = \tau_{L,t} \left(V_t U_t - P_t \Gamma_t^U \right)$ and on households' consumption, $RV_{C,t} = \tau_{C,t} P_t^{\mathcal{C}} C_t$. In addition, Government charges social security contributions on firms' payroll, $RV_{SP,t} = \tau_{SP} V_t U_t$, and corporate income taxes due on operational profits by both manufacturers and distributors, $RV_{K,t}$, defined as:

$$\begin{aligned} RV_{K,t} = & \sum_{J=\mathcal{T},\mathcal{N}} \tau_{K,t} \left[P_t^J \left(Z_t^J - \Gamma_t^{PJ} - T_t \omega^J \right) - (1+\tau_{SP,t}) V_t U_t^J - P_t^I \left(q_t^J \delta^J K_t^J + \Gamma_t^{IJ} \right) \right] + \\ & + \sum_{F=\mathcal{C},\mathcal{I},\mathcal{G},\mathcal{X}} \tau_{K,t} \left[P_t^F \left(Y_t^F - \Gamma_t^{PF} - T_t \omega^F \right) - P_t^T Z_t^{TF} - P_t^* M_t^F - P_t^N Z_t^{NF} \right] \end{aligned}$$

Finally, it is considered the possibility of Government expenditures being partly funded through transfers from the rest of the monetary union, TRE_t.

It should be noted that the Government finances its expenditure mostly through distortionary taxation. In particular, taxation on labour income and/or higher social security contributions rate induce households to substitute consumption for leisure and/or manufacturers to use technologies with higher capital intensity. In addition, the consumption

tax rate also induces households to substitute away from consumption.

As previously mentioned, the Government issues one-period bonds, paying interest outlays at the beginning of period t on the stock held from period $t-1$. For the sake of simplicity, full home bias is assumed, i.e. all government debt is held by domestic households. However, since type $\mathcal{A}$ households can access international debt markets and borrow abroad to buy the bonds at a rate identical to Government this assumption is neutral.

The issuance of public debt allows for the postponement of charging the taxes required to finance expenditure in each period, implying that the public sector account does not need to balance out in each and every period. This has a non-trivial impact in households decisions, since the model is inherently non-Ricardian and, therefore, part of the public debt is taken as net wealth by asset holders.

Government's budget constraint can be represented as:

$$B_t = i_{t-1}B_{t-1} + P_t^{\mathcal{G}}G_t + TRG_t - RV_t - TRE_t \tag{21}$$

where $RV_t = \sum_{A=C,L,SP,K} RV_{A,t}$ are overall revenues.

To ensure that public debt follows a non-explosive path, a fiscal policy rule is featured, imposing that public debt and the fiscal balance (henceforth $SG_t = B_{t-1} - B_t$) converge to pre-determined target ratios in the steady state. The fiscal balance target ratio, $\left(\frac{SG}{GDP}\right)_t^{target}$, pins down a unique public debt target ratio, $\left(\frac{B}{GDP}\right)_t^{target}$, which is a key steady-state figure. For each period, the fiscal rule sets the fiscal balance that is consistent with a stable debt path, imposing that the budget constraint is binding and at least one of the fiscal instruments adjust endogenously to fulfil it. In line with Kumhof and Laxton (2009*a*), the following rule is considered:

$$\left(\frac{SG}{GDP}\right)_t = \left(\frac{SG}{GDP}\right)_t^{target} + d_1\left(\frac{RV_t - RV_t^{ss}}{GDP_t^{ss}}\right) + d_2\left(\frac{B_t}{GDP_t^{ss}} - \left(\frac{B}{GDP}\right)_t^{target}\right) \tag{22}$$

where RV_t^{ss} is the structural overall tax revenue (*i.e.* the tax revenue that would have been gathered in case tax bases stood at their steady-state levels); GDP_t and GDP_t^{ss} are the observed and the steady-state levels of Gross Domestic Product. The speed of convergence and the response to business cycle fluctuations depend on parameters d_1 and

Table 1: Simplified public sector account

Expenditures		**Revenues**	
Govt. Consumption	$P_t^{\mathcal{G}}G_t$	Consumption tax	$RV_{C,t}$
Transfers	TRG_t	Soc. Sec. Contributions	$RV_{SP,t}$
Interest Payments	$(i_{t-1}-1)B_{t-1}$	Labour income tax	$RV_{L,t}$
		Corporate income tax	$RV_{K,t}$
		Foreign transfers	TRE_t
Fiscal balance	$-(B_t - B_{t-1})$		

d_2. Parameter d_1 controls for the response to the tax revenue gap, while d_2 controls for the Government (in)tolerance to deviations of debt from the target ratio. Since revenue and debt gaps vanish in the steady state, the rule implies a convergence of the fiscal balance to its target level.

At this point, the fiscal instrument that becomes endogenous remains to be defined. This is an open fiscal policy decision and is largely a political matter. *Ex-ante*, the government has the following fiscal instruments: Government consumption (G_t), lump-sum transfers to households (TRG_t) (which can be targeted at rule-of-thumb households or uniformly distributed across all households), the labour income tax rate ($\tau_{L,t}$), the consumption tax rate ($\tau_{C,t}$), the employer's social security contributions rate (τ_{SP}) and the corporate income tax rate ($\tau_{K,t}$)[7]. However, *ex-post* one of these instruments is endogenously adjusted to meet the fiscal balance imposed by the fiscal rule.[8] The most common option relies on the use of the labour income tax rate as the endogenous fiscal policy instrument (Kilponen and Ripatti 2005, Kumhof et al. 2010, Kumhof and Laxton 2007). The benchmark specification of *PESSOA* also takes this option, but it allows for other possibilities, including not only the remaining taxes, but also transfers to households or Government consumption. In addition, it is also possible to consider alternative combinations of instruments.

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 of reality. In particular, Government consumption does not affect the marginal utility of consumption and leisure or the firms' productivity level. Therefore, the only tangible impact of Government consumption is changing demand conditions for a specific type of final good, which is particulary intensive in non-tradable intermediate goods and has a negligible import content. The model is thus silent to other roles of the Government, for instance as employer or investor. As Hall (2009) clarifies, it is not the case that effects operating through externalities are unimportant, but simply that the fiscal stimulus has to be undertaken as an experiment on a limited and controlled macroeconomic environment. It is beyond the scope of this paper to define externalities' effects conditional on different fiscal policies. Note also that the model does not feature unemployment benefits explicitly, since labour market details are reduced to the minimum and, therefore, unemployment developments are not explicitly modeled.

3.5 The rest of the world

By assumption, the rest of the world (RoW) corresponds to the rest of the euro area, and therefore the nominal effective exchange rate is irrevocably set to unity.

Regarding financial flows, it is assumed that changes in the net foreign asset/debt

[7]The distinction between Government consumption and investment is not considered in the model.

[8]In many studies, the budget constraint is simplified to include a non-distortionary lump-sum tax. Though it may be an appealing academic benchmark, it is largely unrealistic since the role played by lump-sum taxation is very limited.

position of the domestic economy have no impact on foreign macroeconomic aggregates and therefore on monetary policy decisions. As for trade flows, the demand for imports by domestic distributors results from the dividend maximisation problem presented in section 3.3 and reflects demand conditions and competitiveness. Concerning exports, let $Y_t^{A*}(f^*)$ be the good demanded by a continuum $f^* \in [0,1]$ of importers located abroad. This good is assumed to result from the assembling of a domestic exported good $X_t(f^*)$ and an intermediate tradable good $Z_t^{T*}(f^*)$ produced by foreign manufacturers. The production process is given by the following CES technology:

$$Y_t^{A*}(f^*) = \left((1-\alpha^*)^{\frac{1}{\xi^*}} \left(Z_t^{T*}(f^*) \right)^{\frac{\xi^*-1}{\xi^*}} + (\alpha^*)^{\frac{1}{\xi^*}} \left(X_t(f^*) \right)^{\frac{\xi^*-1}{\xi^*}} \right)^{\frac{\xi^*}{\xi^*-1}} \tag{23}$$

where ξ^* is the elasticity of substitution between foreign tradable goods and home exports and α^* is the foreign economy bias parameter.

Each foreign distributor will set the demand for the export good produced in the SOE and for the tradable goods produced in foreign economy that minimises the cost of producing the desired quantity of final good, subject to the technology constraint imposed by (23). Aggregating across importers and export good varieties, the demand for exports is:

$$X_t = \alpha^* \left(\frac{P_t^X}{P_t^{T*}} \right)^{-\xi^*} Y_t^{A*} \tag{24}$$

where P_t^X is the price of the exported good charged by domestic distributors, P_t^{T*} is the price of the foreign tradable good and Y_t^{A*} is aggregate production of the foreign assembled good. It should be noted that this equation is fundamental to render the model dynamically stable, namely due to a large elasticity of exports to real exchange rate movements. The model operates *de facto* like a real model (or a fixed nominal exchange rate model under perfect credibility), since domestic price levels are pinned down by the external constraint that uniquely sets the real exchange rate in the steady state. Like the remaining foreign variables, both P_t^{T*} and Y_t^{A*} are assumed to be independent of domestic developments.

Finally, some comments should be made concerning the external environment of *PESSOA*. Firstly, though restricting the RoW to the rest of the monetary union may be a limiting assumption, it does not seem to be very stringent for fiscal policy analysis and allows for a more parsimonious external block. More specifically, under this assumption one does not need to explicitly model interactions between the euro area and the world excluding the euro area. Obviously, this breakdown becomes clearly relevant in case one wants to assess the impact on the domestic economy of shocks originated abroad, in particular if a large share of external trade in goods and assets is done with countries outside the euro area. Secondly, while a country's exports in a multi-country framework are endogenously determined by imports demand of the trading partners, in a SOE model foreign economy

developments influence the domestic economy significantly, but are not influenced by it (Adolfson et al. 2007). Therefore, it seems reasonable to assume that foreign demand and prices are exogenous, with endogenous movements in exports being driven by real exchange rate fluctuations.

3.6 Market clearing conditions and GDP definitions

The model relies on a set of equilibrium conditions, which ensure that all markets clear in each and every period.

In the labour market, overall labour supply by households must equal overall labour demand by manufacturers:

$$L_t^{\mathcal{A}} + L_t^{\mathcal{B}} = U_t^{\mathcal{T}} + U_t^{\mathcal{N}} \tag{25}$$

In the intermediate goods market, the output produced by each type of manufacturer must meet demand by distributors and cover price adjustment and fixed costs:

$$Z_t^{\mathcal{T}} = Z_t^{\mathcal{TC}} + Z_t^{\mathcal{TI}} + Z_t^{\mathcal{TG}} + Z_t^{\mathcal{TX}} + \Gamma_t^{P\mathcal{T}} + T_t\omega^{\mathcal{T}} \tag{26}$$
$$Z_t^{\mathcal{N}} = Z_t^{\mathcal{NC}} + Z_t^{\mathcal{NI}} + Z_t^{\mathcal{NG}} + Z_t^{\mathcal{NX}} + \Gamma_t^{P\mathcal{N}} + T_t\omega^{\mathcal{N}} \tag{27}$$

In the final goods market, the output supplied by each type of distributor must meet demand by its respective costumers and cover adjustment and fixed costs:

$$Y_t^{\mathcal{C}} = C_t^{\mathcal{A}} + C_t^{\mathcal{B}} + \Gamma_t^{P\mathcal{C}} + T_t\omega^{\mathcal{C}} \tag{28}$$
$$Y_t^{\mathcal{I}} = I_t^{\mathcal{T}} + I_t^{\mathcal{N}} + \Gamma_t^{\mathcal{TI}} + \Gamma_t^{\mathcal{NI}} + \Gamma_t^{P\mathcal{I}} + T_t\omega^{\mathcal{I}} \tag{29}$$
$$Y_t^{\mathcal{G}} = G_t + \Gamma_t^{P\mathcal{G}} + T_t\omega^{\mathcal{G}} \tag{30}$$
$$Y_t^{\mathcal{X}} = X_t + \Gamma_t^{P\mathcal{X}} + T_t\omega^{\mathcal{X}} \tag{31}$$

In the foreign bond market, households change in asset net holdings must equal the current account:

$$B_t^* - i_{t-1}^*\Psi B_{t-1}^* = P_t^X X_t - P_t^* M_t + TRE_t \tag{32}$$

Finally, nominal GDP is defined as:

$$GDP_t = P_t C_t + P_t^G G_t + P_t^I I_t + P_t^X X_t - P_t^* M_t \tag{33}$$

while real GDP is defined as nominal GDP evaluated at the price levels prevailing in the initial steady state.[9]

[9]This mimics the national accounts definition of GDP at reference year prices.

3.7 Calibration

PESSOA was calibrated using actual data of the Portuguese economy and information from several studies on the Portuguese and euro area economies, including DSGE models. The model parameters are presented in detail in Appendix A.

The data on the Portuguese economy was mainly taken from the Banco de Portugal quarterly database (included in the 2009 Summer issue of the Economic Bulletin), and from the National Accounts data released by Statistics Portugal. These data sources were primarily used to pin down those parameters affecting the steady-state key macroeconomic ratios. As reported in Appendix A, the model matches fairly reasonably the key ratios of the Portuguese economy and delivers a plausible capital-to-output ratio.

Among the relatively large set of parameters and assumptions behind the model, it seems worth mentioning that the steady-state real GDP growth was assumed to be identical in the entire monetary union, which ensures the existence of a balanced growth path. The annual growth rate of the labour-augmenting productivity was set to 2%, which is consistent with the available estimates for the potential output growth in the euro area (Musso and Westermann 2005, Proietti and Musso 2007). This figure also seemed plausible for Portugal (Almeida and Félix 2006). Regarding inflation, the ECB inflation objective was assumed to be fully credible. Hence, the steady-state was solved under the assumption that foreign inflation stands at 2% per year. The euro area nominal interest rate in the steady state was set to 4.5% (Coenen, McAdam and Straub 2007). The parameters related with the Blanchard-Yaari households behaviour, namely the instant probability of death and the decay in productivity over the lifetime 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 were calibrated using Kumhof et al. (2010), Coenen et al. (2007) and estimates for Portugal, whenever they were available.

4 Macroeconomic effects of fiscal consolidation

This section assesses the macroeconomic effects of fiscal consolidation in a small euro area economy. Fiscal consolidation is defined as a permanent reduction in the public debt ratio and is implemented through a gradual fiscal tightening, followed by a stabilisation around the new steady-state level. Over time debt falls and so does Government interest outlays, which allows for a larger primary deficit in the new steady-state.

The analysis presented in this section is conducted by implementing a set of fiscal policy simulations using the model described in section 3, to study the costs and benefits of fiscal consolidation. We analyse the effects of two alternative fiscal consolidation scenarios: a pure fiscal consolidation and a fiscal consolidation accompanied by a tax reform. Those scenarios are based on a very specific set of policy measures, which were selected partly on the basis of their macroeconomic impacts. Therefore, before discussing those scenarios,

subsection 4.1 presents four simulations in which the impact of each available fiscal policy instrument on the main macroeconomic variables is analysed in isolation to illustrate the main transmission channels.

Subsection 4.2 studies the transitional dynamic, the steady-state and the welfare impacts of a pure fiscal consolidation programme and of a fiscal consolidation programme accompanied by a tax reform. The first scenario is focused on the potential benefits and costs of a fiscal consolidation, while in the second scenario it is examined whether costs can be minimised and benefits can be enhanced by a change in the policy mix.

In subsection 4.3 the pure fiscal consolidation scenario is expanded to implement a sensitivity analysis focused on the duration of the consolidation process. More specifically, we considerer two alternative scenarios. The first one concerns the possibility of a protracted consolidation period (the "slow consolidation scenario"), which is characterized by a less aggressive policy towards reaching the target debt-to-GDP ratio. The second one considers a shorter consolidation period (the "fast consolidation scenario") with a more aggressive policy towards reaching the target debt-to-GDP ratio.

In the above-mentioned scenarios it is assumed that the risk premium on Government debt is not affected by the level of the debt-to-GDP ratio. However, particularly in the current juncture, characterized by high risk premium on sovereign debt of some euro area economies and a low risk tolerance among investors, the assumption of an unchanged risk premium does not seem very realistic. Hence, subsection 4.4 considers a baseline where the risk premium in the small euro area economy is positive, reflecting the elevated public debt ratio, and an alternative exercise is conducted, adding to the pure fiscal consolidation strategy a permanent reduction in the country risk premium as consolidation takes place. The sensitivity of results to alternative paths for the risk premium on sovereign debt is also addressed.

Throughout this section, the fiscal consolidation experiments are all based on a permanent reduction in public deficit of 1 percent of initial steady-state GDP. Given the assumptions of the model for nominal interest rates and nominal GDP growth, around 4.5 and 4 per cent respectively, a permanent reduction in public deficit of 1 p.p. of initial steady-state GDP corresponds to a decline in Government debt-to-GDP ratio of around 25 p.p. in the long-run. However, given the extremely long-lived dynamics of fiscal consolidation, changes in flows take literally decades to be fully reflected in the corresponding public debt stock. Thus, in the following subsections impulse response functions are shown by lines for the first 10 years and by points representing outcomes as from year 20 onwards.

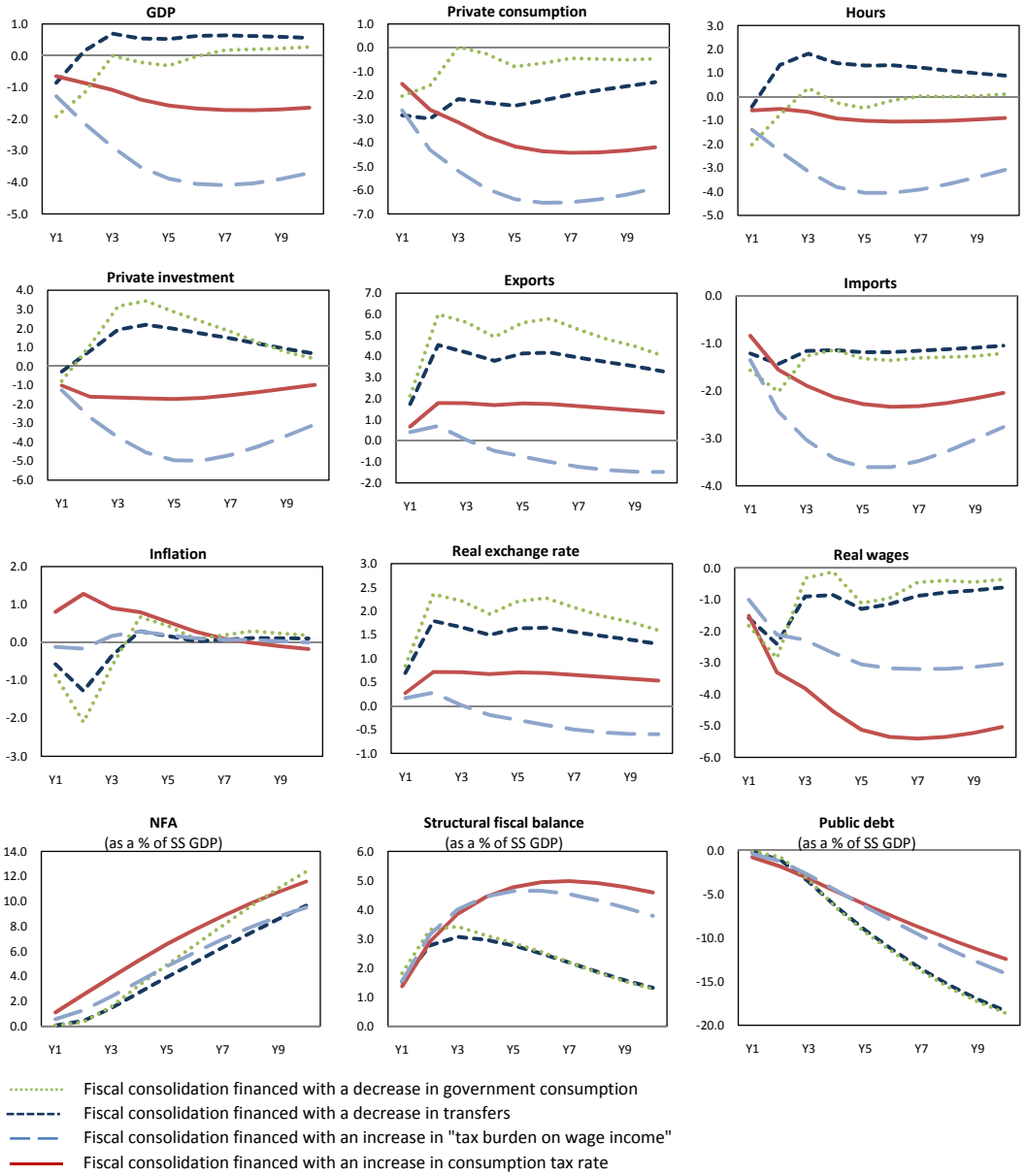
4.1 Impact of alternative instruments

Figure 2 presents the results of 4 alternative fiscal consolidation instruments, with one fiscal instrument being used at a time (transfers to households, Government consumption, "tax burden on wage income"[10] or consumption tax) to reach a reduction on the fiscal

[10] "Tax burden on wage income" corresponds to the labour income tax rate paid by employees and employers' social security contributions, which are adjusted in equal magnitudes in terms of percentage

Figure 2: Alternative fiscal instruments

(deviation from steady-state)



Note: Inflation, NFA and Public debt deviations are in percentage points. The remaining variables are in percentage. Higher real exchange rate implies depreciation.

deficit equal to 1 per cent of initial steady-state GDP. In each simulation, the remaining tax rates or spending components are held constant.

Starting with fiscal consolidation based on expenditure cuts, it affects macroeconomic

point changes in their average tax rates.

outcomes mainly through their impact on households' wealth and on the resulting responses of labour supply and private consumption.[11] A reduction in transfers has a significant negative wealth effect, leading to a drop in consumption and leisure and thus to an increase in labour supply.[12] Rule-of-thumb households strongly cut their consumption and simultaneously increase hours worked to compensate foregone income. Consumption of asset holders is less affected, reflecting expected dividend prospects and the possibility of consumption smoothing. Moreover, the shift in labour supply leads to lower real wages and to a decrease in the firm's' marginal costs implying a drop in domestic prices and a real exchange rate depreciation.

A decrease in the demand for Government consumption goods, which are labour intensive, implies a reduction in labour demand. As a consequence, real wages decline and so households' wealth and private consumption. In this simulation, unlike what happens in the transfers cuts, the impact in labour supply and consumption is similar for both types of households. Moreover, Government consumption goods production employs resources that would otherwise be available to produce other types of goods and so a cut in Government consumption reduces demand side pressures and contributes to a decrease in domestic prices and thus to international competitiveness gains, through real exchange rate depreciation.

Expenditure-based consolidation policies that reduce the demand pressures, promotes a real exchange rate depreciation and benefits the international competitiveness of domestic firms. This stimulates domestic production and factor demand and improves external imbalance, partly offsetting the recessionary impacts of fiscal consolidation. On the other hand, the fall in inflation raises the real interest rate, exacerbating the decline in aggregate demand and amplifying the short-run contractionary effect of fiscal consolidation.[13]

In turn, fiscal consolidation based on tax increases implies a protracted decline in output, private consumption and investment to below steady-state levels. Concerning "tax burden on wage income" it should be noted that it includes the labour income tax rate paid by employees and the employers' social security contributions. An increase in the labour income tax affects the economy mainly through their impact on the marginal rate of substitution between consumption and leisure. Hence, a rise in labour income tax discourages work effort, implying a decrease in labour supply. At the same time, an increase in employers' social security contributions leads to an increase in the marginal costs of firms and thus firms substitute labour for capital, reducing labour demand. Therefore, a rise in "tax burden on wage income" implies a decrease in hours worked and an increase in domestic prices, which implies a real exchange rate appreciation and a loss in competitiveness.

[11] For a detailed analysis on the impact of alternative fiscal instruments on the main macroeconomic variables and the implied transmission mechanisms see Almeida, Castro, Félix and Maria (2010).

[12] The underlying assumption behind the effect on labour supply is that all households act as labour suppliers, and therefore a cut in transfers induce a shift in labour supply. In practice, a part of the transfers are received by disability or old-age pensioners, which do not actively supply labour.

[13] In models with endogenous nominal interest rate, the contractionary short-term impact of fiscal consolidation is partly compensated by the monetary policy reaction, if the zero lower bound is not binding.

Regarding consumption tax, it is far less distortionary of the consumption/leisure allocation than "tax burden on wage income". Changes in consumption tax affects the economy mainly through the price transmission channel, reducing the real value of households wealth. This induces households to supply more labour in order to cushion the impact of the negative wealth effect on consumption, explaining the smaller decline in hours worked than in the case of the "tax burden on wage income".

Accordingly, "tax burden on wage income" is likely to be the instrument that involves higher short and medium term losses in terms of GDP, consumption and investment when used to perform fiscal consolidation. Consolidation strategies based on transfers and Government consumption cuts are the less penalising for real GDP, private consumption and investment. These results suggests that expenditure cuts tends to dominante tax increases in a fiscal consolidation strategy (Giancarlo Corsetti and Müller 2010), which could be particular true in the case of some European economies where taxes are high and where the recent period has been characterized by a huge rise in public expenditures. However, expenditure cuts are also likely to imply some reforms that take time to implement and so, in the short-run, taxes may help to speed up fiscal consolidation.

Therefore, we choose a fiscal consolidation strategy mainly based on expenditure cuts (Government consumption and transfers to households), but where "tax burden on wage income" adjusts endogenously, increasing slightly in the short-run in order to reach the lower target level for Government deficit more quickly (henceforth the pure consolidation scenario).

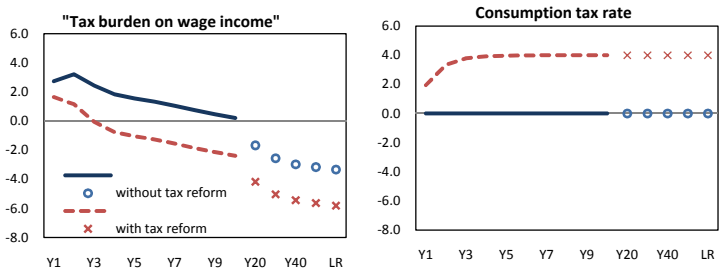
4.2 Two fiscal consolidation strategies

This subsection analises the impact on the main macroeconomic variables of two alternative fiscal consolidation scenarios that are based on specific fiscal instruments. The exercise is conducted assuming perfect foresight and full credibility of the fiscal authority and therefore the risk premium on Government debt is not affected by the consolidation strategy chosen. However, it should be highlighted that this assumption looks too strong at the current juncture and thus results should be interpreted with caution. In fact, if an economy is facing high market pressures and a rise in the risk premium, a credible fiscal consolidation may reduce it, implying lower borrowing rates and therefore smaller short-run costs of fiscal consolidation (see subsection 4.4).

The first scenario considers a pure fiscal consolidation strategy and corresponds to a permanent reduction in public deficit of 1 percent of initial steady-state GDP. The reduction in the deficit is mainly achieved through spending cuts, which are the least penalising fiscal instruments for economic activity. More specifically, it is considered a permanent cut in Government consumption and in transfers to households, each one contributing 0.5 per cent of initial steady-state GDP for the tightening. These fiscal measures are assumed to be gradually factored in over a period of four years. In the short-run, the adjustment to a lower deficit level implies that "tax burden on wage income" increases slightly (see Figure

Figure 3: Fiscal consolidation scenarios - evolution of tax rates

(deviation from steady-state in percentage points)



3). However, as Government debt falls, interest payments will decline and the resulting savings may be used to finance either new tax cuts or spending increases. We assumed that the savings are used to reduce "tax burden on wage income" over the medium and the long-run, since this instrument is the most distortionary and, therefore, a cut in "tax burden on wage income" enhances the impact on economic growth and welfare (this issue will be discussed below).

The second scenario regards a fiscal consolidation with a tax reform. Labour taxes or consumption taxes affect differently savings and labour supply decisions. It is often claimed that shifts towards taxes on consumption stimulate private saving, enhance economic growth and promote job creation. Moreover, it is also argued that the substitution of labour taxes for consumption taxes, for example the VAT, which is levied on final consumption and not on investment or exports, is a competitiveness-enhancing tool and can be seen as a devaluation of the domestic currency, but without the inflationary pass-through to domestic prices.

In this context, the scenario of fiscal consolidation with tax reform preserves the assumptions described previously, but adds a shift in the tax burden away from wage income towards consumption tax. In this scenario, it is assumed that the average consumption tax rate increases by 4 p.p.. "Tax burden on wage income" adjust endogenously as in the previous exercise, but given the additional revenue generated by the consumption tax it increases by less in the short run and falls more substantially in the long run. Hence, in the case of the simulation without tax reform "tax burden on wage income" remains above the baseline level during the first 10 years and then start to decline, whereas in the case of tax reform it only remains above the baseline level during the first 3 years (see Figure 3).

Figure 4 shows the short and long term impact in the main macroeconomic variables of the two fiscal consolidation scenarios. Regarding the short-tem, the pure consolidation scenario points to a fall in GDP, which reaches a trough in the second year, around 2.1 per cent below the baseline and starts to recover gradually thereafter. This scenario leads to a protracted period of below-steady-state real GDP, almost 10 years. Private consumption

strongly decreases in the first years, due not only to the direct impact of fiscal measures on wealth, but also to its impact on the real interest rate, which increases the return on savings, measured in terms of future consumption, and implies a further disincentive to present consumption. The negative impact on consumption and investment is slightly counterbalanced in the short-run by the anticipation of more favourable future wealth and dividends prospects due to expected lower distortionary taxes. On the other hand, the decrease in the price level leads to a gain in international competitiveness, which implies an increase in exports market share and a decline in the import content. Thus, in the short-run, fiscal consolidation leads to an improvement in the trade balance-to-GDP ratio.

In the case of a fiscal consolidation accompanied by a tax reform, it is assumed a permanent increase in the consumption tax, allowing a higher reduction of "tax burden on wage income" in the new steady-state, which in a rational expectation framework is anticipated by households. Hence, the tax reform reduces distortions in the economy, promoting a higher labour utilisation and an increase in international competitiveness, and therefore has a positive impact on GDP. Output decline is smaller in the short-run than in the pure fiscal consolidation, reaching a trough in the first year (around -1.6 per cent) and starting to recover thereafter. The period of below-steady-state real GDP is however substantially shortened, from 10 years in the first scenario to 6 years.

Overall, we can conclude that a fiscal consolidation has unavoidable contractionary short-run effects on economic activity, in particular in consumption and investment. At the same time, an expansion in net exports usually occurs, partly offsetting the negative impact of domestic demand on GDP. Moreover, we can conclude that short-run costs can be limited by changing the policy mix towards less distortionary taxation.

Regarding the long-run effects, Figure 4 also allows to shed some light on the question: Does fiscal consolidation generate long-term benefits?

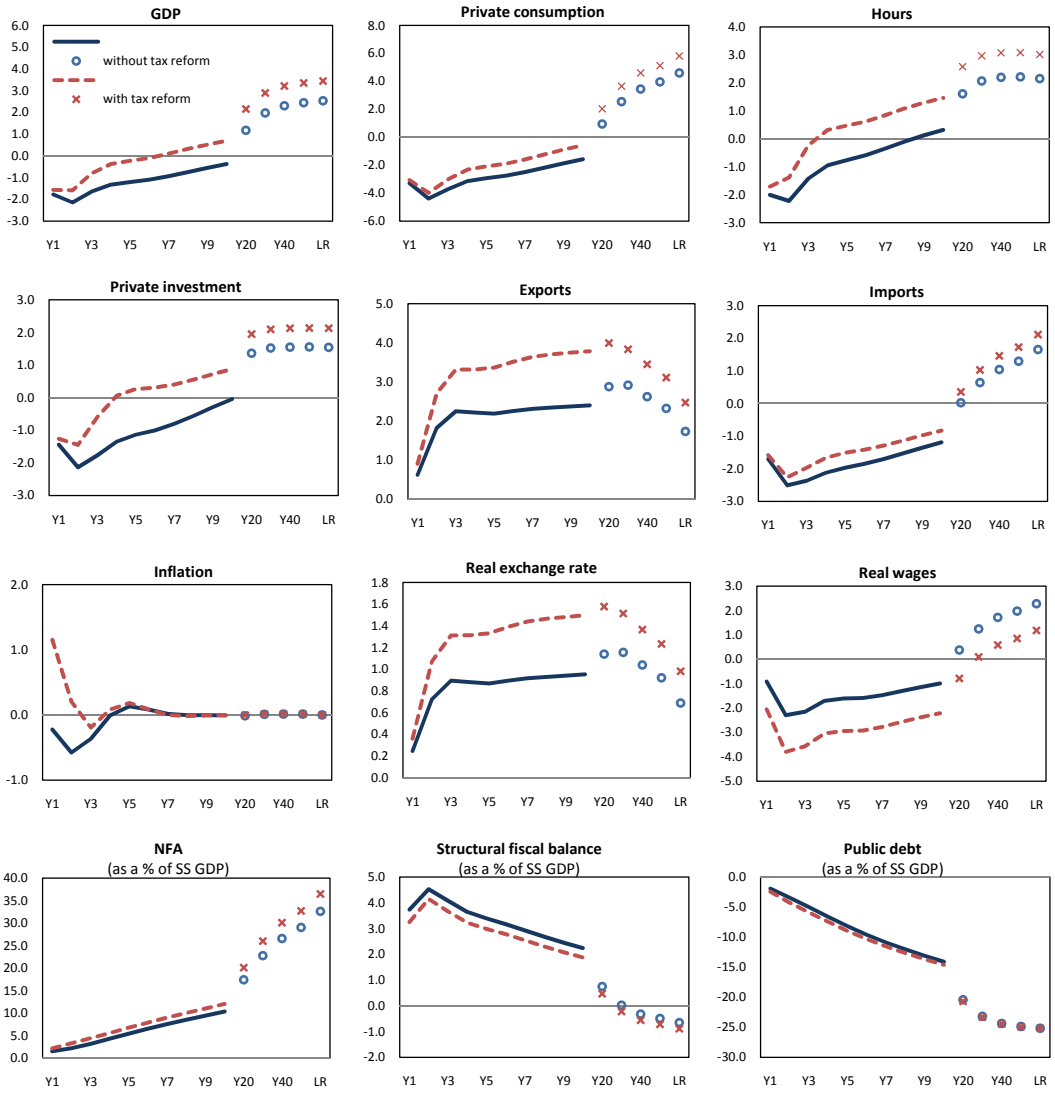
Lower public debt reduces over the longer time horizon the burden of Government interest payments, which in the simulations illustrated in Figure 4 is used to reduce the "tax burden on wage income". In the case of a fiscal consolidation without tax reform, the "tax burden on wage income" declines 3.3 p.p. in the new steady-state. Hence, households' after-tax real wage increases, raising the opportunity cost of leisure and therefore leading to an increase in households' labour supply. At the same time, labour costs of firms fall and labour demand increases, leading to a rise in the marginal product of capital and fostering capital accumulation. The increase in wealth, due to the increase in wage income and capital accumulation, boosts consumption and investment and therefore real GDP. In the long-run, real GDP is 2.5 per cent above the baseline.

In the case of a fiscal consolidation with tax reform the qualitative effects are quite similar, but the magnitudes are magnified. The "tax burden on wage income" declines 5.8 p.p. in the new steady-state and the long-run impact on real GDP is 3.5 per cent above the baseline, which is significantly higher than the impact of a pure fiscal consolidation.

The decrease in public debt implies a decline in the net foreign liabilities-to-GDP ratio of the small-open economy. Hence, the temporary trade balance improvement mentioned

Figure 4: Fiscal consolidation scenarios: without and with tax reform

(deviation from steady-state)



Note: For Inflation, NFA and Public debt deviations are in percentage points. The remaining variables are in percentage. Higher real exchange rate implies depreciation.

in the short-run analysis, mainly due to the real exchange rate depreciation, declines gradually, resulting in a lasting trade deficit financed by lower burden of interest payments on the domestic holdings of foreign debt in order to ensure that the net foreign liabilities stabilize at a lower level.

Finally, the effects of fiscal consolidation can also be assessed by analysing the impact on households' welfare. We consider a discrete time counterpart of the suggestion of Calvo and Obstfeld (1988), which has also been used in Ganelli (2005) and Kumhof, Laxton and

Table 2: Welfare assessment - compensating variation in consumption

(in percentage)

Discount rate	0.1%	2.8%	6.3%	30%
Average planing horizon of agents (years)	1000	36	16	3
Fiscal consolidation without tax reform	7.9	1.5	-3.4	-8.9
Fiscal consolidation with tax reform	10.4	3.5	-1.9	-8.2

Leigh (2008). Welfare analysis can be seen as a benchmark metric for the impact of a particular policy experiment in households welfare, as measured through the aggregate lifetime utility, which is a function of goods valued by households (consumption and leisure in the case at hand). Hence, welfare corresponds to a weighted average of the utility of the individuals alive in current and future periods, where a weighting factor W reflects the importance of future generations in the welfare from the viewpoint of the policymaker. The welfare impact is synthesised in the standard compensated variation of consumption measure proposed in Lucas Jr. (1987), which transforms utility into corresponding units of consumption good in the steady-state.[14] Table 2 presents the impact on households' welfare measured by the compensated consumption variation from a fiscal consolidation with and without tax reform. As the planing horizon increases the gains from consolidation in terms of households' welfare also increase. In the pure consolidation scenario households' welfare, in aggregate terms, varies from -7.5 per cent, if the planning horizon is very short, to 14.2 per cent, in a long term planning horizon. That is, for a planning horizon of more than 16 years there are welfare gains. In a scenario of fiscal consolidation with tax reform the welfare losses are lower in the short-run and the long-run gains are enhanced.

As mentioned before, we have assumed that the fiscal room created by lower interest rate payments on outstanding Government debt is used to lower "tax burden on wage income". This assumption was selected on the basis of their macroeconomic impact, as illustrated in Table 3. This table compares the long run impacts of a pure fiscal consolidation if savings on the burden of interest payments are used to cut consumption tax or to raise one of the spending components (Government consumption or transfers to households) instead of using them to cut the "tax burden on wage income". The results points to positive long-run impacts on economic activity from fiscal consolidation, regardless of the strategy chosen, except in the case that the fiscal authority uses the improvement in the fiscal position to raise transfers.[15] The positive effects on output vary from around 0.5 per cent (increase in Government consumption) to 2.5 per cent (cut in "tax burden on wage income"). When fiscal authority uses savings on interest payments to cut consumption tax, real GDP increases around 1.4 per cent. Thus, stronger positive impacts on GDP and in all private expenditure came from using savings to cut "tax burden

[14] A brief description of the methodology used for the welfare analysis is presented in the Appendix B.

[15] This result is conditioned to the assumption that all households act as labour suppliers and therefore a cut in transfers induce a shift in labour supply.

Table 3: Long-term effects of a permanent reduction of 1 p.p. in Government deficit

(deviation from steady-state in percentage)

	Lower interest burden used to:			
	Reduce τ_L	Reduce τ_C	Raise G	Raise TRG
GDP	2.5	1.4	0.5	-0.4
Private consumption	4.6	3.1	-0.2	0.8
Private investment	1.5	0.7	0.6	-0.3
Exports	1.7	1.1	0.4	0.2
Imports	2.1	1.0	0.4	-0.6
Hours	2.1	1.0	0.4	-0.6
Real wage rate	2.3	4.1	0.2	0.2
Real exchange rate	0.7	0.3	-0.2	-0.3
Compensating variation in consumption (in SS)	12.1	8.8	-1.6	3.7

Notes: All variables are measured in percent deviations from the steady-state levels. The "reduce τ_L scenario" corresponds to the one illustrated in Figure 4 without tax reform. Higher real exchange rate corresponds to a depreciation. The real exchange rate is computed with the prices of export goods. The fiscal instruments are "tax burden on wage income" (τ_L); consumption tax (τ_C); Government consumption (G); transfers (TRG).

on wage income", which is in line with the standard view of relative distortionary features of the different fiscal instruments. The same conclusion is achieved if we consider welfare analysis (see last row of Table 3).

We can conclude that despite the short-run costs of fiscal consolidation, in the long-run a lower Government debt-to-GDP ratio has positive impacts on economic activity, enhancing consumption, investment and exports, and increasing households' welfare. Moreover, the change in the composition of fiscal balance, in particular reducing "tax burden on wage income" and increasing consumption tax, is beneficial not only to reduce the short-run costs of fiscal consolidation but also to boost the long-run benefits. In short, reductions of fiscal distortions have sizeable expansionary effects on the economy and positive effects on aggregate welfare.

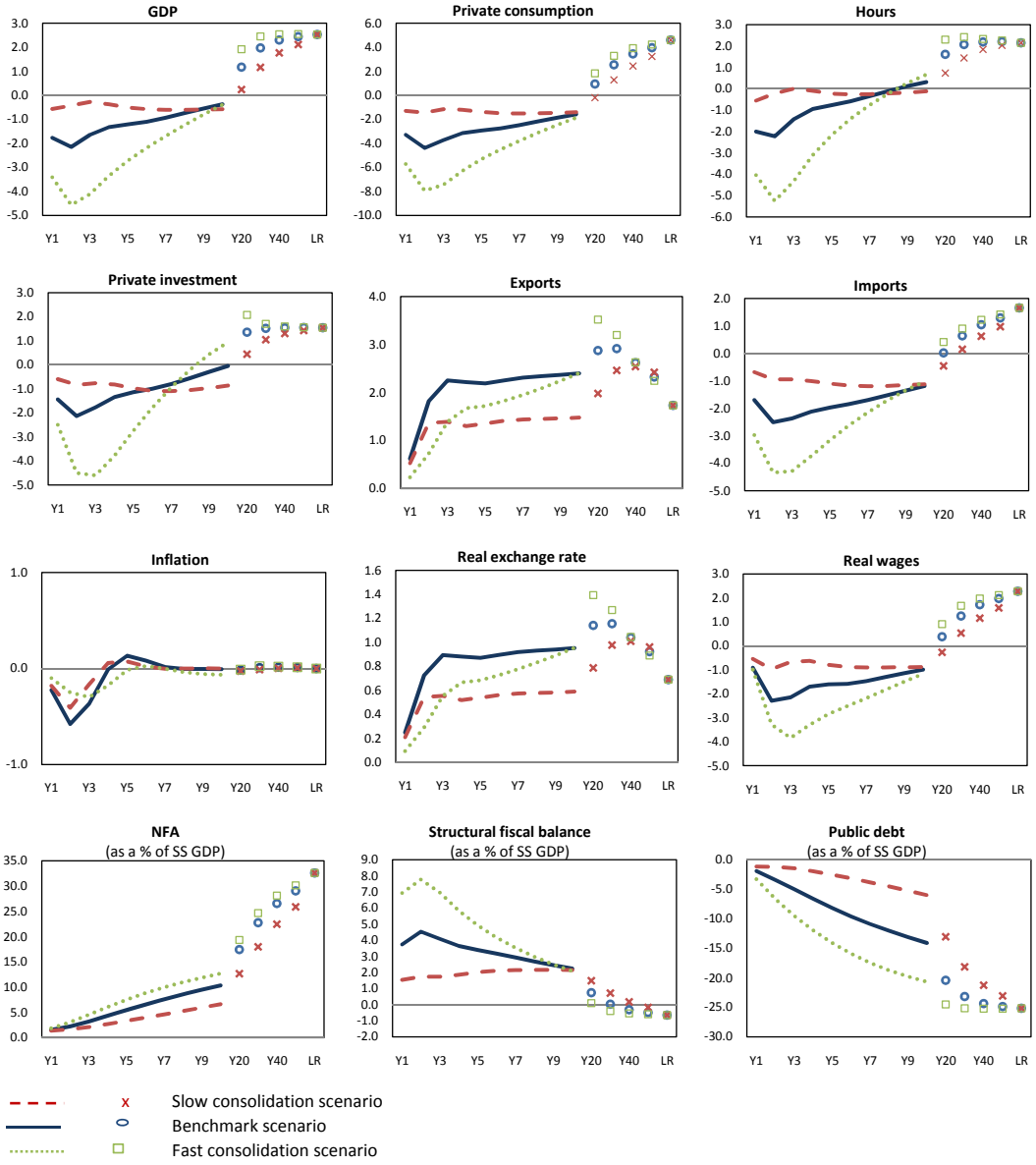
Finally, it is worth recalling that the analysis presented in this section does not take into account the probability that reduced Government debt will affect the foreign risk premium on euro area interest rates.

4.3 Alternative timings for fiscal consolidation

In this subsection we illustrate the impact of alternative timings to complete the fiscal consolidation. The scenarios differ in the time horizon in which the new target for the debt-to-GDP ratio has been reached: the benchmark scenario, which corresponds to the one illustrated in Figure 4 without tax reform, the "slow consolidation scenario" and the "fast consolidation scenario". The time by which half of the reduction in the target debt ratio is reached is 8 years, 19 years and 4 years, respectively. It is worth mentioning that, similar to previous simulations, our analysis is conducted under the assumption of perfect foresight, full credibility of the fiscal authority and unchanged sovereign risk premium.

Figure 5: Fiscal consolidation scenarios - alternative timings for fiscal consolidation

(deviation from steady-state)



Note: Inflation, NFA and Public debt deviations are in percentage points. The remaining variables are in percentage. Higher real exchange rate implies depreciation. The Benchmark scenario corresponds to the one illustrated in Figure 4 without tax reform.

The results are summarized in Figure 5.

A front-loading fiscal consolidation - the "fast consolidation scenario"- implies a deep recession, with significant losses in output, consumption, investment and hours worked in the short term. On the other hand, a slow fiscal consolidation, with a longer duration of the consolidation period, implies smaller output, consumption and investment losses

Table 4: Welfare assessment - compensating variation in consumption

(in percentage)

Discount rate	0.1%	2.8%	6.3%	30%
Average planing horizon of agents (years)	1000	36	16	3
Alternative timings for fiscal consolidation:				
Slow consolidation	7.2	1.4	-2.1	-3.9
Benchmark	7.9	1.5	-3.4	-8.9
Fast consolidation	7.9	0.7	-5.6	-14.8
Fiscal consolidation with decrease in the risk premium:				
$\rho^{\Psi} = 0.995$	24.5	11.9	3.4	-5.6
$\rho^{\Psi} = 0.98$	29.8	19.1	10.5	-0.8
$\rho^{\Psi} = 0.75$	31.7	23.9	17.2	6.9

and a smaller reduction in hours worked in the short and medium term, but a more protracted period of below steady-state GDP. Moreover, improvements in the international competitiveness of domestic firms', which takes place in all scenarios, are more limited in the case of a slow consolidation strategy.

The upper part of Table 4 presents the welfare costs and benefits for the 3 scenarios. Results show that for short-term horizons the slow consolidation scenario implies lower welfare losses, and therefore current generations may prefer this fiscal policy strategy. As the planning horizon increases, the difference between the alternative fiscal consolidation strategies in terms of costs and benefits narrows and therefore a slow consolidation may no longer be the optimal strategy for future generations.

The above results suggest that in general a credible slow fiscal adjustment implies in the short-run lower output and welfare costs.[16] However, it should be emphasized that results are conditioned by the assumption of an unchanged risk premium. In the current juncture, characterised by high risk premium on sovereign debt of some euro area economies and a low risk tolerance among investors, this assumption does not seem very realistic. Therefore, subsection 4.4 offers some evidence regarding the importance of considering the likely impact of risk premium changes conditioned to the chosen fiscal consolidation strategy.

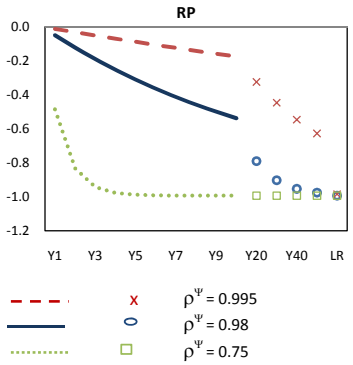
4.4 Fiscal consolidation with a decrease in the risk premium

This subsection presents a simple exercise to illustrate the importance of considering the role of the risk premium in the analysis of the costs and benefits of fiscal consolidation. The discussion of the impact of fiscal consolidation in a context of a small open economy that faces a high risk premium is particularly relevant in the current juncture. However, in *PESSOA* the risk premium is orthogonal to economic developments and do not reflect probabilities of default. In this context, an ad-hoc exercise was implemented to illustrate the impact of a reduction in the risk premium as a credible fiscal consolidation is im-

[16] For a similar result see Coenen, Mohr and Straub (2008*b*).

Figure 6: Fiscal consolidation scenario - evolution of risk premium

(in basis points)



plemented. The baseline of the pure fiscal consolidation scenario was changed in order to include a risk premium of 100 basis points in the small open economy. As the observed debt-to-GDP ratio converges to a lower target level, the risk premium decreases and reaches zero in the final steady-state. The risk premium (Ψ_t) is modeled as a shock that follows a first-order auto-regressive process:

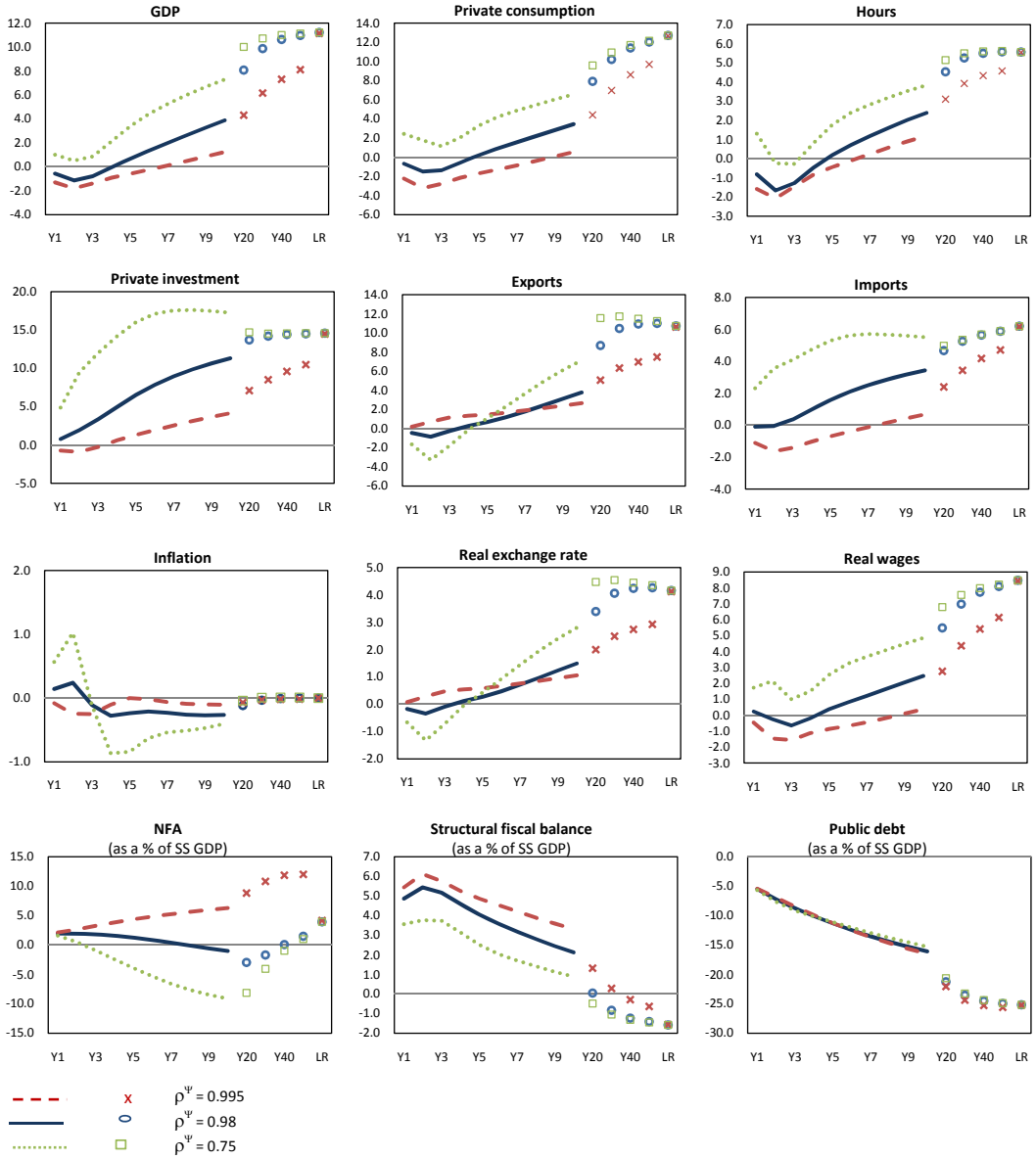
$$\ln \Psi_t = (1 - \rho^{\Psi}) \ln \bar{\Psi} + \rho^{\Psi} \ln \Psi_{t-1} + e_t^{\Psi} \tag{34}$$

Where ρ^{Ψ} is the persistence parameter, $\bar{\Psi}$ is the steady-state risk premium and e_t^{Ψ} stands for time t iid zero mean innovation. Figure 6 presents 3 alternative trajectories for the risk premium, which differs on the calibration of parameter ρ^{Ψ}.

Figure 7 shows the results of the pure fiscal consolidation scenario accompanied by a reduction in the risk premium, considering the 3 above-mentioned trajectories. The results point to a significant impact of a decrease in the risk premium on domestic demand and GDP developments. The decrease in the risk premium directly affects households and firms decisions, stimulating both consumption and investment. On the one hand, it implies a lower discount rate on future income, which increases net wealth and has a positive effect on households consumption. On the other hand, the decrease in the domestic interest rate and the higher demand prospects implies a higher desired capital stock level and thus has a positive impact on private investment. Additionally, the decrease in Government interest outlays implies a lower increase of the "tax burden on wage income" in the short-run and a more substantial fall in the long run, which leads to positive wealth effects enhancing the impact on economic growth.

The gains of fiscal consolidation in terms of households' welfare are enhanced and the short-term costs are reduced if the consolidation is accompanied by a decrease in

Figure 7: A pure fiscal consolidation scenario with a decrease in the risk premium
(deviation from steady-state)



Note: Inflation, NFA and Public debt deviations are in percentage points. The remaining variables are in percentage. Higher real exchange rate implies depreciation.

the risk premium (see Table 4). In the case of a sharp decrease in the risk premium (ρ^{Ψ}=0.75), fiscal consolidation leads to gains in current generations' welfare even for very short planning horizons.

Although the reduction in the risk premium is ad-hoc, it clearly shows the importance of taking risk premium effects into account in the discussion of the gains and costs of fiscal

consolidation. The results point to lower short-term costs and higher long-term benefits if the reduction in public debt is accompanied by a reduction in the risk premium, implying that short-term costs of fiscal consolidation are smaller in economies that face higher market pressures. Moreover, in a scenario of a sizeable immediate decrease in the risk premium, the impact of the fiscal consolidation may be even positive in the short-run, both in terms of GDP growth and households' welfare. This result is in line with the literature that highlights that fiscal contractions can have expansionary effects in some situations, namely if confidence in a country's public finance is low and the fiscal consolidation is pursued in a credible and consistent manner, fostering the sustainability of public finances in the long term.

The above results suggest that the appropriate fiscal consolidation strategy may not be identical for all economies. Sharp corrections are probably needed in countries that already face high and increasing foreign risk premium. Mild correction are nevertheless more desirable if the risk premium is in a more comfortable situation and is not largely influenced by fiscal developments. In the current juncture, it is particularly important to define an appropriate pace of fiscal consolidation, assessing very carefully the balance of risks, to minimise the contractionary effects on aggregate demand, which would undermine a stable macroeconomic environment for households and firms to restore confidence, and to avoid damaging credibility that would probably lead to upward pressures in the risk premium.

5 Conclusions

In the present juncture, a credible fiscal consolidation strategy seems necessary in many euro area countries to bring the public debt ratio to a declining and sustainable path. Moreover, some economies have been facing a surge in sovereign debt spreads and are being forced to take immediate and rapid measures to ensure the access of the public sector to the sovereign debt markets. However, debt reduction is painful for slow-growing economies, since it may imply output losses in the short-run. At the same time, lowering debt and thus reducing interest rate payments on outstanding government debt will bring long run benefits. In this context, evaluating the costs and benefits of fiscal consolidation and creating the conditions for a successful consolidation process have become an important policy issue. The present article contributes to the discussion of costs and benefits of fiscal consolidation in a small euro area economy.

This article analises the impact on the macroeconomic scenario and on households' welfare of alternative fiscal consolidation strategies, using a dynamic general equilibrium model with non-Ricardian features (*PESSOA*). Simulations show that fiscal consolidation, in general, implies a trade-off between the short-run costs and the long-run benefits. We also conclude that consolidation strategies based on transfers to households and Government consumption cuts are the less penalising for real GDP, private consumption, investment and welfare in the short-run. At the same time, long-term gains of fiscal con-

solidation are enhanced if the fiscal room created by lower Government interest outlays on outstanding debt is used to cut distortionary taxes, in particular, on labour. Therefore, well-designed consolidation strategies could minimise the short-term costs and enhance the long-run benefits. Additionally, we show that gains can be boosted if the fiscal consolidation strategy involves a tax reform that shifts the tax burden away from labour services towards the households consumption expenditures, in a deficit-neutral way, encouraging investment and labour supply and enhancing competitiveness by a real exchange rate depreciation.

The results also suggest that a front-loading fiscal consolidation implies a deeper recession, with significant short-term losses in output, consumption, investment, hours worked and welfare, when compared with a protracted consolidation strategy. Thus, if possible, a credible slow fiscal adjustment is in general more beneficial for the economy, in line with the optimality of tax smoothing. However, those results are conditioned by the assumption of an unchanged risk premium and, therefore, do not take into account the likelihood that domestic interest rates could be correlated with the debt level. In this case, the balance of short-run costs and long-run benefits might be quite different. The results show that if a fiscal consolidation strategy is pursued in a credible and consistent manner and implies a decreases in the risk premium on domestic interest rates, the short-term costs are reduced and, in extreme cases, the short-run impact may be expansionary. Therefore, the appropriate fiscal consolidation strategy may not be identical across the economies.

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Appendices

A Model calibration

This appendix reports in some detail the calibration of the model parameters reported in Table 1. As reported in the main text, the model matches fairly reasonably the key ratios of the Portuguese economy and delivers a plausible capital-to-output ratio by industry standards, as depicted in Table 2.[17]

The calibration of households parameters took into consideration the fact that the model features Blanchard-Yaari overlapping generations, instead of the infinitely-lived agents framework. These parameters were therefore largely based on Fagan et al. (2004), Harrison et al. (2005) and Kumhof and Laxton (2007). $\eta_{\mathcal{A}}$ and $\eta_{\mathcal{B}}$ were calibrated so as to ensure that the elasticity of labour supply to real wage is 0.5, a value commonly found in the literature. Since the Blanchard-Yaari overlapping generations households framework allows for an endogenous determination of the net foreign asset position, the discount rate was calibrated to ensure a net foreign debt position of 60% of GDP in the steady state. The coefficient of relative risk aversion was set to calibrate the inter-temporal elasticity of substitution to 0.2, which might seem a low figure in comparison with the values typically used in infinitely-lived agents models, but is in the range of the values regularly used in models featuring Blanchard-Yaari households. The share of liquidity constrained households was set to 40%, broadly in line with the estimates for Portugal presented in Castro (2006).

Concerning the labour unions parameters, we considered a 25% steady-state wage markup, which is at the upper limit of the values usually found in the literature. Note, however, that since the labour market in Portugal is strongly regulated, one may argue that the markup could be even higher than the figures usually found in the DSGE literature. 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 manufacturers, the depreciation rate was assumed to be identical across firms and was calibrated to get the investment-to-GDP ratio in line with the National Accounts data. As regards the production function, a standard Cobb-Douglas function between capital and labour was assumed and the distribution parameters were calibrated to match the labour income share in the National Accounts data. 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). In particular, the price markup of the non-tradable goods was set to 20%, which is at the upper bound of the range of values commonly found in the literature, but consistent with the evidence pointing to low competition in the Portuguese

[17] The Portuguese National Accounts do not include figures for the capital stock.

Appendix - Table 1: 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 death (annualised)	$1-\theta$	0.04
Households habit persistence	ν	0.70
Consumption share - Type $\mathcal{A}$ households	$\eta_{\mathcal{A}}$	0.74
Consumption share - Type $\mathcal{B}$ households	$\eta_{\mathcal{B}}$	0.66
Lifetime productivity decline rate (annualised)	$1-\chi$	0.04
Share of type $\mathcal{B}$ households	ψ	0.40
Wage mark-up	$\frac{\sigma_U}{\sigma_U-1}$	1.25
Wage rigidity - Adjustment cost	ϕ_U	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
Employers' social security contribution 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

Appendix - Table 2: Steady-state key ratios

	Data	**Model**
Expenditure (as a % of GDP)		
Private consumption	0.64	0.61
Government consumption and GFCF	0.22	0.21
Private investment	0.21	0.21
Exports	0.29	0.29
Imports	0.37	0.33
Labour income share (as a % of overall income)	0.57	0.56
Tradable goods	0.54	0.54
Non-tradable goods	0.58	0.58
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	0.57	0.53
Fiscal balance	-0.07	-0.02
Overall revenues	0.38	0.39
Overall expenditure	0.45	0.41
External account (as a % of GDP)		
Net foreign assets	-0.60	-0.60
Current account	-0.06	-0.02
Trade balance	-0.08	-0.04

non-tradable goods market. As for real rigidities, capital adjustment costs were calibrated so as to ensure plausible impulse responses in terms of investment volatility. Regarding nominal rigidities, price growth adjustment costs were calibrated to match average adjustment time spans, in line with what is suggested in the literature. In particular, we impose that the adjustment of prices in the non-tradable goods sector is slightly slower than in the tradable goods sector, reflecting the fact that fiercer competition and lower markups imply lower price stickiness.

We now consider distributors parameters. In the assemblage stage, the elasticity of substitution between domestic tradable goods and imports was taken to be identical across distributors and set above unity, as in most of the literature on open economy DSGE models (see for instance Coenen et al. (2007), Harrison et al. (2005), Erceg et al. (2000) or Kumhof et al. (2010)); on the other hand, in the distribution stage, assembled goods (which are basically a composite tradable good) and non-tradable goods were assumed to feature a low substitutability as in Mendoza (2005) and Kumhof et al. (2010). The distribution parameters of the production function in each stage were calibrated to match the National Accounts import content and 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 is likely to determine 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 were calibrated to match the average revenue-to-GDP ratios observed in the data. The same applies to EU transfers and to expenditure components (government consumption and investment and government transfers). The parameters of the fiscal policy rule were calibrated to ensure a smooth tax adjustment. The target debt-to-GDP ratio in the steady state was set to 53%, implying a corresponding fiscal balance-to-GDP ratio of -2.1%.[18]

[18]The values assumed for the debt-to-GDP target and the implied fiscal balance can be questioned in view of the medium term objective that has been set by the European Commission for Portugal (a structural budget balance of -0.5%, implying a debt-to-GDP ratio close to 12%). However, since in the historical period that was used to calibrate the model the debt-to-GDP ratio averaged 57%, it does not seem reasonable to calibrate it to match a remarkably different figure.

B Welfare analysis

Welfare analysis can be seen as a benchmark metric for the impact of a particular policy experiment in social welfare, as measured through the aggregate lifetime utility, which is a function of goods valued by households (consumption and leisure in the case at hand). In a general equilibrium framework, welfare can be seen as the present value multiplier of households' utility (as $k \to \infty$). A widely used metric based on welfare analysis is the compensated consumption variation in the spirit of Lucas Jr. (1987). In infinite horizon models, it is natural to consider the representative agent utility function as the welfare criterion (Ganelli 2005). In overlapping generation models, welfare analysis is much less straightforward, since individuals have finite lifetimes and in each period an infinite number of generations coexist. Hence, the choice of a welfare criteria in these models is far more debatable than in infinitely-lived agents models, since it involves a subjective weighting of the utility of current and future generations.

In this paper, we use a discrete time counterpart of the suggestion of Calvo and Obstfeld (1988), which has also been used in the literature (Ganelli 2005, Kumhof et al. 2008). The method consists in using the utility function of the representative agent, for each period t, at the average per-capita consumption ($\bar{c}_{t+s}$) and leisure ($1 - \bar{l}_{t+s}$), where $\bar{l}_{t+s}$ stands for hours worked. Since these figures in period $t + s$ result from optimal decisions of representative agents of all generations alive in that period, the utility level is a measure of the average utility level in the period. The synthetic welfare indicator is obtained as a weighted average of the utility of the individuals alive in the current and in future periods, where a weighting factor W reflects the importance of future generations in the welfare from the viewpoint of the policymaker. This welfare indicator can be expressed as:

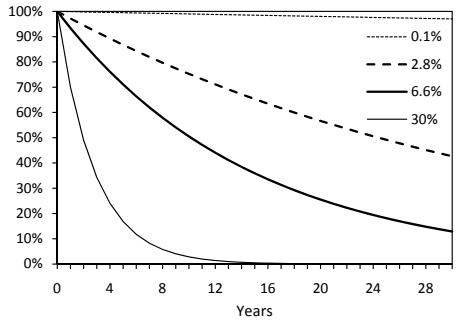
$$Welfare = \sum_{s=0}^{\infty} (W)^s \left[\frac{1}{1-\gamma} \left(\left(\frac{\bar{c}^H_{t+s}}{\left(\bar{c}^H_{t+s-1}\right)^v} \right)^{\eta^H} (1 - \bar{l}^H_{t+s})^{1-\eta^H} \right)^{1-\gamma} \right] \tag{35}$$

Given that the choice of W involves ethical considerations, namely on fairness towards born and unborn generations, we conducted a sensitivity analysis using alternative discount rates. The benchmark value W_B will be the households discount factor corresponding to an annualised discount rate of 6.3%. Alternative schemes are: the steady-state real market interest rate W_K, in line with the rationale proposed in Kaplow (2007) and used in Kumhof et al. (2008), which corresponds to an annualised discount rate of 2.8%; a very low discount rate $W_L = 0.1\%$, which is closer to the view of Ramsey (1928), who advocates that all generations should be treated alike; and, finally, a very high discount rate W_H, corresponding to an annual discount rate of 30% that is a proxy for the view of a very short-sighted government (caring more about the immediate impact of the stimulus, than for instance on the need to also envisage an adequate exit strategy).

The implied weighting scheme over ten years (40 quarters) is illustrated in Figure 1. The lower the discount rate the more future events matter. For instance, an annual

Appendix - Figure 1: Welfare weighting scheme

(in percentage)



discount rate of 0.1% implies that events occurring in 10 years ahead are weighted as much as an event occurring at $t = 0$, while a discount rate of 30% implies that events occurring more than 8 years ahead are to a large extent not considered. The average lifetime of the discount window is simply $\frac{1}{1-W}$, implying that it is virtually unlimited in the first case and limited to slightly more than 3 years in the last case. The remaining cases lie in between.

Once the welfare measure is obtained, then the compensating variation can be computed, which consists in expressing welfare gains (losses) in terms of equivalent increase in consumption in the steady-state. This simply consists in obtaining the value for CV such that:

$$\sum_{s=0}^{\infty}(W)^s \left[\frac{1}{1-\gamma} \left(\left(\frac{\bar{c}^H_{t+s} \cdot (1+CV)}{\left(\bar{c}^H_{t+s-1} \cdot (1+CV)\right)^v} \right)^{\eta^H} (1-\bar{l}^H_{t+s})^{1-\eta^H} \right)^{1-\gamma} \right] = Welfare \tag{36}$$

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